Department of Petroleum Engineering & Geothermal Energy Recovery

Doctoral Thesis

Design of Alkaline-Polymer Flooding in the Matzen Field, Austria - Technical & Economic R&D Evaluation of the planned AP Pilot

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AFFIDAVIT

I hereby declare that the content of this work is my own composition and has not been submitted previously for any higher degree. All extracts have been distinguished using quoted references and all information sources have been acknowledged.

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“If you want to succeed, you must work to overcome the obstacles on your path.”
Lailah Gifty Akita

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Kurzfassung

Tertiäre Erdölförderung erlaubt die Förderung von immobilem Öl, welches durch konventionelle sekundäre Förderverfahren, nicht mehr effektiv gefördert werden kann. Diese Form der Ölgewinnung ist technisch schwierig und erfordert neue Förderkonzepte, wie z.B. chemische tertiäre Förderung. Eine Option ist Alkali-Polymer Fluten, bei welchem alkalipolymerhältiges Flutwasser injiziert wird. Dabei interagiert die Lauge mit den verseifbaren Komponenten des Öls und bindet dieses in eine Emulsion, welche durch das Polymer mobilisiert und durch Gewinnungsbohrungen gefördert wird.

Diese Arbeit stellt anhand technischer und ökonomischer Studien die Implementierung von Alkali-Polymer Fluten im Wiener Becken dar, welches zur Erhöhung der Ölausbeute und zur Verlängerung des Produktionszeitraumes im untersuchten Ölfeld führt.

Unterschiedliche Alkalitypen wurden getestet und deren Leistungsfähigkeit in verschieden Studien verifiziert. Derzeit wird weltweit vor allem Natriumcarbonat (Na_2CO_3) als Lauge für das chemischen Fluten verwendet. Zusätzlich wurde Kaliumkarbonat (K_2CO_3) als Alkali untersucht, welches deutlich bessere Ergebnisse als Na_2CO_3 lieferte. Der Zusatz von Co-Solvents erzielte wenig Verbesserung.

Öle aus dem 8. und 16. TH wurden untersucht, wobei beide Lagerstätten vielversprechende Ergebnisse lieferten. Phasenexperimente wurden durchgeführt, welche Rückschlüsse auf das Verseifungsvermögen der Laugen, sowie auf die gebildeten Emulsionsvolumina lieferten. Zur Findung optimaler Injektionsformulierung, wurde die „fluid-fluid interaction“ durch Viskositäts- und Oberflächenspannungsmessungen analysiert und Unterschiede im Verseifungsverhalten der Öle in den Phasenexperimenten erkannt, welche anhand des Biodegradationsmodelles verifiziert und beschrieben werden konnten.

In einer weiteren Studie wurde die Alkali-Gesteinsinteraktion untersucht, um mögliche Ausfällungserscheinungen des Lagerstättengesteins im basischen Milieu bei der Injektion der Laugen zu vermeiden. Dabei wurden Gesteinsproben in mit Lauge gefüllte Autoklaven (NaOH, Na_2CO_3 und K_2CO_3) für rund 90 Tage bei Lagerstättentemperatur ausgelagert, in regelmäßigen Abständen beprobt und die Wasserphase im Detail analysiert. Zusätzlich wurde die Interaktion von Gravel-Pack Material (Carbolite® und Glaskugeln von Swarco®) mit den Laugen untersucht. Natronlauge führte zu massiven Veränderungen der Oberflächenstrukturen und Lösungserscheinungen, während bei Karbonaten nur geringfügige Alterationen beobachtet wurden.

Die Aufbereitung von rückproduzierten polymerhältigen Lagerstättenwässern (HPAM) ist eine der schwierigsten Aufgaben bei der Anwendung von chemischem Fluten. Hierzu wurden Versuche in einer Pilotanlage durchgeführt, welche die gleichen Aufbereitungsschritte wie die

Wasserflutanlage Schönkirchen verwendet. Der Einfluss von HPAM auf Parallelplattenabscheider, Flotationseinheit und Nussschalenfilter wurde untersucht und die Effizienz von zwei verschiedenen chemischen Flotationschemikalien hinsichtlich Entfernung von Kohlenwasserstoffen getestet. Der Pilotversuch zeigte keinen Einfluss des Polymers auf die mechanische Abtrennung. Ein starker Leistungseinbruch der Flotationsanlage wurde nachgewiesen, wenn das HPAM nicht durch das Flockungsmittel aus der Wasserphase entfernt werden konnte, was zu erheblichen operativen Schwierigkeiten im Nussschalenfilter führte.

Ein ökonomisches Model für die Durchführung und Bewertung von Forschungs- und Entwicklungsprojekten (F&E) im Upstream Segment wurde entwickelt und neue Indikatoren für die wirtschaftliche Bewertung definiert. Frühzeitige Erkennung von auftretenden Umwelteinflüssen für die Entscheidungsfindung wird immer wichtiger, weshalb Ökobilanzen Teil der festgelegten Indikatoren sind. Das Model wurde anhand des Alkali-Polymer Projektes praktisch getestet und bewertet.

Bei allen Studien konnte K_2CO_3 als vielversprechendes und aussichtsreiches Alkali verifiziert werden.

Abstract

Enhanced oil recovery (EOR) techniques enable displacement of trapped oil, which is more difficult to extract than mobile oil and can be displaced by chemical flooding. Alkali-polymer flooding represents an option in which alkali-polymer containing water is injected. Injection of alkali solution leads to several chemical reactions, including alkali-oil interaction to generate in-situ soaps (emulsions), alkali-reservoir rock and alkali-water-reaction. Use of alkali-polymer formulations lowers interfacial tension, emulsifies trapped oil and sweeps generated in-situ soap to the producer wells.

This thesis yields a precise overview about the implementation of alkali-polymer flooding in the Vienna Basin. Technical and economic studies were conducted to reduce uncertainties of the planned prospect and explain the performance of the used alkali lyes. Implementation of EOR further supports the increase of the ultimate recovery and prolongs the field lifetime of the described oilfield.

Different alkali lyes were examined and their performance was verified in different studies. Currently sodium carbonate (Na2CO3) is mostly screened and applied as alkali lye for alkali-polymer/ alkali-polymer-surfactant floods. K2CO3 was additionally examined and showed more promising results than Na2CO3. Usage of co-solvents didn’t enhance in-situ soap generation or reduce emulsion viscosity.

Oils from the 8.TH annd 16.TH were tested, whereby both reservoirs showed promising results. Phase experiments were carried out to get a better understanding for the in-situ soap generation of the alkalis. In order to find the optimal chemical formulation, the fluid-fluid interaction was examined through viscosity and interfacial tension measurements. Additionally, differences in the in-situ soap generation of the oils could be identified and successfully verified, as well as described through the biodegradation model.

Alkali-rock interaction was analyzed to avoid dissolution of the reservoir rock in alkaline environment during injection. Reservoir rock samples were exposed at reservoir temperature for 90 days in autoclaves containing the alkali lyes (NaOH, Na2CO3 and K2CO3). The autoclaves were sampled in periodic time intervals and the aqueous phase was analysed. Furthermore, the interaction of alkalis with gravel pack material (Carbolite® and Swarco® glass beads) was evaluated. Usage of NaOH led to massive alterations and dissolution of the reservoir rock and the gravel pack material, whereas carbonate-based alkalis showed only minor alterations.

Treatment of back-produced polymer-containing water (HPAM) is a key task for successful chemical flooding. A water treatment plant in pilot scale was operated, using breakthrough polymer-containing water. The impact of HPAM on a corrugated plate separator, a flotation unit and a nutshell filter was evaluated. Re-injection water quality is crucial for EOR techniques and leads to significant water treatment costs. The achieved results showed no influence on the mechanical treatment step by HPAM, whereas the chemical step (flotation) suffered most, especially when HPAM can’t be removed through the flotation chemicals from the aqueous phase, which results in operative challenges in the nutshell filter. Another chemical package was tested, whereby it was possible to treat successfully breakthrough polymer water.

An economic evaluation model for research and development (R&D) projects for the upstream segment was developed. It provides a concept funnel, discusses relevant R&D key performance indicators (KPIs) and combines economic KPIs with R&D KPIs. As environmental aspects become more relevant in the upstream business, it is essential to include them in project evaluations in terms of life cycle assessments. Technological, economic and environmental aspects are combined in this developed R&D model & were tested on the alkali-polymer project.

All executed studies verified that use of K2CO3 for chemical EOR formulations might be promising.

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List of Abbreviations

AC	Alkali Co-Solvent
ACP	Alkali Co-Solvent Polymer
Al_2CO_3	Corundum
Al_2O_3	Bauxite
AN	Acid Number
AP	Alkali Polymer
AS	Alkali Surfactant
ASP	Alkali Surfactant Polymer
Bo 112	Bockfliess 112
BOE	Barrel of Oil Equivalent
C_6H_{12}	Cyclohexane
$CaAl_2Si_2O_8$	Anorthite
$CaCO_3$	Calcium Carbonate
CAPEX	Capital Expenditures
cEOR	chemical Enhanced Oil Recovery
CF	Cash Flow
CH_4	Methane
CO_2	Carbon Dioxide
CoF	Cost of Failure
CoM	Chance of Maturation
CPI	Corrugated Plate Interceptor
CPM	Capital Project Management
DCF	Discounted Cash Flow
DGF	Dissolved Gas Flotation
DMN	Dimethylnaphthalenes
DPI	Discounted Profitability Index
E&P	Exploration & Production
EI	Environmental Impact
EMV	Expected Monetary Value
EOR	Enhanced Oil Recovery
Epi-DMA	Epichlorhydrine-Dimethylamine
EPMS	Exploration Project Management System
ESP	Electric Submersible Pump
ExCom	Executive Commission
FAWAG	Foam Assisted Water Alternated Gas
F&E	Forschung & Entwicklung
GC-FID	Gas Chromatography-Flame Ionization Detector
GC-MS	Gas Chromatography-Mass Spectrometry
GG	Greenhouse Gases
H_2S	Hydrogen Sulfide

H_4SiO_4	Orthosilicic Acid
HC	Hydrocarbon Content
HCl	Hydrogen Chloride
HH	Human Health
HNO_3	Nitric Acid
HPAM	Hydrolysed Polyacrylamide
HQ	High Quality
HSE	Health, Safety and Environment
HSSE	Health, Safety, Security & Environment
HW	Hazardous Waste
IC	Ion Chromatography
ICP-OES	Inductively Coupled Plasma-Optical Emission Spectrometry
IFT	Interfacial Tension
IPA	Independent Project Analysis
IRR	Internal Rate of Return
K_2CO_3	Potassium Carbonate
$KAlSi_3O_8$	Potassium Feldspar
KOH	Potassium Hydroxide
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LU	Land Use
MBF	Micro Bubble Flotation
MCFS	Minimum Commercial Field Size
MEFS	Minimum Economic Field Size
MEOR	Microbial Enhanced Oil Recovery
$Mg(OH)_2$	Magnesium Hydroxide
$MgCO_3$	Magnesium Carbonate
$MgFe(SiO_4)_3$	Garnet
MN	Methylnaphthalenes
MP	Micellar-Polymer
MTP	Mid-Term Planning
MW	Molecular Weight
Na_2CO_3	Sodium Carbonate
Na_2SiO_3	Sodium Silicate
Na_4SiO_4	Sodium Orthosilicate
$NaAlSi_3O_8$	Albite
NaCl	Natrium Chloride
$NaHCO_3$	Sodium Bicarbonate
NaOH	Sodium Hydroxide
NCF	Net Cash Flow
NH_3	Ammonium

NPV	Net Present Value
NSF	Nutshell Filter
NSO	Nitrogen-Sulphur-Oxygen
OMPD	Opportunity Maturation & Project Delivery
OOIP	Original Oil in Place
OPEX	Operational Expenditures
PAC	Poly-aluminium Chloride
PAM	Polyacrylamide
PV	Pore Volume
R&D	Research & Development
RD	Resource Depletion
RF	Recovery Factor
S 85	Schoenkirchen 85
SAC	Strong Acid Cation
SARA	Saturated, Aromatic, Resin, Asphaltenes
SDT	Spinning Drop Tensiometer
SEC	Size Exclusion Chromatography
SEM	Scanning Electron Microscope
SiC	Silicon Carbide (Corborundum)
SiO_2	Silica
SP	Surfactant-Polymer
STB	Stock Tank Barrel
TAN	Total Acid Number
TDS	Total Dissolved Solids
TG	Tollgate
TH	Tortonian Horizon
TMN	Trimethylnaphthalenes
TQ	Technical Quality
TSS	Total Suspended Solids
TVDss	True Vertical Depth Sub-Sea
WAC	Weak Acid Cation
WACC	Weighted Average Cost of Capital
WBF	Water-Blocking-Factor
WC	Water Cut
WOR	Water Oil Ratio
WTP	Water Treatment Plant
XRD	X-ray Diffraction

1 Introduction

In the near future crude oil production and consumption rate will further increase (**Figure 1-1**). Nevertheless, large crude oil resources are already recovered and discovering new oilfields tend to be even more challenging and difficult. Largely unexplored frontier basins are located in politically or environmental sensitive regions of the world. A majority of international oil companies try to maximise the recovery factor of their mature oilfields. By implementing an enhanced oil recovery (EOR) technique, the production lifetime of an oilfield can be tremendously increased. However, the crude oil price must be high enough to make the application of such technology economically feasible. According to data from 2012, the average recovery factor of oilfields ranged between 20 to 40%, whereas gas fields could be exploited to around 80 to 90%. The currently economically proven oil reserves will last around 54 years based on today's consumption [1, 2].

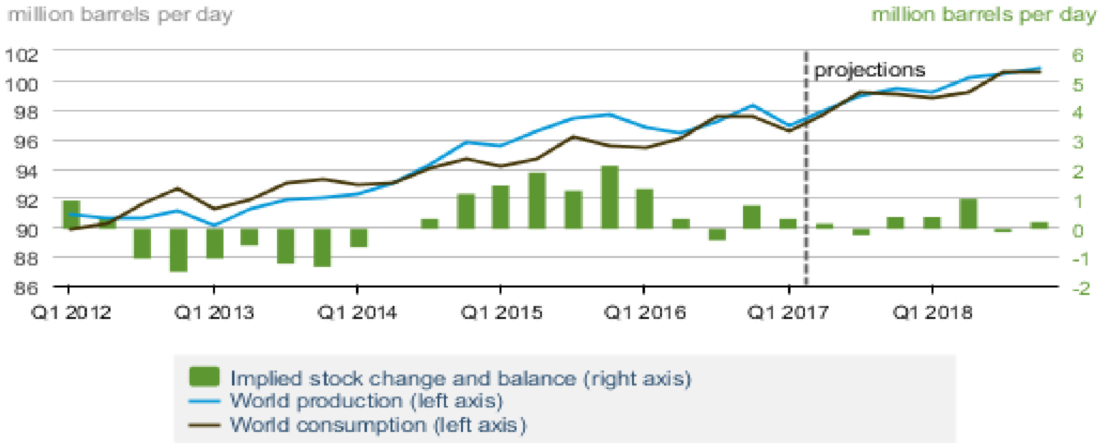


Figure 1-1: World crude oil production and consumption rate [3].

The oil production can be subdivided into three main stages: primary, secondary and tertiary recovery. Primary and secondary recovery methods focus on mobile oil; tertiary processes target the recovery of immobile oil. With primary extraction, oil is produced through the natural depletion drive mechanisms (natural pressure) in the reservoir. The process is performed without injection fluids such as gases or water for pressure maintenance. Through primary recovery, only 10% of the original oil in place (OOIP) can be exploited based on the oil quality (API gravity) [4, 5].

Secondary recovery is an additional recovery improvement process and extends the production life of a reservoir [6]. For pressure maintenance and volumetric sweep efficiency, water is injected to flood the residual oil and gas out of the reservoir. Water flooding is currently the most commonly used method. On average, around 25-30% of the oil can be extracted [4, 5]. In secondary recovery, the oil gets pushed through the reservoir, while in tertiary recovery (such as gas flooding, chemical flooding, in-situ combustion, steam flooding) the reservoir interactions between rock, formation water, and crude oil are modified. Frequently, different substances are injected to improve the flow rate between the displaced fluid and the formation [4, 7].

The amount of crude oil recovered with EOR techniques (**Eq. 1**) depends on the amount of oil in place, the macroscopic sweep efficiency (E_s) and the microscopic displacement efficiency (E_{PS}) [8]. Additional 20 to 30% of the remaining oil can be produced with EOR techniques [9, 5, 4, 10].

$$\mathrm{RF} = \mathrm{E_{PS}} * \mathrm{E_S} * \mathrm{E_D} * \mathrm{E_C} \qquad \textbf{(1)}$$

RF= recovered oil volume over the volume of OOIP
E_{PS}= displacement of oil from the pores through the injection of water
E_S= connected reservoir volume swept through the injected fluids
E_D= amount of the total reservoir volume linked to wells
E_C= economic efficiency factor [11]

In 2012, about 370 EOR projects worldwide were implemented and most are still in operation (**Figure 1-2**). Koottungal (2013) demonstrated that roughly 3.7 million barrels of oil per day could be produced using EOR applications [12]. The most frequently performed EOR techniques worldwide are thermal methods (steam injection), which make up approximately 48% of the projects; followed by miscible gas injection with around 40% and chemical projects of about 11%. Microbial EOR processes are not yet commonly performed and make up less than 1% of the overall applications [13].

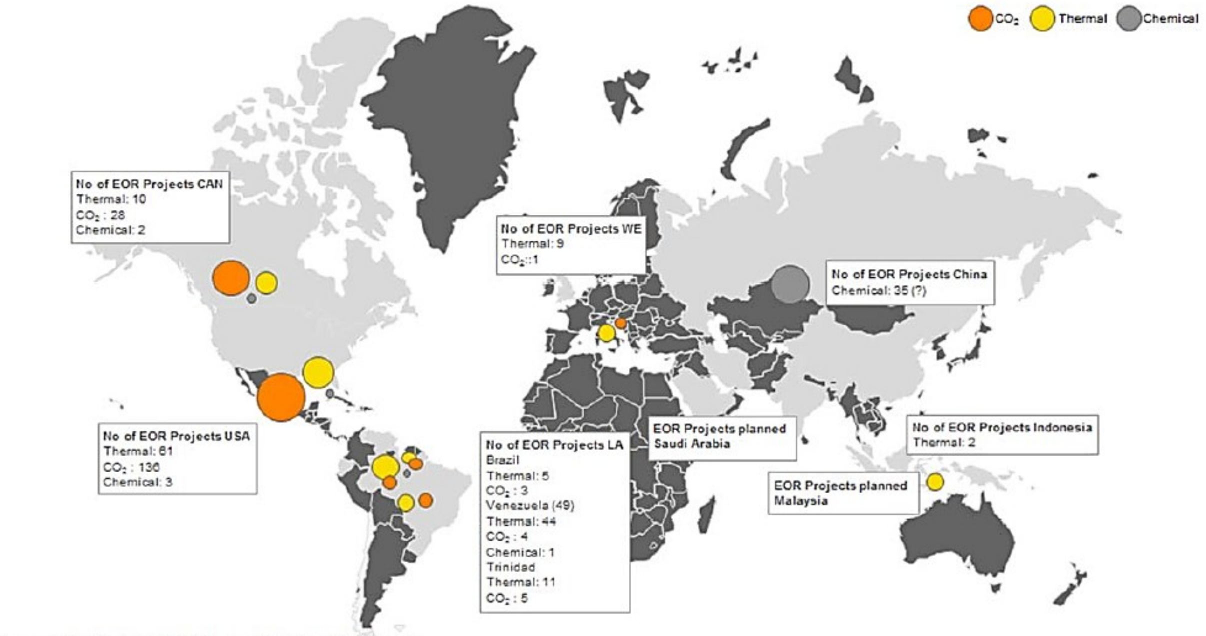


Figure 1-2: Distribution of EOR projects performed globally (2012) [12].

Thermal processes such as steam injection (hot fluid injection) and in-situ combustion (burning a part of the oil in place) belong to the most abundant and widespread tertiary recovery methods. In this processes, heat is used to lower the oil viscosity and to enable a better flow as well as an easy transport through the reservoir and towards the surface [8, 14]. Adversely, this method demands a high level of process chemicals due to the high operating temperatures. In addition, corrosion inhibitors, scale inhibitors, and emulsion breakers are required [13].

In chemical flooding processes interfacial-active components like surfactants, co-solvents, or alkaline substances as well as polymers are injected to further improve the water flooding process. The chemicals can be applied individually or combined, resulting in an increase of the capillary number [8]. Through the application of micellar, alkali or soap-like substances the interfacial tension (IFT) between the oil and water in the reservoir gets decreased. Polymers improve the sweep efficiency. The following components can be mostly found in a chemical flood activity: pre-flush (low-salinity water), chemical solution (micellar or alkaline), a mobility buffer (polymer) and a driving fluid (water) that transfers the chemicals and the resulting oil bank to the producer wells [15].

During gas flooding miscible gas (frequently CO_2) is injected into the reservoir. The gas is mixed with the crude oil resulting in a decrease of the oil viscosity to provide a more efficient miscible displacement effect. Compared to other gases, CO_2 has a relatively low miscibility pressure [16]. Miscible gas injection systems reduce the interfacial tension and the residual oil saturation to recover more oil. A perfect miscibility can be attained with a vaporized or condensed gas drive [8]. Sometimes also foam assisted water alternated gas technique (FAWAG) is applied. The viscosity of the injection front is increased through adding soluble surfactants to the water followed by gas injection to enhance the sweep efficiency [16].

Microbial enhanced oil recovery (MEOR) uses microbial solutions to stimulate the bacterial growth of indigenous or injected bacteria at the oil/ water interface resulting in a decrease of the interfacial tension. Mostly, the reservoir is conditioned by a water pre-flush followed by the injection of a microorganism and nutrients solution. The solution is pushed through the reservoir with drive water, producing gases and surfactants to mobilize the oil in place. Finally, the crude oil and the product solution are pumped through the production well to surface facilities [17].

1.1 Problem Definition

EOR projects typically start when the production in mature oilfields start to decline (**Figure 1-3**). In order to maximize the production as well as the recovery factor, possible applications are screened beforehand. Afterwards a proper selection of the most promising technology is set and various studies are getting investigated in laboratory scale. After the first gain of knowledge and when the results are promising/ positive, further tests are carried out and applied to pilot scale. In the last step, the technology gets implemented in the field either for a specific sector or as field roll out.

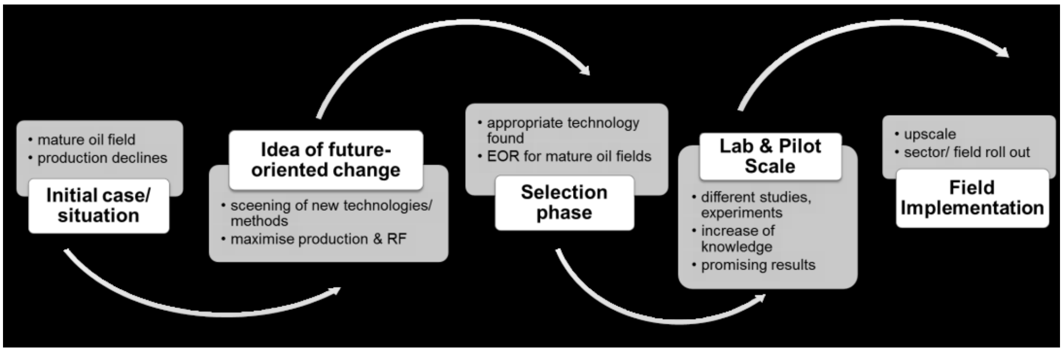


Figure 1-3: EOR project phases from the idea to the field implementation.

Especially, in heavy and extra-heavy oil reservoirs thermal and chemical techniques can be applied to achieve a better recovery rate and extend the reservoirs life [18]. Alkaline-polymer (AP) and alkaline-polymer-surfactant (ASP) flooding are potential opportunities for reservoirs with oil gravities from 14 to 22 API [7]. Sheng (2015) reported that there are only a few alkali flood projects worldwide because the observed incremental oil recovery increase was in average just 1-2% [18].

Alkali-polymer flooding or combinations with co-solvents provide a cost-effective alternative to micellar-polymer (MP) and ASP flooding. The expensive surfactants are substituted against cost-efficient solutions like alkalis (caustic solutions), which are able to generate naturally in-situ soaps (surfactants). Through the injection of alkali-polymer solutions nearly a doubled recovery rate can be achieved compared to a single polymer injection process [10]. Adversely, scale issues might result from injection of chemicals into the reservoir. Possible water source strategies must be elaborated to enable a successful EOR process [7].

Nevertheless, there are just eight AP field projects implemented worldwide; located in Canada (four), China (two), and in the USA (two). All of them were performed onshore in sandstone reservoirs. Na_2CO_3 was injected as alkali lye and polyacrylamide types were used for the polymer slug. The low number of performed field projects indicates the complex interactions of the alkali with the formation water, the reservoir rock, the crude oil as well as the polymer, which requires proper investigations beforehand [19].

1.2 Research Objectives

OMV Austria Exploration & Production GmbH has conducted water flooding in the Vienna Basin (Austria) since decades. Currently the water-cut has risen to over 90%. Therefore, OMV plans to implement alkali-polymer flooding as further cEOR method to sustain and further enhance the production of the mature giant Matzen oilfield. Various challenges arise while implementing a chemical flood into the field. In order to minimize these risks and to enhance the progress of this research and development (R&D) project a multidisciplinary approach for alkali-polymer (AP) flooding was developed in the frame of this thesis. At present, the R&D project is in the select and define phase before moving on to the implementation phase. Therefore, intensive laboratory investigations were performed. Studies included the screening of various chemical formulations, characterization of the fluid-fluid interaction, alkali-rock interaction, treatment of back-produced fluids and the development of an economic R&D evaluation model.

This doctoral thesis deals with the interactions of caustic solutions and polymer on subsurface and surface facilities. Several studies were conducted to get a better understanding about the technology. The chemical formulation which should be tested for the planned AP trial was investigated. The most promising reservoirs (8.TH and 16.TH) in the Matzen field were examined. Therefore, two alkali lyes (Na_2CO_3, K_2CO_3) were experimentally tested in laboratory scale. This research study gives an overview, which issues can come up and should be considered, when alkaline substances are used for chemical flood purposes. The gathered results of the studies will lead to a composition of the advocated injection fluids.

In the first study the emulsification process (in-situ soap generation) of alkali solutions was analysed. Therefore, phase experiments with various alkali-oil mixtures were performed. The gathered results demonstrate the phase behaviour of diverse alkali solutions at different oil-water-ratios over time. Moreover, the influence of co-solvents and polymer on the phase behaviour was tested. Output of this study is an optimal formulation for the two analysed reservoirs. Differences in the oil composition of the two reservoirs and the formed micro emulsions were worked out. The prepared formulations compare the influence of synthetic and real softened formation water as well as dead oil and viscosity-matched oil on the phase behaviour (as alkali slug, AP and ACP slug).

These formulations were evaluated with different screening methods such as phase experiments, viscosity and interfacial tension measurements. Thereby, a better understanding about the generated middle-phase emulsion regarding its stability, equilibrium time and properties can be made. Besides, various co-solvents as well as polymer were added to optimize the formulation. K_2CO_3 was until now never used in any EOR flood application and was tested according to its efficiency. Furthermore, the stability of polymers in alkali solutions had been investigated (alkali-polymer interaction).

The second study deals with alkali interaction on rock surfaces. The chemical interaction between reservoir rock and EOR fluids in the reservoir is until now poorly understood. The mineral composition in the Vienna Basin implies that especially, dissolution and precipitation, caused by alkali-silica and alkali-dolomite reactions could be problematic. According to literature, it can result in formation damage or precipitations of insoluble material in the subsurface and in surface facilities. To minimize this risk, autoclave experiments were conducted. The same alkali solutions, as used in the first study, were intensively researched under different pH and temperature conditions. Subsequently, the caustic solutions and the occurring precipitations on rock surfaces were assessed. The performance of autoclave tests and the knowledge about simultaneous rock reactions mitigate the risk using inappropriate EOR fluids in chemical flooding processes. In addition, sanding may become an issue during operation. For this purpose, the alkali lye interaction with gravel pack materials (Carbolite beads and Swarco® glass beads) was tested as well.

Focus of the third study was the separation efficiency of oil-water solutions containing back-produced polymer solutions in surface facilities. According to the literature, the treatment process of back-produced polymer is more difficult and more problems can occur than with caustic solutions alone. Consequently, the treatment of back-produced polymer was separately and intensively studied in an OMV pilot plant. Thereby, the separation efficiency of every single treatment step and the injection water quality was evaluated following OMV internal standards. The treatment of alkali-polymer solutions could not be tested because no back-produced fluids were available to test within a pilot plant at the time this study was conducted. Artificially generated emulsions in the laboratory do not reflect the real back-produced fluid properties as well as the field conditions (e.g. water cut, dilution of the fluids from other producing wells, droplet size). The usage of the same kind of demulsifier as well as dosing quantity identified in the laboratory would probably alter in the field. As a remark, the demulsifier needs to be adjusted onsite to suit the field conditions as soon as the first emulsions are produced.

The last study focuses on the economic assessment of the planned alkali-polymer project. An economic model for R&D projects was established based on the currently used exploration and production (E&P) model within OMV. The required components for R&D economic evaluations are worked out, whereby life cycle assessments (LCA) represent an integrative evaluation part of R&D projects. This model provides base criteria to support R&D project decisions. Nevertheless, it does not include final management decisions which are based on the targets and premise of the company. The model approach was finally tested and applied to the practical case study of alkali-polymer flooding. Different injection scenarios and formulations were modelled using Palantir Cash® software and compared regarding the established R&D criteria. The LCA results represent the environmental impacts occurring in this AP process.

2 Chemical Flooding – Fundamentals of AP Flooding

Nowadays, chemical flooding becomes more and more attractive especially for heavy oil reservoirs. Sheng (2011) and Olsen *et al.* (1990) published that the oil recovery gets almost doubled by the use of alkali-polymer flooding. A higher incremental oil production could be achieved by applying AP flooding after performing conventional water flooding [10, 20]. **Table 2-1** compares the mechanism of polymer flooding with AP flooding. Taber and Martin (1983) published associated issues as well as typical required chemical amounts (referred to one barrel crude oil) with these methods.

Table 2-1: Comparison of polymer and combined AP flooding (Adapted from [21]).

Process	Recovery mechanism	Issues	Typical chemical consumption
Polymer	improves volumetric sweep by mobility reduction	injectivity, stability, high salinity	0.3-0.5 lb polymer per bbl oil produced
AP	same as polymer + reduces capillary forces + oil solubilisation & wettability alteration	same as polymer + chemical availability, retention, high salinity + oil composition	35-45 lb chemical per bbl oil produced

Samanta *et al.* (2012) reported that the recovery effect is mainly dependent on the fluid as well as the reservoir rock properties. The required formulation concentrations (influenced by the rock permeability) are different for each field and therefore intensive investigations are needed beforehand [22]. A summary of the screening criteria proposed for alkali, polymer and alkali-polymer can be found in **Table 2-2**.

Table 2-2: Screening criteria for alkali, polymer, and AP flood projects.

Criteria proposed for	Alkali [18]	Polymer [19]	AP [19]
Lithology	sandstone	sandstone	sandstone
Clay	low	low	low
Reservoir temperature (°C)	<93.3	<93.3	<93.3
Average permeability (mD)	>10	>50	>50
Formation water salinity TDS (ppm)	<50,000	<50,000	<50,000
Divalent cations (ppm)	<100	<100	<100
TAN	organic acid	not critical	organic acid
Oil viscosity (cP)	<150	<150	<150
Oil saturation	>0.35	$(S_o\text{-}S_{or}) > 0.1$	>0.35
Aquifer	weak	weak	weak
Gas cap	weak	weak	weak

In order to achieve an optimal flooding effect, Sheng (2013, 2015) stated that the oil saturation should be high enough (>35%). Furthermore, clay content should be relatively low otherwise it will result in high alkali consumption [23, 18]. There are numerous options regarding the injection design (**Figure 2-1**) [24]. As a first step, low-salinity water (pre-flush) is injected prior to the chemicals are brought into the reservoir (conditioning). Accordingly, an aqueous fluid buffer between the high salinity brine and the chemical solutions is generated. It can be negatively affected through the dissolved salts. Afterwards, an alkali solution is injected to mobilise the crude oil which is adsorbed or trapped in the rock pores (emulsification). The caustic front is followed by a polymer solution to enhance the fluid viscosity. Function of the polymer is to support the displacement and reduce the loss through dilution or channelling (mobility control agent) [25]. As final step, a post-flush with water is injected. Instead of a single alkali flush, a mix of AP can be used. Sheng (2013) stated that it is relevant to mix AP in the same slug in order to have the synergistic effect of both components and to avoid possible chromatographic effects [26].

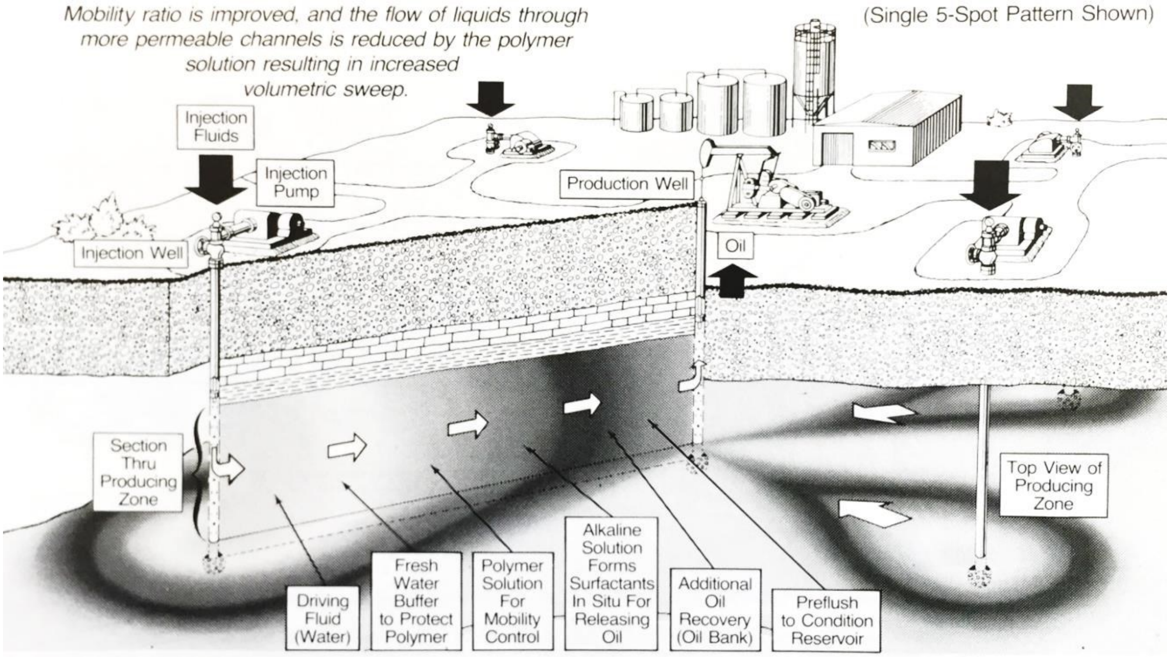


Figure 2-1: Illustration of a typical alkaline-polymer flooding process [25].

Every crude oil system is different and requires a proper choice of chemical formulations. In the upcoming chapters the mechanism of the alkali-polymer process is split into alkali and polymer and separately discussed.

2.1 Alkali Interaction

The implementation of pure alkali floods is not that promising and results in poor oil recovery. Gao *et al.* (2010) states that a massive alkaline loss is caused by chemical reactions with the reservoir rock, the high acid number of the crude oils leads to high retention [27]. Commonly used alkali lyes are sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium carbonate (Na_2CO_3) and sodium silicate (Na_2SiO_3) [28, 10, 29, 30].

2.1.1 Mechanism

Alkaline flooding distinguishes from other chemical flooding processes by the in-situ soap generation through saponification. The generated emulsion improves the sweep efficiency, which can be further increased by adding polymers or surfactants to the injection slug [23]. The following mechanisms are mainly predominant for the recovery of crude oil with alkali solutions after water flooding:

- In-situ generation of surface-active products through the reaction with the acidic oil components.
- Oil Emulsification into the aqueous phase.
- IFT reduction between oil and water.
- Enhancement of the sweep efficiency through emulsification and entrapment.
- Wettability alteration [31, 32].

Emulsification and entrapment are predominantly relevant in water flooded reservoirs with viscous oil, in which the sweep efficiency from the water flood is relatively poor. Ehrlich and Wygal (1977) conducted a series of experiments and discovered that the minimum acid number for a successful emulsification ranges from 0.5 to 1.5 mg potassium hydroxide (KOH) per gram crude oil [33].

Subkow (1942) pointed out, that the residual oil is emulsified and entrained into the aqueous solution, flowing through pores and produced as an emulsion. The alkali in the aqueous phase reacts with the organic acids (naphthenic acids) of the crude oil phase by the in-situ acid-base reaction, whereby a surface-active product is generated. The in-situ soap is able to adsorb on the rock surface according to Subkow (1942) [34]. In this way the wettability of the reservoir rock changes and/or adsorption on the oil-water interface is possible due to lower interfacial tension (1-10 dyne/cm). At those low tensions stable oil-in-water emulsions or unstable water-in-oil emulsions are formed [31, 34]. IFT is basically dependent on pressure, temperature, electrolyte concentration but also on the phase composition. Adding a co-surfactant or co-solvent can further decrease the IFT [10, 35].

Initially, the residual oil was mobilized through emulsification and wettability alteration, followed by the macroscopic production of the mobilized oil phase. In this emulsification and entrapment process, the emulsified oil is trapped into the small pore throats, where the emulsion droplets cannot penetrate. This mechanism needs a high pH value, a moderate acid number and a low salinity. Besides, the oil-water emulsion size must be smaller than the pore throat diameter. The injection water (aqueous phase) is forced into pores that have not been previously displaced. The mobility of the aqueous phase results in an increase of the displacement efficiency and in overall in the enhancement of the recovery process [31, 34, 36].

Using caustic solutions in the recovery process leads to an increase of the pH value and the ionic strength (salinity). There are two possibilities how the chemical formulation can be chosen, either the salinity of the injection water is changed at a fixed alkaline concentration or the alkaline concentration is varied at a defined salinity [10]. The pH change is caused by the dissociation reaction of the alkali. The following equations show the ongoing reactions for NaOH (**Eq. 2**), K_2CO_3 (**Eq. 3**) and Na_2CO_3 (**Eq. 4**). The sodium hydroxide dissociates to OH^- and the carbonate-based alkalis to CO_3^{2-} [10].

$$\mathrm{NaOH} \rightarrow \mathrm{Na^+} + \mathrm{OH^-} \qquad (2)$$

$$\mathrm{K_2CO_3} \rightarrow 2\,\mathrm{K^+} + \mathrm{CO_3^{2-}} \qquad (3)$$

$$\mathrm{Na_2CO_3} \rightarrow 2\,\mathrm{Na^+} + \mathrm{CO_3^{2-}} \qquad (4)$$

The carbonate dissociation reaction is followed by a hydrolysis reaction (**Eq. 5**).

$$\mathrm{CO_3^{2-}} + \mathrm{H_2O} \rightarrow \mathrm{HCO_3^-} + \mathrm{OH^-} \qquad (5)$$

According to Labrid (1991), carbonate-based alkalis are less dependent on the salt concentration compared to sodium hydroxide solutions [10, 37].

2.1.2 Wettability Alteration

Most crude oil is retained in the reservoir because of viscous, capillary and gravitational forces. The capillary number and the mobility ratio describe the relative correlation of these forces when the crude flows through the porous medium. In the following **Eq. 6** the capillary number (N_C) is demonstrated. It describes the relationship between the viscous forces to the surface tension forces σ. The displacing fluid viscosity is expressed as μ and the fluid velocity as u [38].

$$\mathrm{N_C} = \mathrm{Ca} = \frac{\mu * u}{\sigma} \qquad (6)$$

The residual oil saturation S_{or} decreases with an increasing capillary number N_c. Three options exist to raise N_c: either through the increase of u, μ or through the reduction of σ. Nevertheless, the increase of fluid velocity is limited by the pump capacity or by the formation injectivity. An increase of fluid viscosity is in practice restricted through OPEX because higher polymer concentrations are required [23].

The reservoir fluid propagates through the porous media according to the Darcy equation (**Eq. 7**). The term k reflects the permeability, p the pressure and x the length. In a single-phase flow k represents the absolute permeability and in a multi-phase flow the effective permeability. The phase mobility (λ) of the fluid can be described with **Eq. 8** [39].

$$u = \frac{k}{\mu} * \frac{dp}{dx} \qquad \textbf{(7)}$$

$$\lambda = \frac{k}{\mu} \qquad \textbf{(8)}$$

The initial residual oil content is controlled by the reservoir wettability. When wettability reversal agents such as caustic solutions are added, the capillary forces are reduced [40, 41]. Michaels and Timmins (1960) discovered that under water-wet conditions, an oil droplet gets trapped in a pore throat. When an alkali agent enters the pores a wettability change takes place and alters the pores slowly to oil-wet. The oil droplet in the pore undergoes a continuous wetting phase, resulting in a propagation of the wetting phase along the rock surface (**Figure 2-2**). When the caustic concentration decreases, the rock undergoes a change of water-wet to oil-wet conditions and the crude oil becomes displaced [42].

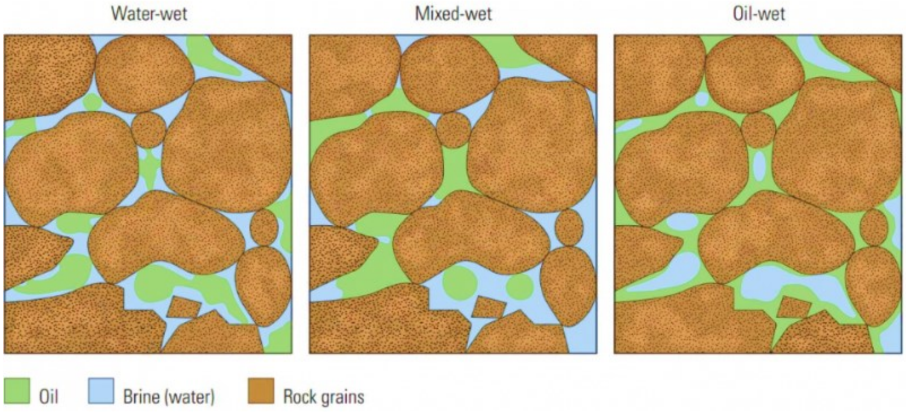


Figure 2-2: Wettability alteration from water-wet to oil-wet [41].

Leach *et al.* (1962) argued that wettability alteration results are achieved through the reaction of alkali and acidic polar compounds. It leads to a favourable increase of the oil/water relative permeability ratio and enhances the displacement efficiency [43].

2.2 Polymer: Mobility Control & Flooding Effect

Polymer flooding is the most promising and frequently performed cEOR method in high water-cut oilfields and successfully applied since the 1960´s. Performed polymer flood projects showed an increase in the recovery of approximately 10-15% from the original oil in place. Through the usage of dilute, high-molecular-weight polymer solutions the sweep efficiency (displacement of OOIP by a flooding agent) of the water flooding process and the relative mobility ratios of the oil-water front are improved. This leads to an accelerated oil production. If the mobility ratio of water floods itself is unfavourable ($M \leq 1$); large quantities of oil is still trapped within the reservoir rock (**Figure 2-3**). Particularly when a flow path had already been formed by water flooding the displacing fluid (polymer) flows directly from the injector to the producer, leaving the oil-bearing zones untouched and resulting in a low oil recovery [44].

The sweep efficiency defines the effectiveness of a performed EOR process and is expressed in percentage. It is affected by several reservoir aspects such as injection pattern, fractures, thickness, heterogeneity, and permeability. Furthermore, it is dependent from the mobility ratio, the density differences between the displacing and displaced fluid, the flow rate and positioning of gas-oil and oil-water contacts [45, 46, 47].

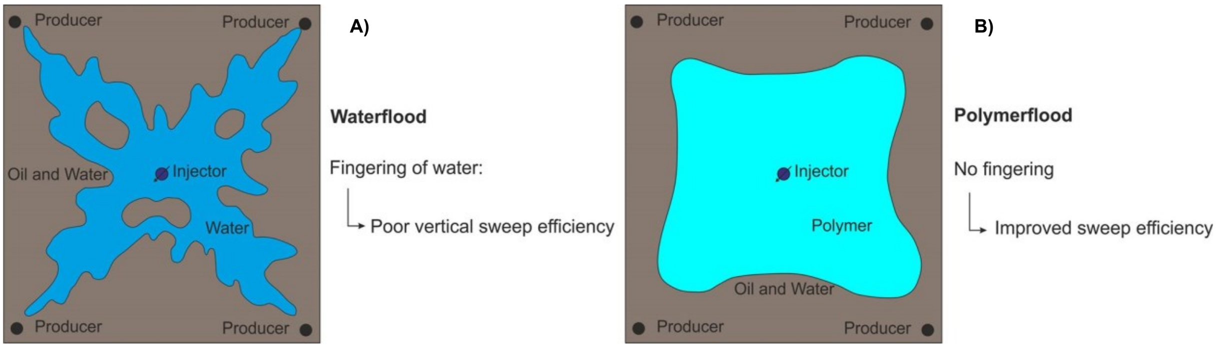


Figure 2-3: Comparison between water and polymer flooding: water flooding (A) shows fingering and polymer flooding (B) represents an optimal oil recovery profile (Modified from [48]).

The main polymer mechanisms can be summarised as follows:

- Mobility control of the displacing phase (water).
- Permeability reduction through polymer retention in the porous media.
- Flow resistance enhancing the volumetric or macroscopic sweep efficiency [44].

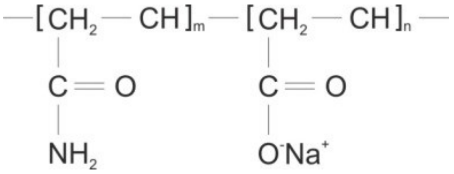
In mobility control processes, polymers alter the fractional flow characteristics of the water phase. Consequently, the relative water permeability is reduced and the viscosity of the injection water gets increased. The relative flow of the oil is improved, when the flow of the aqueous phase in a porous medium decreases compared to the oil flow. As a result, the mobility ratio is lowered and helps mobilizing the oil; the recovery process is improved. A decrease of the mobility ratio means a higher oil production at a given injected water volume [49, 50].

The mobility ratio expressed in **Eq. 9** is defined by mobility (λ), viscosity (μ) and relative permeability (k_r). The subscript o expresses the oil and w the water phase. In order to mobilise trapped oil the viscous-to-capillary force balance between the two phases (oil and water) needs to be significantly enhanced. By using polymers, the viscosity of the flood water is increased. Oil stays in the reservoir because residual oil is trapped by capillary forces [51].

$$M = \frac{\lambda_w}{\lambda_o} = \frac{k_{rw}/\mu_w}{k_{ro}/\mu_o} = \frac{k_{rw}\mu_o}{k_{ro}\mu_w} \qquad \textbf{(9)}$$

Sheng (2011), Lake (1989) and Dynes *et al.* (1954) stated that the mobility of the displacing fluid should be equal or less compared to the overall mobility of the displaced multiphase fluids [10, 52, 53].

Mostly, water-soluble polyacrylamides (synthetic) or polysaccharides (biopolymers, for example xanthan gum) are used [25]. Polyacrylamide adsorbs strongly on rock surfaces. Therefore, it is partially hydrolysed (15-35%) to minimise adsorption when it reacts with alkalis like sodium hydroxide, sodium carbonate or potassium hydroxide. The hydrolysis process (**Figure 2-4)** leads to negative charges in the carbon chain, affecting the rheological properties of the polymer solution [10].



$$-[CH_2-CH]_m-[CH_2-CH]_n- \quad \text{with } C{=}O,\ NH_2 \text{ and } C{=}O,\ O^-Na^+$$

Figure 2-4: Molecular structure of hydrolyzed polyacrylamide (After [10]).

Hydrolyzed polyacrylamide (HPAM) is a copolymer of acrylamide and acrylic acids [45]. HPAM and xanthan gum (biopolymers) are so called polyelectrolytes [54]. HPAM shows better viscoelasticity compared to xanthan gum solutions. It has a good tolerance to high mechanical shear forces during flooding operations and possesses persistence to bacterial degradation. Adversely, it is extreme sensitive to variations of the brine salinity, water hardness and the presence of chemicals or surfactants [45]. When HPAM interacts with brine, the charge gets neutralized. Therefore, the flexible chains become compressed which consequently leads to a reduction of viscosity [45].

Through the viscoelastic properties of the polymer solutions, the microscopic sweep efficiency is also enhanced. Thereby, the polymer creates a larger force on the oil droplets and pushes them out of the dead-end pores [23]. Generally, the macroscopic displacement defines how effective the displacing fluid is touching the oil zone volumetrically and the microscopic displacement how trapped oil is mobilized through capillary forces [44].

2.2.1 Displacement Mechanism by the Use of Viscoelastic Polymers

According to Huh and Pope (2008) the achieved recovery factors are generally higher through polymer flooding compared to conventional water floods. As mentioned earlier, parts of the residual oil stays trapped in the reservoir rock after water flooding [55]. Oil trapped in the reservoir can be associated to four distinct entrapment types [10]:

1. Crude oil is adsorbed on the rock surface as well as on the dead ends of the flow channels and occurs normally in oil-wet and mixed-wet reservoir rocks (**Figure 2-5**, **a**).
2. Rock surfaces are coated through an oil film. This distribution type normally occurs in oil-wet rocks (**Figure 2-5**, **b**).
3. Crude oil droplets also called “oil globules” are trapped at the pore throats as a result of capillary forces. This type is mostly observed in strongly water-wet rocks (**Figure 2-5**, **c**).
4. This distribution type occurs in reservoirs with very small-scale heterogeneity. In this case, crude oil droplets are trapped in microscopic pores (**Figure 2-5**, **d**).

As a result of the viscoelastic behaviour of polymer, the percolation displays different characteristics compared to a normal water front. There are several different mechanisms which are responsible for this behaviour for example: pulling, stripping, oil thread flow and the shear-thickening effect [10].

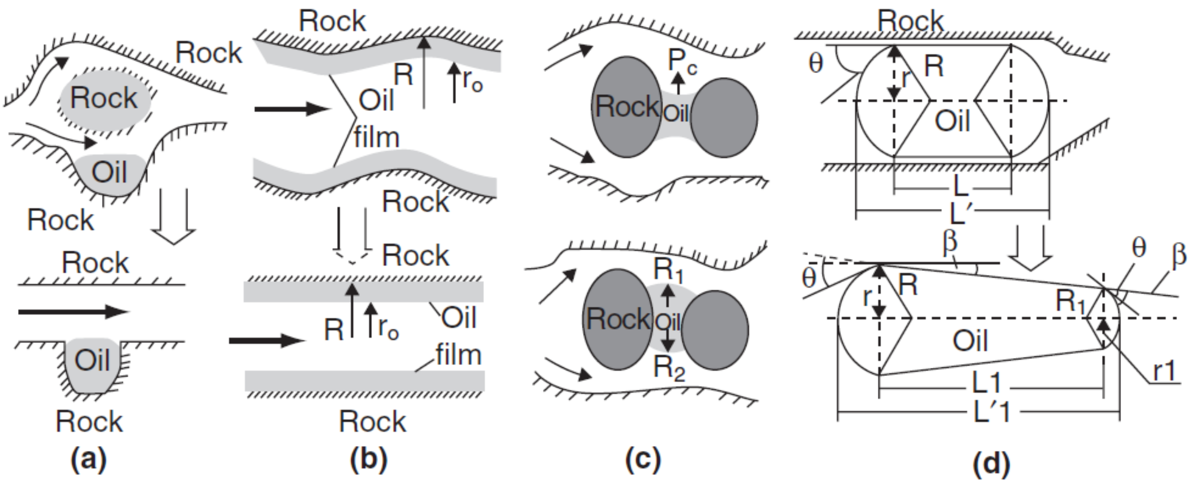


Figure 2-5: Possible residual oil saturation distribution after water flooding [56].

2.2.2 Polymer Stability

When polymer solutions are used in EOR applications their stability should not change directly through degradation, otherwise the flooding effect cannot be achieved in the same effective way [54]. Degradation leads to a breakdown of the molecular structure and can be classified into:

- Biological degradation: through microbial activities in storage tanks or in the reservoir. This effect appears at lower temperatures or when no biocides like formaldehyde are used [54].
- Chemical degradation: through contaminants such as O_2 or iron (short-term) or over a longer period through hydrolysis of the molecular backbone [54]. Luo *et al.* (2006) published that the influence of oxygen on the HPAM viscosity is irrelevant and minor

at low temperatures and long exposure times. Thus, the polymer stability declines with increasing temperature (>50°C) and rising oxygen concentration [57].

- Mechanical degradation (shear degradation): is a short-term effect and appears in high flowrate areas (wellbore region) through mechanical stresses above critical Deborah number but also possible in chokes or other polymer handling equipment [54].

Several different studies conducted by Yang and Treiber (1985), Ryles (1983), Luo *et al.* (2006) and Han *et al.* (2006a) reported the effect of the polymer viscosity in presence of oxygen [58, 57, 59, 60]. HPAM solutions show a high resistance in brine solutions under O_2-free conditions (anaerobe environment) [54].

3 Vienna Basin – Introduction to the Matzen Oilfield

The giant Matzen field is the largest connected oil and gas field in Central Europe with an entire area of 100 km² and an OOIP of about 190 million m³ [61]. Since several years, the reservoir pressure is artificially augmented through the re-injection of produced water. Nevertheless, over the production lifetime, the water cut increased significantly and is currently already higher than 96%. Before implementing any EOR method an intensive screening of possibilities needs to be conducted to make sure that the chosen technique is the best decision in terms of technical and environmental regulatory aspects. **Figure 3-1** shows the screening possibilities of the Matzen field including gas and steam injection, in-situ combustion, polymer and ASP flooding. Regarding the field properties it is obvious that chemical flooding (ASP/ AP) is the technology that covers most reservoirs and will significantly enhance the recovery process.

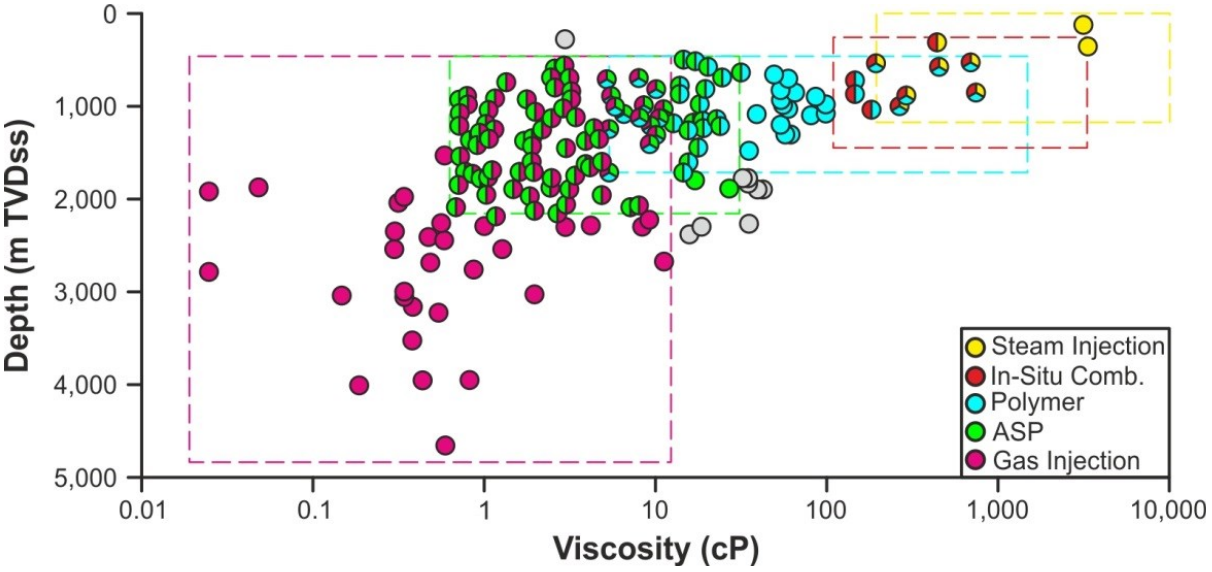


Figure 3-1: Example of screening possible EOR methods in the Matzen oilfield (After [62]).

3.1 Geographic & Geological Description

The Matzen oilfield is located roughly 20 kilometres northeast from Vienna in the north-central part of the Miocene Vienna Basin, which is based in the Alpine-Carpathian transition zone (**Figure 3-2, A**) [63]. The total length of the Basin is 200 km with a width exceeding 50 km and can be split along the Danube river into a northern and a southern part [64]. The Basin is divided spatial and temporal into four tectonic units: the Mesozoic rifting and passive margin, the Paleogene Foreland Basin, the Proto-Vienna Basin (early Miocene) and the Neo-Vienna Basin (middle-late Miocene, **Figure 3-2, B**). Several different studies and interpretations about the Basin conducted by Rupp (1986), Kreutzer (1986 & 1992), Pogacsas and Seifert (1991) led to the conclusion that sediments were deposited in deltas and originate from subaquatic and subaerial origin. Several tectonic nappes got stacked during the evolution of the tectogenesis in the Vienna Basin [65, 66].

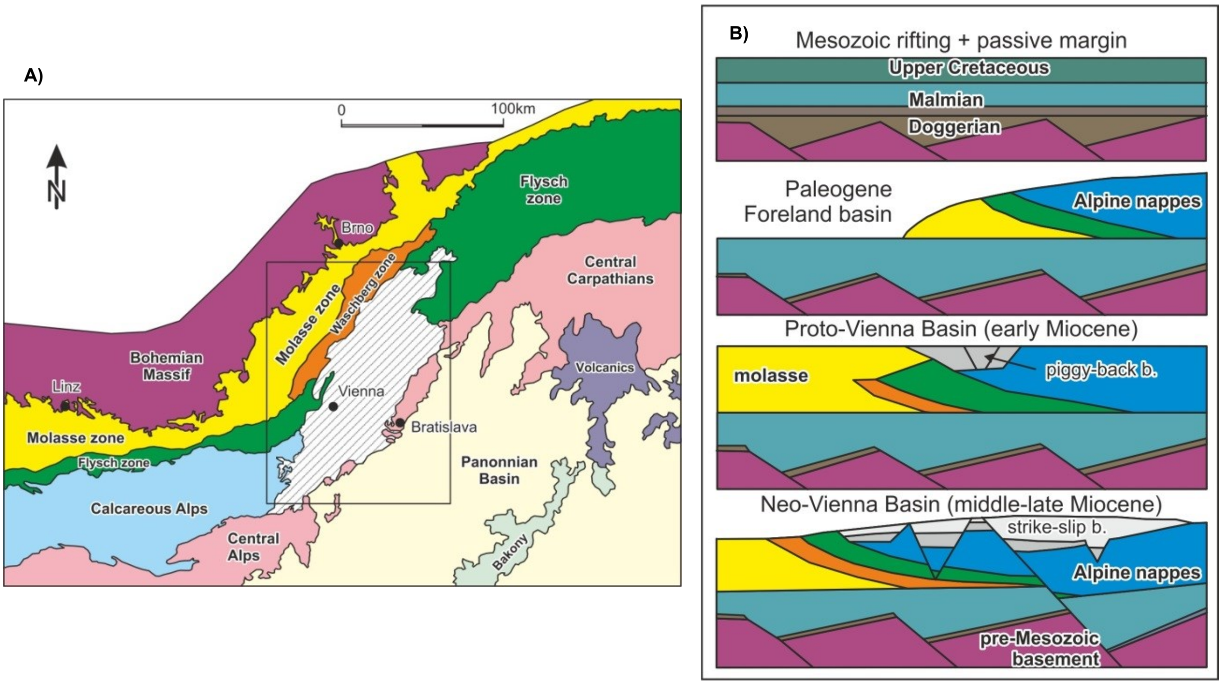


Figure 3-2: General map of the regional geology (A) from Central Europe showing the Vienna Basin and its evolution (B), modified from [64, 63].

Most of the reservoirs in the Vienna Basin are 900 to 2,000 mSS deep and consist of sandstone layers from the Middle Miocene (Badenian, 17-12 million years old) and the Eocene (Flysch nappes, 55 million years old). The geology of the Basin is complex and characterised by multiple stacked reservoirs [67, 68]. In this study, two possible reservoir candidates from the Matzen field (**Figure 3-3**) where an alkaline-polymer flooding project could be realized in the future were examined in detail. The two candidates are the 8.TH and 16.TH (most prominent reservoir). These sandstone reservoirs show significant differences regarding their locality, depth as well as their reservoir properties, such as absolute permeability, oil viscosity, and reservoir temperature.

The 16.TH consists of the first sands which transgress over the Spannberg Flysch Ridge to the South onto the Aderklaa conglomerate into the Parathetian Sea. These sands are characterized by high porosity and permeability, considerable thickness as well as high structural and compositional maturity [66]. The oil saturation in the 16.TH is relatively high with over 30%. Therefore, the application of AP flooding would enhance the production of trapped oil. A further aspect is the high total acid number (TAN) in both reservoirs, which make them favorable for chemical floods.

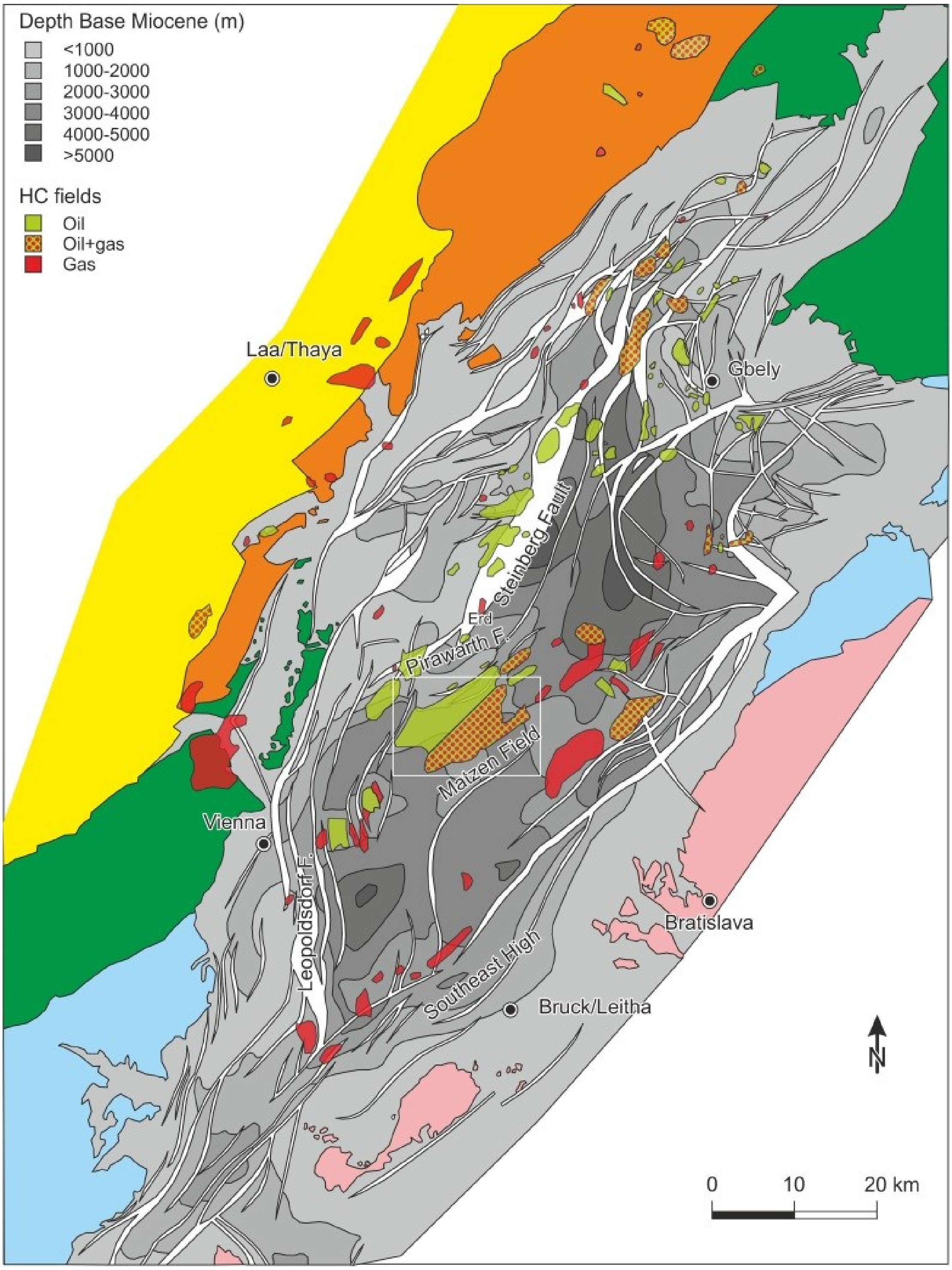


Figure 3-3: Structural map of the Matzen field in the Vienna Basin (Modified from [69]).

The 8th Tortonian production horizon differs from the ones of the 16.TH (**Figure 3-4**). In the 8.TH the sands have been deposited as delta sediments into the sea to the south resulting in higher clay contents and instable minerals. This leads to a less favorable reservoir quality.

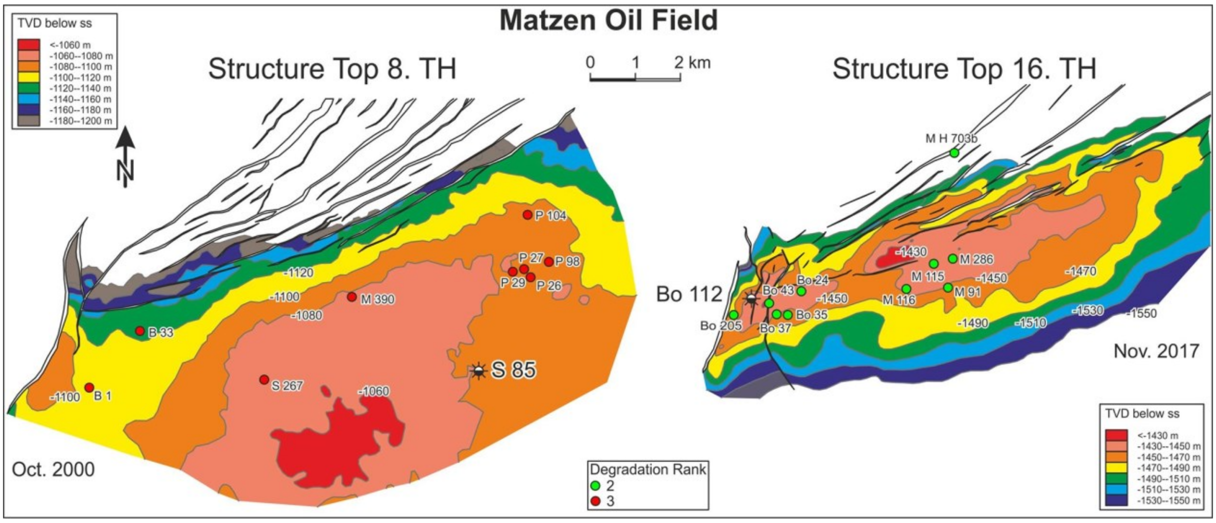


Figure 3-4: Structural map of the 8.TH and 16.TH production horizon of the Matzen Field. The production wells S 85 and Bo 112 used in this study are highlighted. BBDS= biodegradation scale (base map modified from personal communications A. Gauer)

3.2 Reservoir Candidates: Production & Reservoir Data

The 8.TH and 16.TH are possible candidates for implementing a chemical EOR technique. Nevertheless, the main focus in this study has been the 16.TH. The characteristics of both reservoirs are summed up in **Table 3-1**.

Table 3-1: Reservoir and fluid parameters of 8.TH and 16.TH (data provided by OMV).

	Reservoir	**16.TH**	**8.TH**
Field aspects	Field	Matzen	
	Area	Bockfliess	Schoenkirchen
	Production since	1952	1951
	Fluids	oil, associated & non-associated gas	oil, associated gas
	Recovery	water injection	
	Water cut (%)	96.4	96.2
	Recovery factor (%)	61.2	39.8
Reservoir parameters	Lithology	sands, sandstone	
	Measured depth (m)	1,650	1,250
	Net pay thickness (m)	1-70	2-3
	Ø Porosity (%)	27	28-30
	Ø Absolute permeability (mD)	1,190	450-800
	S_{wi} (%)	17	21-29
	Initial pressure (bar)	160.1	114
	Bubble point pressure (bar)	160.1	67
	Oil viscosity; p_b (cP)	4.2	19
	Oil density (kg/cm)	905	933
	Original oil in place (E^3 to)	12,233	24,165
	Temperature (°C)	60	49

The 16th Tortonian reservoir is the most important and largest oil reservoir within the Matzen oil field with an area of 2.6 km². The production commenced in 1952 and reached its peak oil production with 7,000 m³ per day in 1954. The oil production is steadily declining and the water cut continuously increasing with currently 96.4% (**Figure 3-5**). The actual crude oil production is about 210 tons per day. The reservoir is developed with 73 wells, whereby currently 39 wells are in production and nine wells are used for injection purposes. The current recovery factor is 61.23%.

The reservoir´s initial pressure was 160 bar with an in-situ oil viscosity of 4.2 cP, while the reservoir temperature is 60°C with an oil density of about 25°API. Over the production time there has been a drop of pressure and at the moment it is around 125 bar. The reservoir is characterised by an excellent porosity of 27%, an average absolute permeability of 1,200 mD with an initial water saturation of 15%. The net pay thickness of the 16.TH sands varies between 1 to 70 m. The depth of the reservoir is in average 1,650 mMD and the initial oil/water contact was located at a depth of 1,490 mSS [70].

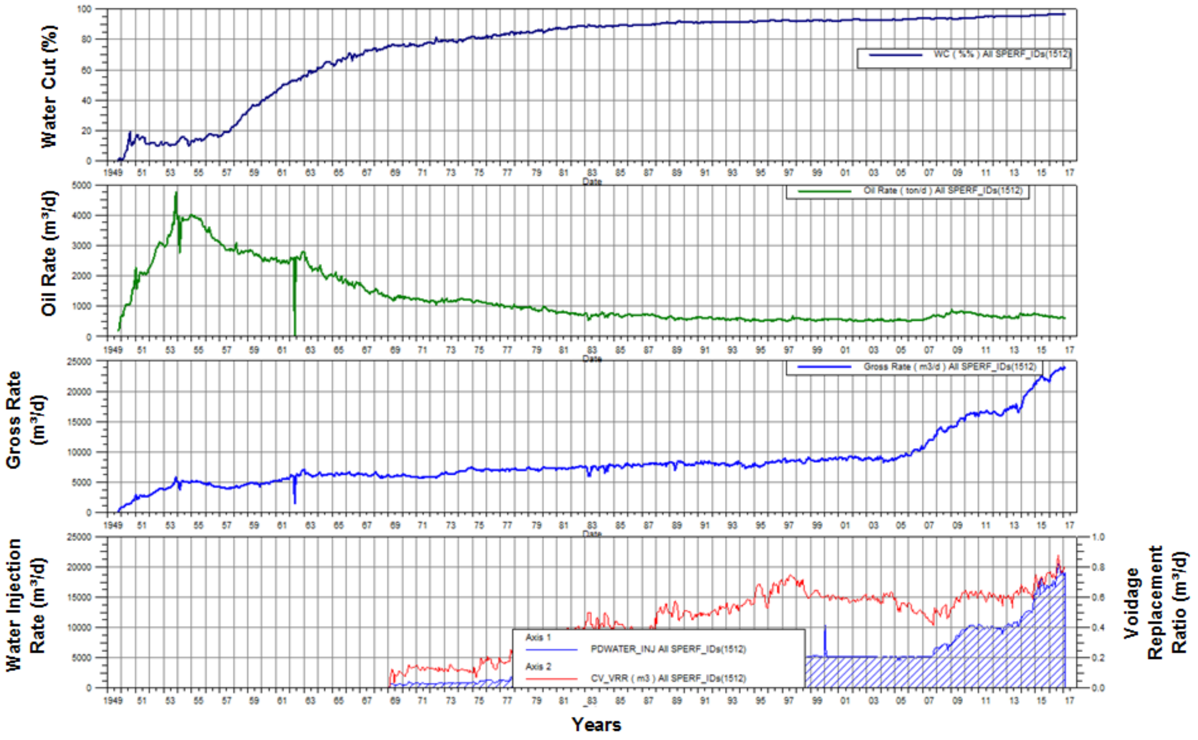


Figure 3-5: Production history and decline curves of the 16.TH reservoir (data provided by OMV).

The 8th Tortonian reservoir is located below Schoenkirchen and production started in 1951. The peak oil production took place in 1957 with approximately 2,000 m³ of oil per day. The oil production declined steadily over time (**Figure 3-6**). Therefore water flooding was started in 1960 to stabilize the production [71, 62].

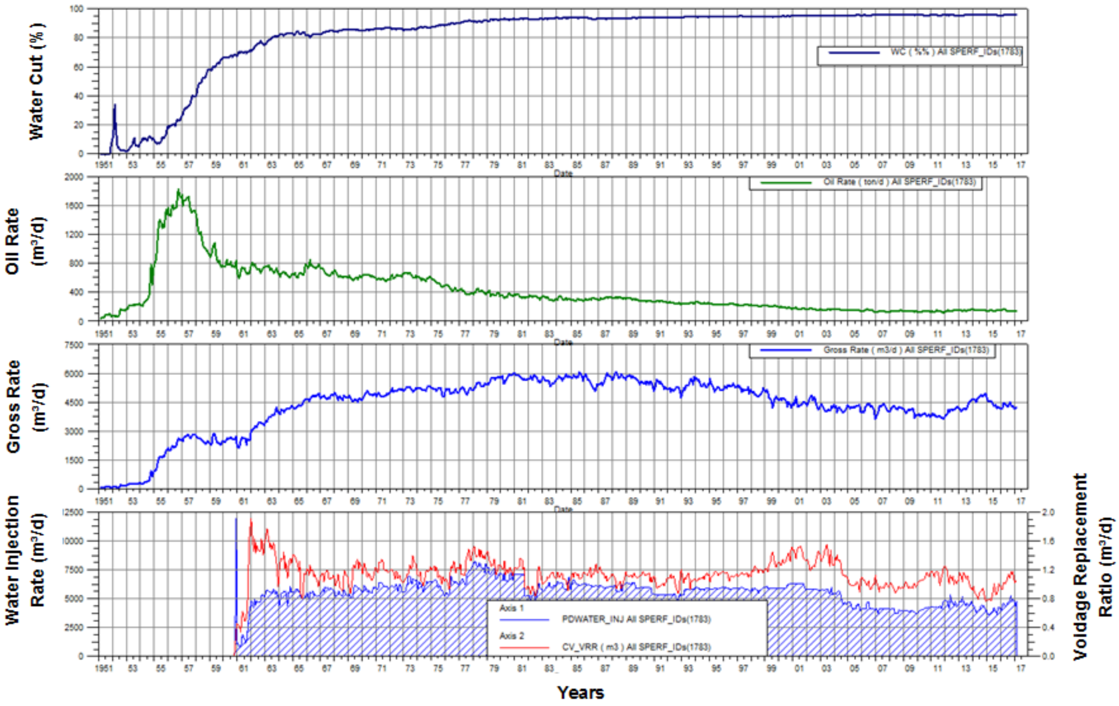


Figure 3-6: Production history and decline curves of the 8.TH reservoir (data provided by OMV).

Nevertheless, the water cut steadily increased and is up to date at 96.2% and the field recovery factor is relatively low with 26%. It can be attributed to the difficult to produce high density and viscous oil (20°API, 19 cP) and the reservoir temperature (49°C) as well the low initial reservoir pressure (113 bar). The current production is around 140 tons crude oil per day. The reservoir consists of a very complex geology – six sandstone layers deposited in shallow marine environment. It has an average porosity of 28% with a net thickness of approximately 20 meters. The average absolute permeability varies between 450 mD to 800 mD with a reservoir depth of 1,150 m TVDss. At the northern edge of the 8.TH a weak aquifer is located [71, 62, 45].

Since 2012, a polymer pilot with hydrolyzed polyacrylamide (HPAM) is performed, to increase the recovery rate. The used polymer has a molecular weight of 20 MDa with a hydrolysis degree of 30 % to resist biological degradation. Treated produced water from the central water treatment plant (WTP) Schoenkirchen is used for the preparation of a 5,000 ppm mother solution, which is further diluted until the wished injection concentration is reached. At the inlet of the polymer unit the water first gets filtered through multimedia filter to reach the required water quality. Diluted polymer solutions are then injected into two producer wells (SC 1 and S 81) and surrounded by six more producer wells (**Figure 3-7**). Breakthrough polymer was found in the producers S 95 and S 66. In the near future, the pattern will be extended with additional injection wells to further boost the gross rate [71, 45].

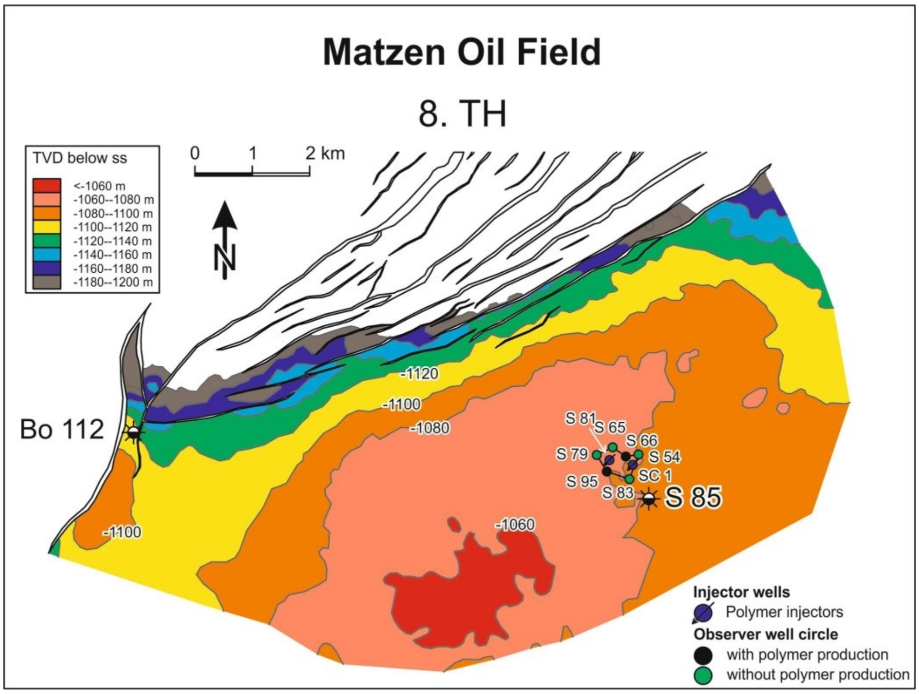


Figure 3-7: Structural map of polymer pilot area in the 8.TH reservoir showing the polymer injectors and the production wells (Base map modified from personal communications A. Gauer and [71]).

3.3 Water Production, Handling & Injection

The produced formation water in the Vienna Basin is collected and treated in two different gathering stations located in Auersthal and Matzen. The water streams coming from the 16.TH producer wells are treated in the gathering station Auersthal and those from 8.TH are treated in Matzen. Both gathering stations use different water treatment technologies and handle different amounts of produced water. An overview about the treatment system installed in the Vienna Basin can be found in **Figure 3-8**.

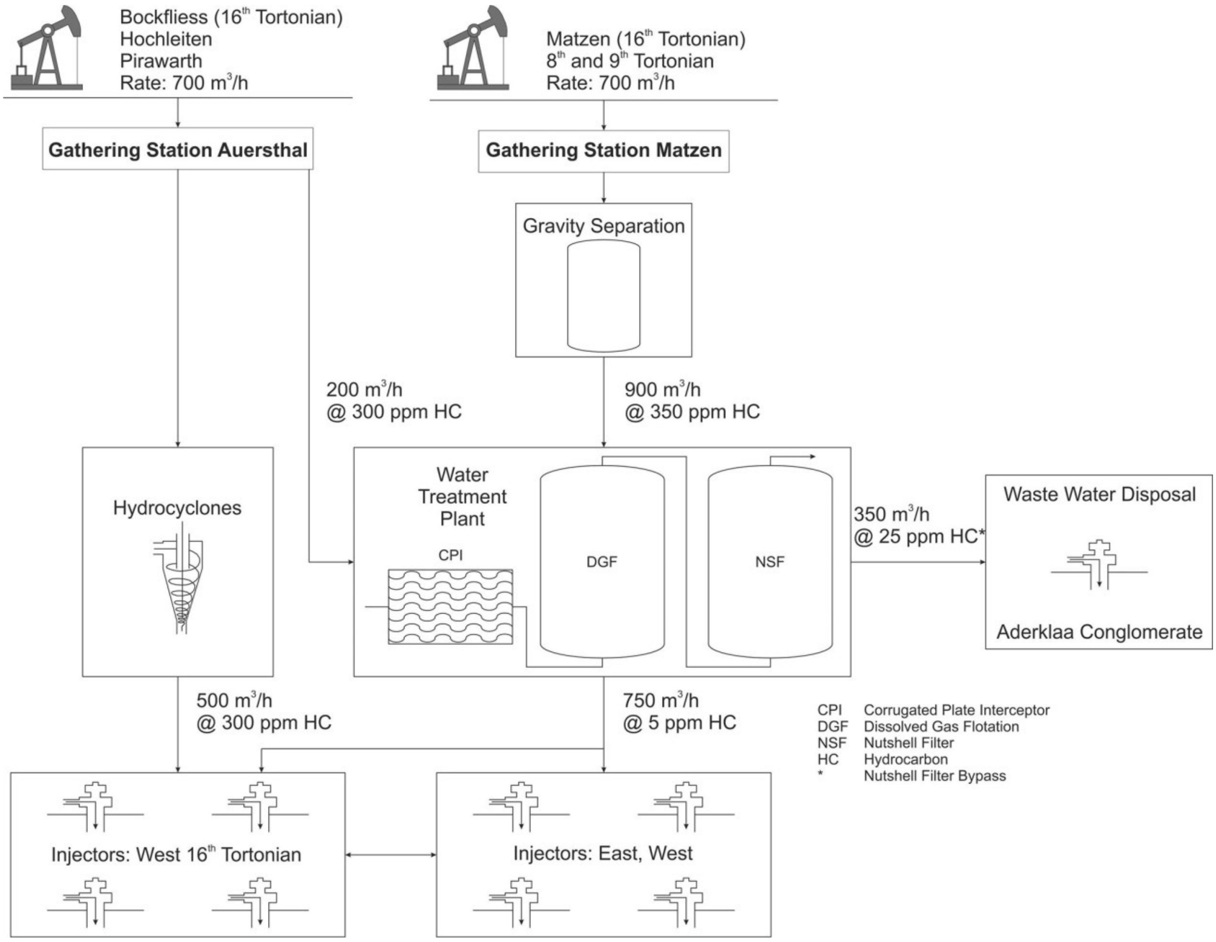


Figure 3-8: Overview of the water treatment system in the Vienna Basin.

In the gathering station Auersthal, water streams from the 16.TH coming from the producer wells located in Bockfliess are treated together with the water from Hochleiten and Pirawarth. The system (**Figure 3-9**) can handle a volume flow of 850 m³ per hour. The inlet water stream enters a slug catcher first and then gets transferred to separators, where most of the hydrocarbons are removed. In a second step, the stream flows to the hydrocyclones were the inlet hydrocarbon content of approximately 1,000 ppm is reduced to 200 to 300 ppm (injection water quality). The total gross rate of the injection water into the west injectors is around 500 m³ per hour with possible fluctuations in production. Approximately 200 m³ per hour are transferred to the water treatment plant and treated over there.

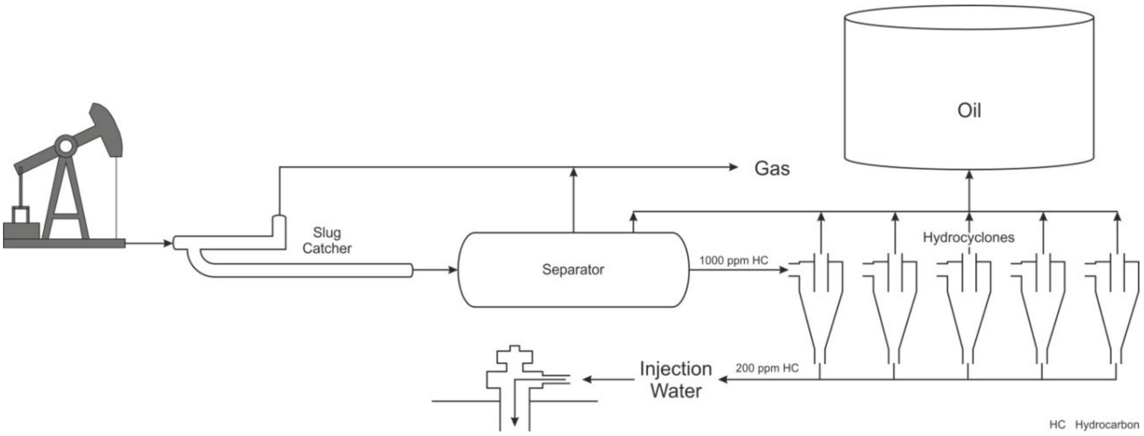


Figure 3-9: Flow chart of the water treatment system in the gathering station Auersthal (Modified from [72]).

In Schoenkirchen, a water treatment plant (WTP) is installed to treat produced water from the 8.TH, 9.TH but also small flow rates around 200 m³ per hour from the 16.TH the so called Matzen producer wells. The main treatment steps (**Figure 3-10**) are corrugated plate separators, a dissolved gas flotation and nutshell filters. The oxygen-free system is able to treat a total gross rate of 900 m³ water per hour. The hydrocarbon content at the inlet stream is reduced by the first treatment step to around 100 ppm and gets further decreased by the flotation to around 25 ppm. At the end of the treatment, the outlet water stream has a hydrocarbon content of around 5 ppm before re-injection. Fluctuations in the water quality can come up during the production process. The treated water is then re-injected into the reservoirs and the process water transferred to the process water plant and there further treated. A closed ring system is used, where the injectors can be split into west and east side injectors.

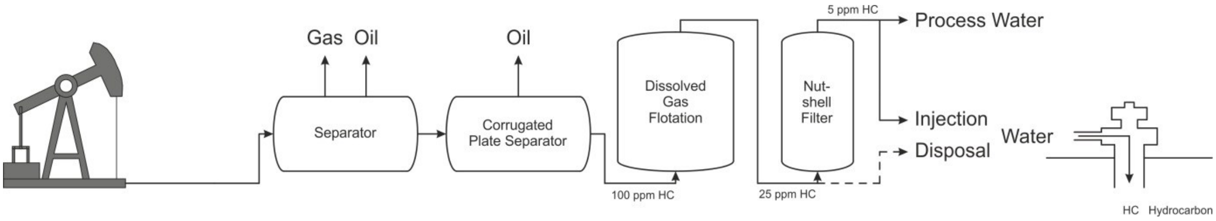


Figure 3-10: Flow chart of the water treatment system installed in the gathering station Matzen (Modified from [71]).

4 Screening of possible Alkaline Formulations

The efficiency of every alkali flooding process is massively influenced by the choice of the right chemical formulation for generating in-situ soaps, whereby just the middle-phase micro emulsions are of interest. As screening methods phase experiments, viscosity and interfacial tension measurements were used.

In order to simulate and better understand spontaneous emulsification, the phase behaviour of micro emulsions has been investigated in bench scale over time. Therefore, two different alkalis (sodium and potassium carbonate) were intensively screened and studied at various concentration ranges. The experiments were performed with two different crude oils from the Vienna Basin at various oil-water-ratios by using the respective types of produced water (outlet hydrocyclone and outlet WTP). Besides, synthetic make-up water was prepared for comparison. Furthermore, the impact of adding several co-solvents to the formulation was analysed. At a final step, the most promising formulation was mixed with polymer (HPAM) and the alkali-polymer interaction studied. In order to describe the differences between the two alkali lyes and the two oils, the alkali-crude oil interaction was studied by using GC-MS/ GC-FID.

4.1 Phase Behaviour

The phase behaviour is a static method and reflects a function of used crude oil, alkali and brine solution. The phase screening gives information about the ability of various alkali solutions to generate in-situ surfactants at different concentration ranges. According to the literature, thermodynamic stable micro emulsions between the carboxylic acids of the crude oil (saponifiable components) and the injected alkali-water solution are formed [10, 73, 74]. Nelson *et al.* (1984) published that the salinity range for an optimal middle-phase micro emulsion generated by alkali solutions is relatively low compared to formulations prepared with surfactants. Since, surfactants require a relative high salinity range in order to reach their optimum [75].

4.1.1 Chemical & Physical Properties of used Alkaline Agents

The most frequently used alkaline agents in caustic flood operations are sodium hydroxide (NaOH) and sodium carbonate (Na_2CO_3). Also sodium orthosilicate (Na_4SiO_4), sodium metasilicate (Na_2SiO_3), and ammonium (NH_3) have already been tested. Cheng (1986) compared the chemical consumption of various alkaline agents during flood applications and concluded that sodium carbonate is a good candidate for alkaline flooding. Permeability is less damaged and it is compatible with carbonate formations. Adversely, alkali may be consumed through ion exchange reactions, mineral dissolution, and precipitations through reactions with the hardness ions at the rock surfaces [30]. Sodium hydroxide is at the moment no longer used for field implementations because in some ASP field projects severe scaling and emulsion issues appeared in the surface facilities; although it showed very positive effects on the recovery efficiency (**Table 4-1**) [30, 76, 77].

Table 4-1: Comparison of strong and weak alkalis for the usage in EOR applications (Adopted from [77]).

Alkali Lye	NaOH	Na_2CO_3	Na_4SiO_4
Equivalent Na_2O	1.0	1.32	1.15
pH (1 % solution)	13.15	11.37	12.92
Hardness	ppt. Ca^{2+}, Mg^{2+}	ppt. Ca^{2+}	ppt. Ca^{2+}, Mg^{2+}
Residual in solution	30-50 ppm	50-120 ppm	5-10 ppm
IFT (hard water)	Good	Fair	best
Consumption	High	Least	moderate
Surfactant absorption minimized	Poor	Fair	best
Water wetness	Fair	Unknown	best
Sweep improvement	Fair	Fair	best
Recovery	good (0.8)	fair (0.65)	best (1.0)

Carbonate-based alkalis possess various abilities that make them more favourable for flooding applications. Carbonates are weaker alkalis than hydroxide solutions (NaOH, KOH) and lead to a reduction of ion exchange and mineral dissolution reactions. Typically dissolution rate increases with the pH value. No serious pH changes need to be expected from carbonate-based alkalis because of their buffer capacity. In addition, no severe emulsion and scaling problems arise in the surface facilities compared to strong alkalis. Furthermore, strong alkalis cause difficulties in breaking the emulsions. With regard to the chemical price, sodium-based alkalis are relatively cost-effective and are gained through mining operation [10, 78, 79, 80].

Potash or potassium carbonate (K_2CO_3), as an alternative alkali agent for EOR flood applications, is until now not very well studied and might be considered due to its high stability. Potassium carbonate (1,120 g/l at 20°C) is more soluble in water than sodium carbonate (217 g/l at 20°C). It may help to replace the crude oil through an increase of the density from the injection water (gravity stable). Besides, the pH value can easily be controlled because of its buffer capacity. Furthermore, it acts as a corrosion inhibitor and may help to impede corrosion on materials which are in direct contact with the alkaline water. Another positive impact is its environmental friendliness, biocompatibility, and resistance to any kind of degradation (bacterial or thermal). It is already successfully applied in drilling fluids and it is well established that the potassium ion can stabilize clay minerals in the reservoir and avoid swelling [81, 80]. However, both alkalis differ considerable in the price, whereby K_2CO_3 is three times more expensive than Na_2CO_3.

4.1.2 Alkaline-Water Reaction

The water composition plays a major role for alkali and polymer flooding processes. Especially, the mono- and divalent metal ions affect the interfacial tension, the viscosity and the phase stability of the solutions. An optimal sodium chloride concentration at which the IFT is the lowest (**Figure 4-1**) exists for every crude oil-soap solution system (multiphase region). This two-phase region is dependent from the sodium chloride concentration in the brine [82, 83].

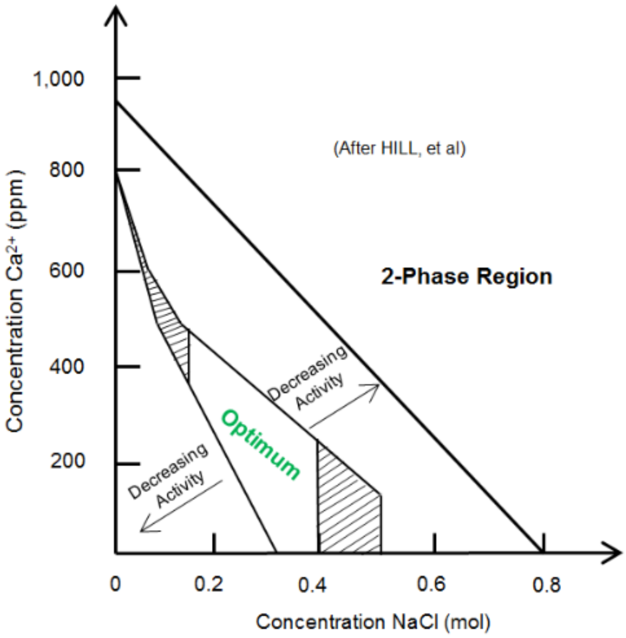


Figure 4-1: Influence of the calcium ions on the interfacial activity (Modified from [84]).

Hardness ions (e.g. Ca^{2+}, Mg^{2+}) present in the formation/ injection water are unfavorable. These ions react with the alkali, consequently resulting in an alkalinity loss and in the prevention of the emulsification capacity of the middle-phase micro emulsion. This leads to a reduction of the displacement efficiency. If the ions react with the generated in-situ soap, insoluble calcium and magnesium precipitates ($CaCO_3$ and $MgCO_3$), are formed which will adversely lead to plugging of the injection lines/ wells. The formation of these flakes is depending on temperature, pH and other present ions [85]. The occurring chemical reactions are presented in **Eq. 10** and **Eq. 11** when sodium carbonate is used as caustic solution.

$$Ca^{2+} + Na_2CO_3 \rightarrow CaCO_3 + 2\,Na^+ \qquad \textbf{(10)}$$

$$Mg^{2+} + Na_2CO_3 \rightarrow MgCO_3 + 2\,Na^+ \qquad \textbf{(11)}$$

Consequently, the injection water should be softened before usage (reduction of the hardness level to less than 1 mg/l) in order to minimize the potential of scale formation or plugging during the injection and also to ensure proper flooding properties [86, 87].

4.1.3 In-Situ Emulsification

Crude oil is a natural mixture of various elements mostly carbon and hydrogen but also nitrogen, sulphur, oxygen and small quantities of other compounds are included. The composition of the crude is characterised by the initial organic matter and thermal maturation in the source rock. The composition of the oil might change during entrapment in the reservoir as a result of alteration processes. Furthermore, contaminants (e.g. mud additives, greases, corrosion inhibitors, elastomer seals, etc.) brought in during production, sampling or storage are an uncertainty in the evaluation of the appropriate crude composition. For the evaluation of the crude sample distillation or liquid/ gas chromatography can be applied. Every crude composition is different and consists of several thousand compounds, whereby the hydrocarbons can be further split into aliphatic, aromatic and N-, S-, O-bearing compounds. The normal alkanes make up 15-20% and the naphthenes 30-60% of the crude [88].

Many crude oils are altered through biodegradation, which changes the oil composition and its properties. The oil composition has a major influence in alkali flooding (in-situ soap generation) compared to the use of surfactant-augmented methods, which are independent from saponifiable oil components. Biodegradation is a process which is widely observed in all hydrocarbon-bearing basins [89]. The degree of alteration is controlled by mechanisms suppressing the bacterial activity through temperature, salinity, pH, pressure and nutrient supply [90]. With increasing ranks of biodegradation the compounds are removed in the order of persistence against degradation and can be mapped via the Biomarker Biodegradation Scale (BBS) [90]. Bacterial activities also generate additional metabolite products, like acids, which are found in the oil.

The crude oils of the Vienna Basin are degraded through microbes in various extends which has an influence on the oil-quality properties. These organisms prefer removing the saturated hydrocarbons first, which results in an increase of the heavy polar compounds and asphaltenes in the residual crude oil. Moreover, the acidity of the oil (TAN) changes due to higher persistence of acids to degradation and the formation of naphthenic acids. A higher TAN may cause issues like corrosion or emulsion generationon the production side and in downstream handling. Strong biodegradation leads in general to a deterioration of the crude quality, a decrease in the API gravity and an affected producibility. Additionally, not only the quality of oil is influenced it also leads to a rise in viscosity, total acid number (TAN), metal, asphaltenes and sulfur contents but also in vacuum residua [91].

OMV classifies its oils into A (aromatic) and P (paraffinic) –oil according to their physical properties (density). Nevertheless, this classification is incomplete in understanding that one source rock will just produce “one” crude oil with equal properties. For better ranking Rupprecht *et al.* (2018) published a model that explains the differences of oil compositions based on different degrees of biodegradation in the reservoirs. Biodegradation is mainly controlled by temperature but several reservoirs display additional inhibition due to low permeability (e.g. Ebenthal, Flysch) [92].

It is assumed that a single pseudo-acid component (HA) soluble in the oil is responsible for the generation of in-situ surfactants. From a chemical perspective, the (HA) component is distributed between the oleic (o) and aqueous phase (w) [93, 29, 74].

When an alkali agent is present in the water phase, a soluble anionic surfactant (soap) A^- is generated through hydrolysis reaction occurring at the oil-water interface. Through the reaction of the alkali solution with the saponifiable components in the crude oil the interfacial tension is reduced and enables an optimal flooding process. The following **Eq. 12** represents the hydrolysis reaction using sodium hydroxide (NaOH) as alkali lye [93, 29, 74].

$$\mathrm{HA_o + NaOH \leftrightarrow NaA + H_2O} \qquad \textbf{(12)}$$

The effectiveness of the overall reaction is dependent on the pH value of the water solution. **Figure 4-2** represents the spontaneous emulsification of an oil droplet in the reservoir.

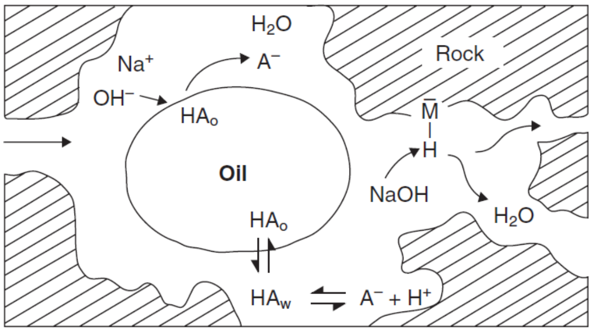


Figure 4-2: In-situ emulsification reaction in the reservoir [29].

Organic acids present in the crude oil are partially ionized, other fractions stay electronically neutral and through hydrogen-bonding interactions between these fractions an acid soap is generated. **Eq. 13** represents the distribution of the acid soap between the oleic and the aqueous phase. The acid dissociation constant is demonstrated in **Eq. 14.** The term A expresses a long organic chain and the brackets the molecular concentrations [93, 29, 74].

$$\mathrm{HA_o \leftrightarrow HA_w} \qquad \textbf{(13)}$$

$$\mathrm{K_D} = \frac{[\mathrm{HA_w}]}{[\mathrm{HA_o}]} \qquad \textbf{(14)}$$

An aqueous reaction will happen as well and is shown in **Eq. 15**. The acid dissociation constant of this equation is expressed in **Eq. 16**.

$$\mathrm{HA_w} \leftrightarrow \mathrm{H^-} + \mathrm{A^-} \qquad \textbf{(15)}$$

$$\mathrm{K_A} = \frac{[\mathrm{H^+}] * [\mathrm{A^-}]}{[\mathrm{HA_w}]} \qquad \textbf{(16)}$$

The water dissociation reaction is expressed in the **Eq. 17** and the dissociation constant in **Eq. 18**. From a chemical point of view, the hydrogen ion (H^+) acts as a strong acid and the hydroxide ion (OH^-) as a strong base. In neutral water the ions occur in equal concentrations with a pH value of 7. Changes of the ratio between (H^+) and (OH^-) ions influence the pH value (**Eq. 19**) [93, 29, 74].

$$\mathrm{H_2O} \leftrightarrow \mathrm{H^+} + \mathrm{OH^-} \qquad \textbf{(17)}$$

$$\mathrm{K_w} = [\mathrm{H^+}] * [\mathrm{OH^-}] \qquad \textbf{(18)}$$

$$\mathrm{pH} = -\log\,[\mathrm{H^+}] \qquad \textbf{(19)}$$

In **Eq. 20** the concentration of the generated soap (A^-) in the aqueous phase is shown:

$$[\mathrm{A^-}] = \frac{\mathrm{K_A} * \mathrm{K_D} * [\mathrm{HA_o}]}{[\mathrm{H^+}]} \qquad \textbf{(20)}$$

The concentration of (A^-) refers to high pH values to ensure complete solubility in the aqueous phase. Another option is that the acid dissociation constant K_D is low enough, so that the acid cannot be extracted into the water phase like in low-pH water flooding processes [93, 29, 74].

Sheng (2015) stated that not all short chain acids in the crude can be saponified because of their hydrophilic character. Alkali is also consumed by phenols and porphyrins and has no influence on IFT changes. Asphaltenes and resin contain carboxylate as functional groups; still they do not get extracted into the aqueous phase [74]. The pH value must be higher than 9.5 to generate in-situ micro emulsions. The recovery process is decreased and ineffective when alkali solutions react with divalent ions (Ca^{2+}, Mg^{2+}). Thereby, fatty and water-insoluble soaps are formed [94, 18].

4.1.4 Micro Emulsion Classification according to Winsor

Micro emulsions distinguish from normal emulsions: they are thermodynamic stable and form spontaneously without any need of additional energy. In comparison, emulsions are unstable, the average droplet size increases with time and they require energy like stirring, shaking or homogenizing [10]. Nevertheless, over the time (**Figure 4-3**) an emulsion separates into the original phases (oil and water) and creates an optimal middle phase [95, 10].

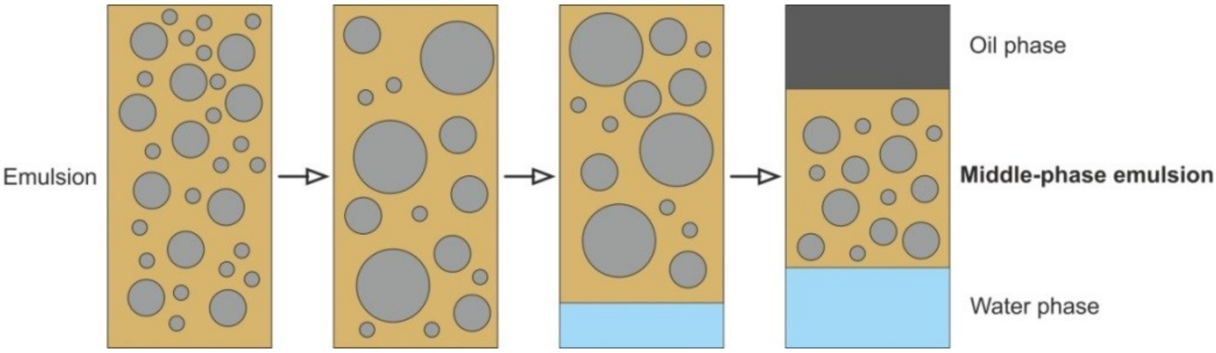


Figure 4-3: Change of the emulsion stability over time (After [96]).

Generally, the formation and physical structure of a micro emulsion is dependent on salinity, type and concentration of the used alkali/surfactant, temperature, crude oil and water composition, co-solvent and to a low extent from pressure. Changing any property may lead to a modification of the structure as well as the composition of the emulsion phase [83].

According to Winsor (1954), the relationship between oil, water, and the formed in-situ soap (middle-phase micro emulsion) through addition of alkalis or surfactants is classified into three main types Winsor type I, II, and III and visualized in a ternary diagram. In alkaline flooding the in-situ surfactant concentration is unknown, therefore using a ternary diagram for representation is impossible. Nelson *et al.* (1984) and Pope (1982) termed them into type II (-), type III, and type II (+) phase environment types [97, 75].

Before starting with the classification, it is necessary that the prepared formulations achieve an equilibrium state (separation of the macro emulsion into single phases) [98]. In **type II (-)** or **Winsor I** the generated soap is better soluble in the water than in the oil phase and creates an oil-in-water (o/w) micro emulsion in the aqueous phase. These properties are not optimal to achieve an ultralow IFT environment. Type II (-) occurs in low salinity concentrations and is visualized in **Figure 4-4** [83].

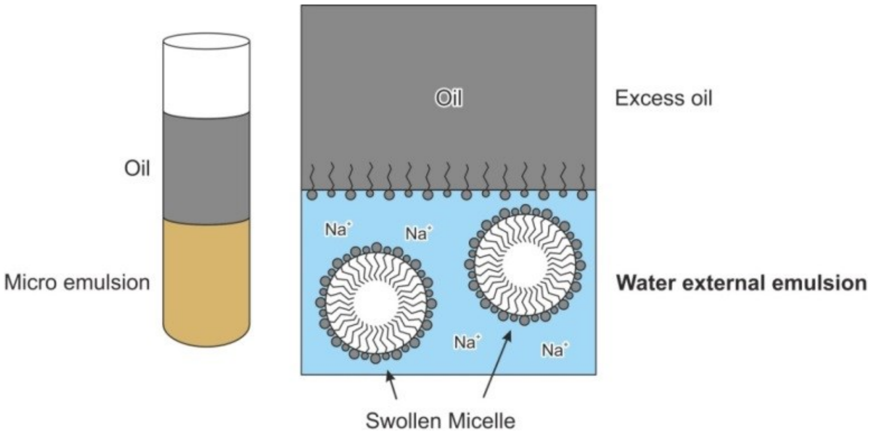


Figure 4-4: Schematic illustration of type II (-): a water external micro emulsion is formed occurring in low salinity environments (Modified from [83, 97]).

In **type III** or **Winsor III** the alkali creates an in-situ middle phase between the excess oil (surfactant-poor phase) and the excess water phase (**Figure 4-5**). Increasing the salinity of the aqueous phase forces the alkali, which is mostly saturated in the water phase, to move through an intermediate three-phase area. Three phases are just created at optimal salinity conditions. This newly formed middle phase contains the in-situ surfactant, water and dissolved hydrocarbons. The micro emulsion phase demonstrates the soap solubility in the oil and in the water phase. Type III has the optimal conditions in order to achieve ultralow IFT regimes and is suitable for EOR applications [83].

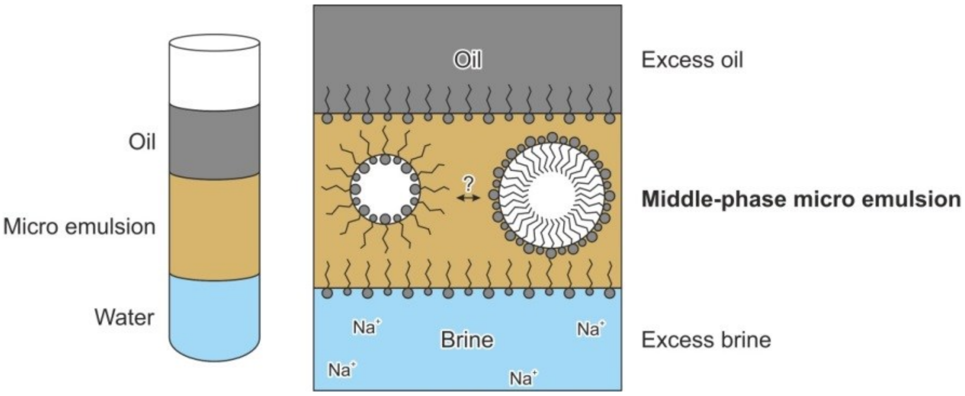


Figure 4-5: Schematic illustration of type III: a middle-phase micro emulsion is forming occurring at optimal salinities (Modified from [83, 97]).

In **type II (+)** or **Winsor II** the in-situ surfactant can be mostly found in the oil phase than in the water phase, which is very unfavorable for EOR processes (**Figure 4-6**). In this type water-in-oil (w/o) micro emulsions are formed and the soap is more soluble in the oil phase than in the water phase [83].

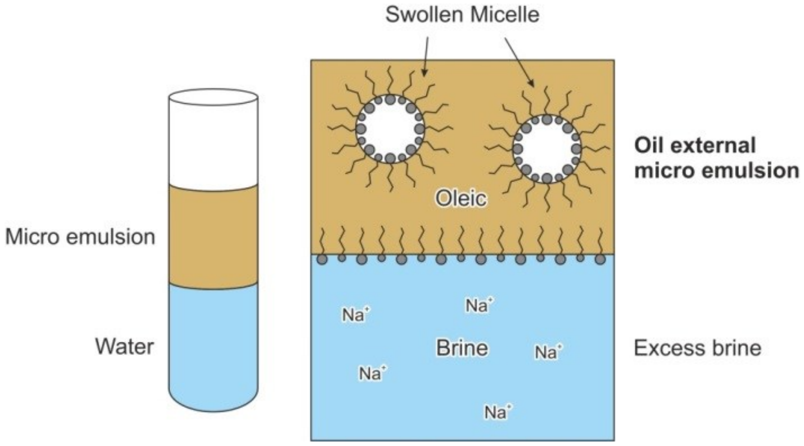


Figure 4-6: Schematic illustration of type II (+): an oil external micro emulsion is formed occurring at high salinities (Modified from [83, 97]).

Co-solvents recently get added more often to the chemical formulations to influence the chemistry but not the generation of the micro emulsions. Several reasons make them favorable as they are able to make the micro emulsions more hydrophilic or hydrophobic.

This leads to a shift of the optimal salinity range (change of Winsor type). Furthermore, co-solvents are often added to surfactant formulations to decrease the viscosities of liquid crystal phases or even to remove them. In particular, short chain alcohols are applied for low salinity ranges while petroleum sulfonates are used for higher ranges. They can also be used if high divalent cation contents are present in the water phase. Besides, alcohol ethoxylates are often used due to their ability to shift the micro emulsion into the optimal salinity range [99].

4.1.5 Rheology of Micro Emulsions & Polymer Solutions

In general, rheology describes the change of fluids through the application of external forces [100]. Analyzing the rheology is complex and different for each substance. Fluids can be characterized into Newtonian or non-Newtonian. Newtonian fluids such as water or organic solvents show a linear correlation between shear rate $\dot{\gamma}$ and shear stress τ ; expressed in the Newton's Law of Viscosity (**Eq. 21, Eq. 22**). The viscosity stays constant over the shear rate (straight line of slope) and is dependent from temperature and pressure only. The fluid is described by the constant μ [101, 100].

Normally, the molecules also known as isotropic are small, symmetric in shape and in its properties. Anisotropic molecules may display a different behavior (e.g. polymer solutions or colloidal suspensions). A reduced viscosity (deviation from the Newtonian behavior can be realized) is observed and can be explained through their large molecular weight [101, 100].

$$\frac{F}{A} = \tau \;\; \alpha \;\; \frac{du}{dy} \qquad \textbf{(21)}$$

$$\tau = \frac{\mu\, du}{dy} = \mu * \dot{\gamma} \qquad \textbf{(22)}$$

Non-Newtonian fluids can be subdivided into Bingham plastics, pseudoplastic and dilatant fluids. Bingham plastics (e.g. mayonnaise) require a minimum stress in order to flow and behave as Newtonian fluids (**Figure 4-7**). Non-Newtonian fluids possess either a non-linear relation between shear stress and rate or show a yield stress. It can also be a combination of all and the viscosity depends on time or deformation history. For this kind of fluids, the viscosity stays not constant at a certain temperature or at a specific pressure range [101, 100].

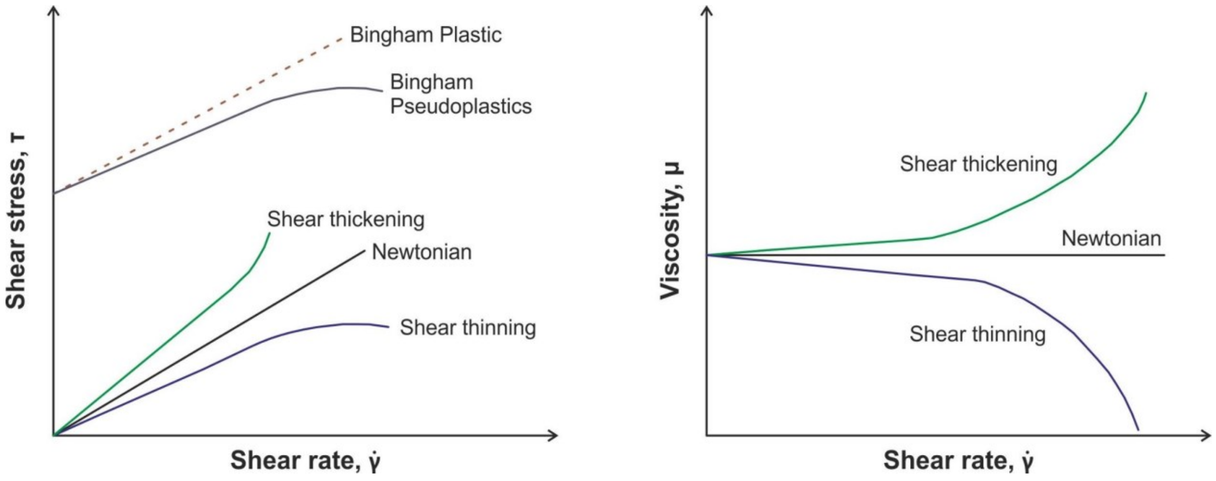


Figure 4-7: Comparison of Newtonian and non-Newtonian behavior of fluids. Left picture demonstrates the shear rate versus shear stress behavior and the right one the shear rate versus the viscosity (After [101]).

Non-Newtonian fluids can show shear thickening, where the viscosity ascends with shear rate, or shear thinning behavior (decline of viscosity with growing shear rate). This is caused through structural reorganization of fluid molecules. Shear thinning appears in colloid fluids and is induced through phase separation. The fluid flow plays an important role and is strongly depending on the fluid viscosity. The viscosity of non-Newtonian fluids is defined through flow characteristic profiles (**Figure 4-8**) [101, 100].

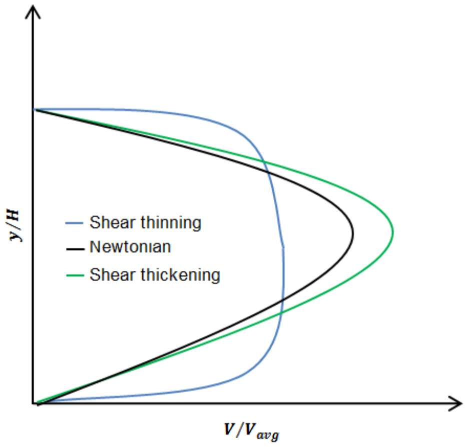


Figure 4-8: Velocity profile of fluids showing the influence on their fluid behavior (After [101]).

A rheometer is used to measure the viscosity which consists of two plates (depending from the application). One plate is stationary and external force (shearing force F) is applied through the moving plate (**Figure 4-9**). A thin fluid layer is set between these two plates with the distance dy. In stabile conditions, the internal fluid force balances the shear force through its viscosity [100].

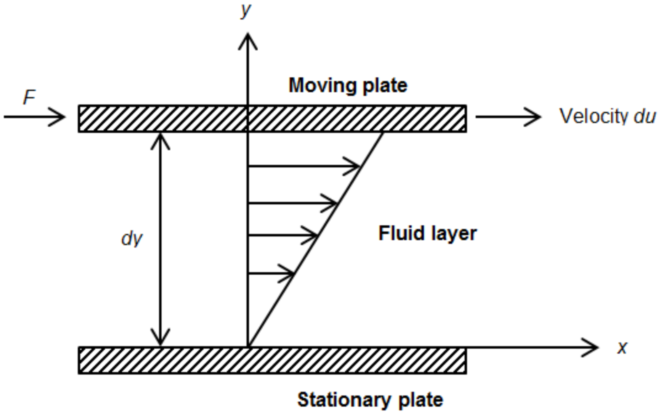


Figure 4-9: Physical principle of a rheometer for measuring fluids (Modified from [102]).

A polymer solution acts like a pseudoplastic fluid and its viscosity (μ_p) can be described by the power-law model (**Eq.23**). According to the model established by Bird *et al.* (1960) represents the term K the flow consistency index and n the flow behavior index [103].

$$\mu_p = K * \dot{\gamma}^{(n-1)} \qquad \textbf{(23)}$$

The flow behavior index does not change at varying concentrations and can be expressed for the pseudoplastic regime as n≤ 1. A Newtonian fluid can be described as n=1, whereby K reflects the constant viscosity. Sorbie (1991) stated that this model is inappropriate for high or low shear rates [54]. A more appropriate model was established for these shear regimes by Meter and Bird (1964) and is shown in **Eq. 24.**

$$\mu_p = \mu_W + \frac{\mu_p^0 - \mu_w}{1 + \left(\frac{\dot{\gamma}}{\dot{\gamma}_{1/2}}\right)^{(p_\alpha - 1)}} \qquad \textbf{(24)}$$

The term μ_p^0 reflects the limiting viscosity at the low shear limit. The term p_α is an empiric parameter and $\dot{\gamma}_{1/2}$ represents the shear rate at which the viscosity is the mean between μ_p^0 and μ_W [104].

Another model which can be generally used is represented by the Carreau equation (**Eq. 25**). Thereby, expresses μ_∞ the limiting viscosity at high shear limit and is used for the water viscosity μ_W. The terms λ and n are specific empirical polymer constants and α is defined to be 2. Nevertheless, this equation represents a power-law relation especially for intermediate shear rate regimes and turns into **Eq. 26**. In case of low shear rates the expression $\mu_p = \mu_p^0$ is applied [103, 105].

$$\mu_p - \mu_\infty = (\mu_p^0 - \mu_\infty)[1 + (\lambda\dot{\gamma})^\alpha]^{(n-1)/\alpha} \qquad \textbf{(25)}$$

$$\mu_p = \mu_p^0(\lambda\dot{\gamma})^{(n-1)} \qquad \textbf{(26)}$$

Figure 4-10 represents the flow curve of viscoelastic fluids (e.g. polymers) which can be split into three flow regimes: the polymer solution behaves first like a Newtonian fluid at low shear rates (shear rate independency). Afterwards at intermediate shear rates the solution changes its behavior to pseudoplastic fluid. A strong decline of the viscosity arises with the shear rate. Finally, at high shear rates appears dilatant behavior (viscosity increase). The viscoelastic behavior is strongly dependent on temperature, salinity, polymer concentration, and surfactants [10].

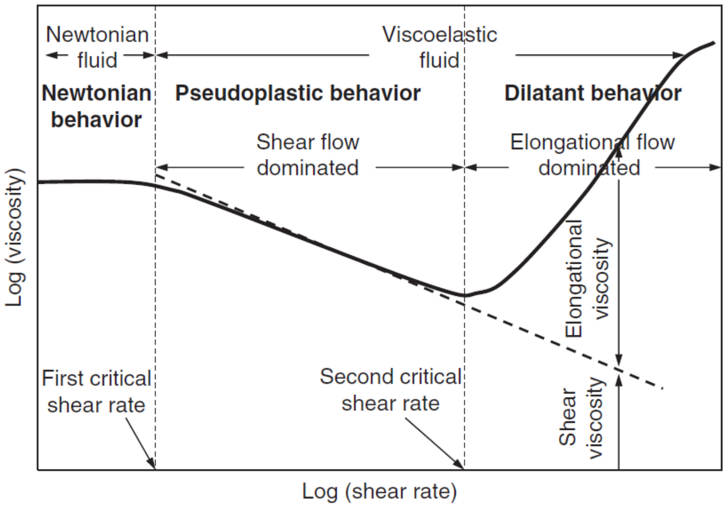


Figure 4-10: Flow behavior of viscoelastic fluids [10].

Through the addition of the caustic solution to the polymer solution, a decline of the HPAM viscosity can occur, as a consequence of the salt effect which is described by Mungan (1969) [106].Guo *et al.* and Samantha *et al.* described the increase of the polymer viscosity as a result of the “charge shielding mechanism” for partial hydrolysed polyacrylamides [107, 108].

The micro emulsion viscosity is strongly influenced by varying parameters such as temperature, salinity, or the concentration of used alkalis which results in a change of the microstructure. For example, increasing the temperature for just 1°C lowers the crude oil viscosity by approximately 10%. Besides, pressure changes lead to viscosity rises. Salinities below or above the optimum can also lead to viscous micro- or macro emulsions due to their strong dependence on the electrolyte environment [109, 110].

Generally, the viscosity changes with the shear rate. Viscous phases can be prevented either through a salinity gradient or by modifying the formulation. For a successful oil displacement, high viscosities are unfavorable and require higher polymer concentrations. If the micro emulsion shows continuous shear thinning behavior at low shear rates it will lead to a decrease of the sweep efficiency and a raise in surfactant retention [109, 110]. The addition of a co-solvent to the aqueous phase tremendously influences the viscosity and leads to less viscous micro emulsion phases. Adversely, higher costs, increased complexity but also a rise of the IFT can be the consequence [111].

4.2 Methods

4.2.1 Crude Oil Preparation

Oil samples used for the experiments were collected from the two reservoirs. Crude oil of the 16.TH was taken from the well Bo 112 and for the 8.TH from the well S 85, at well separator conditions. The crude oils were analysed according to their chemical and physical properties. For further usage the samples were de-watered and solids were removed through high speed centrifugation according to ASTM D 4007-02 [112, 80]. The chemical composition of the dead oil was determined via a gas chromatography-flame ionization detector system (GC-FID, Agilent GC 7890 B) and a quadrupole mass spectrometer (GC-MS). Samples were prepared using established procedures [113]. Individual compounds were identified on the base of retention time and comparison of mass spectra. Detailed analytical settings can be found in Leitenmueller and Rupprecht (under review, 2019) [114]. In addition, the viscosities and the densities were measured under ambient pressure conditions at 15°C and 20°C by using a Stabinger viscosimeter (Anton Paar SVM3000) [115].

In order to match the viscosities of the crudes at reservoir conditions, dead oil was modified with cyclohexane and outlined as viscosity-matched oil (modified oil). Regarding to PVT analysis the oil viscosity in the 16.TH is 4.2 cP at 60°C reservoir temperature and 19 cP at 49°C in the 8.TH. By adding cyclohexane, the oil becomes less viscous and the in-situ oil viscosities at reservoir temperature can be matched. After mixing the crudes with C_6H_{12}, the viscosity of the samples was measured with a Stabinger viscometer (Anton Paar SVM3000) under ambient pressure conditions at reservoir temperature and compared with the initial in-situ oil viscosity. For the 16.TH, a mix of 77 vol% from the oil of S 85 and 23 vol% of C_6H_{12} are required to match 4.2 cP. For the 8.TH a mixture of 89 vol% of the oil Bo 112 and 11 vol% C_6H_{12} are necessary to reach 19 cP.

4.2.1 Water Softening and Alkali Solution Preparation

Fresh water samples were collected from the outlet of the two treatment systems. Water of the 16.TH was taken from the outlet of the hydrocyclones in Auersthal and of the 8.TH from the outlet of the WTP Schoenkirchen. Both waters were analysed regarding their chemical and physical properties. Using these results, the salinity and alkalinity for preparing the synthetic water was chosen.

The fresh water sample was filtered through a folded filter (4-7 µm pore size) made of cellulose fibres. The divalent hardness ions (Ca^{2+}, Mg^{2+}) were removed through a cation exchanger using batch method. Dowex® Marathon® C, a strong acid cation exchanger resin with sulfonate functional groups (20-50 mesh (850-300 µm) in Na^+-form), was used for single step purification. For the batch method, 10 g resin is needed per 100 ml water sample to ensure a hardness removal of 85% of the ions. Then, the resin was added to the water sample, stirred for one hour and afterwards filtered through a folded filter [116]. Nevertheless, when oil particles are contained in the filtered water, the removal efficiency of the resin is reduced.

For the preparation of the solutions the alkalis/ co-solvents are weighed in and mixed with the synthetic/ softened water. The solution is then stirred for some minutes on a magnetic stirrer to ensure proper mixing. All chemicals which were used for the screening are listed in **Table 4-2**.

Table 4-2: Summary of used chemicals in the screening study with purity and manufacturer.

Chemical	Purity	Manufacturer
Cyclohexane	99.9%, for modifying the oil	Merck, Darmstadt, Germany
Dowex® Marathon™ C resin, Na^+ form	N/A, strongly acidic, 20-50 mesh, for water softening	Sigma-Aldrich, St. Louis, US
Sodium hydroxide	97%, for resin regeneration	Merck, Darmstadt, Germany
Sodium chloride	99.9%	Merck, Darmstadt, Germany
Sodium bicarbonate	99.5%	Merck, Darmstadt, Germany
Sodium carbonate	99.9%	Merck, Darmstadt, Germany
Potassium carbonate	99%	Merck, Darmstadt, Germany
Polymer (Co-solvent 1)	N/A	Clariant, Burgkirchen an der Alz, Germany
Isooctyl alcohol polyglycol ether (Co-solvent 2)	N/A	Clariant, Burgkirchen an der Alz, Germany
Cashew nutshell liquid polyglycol ether (Co-solvent 3)	N/A	Clariant, Burgkirchen an der Alz, Germany
Flopaam 3630S	N/A, 10% moisture	SNF FLOEGER, Andrézieux-Bouthéon, France

4.2.2 Polymer Solution Preparation

Flopaam FP 3630S (HPAM) from SNF was used for the preparation of the polymer solution. Oxygen-reduced preparation of polymer solutions was tried by washing the water sample as well as the polymer solution with argon for about two hours. No significant reduction of the oxygen content in the water could be achieved. Hence, further preparation occurred under aerobic conditions (> 1 mg/l O_2) because no anaerobic test set-up was in place at this time.

The preparation follows the recommendation of SNF. First of all, a 5,000 ppm mother solution was produced with softened water. Powdered HPAM consists of 10% moisture (relatively constant), which needs to be considered in the preparation of the mother solution. Dilution of the mother solution to working solution (1,000 ppm) was performed by templating softened water into a 400 ml plastic cup. Then, a mechanical stirrer equipped with an impeller was placed around 1 cm over the bottom of the cup. The water was intensively stirred with 500 rpm for some minutes to generate a water cone. In the meantime, the polymer is weighed in and the solid particles homogenously distributed (within seconds) into the solution. The polymer addition happened with a constant speed. After 15 min the initial velocity of the stirrer was reduced to 200 rpm and the solution stirred for further two hours to ensure a complete dissolution.

4.2.3 Alkali-Polymer Interaction Quantification

In order to evaluate the influence of alkali (Na_2CO_3, K_2CO_3) on FP 3630S different samples (AP, ACP formulations) were prepared and exposed in a convection oven at 60°C for around 100 days. The polymer preparation followed the same procedure described in **Chapter 4.2.2** (under aerobic conditions). In periodic time intervals, samples were taken and further analyzed regarding its molecular weight distribution. The determination of the molecular weight of HPAM in produced water is done by using size exclusion chromatography according to API RP 63-5. The measuring principle is based on the chromatographic separation of high-molecular-mass polymer molecules from low-mass interferences. The quantification is accomplished by ultraviolet detection [45, 117].

4.2.4 Phase Behaviour & Viscosity Measurement Procedure

The phase behaviour experiments were performed according to the procedure described by Sheng (2011) [10]. The samples were prepared in 10 ml glass pipettes from Fisher brand (**Figure 4-11**). The pipettes were sealed at the bottom with a methane-oxygen flame and then filled with different volumes of aqueous solution containing the alkali followed by the crude oil according to the defined WOR. Afterwards, the pipettes were sealed on the top and put for 24 hours on a rotating shaker to ensure proper mixing in the thin capillaries. The samples were then stored at reservoir temperature (49°C or 60°C) and atmospheric pressure in a convection oven and observed over time until equilibrium state was reached.

To provide a qualitative and quantitative analysis of the phase screening, the viscosity of selected middle-phase micro emulsions was measured at equilibrium. The viscosity was investigated for WOR 5:5 of both alkalis at various concentration ranges. Samples were prepared after the same procedure mentioned above in larger vessels (50 ml tubes). After reaching the state of equilibrium, the sample was taken out of the oven and wrapped into aluminium foil to avoid cooling of the sample [109]. Additionally, a water bath with the adjusted reservoir temperature (49°C or 60°C) was prepared to prevent the sample from cooling. The middle-phase was then slowly extracted with a piston-stroke pipette (100-1,000 µl) and a volume of 250 µl slowly applied on the plate. Before using the pipette, the tip was cut to prevent sample shearing while extraction. Viscosity measurements were conducted with a rheometer (Anton Paar Physica MCR 301) using cone-and-plate geometry with 60 mm diameter and 0.5° angle (CP60-0.5). The shear rate was varied from 0.1-70 s^{-1} to examine the steady-shear viscosity at constant reservoir temperature (49°C or 60°C).

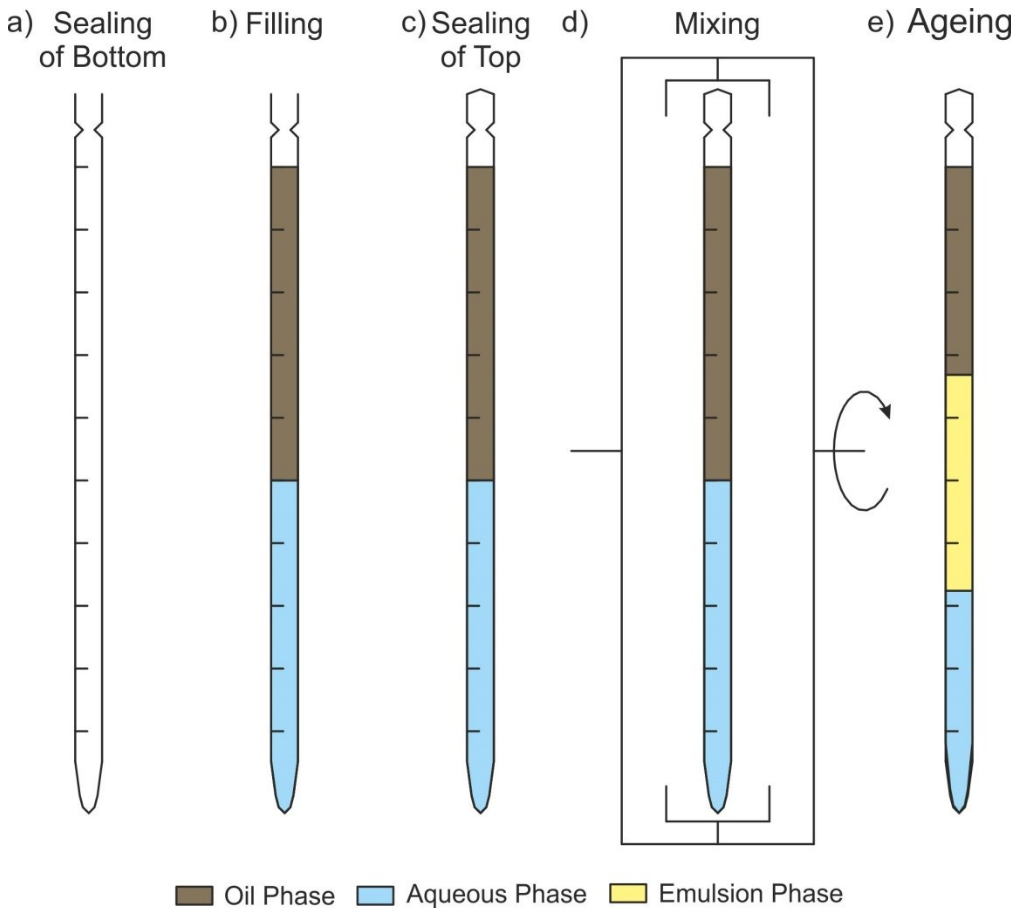


Figure 4-11: Process of preparing a phase experiment [114].

4.2.5 Interfacial Tension Set-Up

A spinning drop tensiometer (SDT) from Krüss Scientific is used to measure ultralow interfacial tensions between two phases (oil-water, oil-gas or gas-water). It is an optical measuring system (**Figure 4-12**), which uses the "Advance"-software.

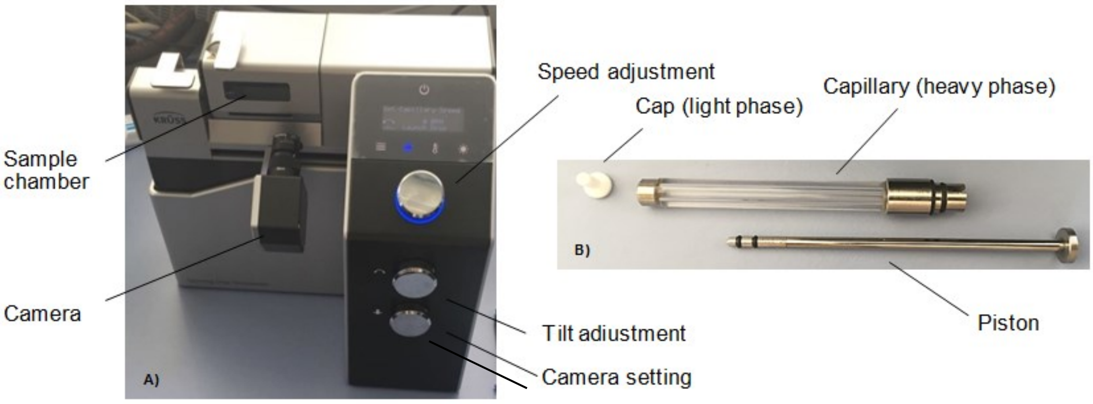


Figure 4-12: Set-up of the spinning drop tensiometer (A) and sample capillary (B).

Before an IFT measurement can be started, the density of the light and heavy phase needs to be determined and entered into the software. The light phase (crude) is measured with a Stabinger viscosimeter from Anton Paar SVM3000 under ambient pressure conditions at reservoir temperature and the heavy phase (aqueous phase) with a viscosimeter from Anton Paar DMA5000.

The IFT measurement follows the procedure recommended by the manufacturer. First, a droplet of the light density liquid (ρ_L) gets placed in the cap by using a syringe. Then, the thin capillary is filled with the aqueous phase, which has a higher density (ρ_H). The cap then gets pulled into the capillary and added into the sample chamber. Every time when a new measurement is started the camera needs to be calibrated. Afterwards the measuring temperature and time is set, the measuring method (Vonnegut or Young Laplace) is chosen and the capillary set in rotation (**Figure 4-13**, **A**). Thereby, an oil droplet is created, distributed horizontally in the capillary and elongated by centrifugal forces. The elongation of the drop (change of the diameter) correlates with the interfacial tension. The IFT is measured at a constant rotation speed. Through increasing the velocity (ω), the droplet turns into elliptical shape and in the end into an elongated cylinder (**Figure 4-13, B**) [118].

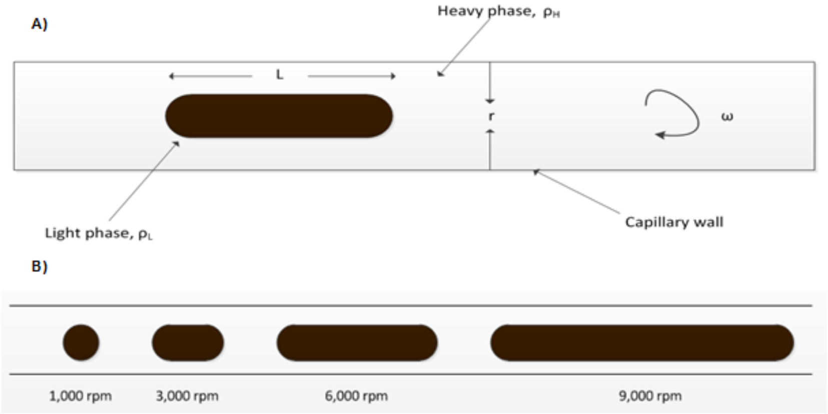


Figure 4-13: Principle of STD (A) and fluid droplet change (B) through increase in speed (After [119, 118]).

After the measurement, the capillary gets released from the sample chamber and the piston gets applied to remove the liquid and the cap. In the end, the capillary is cleaned with deionized water and cleaned with benzene if required to remove water insoluble particles [120].

Two mathematical approaches (Young Laplace or Vonnegut) can be used to determine the IFT through the spinning drop tensiometer. Young Laplace method (**Eq. 27, Eq. 28**) is mostly used, referring to the curvature of the drop shape (H) instead of the diameter. In the Vonnegut approach (**Eq. 28**) drop diameter (d=2r), rotation speed (ω), and density difference of the two phases ($\Delta\rho$) are used for the calculation. For the application of this method the droplet length must be at least four times the drop diameter to reduce errors through the curvature of the interface [121, 122].

$$\Delta p = 2 * H * \sigma \qquad (27)$$

$$\Delta p = \sigma * (\frac{1}{r_1} + \frac{1}{r_2}) \qquad (28)$$

$$\sigma = \frac{r^3 * \omega^2 * \Delta\rho}{4} \qquad (29)$$

4.3 Results

A large number of chemical formulations with K_2CO_3 and Na_2CO_3 were prepared to observe the difference between synthetic and real formation water with dead oil and viscosity-matched oil (containing cyclohexane). The influence on the phase behaviour of various co-solvents (1, 2, and 3) and HPAM (Flopaam 3630S) was additionally observed. Thereby, the concentration of every single component from the formulation (alkali, polymer, and co-solvent) was varied to investigate the maximum potential of in-situ soap generation at various WOR.

In general, the concentration of the used alkali solution, which generates a micro emulsion as middle-phase (type III) and which has the lowest interfacial tension, has the highest potential for a successful AP formulation [10]. Sodium and potassium carbonate were tested regarding their usage as alkali lye in the planned AP flood and their applicability as EOR fluid compared. The performance of both alkali lyes is represented for all tested formulations. Oil scans were performed with different water-oil ratios (1:9 – 9:1). Crude oil from two different reservoirs was screened: oil 1 comes from a well located in the 16th Tortonian reservoir (outlined as Bo 112 oil) and oil 2 from a well of the 8th Tortonian reservoir (outlined as S 85 oil).

The oil scan was shown after two weeks representing the time when clear phase boundaries could be realized. The oil scan pictures representing pipettes filled with different alkali concentrations, whereas the first pipette the blank (without alkali) represents and the white line in the pictures the WOR. The yellow line outlines the oil-to-emulsion interface and the red line the emulsion-to-water interface.

The formed micro emulsions were analysed according to their composition (optically), quantified after their generated amount of “soap” and characterised by their emulsion types. The results were visualised and the equilibrium time recorded. The samples were therefore observed over 100 days and the generated amount of middle-phase emulsion represented as square root of time. Furthermore, the dynamic viscosity and the interfacial tension from the most promising formulations were measured at reservoir temperature. The viscosity results are shown in a shear plot and the concentrations compared at a constant shear rate of $7s^{-1}$ reflecting the reservoir conditions. Low viscosities, which appear at high shear rates, reflect the conditions close to the near-wellbore region. High viscosities typically occur at low shear rates in the wellbore.

The salinity of the produced water was kept constant in this study. In most phase screenings like with surfactants a salinity scan is performed before starting with the phase evaluation. Here, the alkali concentration was varied and therefore labelled as oil scan. In the oil scan the area is highlighted, in which most concentrations reached their equilibrium.

In the end, the most promising alkali concentrations were mixed with HPAM to study the effect on the phase behaviour and to find the best candidates for the AP slug. Moreover, the alkali-polymer interaction in the presence of oxygen was investigated at reservoir temperature over time. The performed test series are summarized in **Table 4-3**.

Table 4-3: Summary of the test series performed for both oils at reservoir temperature. The type of oil can be classified into dead oil (stock tank oil) and viscosity-matched oil (dead oil mixed with C_6H_{12} - outlined as visco.). The expression “real” water stands for real softened formation water.

Formulation Nr.	Type of Water	Type of Oil	Type of Alkali	Alkali Conc. (ppm)	Co-Solvent Type	Co-Solvent Conc. (ppm)	HPAM Conc. (ppm)	WOR
#1	Synthetic	Dead	Na_2CO_3, K_2CO_3	1,000-20,000	x	x	x	1:9-9:1
#2	Real	Dead	Na_2CO_3, K_2CO_3	1,000-20,000	x	x	x	1:9-9:1
#3	Real	Visco.	Na_2CO_3, K_2CO_3	1,000-20,000	x	x	x	1:9-9:1
#4	Real	Dead/ Visco.	Na_2CO_3, K_2CO_3	5,000-12,500	1/2/3	1,000-5,000	x	5:5
#5	Real WTP	Visco.	Na_2CO_3, K_2CO_3	7,500	1/2/3	2,000	x	5:5
#6	Real	Visco.	Technical graded (Na_2CO_3, K_2CO_3)	5,000-10,000	x	x	1,000	5:5
#7	Real	Visco.	Na_2CO_3, K_2CO_3	7,500	3	2,000	1,000	5:5
#8	Real	Visco.	Na_2CO_3, K_2CO_3	Various mixes	x	x	1,000	5:5

4.3.1 Crude Oil Characterisation

The oil samples of both reservoirs were analyzed according to their total acid number (TAN), acid number (AN), density and viscosity. The fresh samples were dewatered and degassed. Every measurement was performed three to four times and the average values listed in **Table 4-4**. The Bo 112 oil contained 7.1*10^{-3} mmol surfactants per gram oil sample and the S 85 oil 8*10^{-3} mmol.

Table 4-4: Chemical and physical properties of cleaned dead oil (stock tank oil): Bo 112 (16.TH) and S 85 (8.TH). From the samples water and suspended solids were removed through high-speed centrifugation.

Producer wells	Bo 112	S 85
Molecular Weight (kg/kmol)	294.6	328.5
TAN (mg KOH/g oil sample)	1.53	1.70
AN (mg TEGO®trant A100/ g oil sample)	2.84	3.20
AN (mmol surfactant/g oil sample)	7.1*10^{-3}	8.0*10^{-3}
Density, standard conditions @ 15°C, 0.1 MPa (g/cm^3)	0.913	0.938
Density @ 20°C (g/cm^3)	0.909	0.935
API (°)	23.29	19.22
Kinematic viscosity @ 20°C (mm^2/s)	87.7	353.7
Kinematic viscosity @ 50°C (mm^2/s)	21.9	56.2
Kinematic viscosity @ 60°C (mm^2/s)	15.5	35.8

Some formulations were prepared with viscosity-matched crude oil, whereby dead oil was mixed with cyclohexane (C_6H_{12}). Through the addition of C_6H_{12}, the crude oil becomes more viscous and the viscosity of the reservoir can be matched. The in-situ oil viscosity in the 16.TH is 4.2 cP at 60°C. A mix of 77 vol% Bo 112 oil and 23 vol% of C_6H_{12} is required. For the 8.TH, a mixture of 89 vol% S 85 oil and 11 vol% of cyclohexane is necessary to reach a viscosity of around 19 cP at 49°C. The viscosities (**Table 4-5**) were measured with a Anton Paar SVM3000 G2 Stabinger Viscometer.

Table 4-5: Dynamic and kinematic viscosity results of viscosity-matched oil samples.

Sample composition	Dynamic viscosity (mPa.s)	Kinematic viscosity (mm^2/s)	Density (g/cm^3)	Shear rate D (s^{-1})	Shear stress (Pa)	Temperature (C°)
77 vol% Bo 112 + 23 vol% C_6H_{12}	4.1785	4.9301	0.8476	0.8478	3.269	60
89 vol% S 85 + 11 vol% C_6H_{12}	20.454	22.857	0.8950	350.9	7.176	49

4.3.2 Produced Water Composition

The fresh water samples were analysed according to its major components by using Thermo Scientific™ Dionex™ ion chromatography (IC) and inductively coupled plasma emission spectroscopy (ICP-OES Blue) from Spectro Ametek. A summary of the composition for the 16.TH (outlet hydrocyclone) and the 8.TH (outlet water treatment plant) can be found in **Table 4-6**.

The water from the 16.TH had a chloride content of 11,570 mg/l compared to water from the 8.TH with a chloride content of approximately 13,675 mg/l. The total dissolved solids (TDS) content in the 8.TH was slightly higher with 24.45 g/l compared to the 16.TH with 21.02 g/l. The water characteristic of the 8.TH differed additionally regarding the hardness load of Ca^{2+} and Mg^{2+}. Furthermore, the water from the outlet hydrocyclone had an alkalinity of 22 mmol/l and a total hardness of 39.5°dH. In comparison, the water from the outlet WTP had a lower alkalinity with around 19 mmol/l and a tremendous higher total hardness of approximately 54°dH.

Table 4-6: Properties of produced water (initial) from the outlet hydrocyclone (16.TH) and outlet WTP (8.TH).

Sampling Point	**Outlet Hydrocyclones**	**Outlet WTP**
pH @ 20°C	7.22	7.11
Conductivity @ 20°C (µS/cm)	28,700	34,100
Alkalinity (mmol/l)	22	19
Total Hardness (°dH)	39.5	53.6
Major components in the brine (mg/l)		
Chloride (Cl^-)	11,570	13,675
Sulfate (SO_4^{2-})	4.7	12.9
Sodium (Na^+)	7,664	8,901
Potassium (K^+)	79.5	86
Magnesium (Mg^{2+})	71.1	82.1
Calcium (Ca^{2+})	150	229
Iron (Fe^{2+})	0.71	4.3
Barium (Ba^{2+})	15.5	13.7
Manganese (Mn^{2+})	<0.01	<0.01
TDS (g/l)	21.02	24.45

As a next step, fresh water was softened with Dowex50 (10 g/100 ml water sample). The strong cation exchanger substitutes divalent cations such as Ca^{2+}, Mg^{2+}, Sr^{2+} and Ba^{2+} against Na^+-ions. Thereby, approximately 90% of the hardness components in the water were removed. **Table 4-7** reflects the water properties after softening. The total hardness was reduced from 39.5°dH to 3.8°dH for the water from the outlet hydrocyclones and for the water from the WTP from 53.6°dH to around 7.2°dH.

Table 4-7: Properties of softened water with Dowex50: characterization with IC and ICP-OES.

Major components in the brine (mg/l)	Outlet Hydrocyclones	Outlet WTP
Lithium (Li^+)	1.43	1.58
Ammonium (NH_4^+)	34.7	29.7
Sodium (Na^+)	8,051	8,979
Potassium (K^+)	40.3	42.0
Magnesium (Mg^{2+})	11.5	17.7
Calcium (Ca^{2+})	8	21.6
Strontium (Sr^{2+})	n.d.	3.7
Total Hardness (°dH, calculated)	3.8	7.2

4.3.3 Investigated Formulations for the 16th Tortonian Horizon

4.3.3.1 Formulation 1a: Synthetic Make-up Water + Dead Bo 112 Oil (Alkali Slug)

This simplified formulation was used as basic model to establish the phase screening methodology in the laboratory. Furthermore, it helped to understand the phase behaviour and the fluid composition for generating in-situ soaps (phase characterization and its evaluation). All further prepared formulations were based on these findings.

Formulation 1 was prepared with synthetic make-up water and dead Bo 112 oil. For the make-up water, deionized water (0.054 µS at ambient temperature conditions) was used and the salinity as well as the alkalinity adjusted concerning the produced water composition from the outlet hydrocyclones (16.TH water treatment system, see **Chapter 3.3**). The produced water in the 16.TH had a salinity of 11,500 ppm with an alkalinity of 22 mmol/l.

Prior to this, pH measurements were performed with strong (NaOH) and weak (Na_2CO_3, K_2CO_3) lyes (0.1 mol/l) to calculate the alkali amount that is required to reach a specific pH value (**Figure 4-14**). According to Sheng (2011), a pH over 9.5 is necessary to generate in-situ soaps [10]. NaOH was used to illustrate the difference between strong caustic solutions and carbonate-based alkalis. A sample volume of 50 ml was used for the measurements. Na_2CO_3 and K_2CO_3 behave similarly according to their buffer capacity as represented in **Figure 4-14**. In comparison, NaOH reacts relatively strong on the addition of small quantities compared to K_2CO_3 and Na_2CO_3 (fast pH increase).

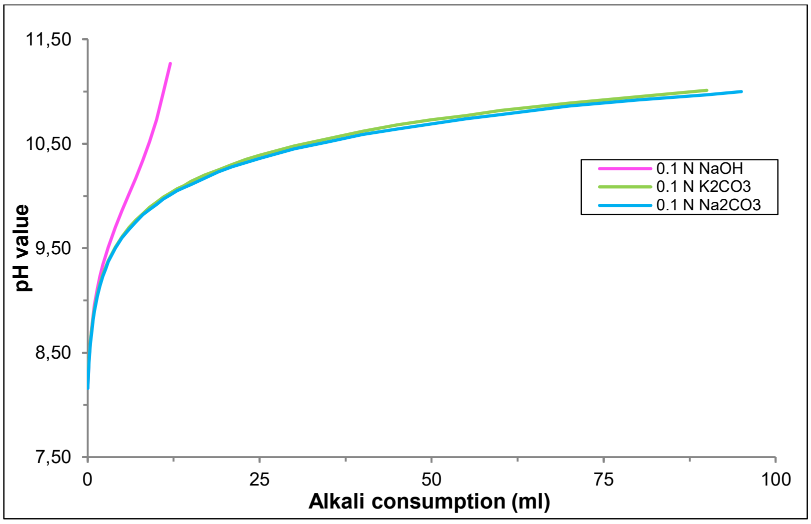


Figure 4-14: pH titration curve to reach a specific value using synthetic make-up water.

In order to reach pH values over 9.5 with the carbonate-based alkalis (Na_2CO_3, K_2CO_3), higher alkali amounts are required (**Table 4-8**) compared to NaOH (<1 kg lye/m^3). Na_2CO_3 is a stronger carbonate-base than K_2CO_3 and lower amounts are needed to reach a specific pH value. For instance, to reach a pH of 10.5, 7.42 kg/m^3 of Na_2CO_3 or 8.28 kg/m^3 K_2CO_3 are approximately necessary.

Table 4-8: Alkali lye consumption to reach a desired pH value using synthetic water.

pH value	NaOH (kg/m^3)	K_2CO_3 (kg/m^3)	Na_2CO_3 (kg/m^3)
9	0.08	0.39	0.30
9.5	0.24	1.10	0.85
10	0.48	3.04	2.54
10.5	0.72	8.28	7.42
11.0	0.88	24.9	20.1

Figure 4-15 illustrates the oil scan performed with formulation 1 after two weeks for the water-oil-ratio (WOR) 5:5. The alkali concentration varied from 1,000 ppm up to 20,000 ppm in 2,500 ppm steps. The WOR 5:5 was used as the base case (ideal case) assuming an equal saturation of the fluids in the reservoir. All other tested WORs are listed in the **Appendix A1.** The samples were evaluated over 100 days and the diffusion process expressed in **Figure 4-16**. Square root of time was used to link the emulsion volume to the diffusion process and might be used as a mechanistic description of the formed emulsions. The samples were stored at constant temperature (60°C) over the whole trial time in order to reach the emulsion equilibrium.

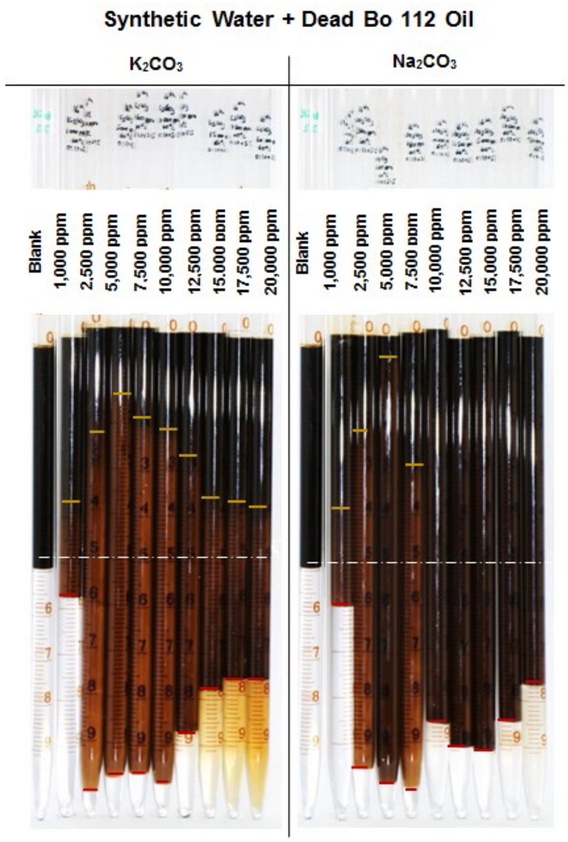


Figure 4-15: Oil scan of synthetic make-up water and dead Bo 112 oil at 60°C after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

Both alkalis showed a decrease of the generated in-situ soap amount over time. Nevertheless, a stronger decline could be observed for the samples prepared with higher alkali concentrations, compared to lower concentration ranges (more stable emulsions are formed). K_2CO_3 generated "cappuccino-like" middle-phase emulsions (type III) at all concentrations. The biggest emulsion quantity was formed with 5,000 ppm followed by a decrease of the in-situ soap amount at higher alkali concentrations. The optimal concentration range with K_2CO_3 is between 5,000 ppm to 12,500 ppm.

Na_2CO_3 produced undesired type II (+) emulsions at higher concentration ranges, which are unfavorable for a successful flood (highlighted as dotted line). Middle-phase emulsions were just generated for concentrations up to 10,000 ppm (**Figure 4-16**).

The emulsion decline over time is less severe and slower for the samples prepared with K_2CO_3 compared to Na_2CO_3 for most of the concentrations. No viscositiy and IFT measurements were performed with formulation 1.

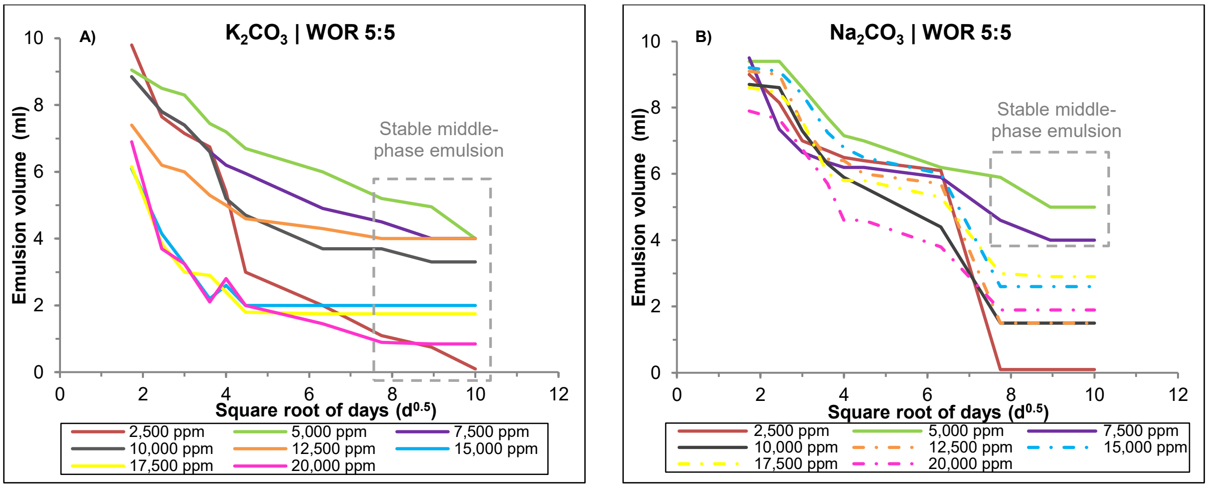


Figure 4-16: Time dependency of formulations prepared with synthetic water containing K_2CO_3 (A) and Na_2CO_3 (B) at different concentrations mixed with dead Bo112 oil to reach middle-phase emulsion equilibrium over 100 days at 60°C for WOR 5:5 (After [80]).

4.3.3.2 Formulation 2a: Softened Water + Dead Bo 112 Oil (Alkali Slug)

Samples of formulation 2 were prepared with real softened water from the outlet hydrocyclones and mixed with dead Bo 112 crude oil. To compare the required alkali amount with the results achieved by the synthetic make-up water pH measurements (titration curves) with fresh (**Figure 4-17**, **A**) and softened real water (**Figure 4-17**, **B**) were performed at the beginning. Similar results could be observed for both cases.

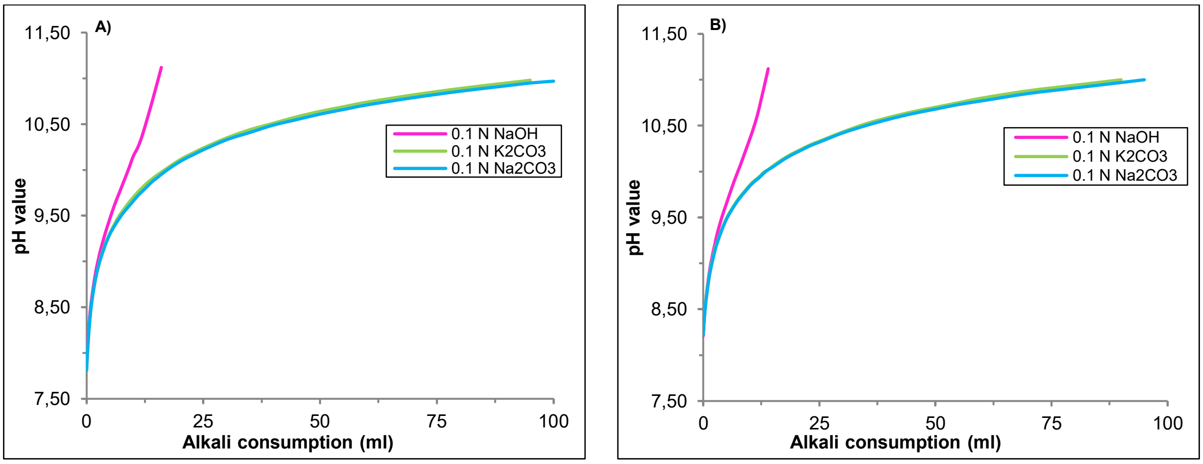


Figure 4-17: Titration curve of fresh water (A) and softened real water (B) from the outlet hydrocyclone.

Slightly higher alkali consumptions (**Table 4-9**) are required in comparison to the samples prepared with synthetic make-up water. The alkali amount from the carbonate-based lyes increased tremendously to achieve a pH value of about 10.5. Basically, the consumption was slightly lower with softened real water than with fresh water samples.

Table 4-9: Comparison of the alkali lye consumption to reach a desired pH using fresh and real softened water from the outlet hydrocyclones.

pH value	Fresh Water NaOH (kg/m³)	K$_2$CO$_3$ (kg/m³)	Na$_2$CO$_3$ (kg/m³)	Softened Real Water NaOH (kg/m³)	K$_2$CO$_3$ (kg/m³)	Na$_2$CO$_3$ (kg/m³)
9	0.21	0.83	0.64	0.15	0.50	0.38
9.5	0.40	1.93	1.48	0.32	1.38	1.06
10	0.72	4.69	3.61	0.56	3.59	2.76
10.5	1.04	11.1	8.48	0.88	9.66	7.42
11.0	1.23	26.3	21.2	1.04	24.9	20.2

It could be observed that the fresh water samples showed precipitations when the alkali lyes were added. Especially, at pH values over 9.5, hydroxide precipitations occurred with the use of NaOH. Carbonate and magnesium precipitations appeared already at a pH value of 9 when carbonate-based were used (**Figure 4-18**, **A**). As a consequence, water softening is mandatory in the field to avoid scaling before the alkali lye is mixed to the injection water (**Figure 4-18**, **B**).

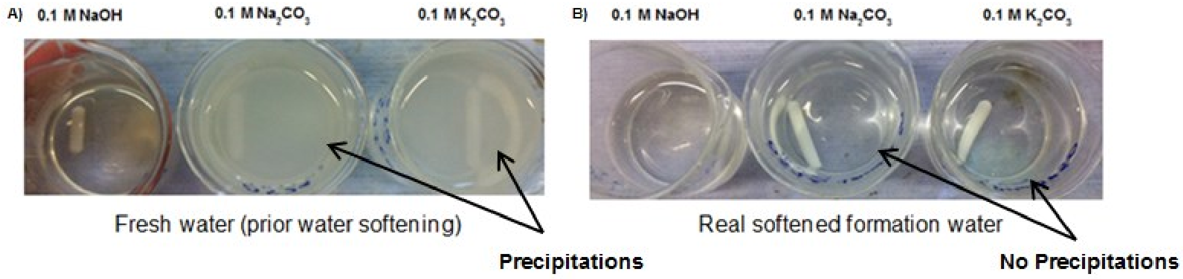
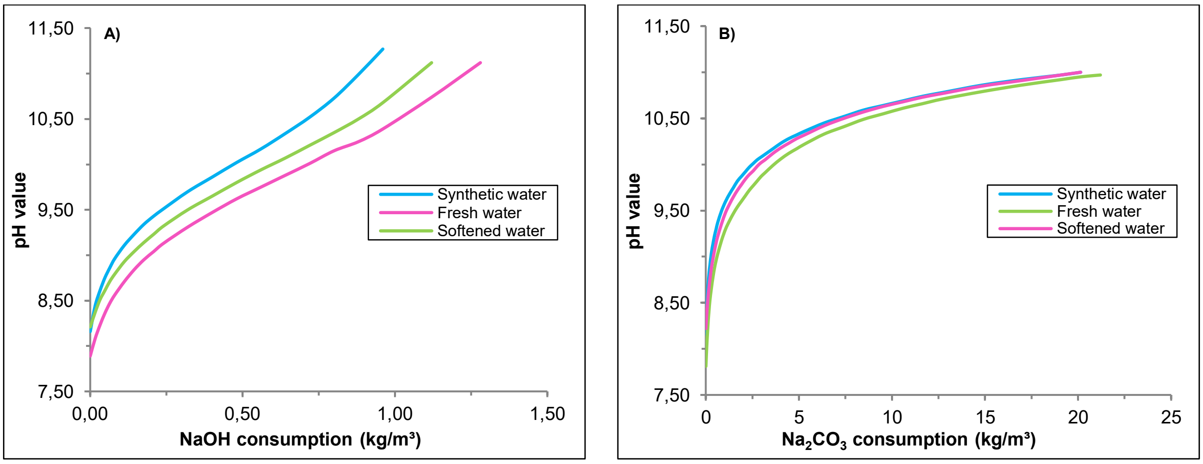


Figure 4-18: Upcoming precipitations of the alkali lyes without softening (A) and no precipitations occurred after water softening (B).

The chemical consumption for NaOH (**A**), Na$_2$CO$_3$ (**B**) and K$_2$CO$_3$ (**C**) comparing synthetic, fresh and softened formation water is displayed in **Figure 4-19**. The alkali concentration was kept constant at 0.1 N for all three lyes.



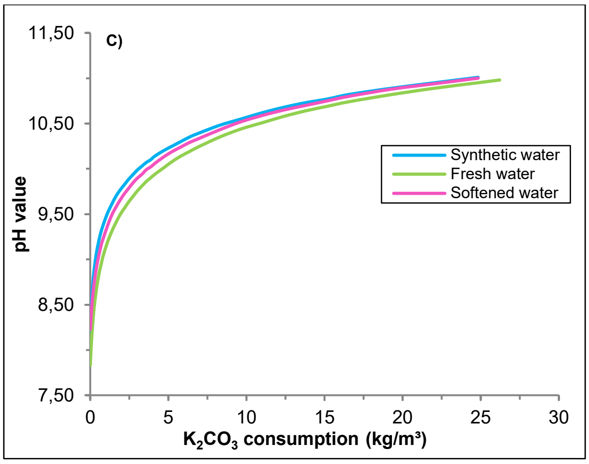


Figure 4-19: Alkali consumption of NaOH (A), Na_2CO_3 (B) and K_2CO_3 (C) comparing synthetic, fresh and softened water from the outlet hydrocyclones.

Na_2CO_3 and K_2CO_3 require higher quantities to reach high pH values than NaOH due to their buffer capacity. Carbonate-based alkalis are insensitive to pH changes, when higher amounts of lye are added (easy pH adjustment in the field possible). Slightly higher amounts of K_2CO_3 were needed to reach a pH of 10.5 compared to Na_2CO_3 (stronger carbonate-alkali).

Figure 4-20 represents the oil scan after two weeks observation time. Samples prepared with K_2CO_3 formed type III emulsions over the whole tested concentration range, whereas samples containing Na_2CO_3 only formed middle-phase emulsions until a concentration of 5,000 ppm. At higher Na_2CO_3 concentrations, beginning with 7,500 ppm, type III emulsions changed to type II (+) emulsions [80].

The aqueous phase in all samples prepared with both alkalis showed a high turbidity through the loss of soap components into the water phase.

The time dependency plots showed that for Na_2CO_3 (**Figure 4-21, B**) the optimal concentration was (only) at 5,000 ppm. All other concentrations were type II (+) emulsions, which are unfavorable for a successful flood. A steep decline of the emulsion amount could be realized especially at low alkali concentrations. The largest amount of emulsion was formed with K_2CO_3 at 5,000 ppm with around 6 ml (**Figure 4-21, A**). Especially at high potassium carbonate concentrations, a faster and stronger decline was observed compared to lower concentration ranges (<10,000 ppm). The optimal concentration range of this formulation with K_2CO_3 was between 5,000 ppm and 10,000 ppm regarding the largest (stable) emulsion amount over time [80].

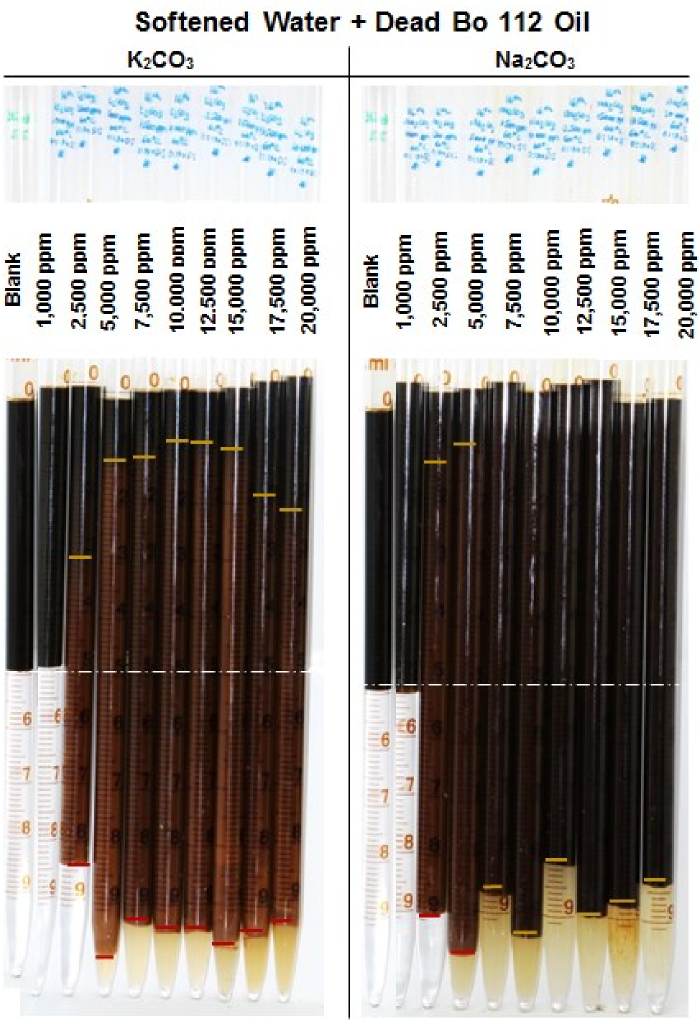


Figure 4-20: Oil scan of softened water and dead Bo 112 oil at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

Viscosity measurements of the generated emulsion amount were performed in the concentration range 5,000 ppm to 10,000 ppm for both alkalis. The shear plots represent mean values; the calculated standard deviation is so small that it is barely visible. The emulsion viscosities of K_2CO_3 are much lower than the ones with Na_2CO_3. At a K_2CO_3 concentration of 5,000 ppm the viscosity was 48.6 cP (**Figure 4-22**, **A**). In comparison, at the same concentration the emulsion formed with Na_2CO_3 had a viscosity of 75 cP at a constant shear rate of $7s^{-1}$. The shear curves for the other two K_2CO_3 concentrations behaved almost the same and reached values of 89 cP.

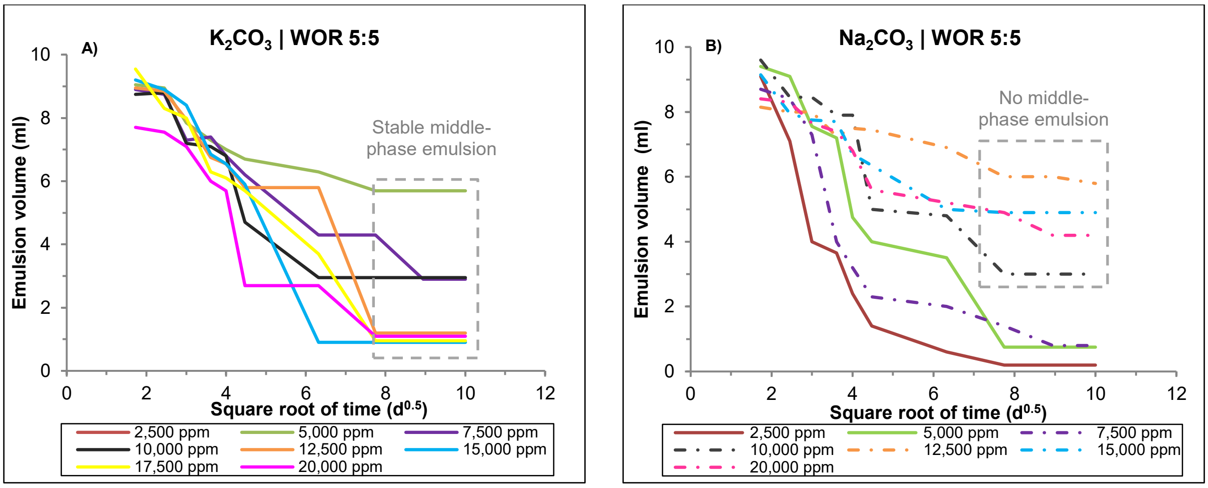


Figure 4-21: Time dependency of formulations prepared with softened water containing Na_2CO_3 at different concentrations mixed with dead oil to reach middle-phase microemulsion equilibrium over 100 days at 60°C for WOR 5:5 (Modified from [80]).

The viscosity increased with increasing Na_2CO_3 concentration (type II (+) emulsions were measured). At a concentration of 5,000 ppm the viscosity was around 75 cP. At 10,000 ppm had the emulsion, formed with sodium carbonate, already a viscosity of over 126.5 cP at a constant shear rate of $7s^{-1}$. All three sodium carbonate concentrations showed shear thinning behavior (**Figure 4-22**, **B**).

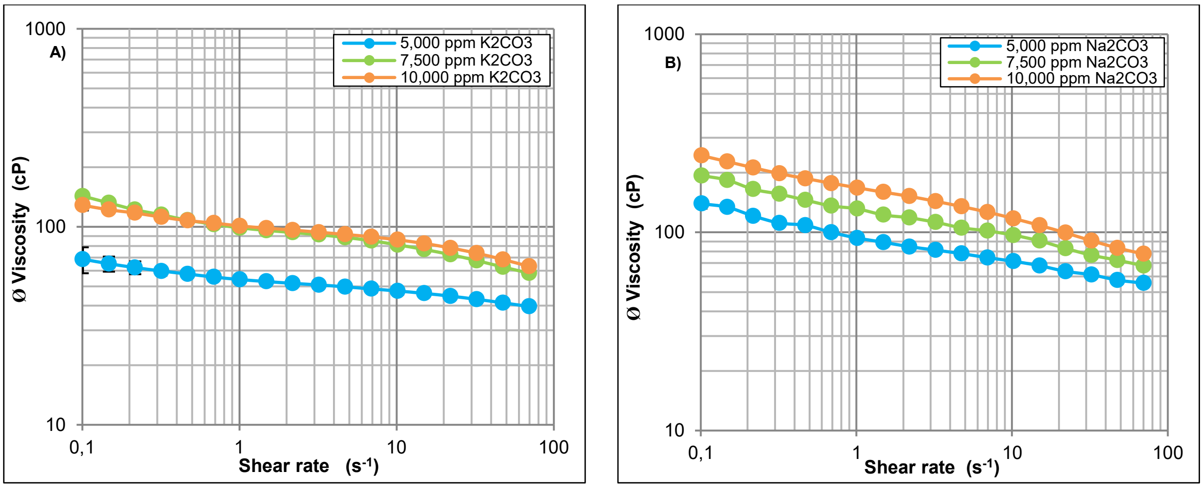


Figure 4-22: Shear plot of softened water from the outlet hydrocyclone mixed with dead Bo 112 (WOR 5:5) at various K_2CO_3 and Na_2CO_3 concentrations at 60°C (Modified from [80]).

Additional WORs were screened with this formulation including WOR 1:9, WOR 3:7, WOR 7:3 and WOR 9:1. The time dependency plots of the emulsion stability from K_2CO_3 and Na_2CO_3 formed emulsions are summarized in the **Appendix A1**. Depending on the concentration and the WOR, the emulsion amount differed significantly. The most stable emulsions with K_2CO_3 were generated of around 2 to 4 ml as middle-phase emulsions (after 100 days observation) at the WORs 3:7 to 7:3.

4.3.3.3 Formulation 3a: Softened Water + Modified Bo 112 Oil with C_6H_{12} (Alkali Slug)

In this formulation dead oil was mixed with cyclohexane to match the viscosities of the oil at reservoir temperature. Thereby, a mix of 77 vol% Bo 112 oil and 23 vol% C_6H_{12} was used to attain a dynamic viscosity of 4.2 cP at 60°C. Again, also in this formulation generated K_2CO_3 larger emulsion amounts than Na_2CO_3. No soaps were formed at alkali concentrations lower than 5,000 ppm. Both alkalis formed type III middle-phase emulsions. The aqueous phase of both alkalis showed a light yellow turbidity through the loss of unstable soap components into the water phase (**Figure 4-23**).

Figure 4-23: Oil scan of softened water and modified Bo 112 oil at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

Interestingly, a tremendous drop of the emulsion amount over time occurred at all Na_2CO_3 concentrations (**Figure 4-24**, **B**), whereas K_2CO_3 formed stable emulsions and its decline was much slower. Dependent on the alkali concentration the following trend could be observed: the higher the alkali concentration, the more stable is the formed in-situ soap with K_2CO_3 (**Figure 4-24**, **A**).

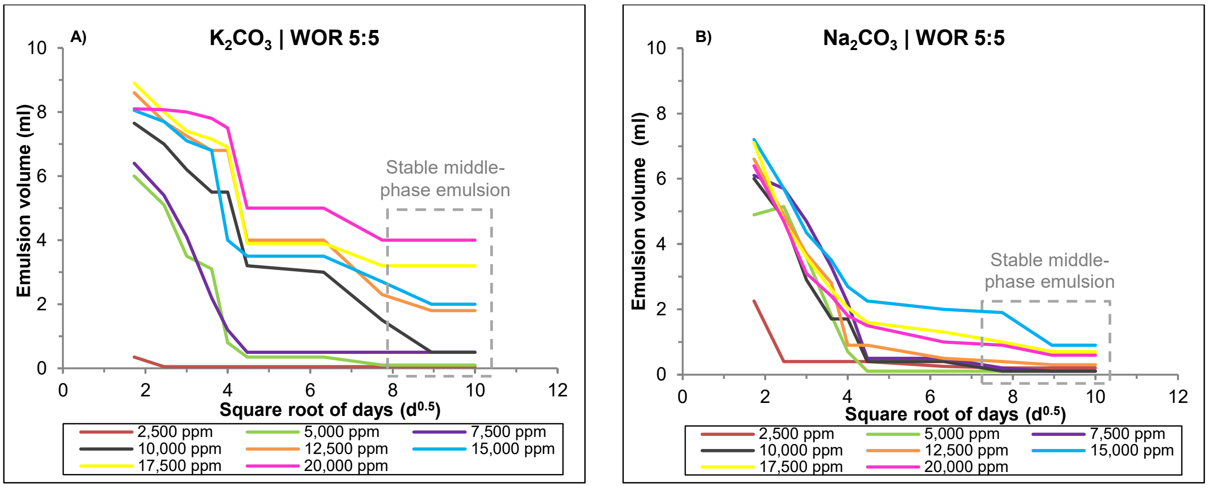


Figure 4-24: Time dependency of formulations prepared with softened water containing K_2CO_3 (A) and Na_2CO_3 (B) at different concentrations mixed with modified Bo112 oil to reach middle-phase microemulsion equilibrium over 100 days at 60°C for WOR 5:5 (Modified from [80]).

The viscosity measurements were performed for concentrations from 5,000 ppm to 12,500 ppm. The viscosities of the emulsions formed with Na_2CO_3 had a lower viscosity than those with K_2CO_3. Both alkalis showed the same shear behavior (no shear thinning). The viscosities of K_2CO_3 were in the range of 39 cP to 50 cP and between 34 cP to 56 cP at a shear rate of 7s^{-1} for Na_2CO_3.

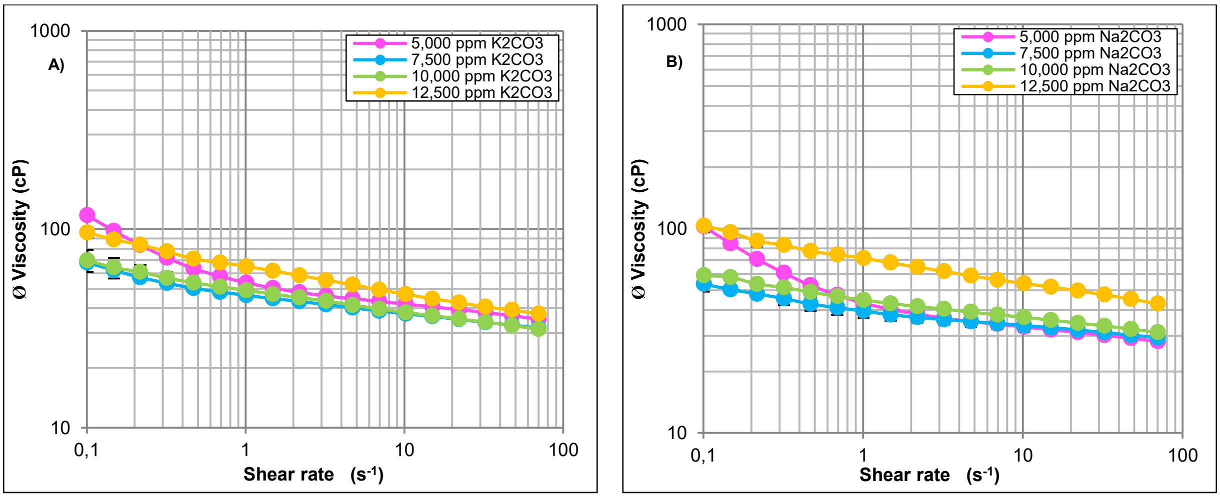


Figure 4-25: Shear plot of softened water from the outlet hydrocyclone mixed with modified Bo 112 oil (WOR 5:5) at various K_2CO_3 (A) and Na_2CO_3 (B) concentrations at 60°C (Modified from [80]).

Additional WORs were screened and summarized in the **Appendix A1**. Especially, at low WORs (1:9) K_2CO_3 formed type II (-) emulsions. This is due to the already high initial oil volume.

4.3.3.4 Formulation 4a: Alkali + Co-Solvents (AC Slug)

Three different types of co-solvents, expressed as co-solvent 1 (polymer-base), co-solvent 2 (Isooctyl alcohol polyglycol ether), co-solvent 3 (cashew nutshell liquid polyglycol), provided by Clariant were used to prepare the chemical formulations. Softened water from the outlet hydrocyclones was used and the performance with dead as well as viscosity-matched Bo 112 oil compared.

Co-Solvent 1:

In this formulation just Na_2CO_3 was tested as alkali lye. The co-solvent 1 concentration was varied from 1,000 ppm up to 5,000 ppm at different alkali concentrations (5,000-10,000 ppm). The oil scan of the tested formulations is represented in **Figure 4-26**. No trend regarding optimal formulation or concentration window could be observed in any of the samples. The color of the generated emulsion varied tremendously from brownish to grey. The best results could be achieved at low co-solvent 1 concentrations (<2,000 ppm, **Figure 4-27**, **B**). Interestingly, the addition of co-solvent 1 led to the generation of multiple emulsions in some formulations.

Figure 4-26: Oil scan of softened water mixed with co-solvent 1 at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

Samples which were prepared with viscosity-matched oil (expressed as visco.) showed a clear water phase. No loss of soap components into the aqueous phase could be observed (**Figure 4-26**). The largest amount of generated in-situ soap of around 9 ml could be recognized by the use of 5,000 ppm Na_2CO_3 mixed with 1,000 ppm of the co-solvent at the beginning of the experiment. A strong emulsion amount decline occurred over the observation time to less than 1 ml (no equilibrium established, **Figure 4-27**, **A**). The emulsion amount decreased with increasing co-solvent concentrations. Minor amounts of emulsion were formed at higher co-solvent concentrations (≥4,000 ppm) with around 1 ml, which stayed constant over time (**Figure 4-27**, **C &D**). The classical "brownish" color of the middle-phase emulsion just occurred in the viscosity-matched oil samples. All samples prepared with viscosity-matched oil formed at all concentration ranges type III emulsions. At high co-solvent concentrations (>4,000 ppm), multiple-emulsions could be observed at all analyzed alkali concentrations (**Figure 4-26**).

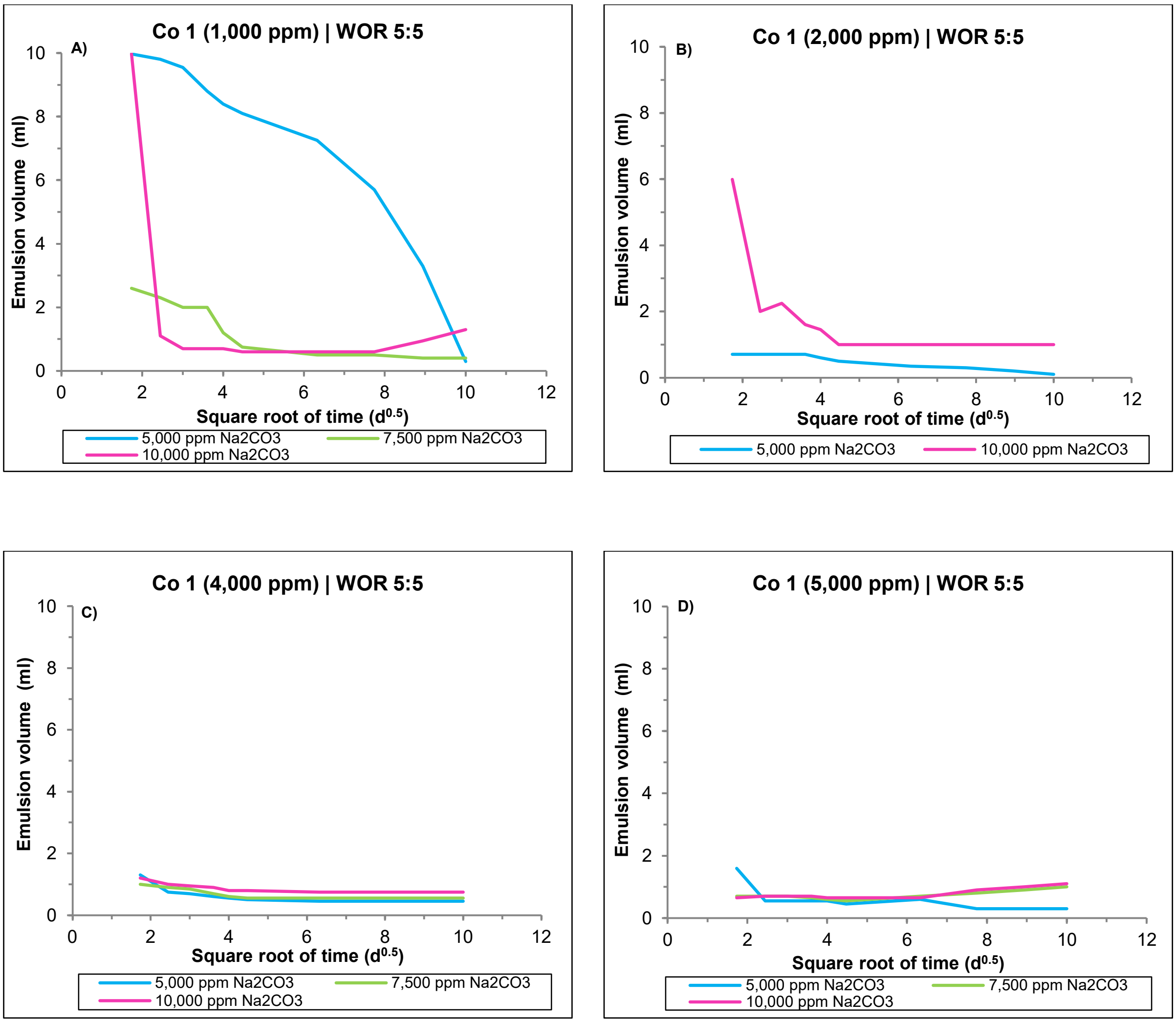


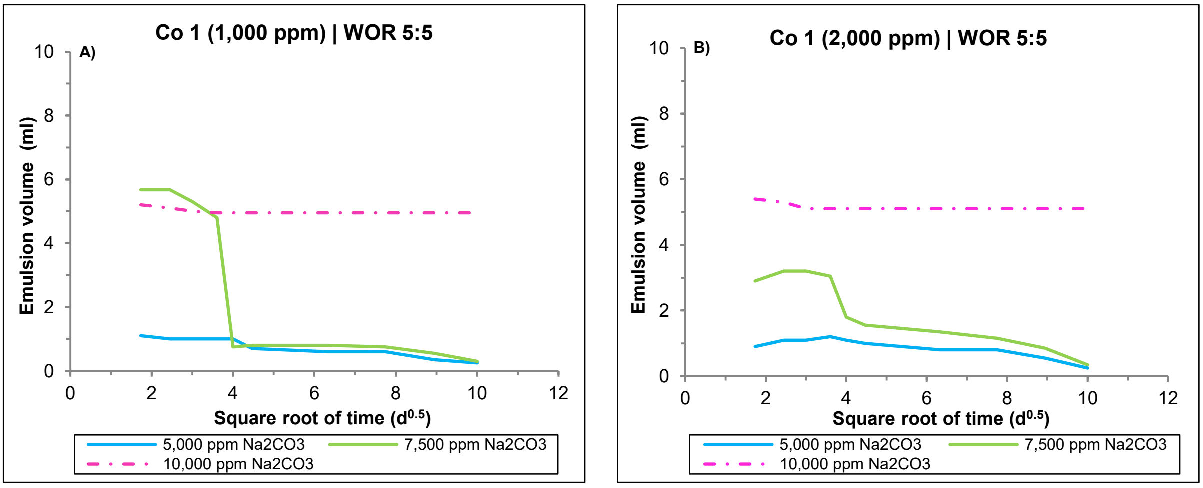
Figure 4-27: Time dependency of formulations prepared with co-solvent 1 containing Na_2CO_3 at different concentrations mixed with modified Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

Samples prepared with dead oil showed strong variations in the optical shape of the formed in-situ soap from light brownish to grey. All formulations prepared with dead Bo 112 showed a colored water phase. No clear phase boundaries could be observed between the emulsion and the aqueous phase at alkali concentrations higher than 7,500 ppm. It was difficult to distinguish between type II (+) emulsion and no emulsion (just coloring of the aqueous phase through loss of soap components) in some cases (**Figure 4-29**). Therefore, these samples were identified as type II (+) emulsions. At an alkali concentration of 10,000 ppm just type II (+) emulsions appeared independent of the co-solvent concentration. Furthermore, multiple emulsions could be observed in a wide range of samples, for instance at 2,000 ppm of the co-solvent mixed with 7,500 ppm and 10,000 ppm of Na_2CO_3; as well as amongst all 5,000 ppm co-solvent samples (**Figure 4-29**, **D**).

At an alkali concentration of 5,000 ppm, type III emulsions occurred in all tested co-solvent concentrations. The emulsion amount was rather low over the examined time with less than approximately 1 ml (**Figure 4-29**, **A, C)**. The sample prepared with 2,000 ppm co-solvent 1 and 7,500 ppm Na_2CO_3 showed a middle-phase emulsions of 3 ml (multiple-emulsion, **Figure 4-29**, **B**).

It was impossible to perform precise viscosity measurements, because the formed in-situ soaps were not stable and broke down into single components when applying the sample to the rheometer (). This would otherwise result in measurement errors.

Figure 4-28: Viscosity samples of formulation 4 prepared with co-solvent 1: no stable emulsions were formed to conduct reproducible and correct viscosity measurements (separation of the emulsion phase).



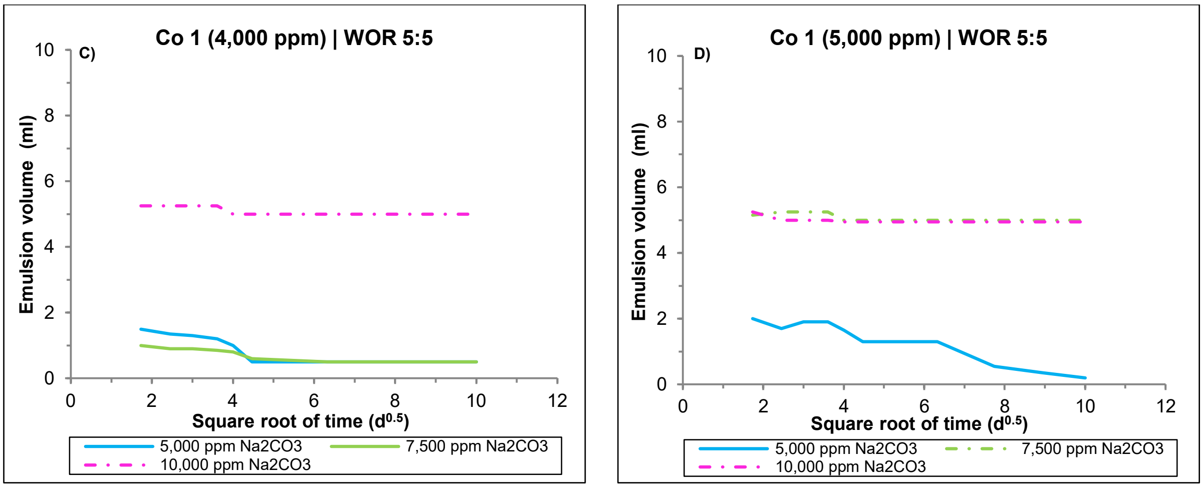


Figure 4-29: Time dependency of formulations prepared with co-solvent 1 containing K_2CO_3 at different concentrations mixed with dead Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

Co-Solvent 2:

These formulations were prepared with Na_2CO_3 at the same concentration range as for co-solvent 1 (5,000-10,000 ppm). The co-solvent 2 concentration was varied from 2,000 ppm up to 5,000 ppm. Dead Bo 112 oil was used for the preparation. Huge variations could be realized in the results because no in-situ soap was generated at low co-solvent 2 concentrations ($\leq$2,000 ppm) over time. Therefore, no time dependency plot is shown. For comparison, only samples containing 4,000 ppm of the co-solvent were tested with viscosity-matched oil, because as mentioned no in-situ soap was generated at 2,000 ppm with dead oil (**Figure 4-30**).

The samples prepared with viscosity-matched oil showed a clear water phase (no soap components were lost into the water phase), whereas the aqueous phase of the samples with dead oil ($\geq$4,000 ppm co-solvent 1) showed a high turbidity. The sample prepared with 7,500 ppm of Na_2CO_3 mixed with 4,000 ppm co-solvent formed a type III emulsion with an emulsion amount of approximately 6.5 ml, which stayed constant over the whole observation time (**Figure 4-32**).

Figure 4-30: Oil scan of softened water mixed with co-solvent 2 and various alkali concentrations at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

Interestingly, type III emulsions were formed with a high emulsion amount of over 9 ml after two weeks equilibrium (**Figure 4-32**, **B**) for the formulations mixed with dead Bo 112 oil at high co-solvent 2 concentrations (5,000 ppm). Samples containing 4,000 ppm prepared with dead oil generated unfavorable type II (+) emulsions (≥7,500 ppm). It was difficult to recognize a clear phase boundary and therefore classified as type II (+) emulsion (**Figure 4-32**, **A**).

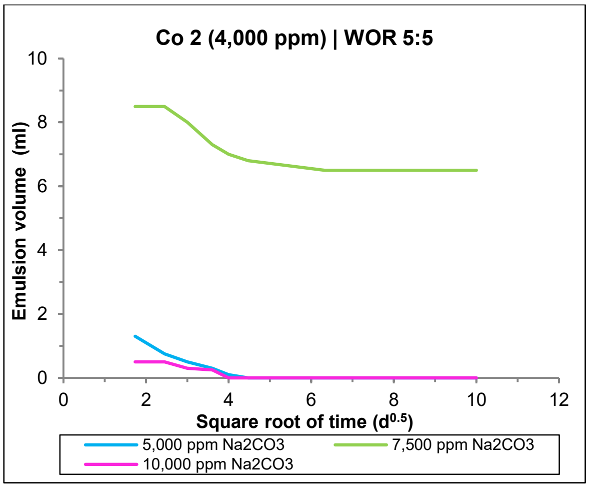


Figure 4-31: Time dependency of the formulation prepared with co-solvent 2 containing Na_2CO_3 at different concentrations mixed with modified Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

No multiple emulsions and grey color of the emulsion/ aqueous phase could be observed as for the formulations prepared with co-solvent 1.

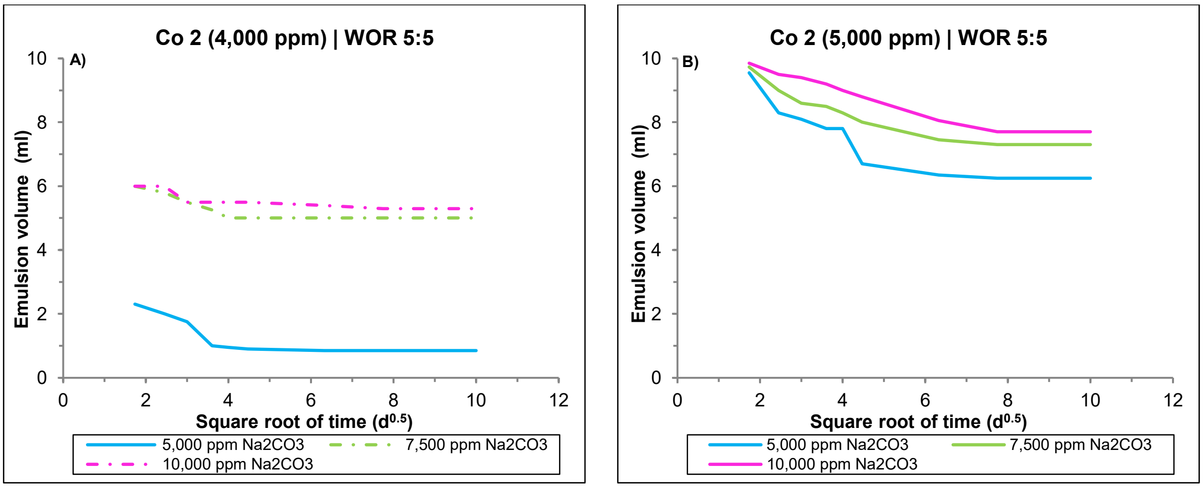


Figure 4-32: Time dependency of formulations prepared with co-solvent 2 containing Na_2CO_3 at different concentrations mixed with dead Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

No viscosity measurements were performed for samples with a co-solvent concentration smaller than 4,000 ppm. Measurements were tried for the formulations prepared with 5,000 ppm of co-solvent 2 because promising type III emulsions were formed over time. Adversely, during extracting the emulsion phase and applying to the rheometer the emulsion separated quickly (no stable emulsion sampling was possible).

Figure 4-33: Viscosity samples of formulation 4 prepared with co-solvent 2: no stable emulsions were formed to conduct reproducible and correct viscosity measurements (separation of the emulsion phase).

Co-Solvent 3:

These formulations were prepared with 1,000 ppm and 2,000 ppm of co-solvent 3 mixed with sodium and potassium carbonate. In this case, just viscosity-matched Bo 112 was examined regarding in-situ soap formation. The alkali concentration was varied from 5,000 ppm up to 12,500 ppm of formulations mixed with 2,000 ppm of co-solvent 3. The analyzed alkali concentration was varied from 5,000 ppm until 10,000 ppm of the samples containing 1,000 ppm of the co-solvent. Compared to the results achieved with co-solvent 1 and 2 both alkalis formed solely type III emulsions (**Figure 4-34**).

Independent of the co-solvent concentration, a large amount of in-situ soap was formed after two weeks observation time. Both alkalis performed similarly. Nevertheless, the generated emulsion amount decreased strongly over time at the end of the observation period a stable equilibrium could just be reached with K_2CO_3 containing 1,000 ppm of co-solvent 3. The samples prepared with Na_2CO_3 had an emulsion amount of less than 2 ml at the end of the experiment (**Figure 4-35**, **A** & **B**).

Figure 4-34: Oil scan of softened water mixed with co-solvent 3 and various alkali concentrations at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

A strong decline of the emulsion volume over time could be realized of the samples prepared with K_2CO_3 (**Figure 4-36**, **D**). For instance the in-situ soap amount declined from initially 9 ml to around 2 ml for the sample prepared with 7,500 ppm K_2CO_3 and 1,000 ppm co-solvent 3 (**Figure 4-36**, **C**). Even though increasing the co-solvent 3 concentration did not result in more stable type III emulsions.

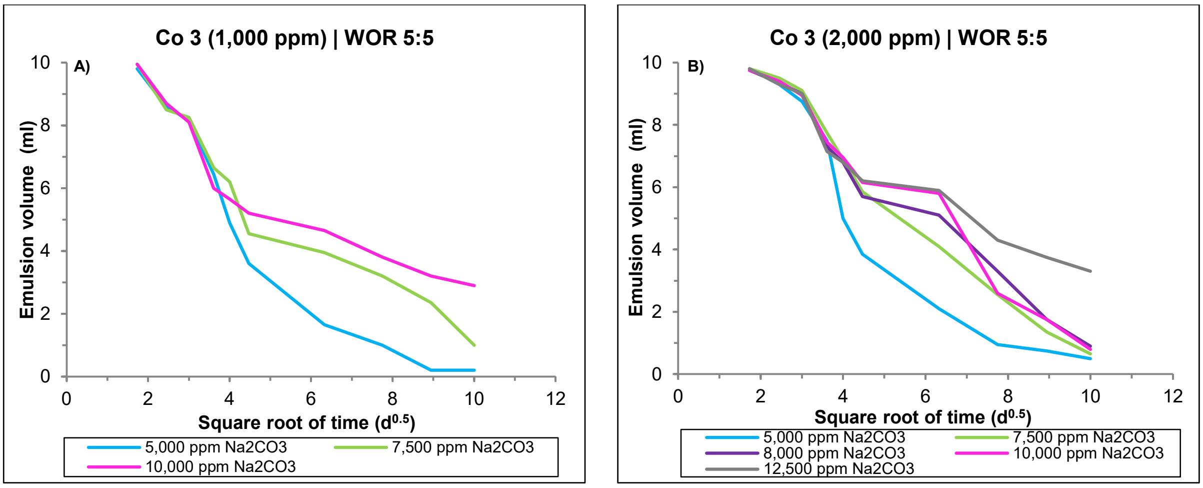


Figure 4-35: Time dependency of formulations prepared with co-solvent 2 containing Na_2CO_3 at different concentrations mixed with modified Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

Viscosity measurements were just performed for the formulations containing 2,000 ppm of co-solvent 3. The emulsion viscosity values varied from 29 cP up to 40 cP for the samples with Na_2CO_3 (**Figure 4-37**, **A**). The shear plots of Na_2CO_3 showed a similar behavior in all concentrations. The lowest viscosity was reached with 7,500 ppm Na_2CO_3. The samples containing 5,000 ppm and 10,000 ppm of K_2CO_3 showed a strong shear thinning behavior.

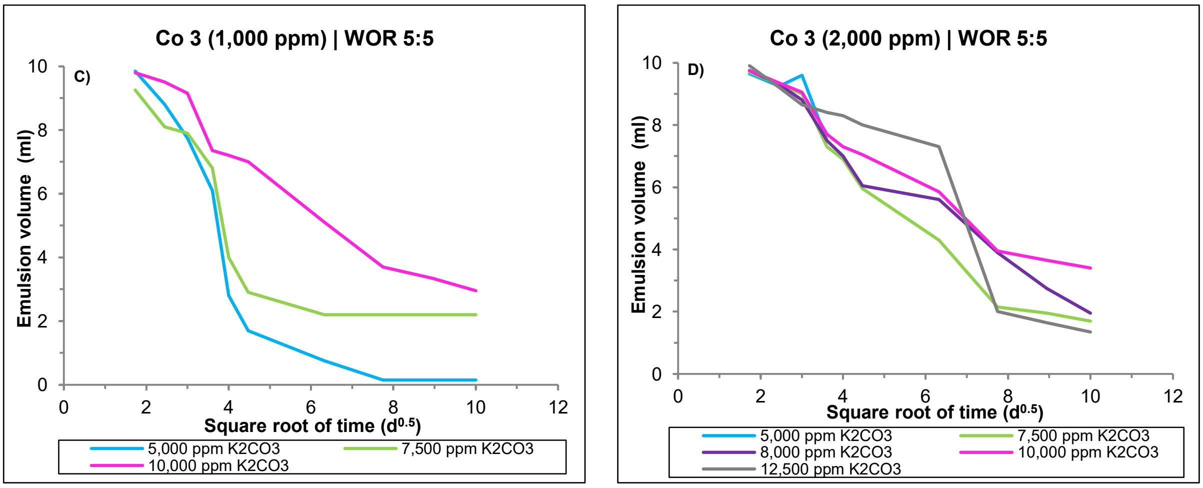


Figure 4-36: Time dependency of formulations prepared with co-solvent 2 containing K_2CO_3 at different concentrations mixed with modified Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

The viscosity of the samples containing 7,500 ppm and 8,000 ppm of K_2CO_3 were almost similar and had a value of around 30 cP at a constant shear rate of $7s^{-1}$ (**Figure 4-37**, **B**). In comparison, the viscosity of Na_2CO_3 at 7,500 ppm was 31.8 cP.

Due to unpromising in-situ soap generation with co-solvent 1 and 2, just co-solvent 3 was used for further investigations and screenings.

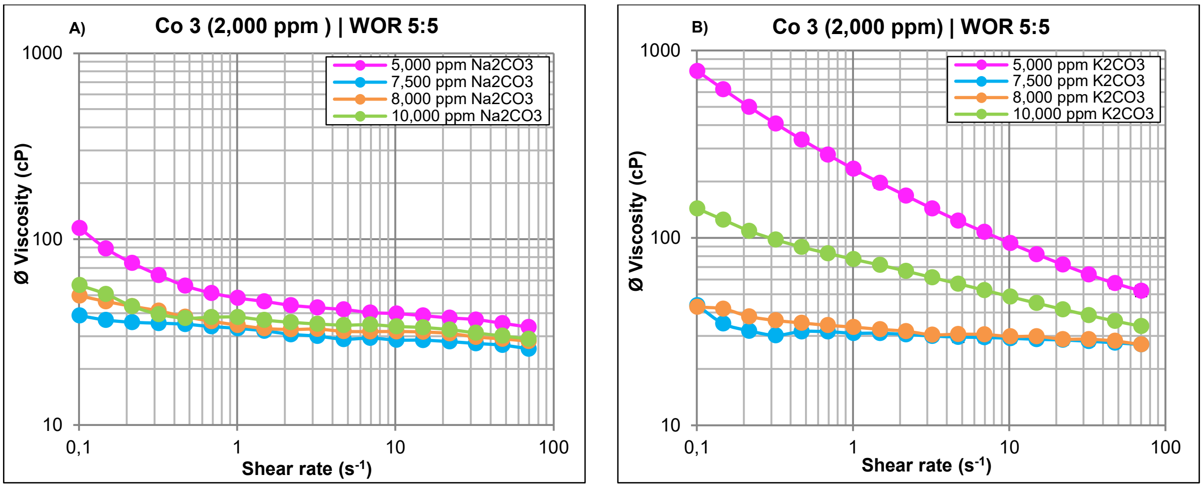


Figure 4-37: Shear plot of co-solvent 3 mixed with modified Bo 112 oil (WOR 5:5) at various K_2CO_3 (A) and Na_2CO_3 (B) concentrations at 60°C.

4.3.3.5 Formulation 5a: Alternative Water Source from WTP (AC Slug)

This formulation was prepared with softened water from the outlet WTP and compared with the water from the outlet hydrocyclones. Water from the outlet WTP was tested as alternative water source option for the planned AP trial. This water basically differs regarding salinity and alkalinity strongly from the other water (**Chapter 4.3.2**). Modified Bo 112 oil was used for the sample preparation. The alkali concentration was set on 7,500 ppm and the co-solvent concentration on 2,000 ppm. The oil scan represents a comparison of the two possible water sources with both alkalis (**Figure 4-38**). In addition, all three co-solvents were tested and added to the samples.

Stable type III emulsions were formed in all samples prepared with the water from the outlet hydrocyclones (**Figure 4-39**). Nevertheless, the highest emulsion amount was formed with K_2CO_3 mixed with co-solvent 3 (~6 ml after 100 days) and also with Na_2CO_3 containing co-solvent 2 (8.85 ml).

Figure 4-38: Oil scan of different types of softened water mixed with co-solvents and alkali at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

Slightly higher emulsion amounts were formed with the samples prepared with water from the outlet WTP containing Na_2CO_3 mixes. Similar results could be achieved with the K_2CO_3 samples (**Figure 4-40**).

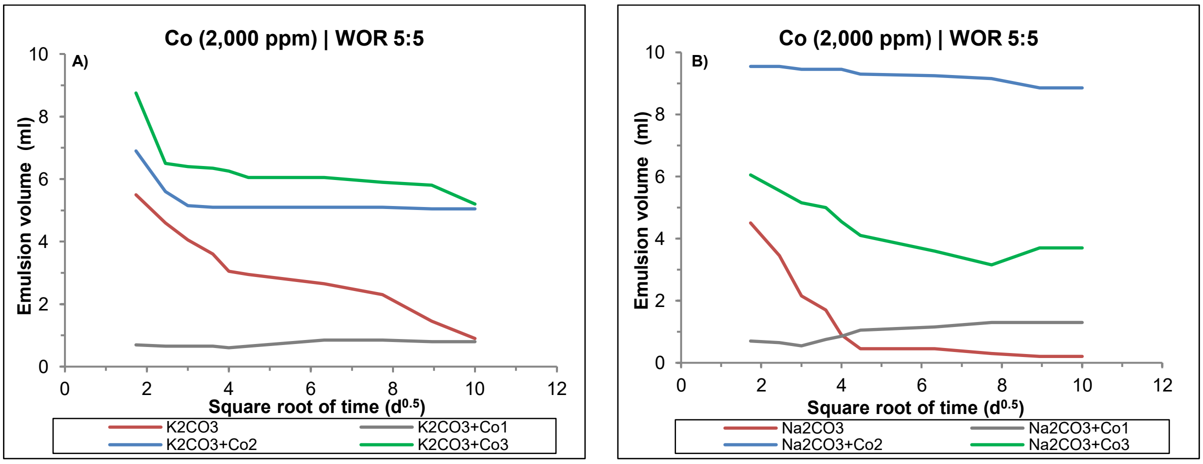


Figure 4-39: Time dependency of formulations prepared with softened water from the outlet hydrocyclones containing alkali and co-solvents 1, 2, 3 mixed with modified Bo 112 to reach middle-phase microemulsion equilibrium over 100 days at 60°C for WOR 5:5.

No huge difference in the emulsion amount could be observed between both water sources.

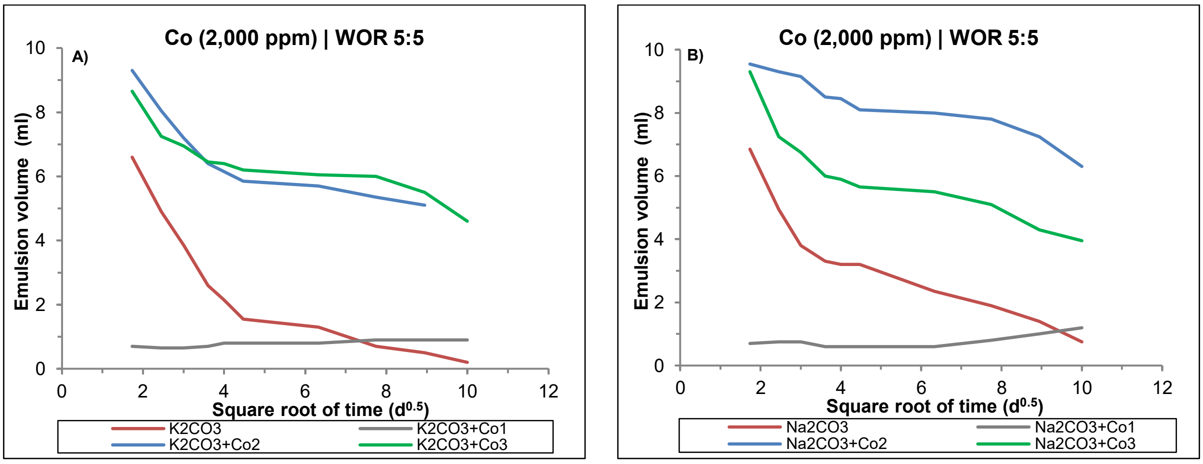


Figure 4-40: Time dependency of formulations prepared with softened water from the outlet WTP containing alkali and co-solvents 1, 2, 3 mixed with modified Bo 112 to reach middle-phase microemulsion equilibrium over 100 days at 60°C for WOR 5:5.

The viscosity shear plots are just shown for the water from the outlet WTP because the measured viscosities of the samples prepared with the water from the outlet hydrocyclones can already be found in **Chapter 4.3.3.4**.

Figure 4-41 represents the shear plots of the water from the outlet WTP comparing both alkalis (Na_2CO_3, K_2CO_3) mixed with co-solvent 2 and 3. Samples containing the co-solvent 1 could not be measured due to immediate separation at the cone plate. The standard deviation is very small and therefore not visible in the plots. The viscosities of Na_2CO_3 were in the range of 31 cP up to 43 cP and for the samples prepared with K_2CO_3 from 35 cP up to 36 cP at a constant shear rate of $7s^{-1}$. The lowest viscosity was achieved with Na_2CO_3 mixed with co-solvent 3 of around 31.55 cP at a shear rate of $7s^{-1}$.

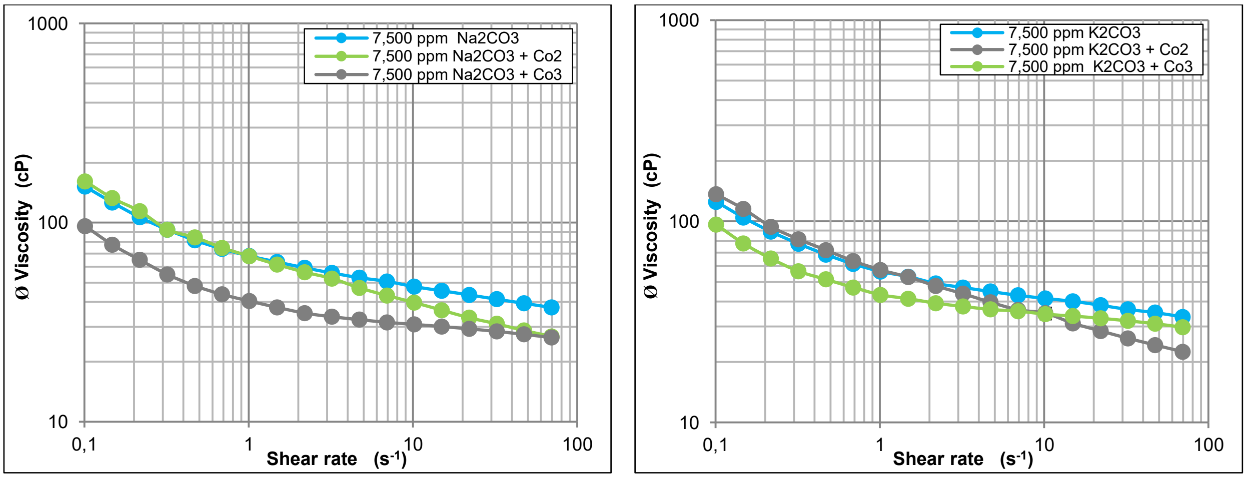


Figure 4-41: Shear plot of softened WTP water mixed with modified Bo 112 (WOR 5:5) at constant Na_2CO_3 concentration (7,500 ppm) with various co-solvents (2,000 ppm) at 60°C.

4.3.3.6 Formulation 6a: Technical graded Alkalis (Alkali/ AP Slug)

The previous formulations were prepared with high quality alkalis. In this experiment, technical graded alkalis were used to prepare the alkali slug (**Table 4-10**) and compared to the results achieved with the high-quality alkalis. Viscosity-matched Bo 112 oil was used for the preparation of the alkali slug (**Figure 4-42**). As a next step, the interaction of both carbonate-based alkalis was investigated on Flopaam 3630S. No autoclave box was available at this time and therefore the interaction was tested in oxygen atmosphere. The solutions were prepared with softened real water from the outlet hydrocyclone.

The AP slug was only prepared for the sample containing 7,500 ppm of alkali mixed with 1,000 ppm of HPAM (Flopaam 3630S). Thereby, the in-situ soap generation of dead and viscosity-matched Bo 112 oil was compared. The efficiency of two different technically graded grain sizes (fine and coarse grained) from Na_2CO_3 was tested (5,000-10,000 ppm).

Table 4-10: Purity of the screened technical graded alkalis from Brenntag.

Type of Alkali	Insoluble Carbonate Matter (mg/kg)	Iron Content (mg/l)
Na_2CO_3 (fine grained)	59.5	0.01
Na_2CO_3 (coarse grained)	75	0.02
K_2CO_3 (fine grained)	14	0.01

Most of the samples prepared with fine grained N_2CO_3 formed type III emulsions. Only the sample containing 10,000 ppm Na_2CO_3 solution showed the formation of type II (-) emulsion. Type II (-) emulsion was formed by the use of coarse grained Na_2CO_3 at 5,000 ppm. The emulsion type changed to type III emulsion with increasing alkali concentration. The emulsion amount decreased strongly over time for the coarse grained Na_2CO_3 samples (**Figure 4-43**, **B**). In contrast, experiments conducted with K_2CO_3 formed type III emulsions in all concentration ranges. A clear water phase could be observed (no loss of soap components into the aqueous phase). A strong decline of both grain types of Na_2CO_3 could be observed, no emulsion equilibrium occurred (<2 ml emulsion amount after 100 days observation time, **Figure 4-43**, **A**).

Interestingly, strong variations of the generated emulsion amount could be observed of the sample containing 5,000 ppm of Na_2CO_3 by the use of the fine and coarse grain size.

The most stable emulsions over time were formed with K_2CO_3, whereby the most promising results could be achieved with 7,500 ppm and 10,000 ppm (**Figure 4-43**, **C**).

Figure 4-42: Oil scan of softened water and modified Bo 112 oil with technical graded alkalis at 60°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

The AP samples prepared with K_2CO_3 formed a higher emulsion amount than the ones with Na_2CO_3 (~3 ml). Type III emulsions could be observed in the tested AP samples (**Figure 4-42**). The aqueous phase showed a high turbidity and parts of the soap were lost into this phase. Strong variations appeared between the results achieved with viscosity-matched oil (more stable) and dead Bo 112. The emulsion amount of K_2CO_3 achieved with modified oil was after day 100 still 6 ml (**Figure 4-44**).

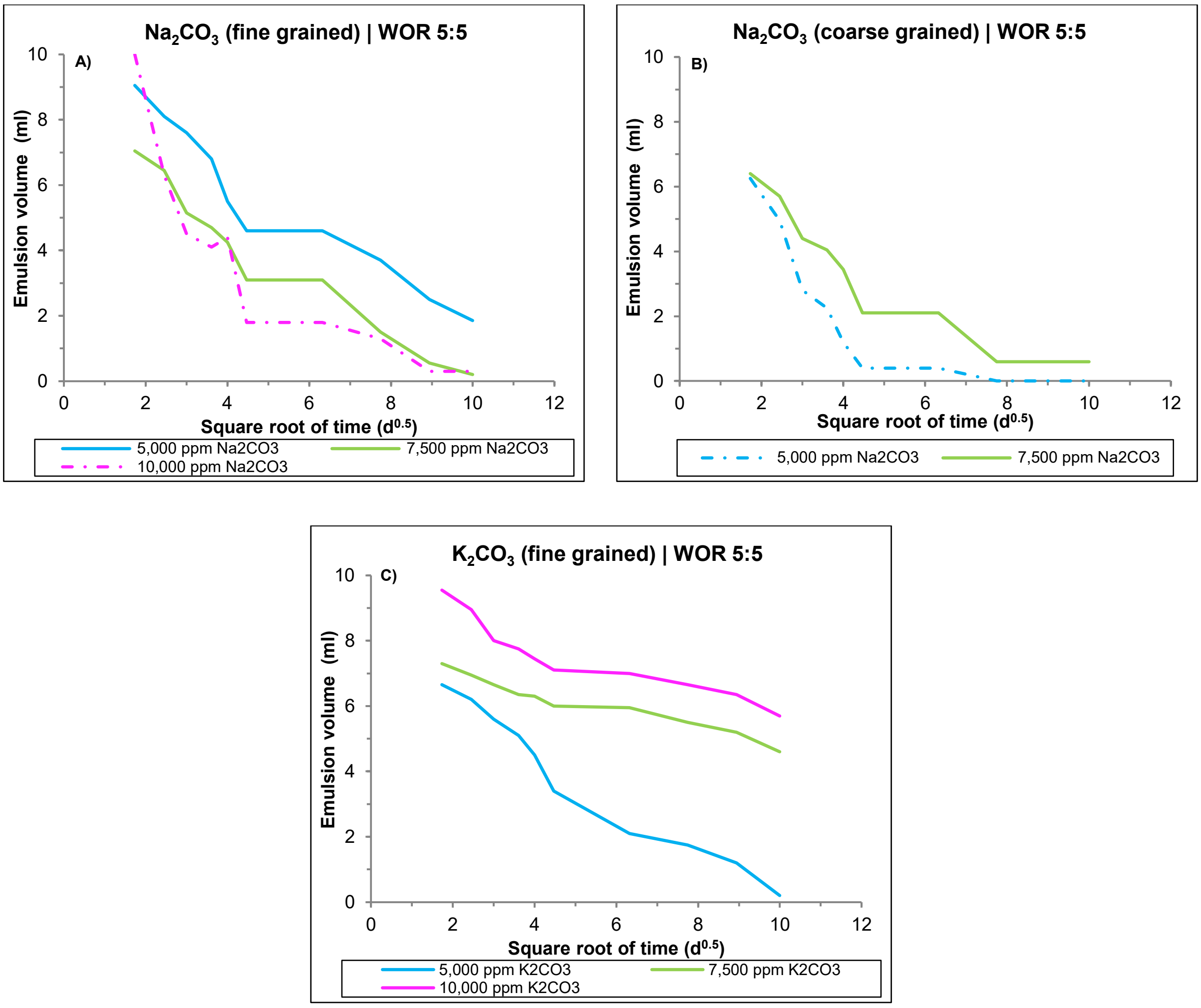


Figure 4-43: Time dependency of formulations prepared with technically grained alkalis at different concentrations mixed with modified Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

The shear plots are displayed in **Figure 4-45**. Shear thinning behavior appeared in all samples. The lowest viscosity of the Na_2CO_3 samples (fine and coarse grained) could be achieved with 7,500 ppm. A massive difference could be observed at a constant shear rate of $7s^{-1}$ between the fine grained Na_2CO_3 with 6.35 cP and the coarse grained Na_2CO_3 of around 20.35 cP. Both Na_2CO_3 samples showed the highest viscosities at 5,000 ppm.

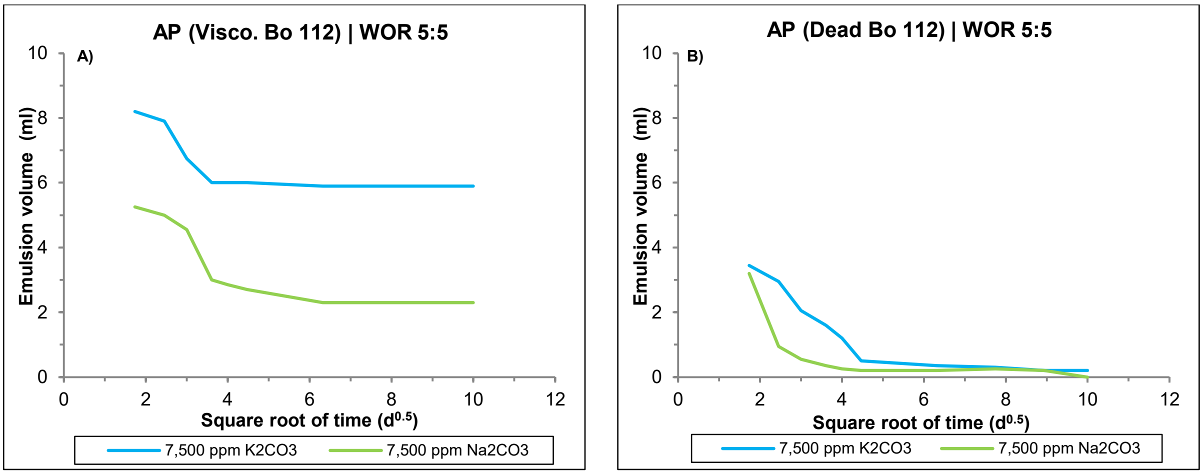


Figure 4-44: Time dependency of formulations prepared with technically grained alkalis at different concentrations comparing modified and dead Bo112 oil to reach middle-phase micro emulsion equilibrium over 100 days at 60°C for WOR 5:5.

The viscosity of the potassium carbonate behaved different than the Na_2CO_3 samples. The lowest viscosity was reached with 10,000 ppm of K_2CO_3 with around 4.83 cP (at a shear rate of $7 s^{-1}$). The highest viscosity was reached with K_2CO_3 at 7,500 ppm.

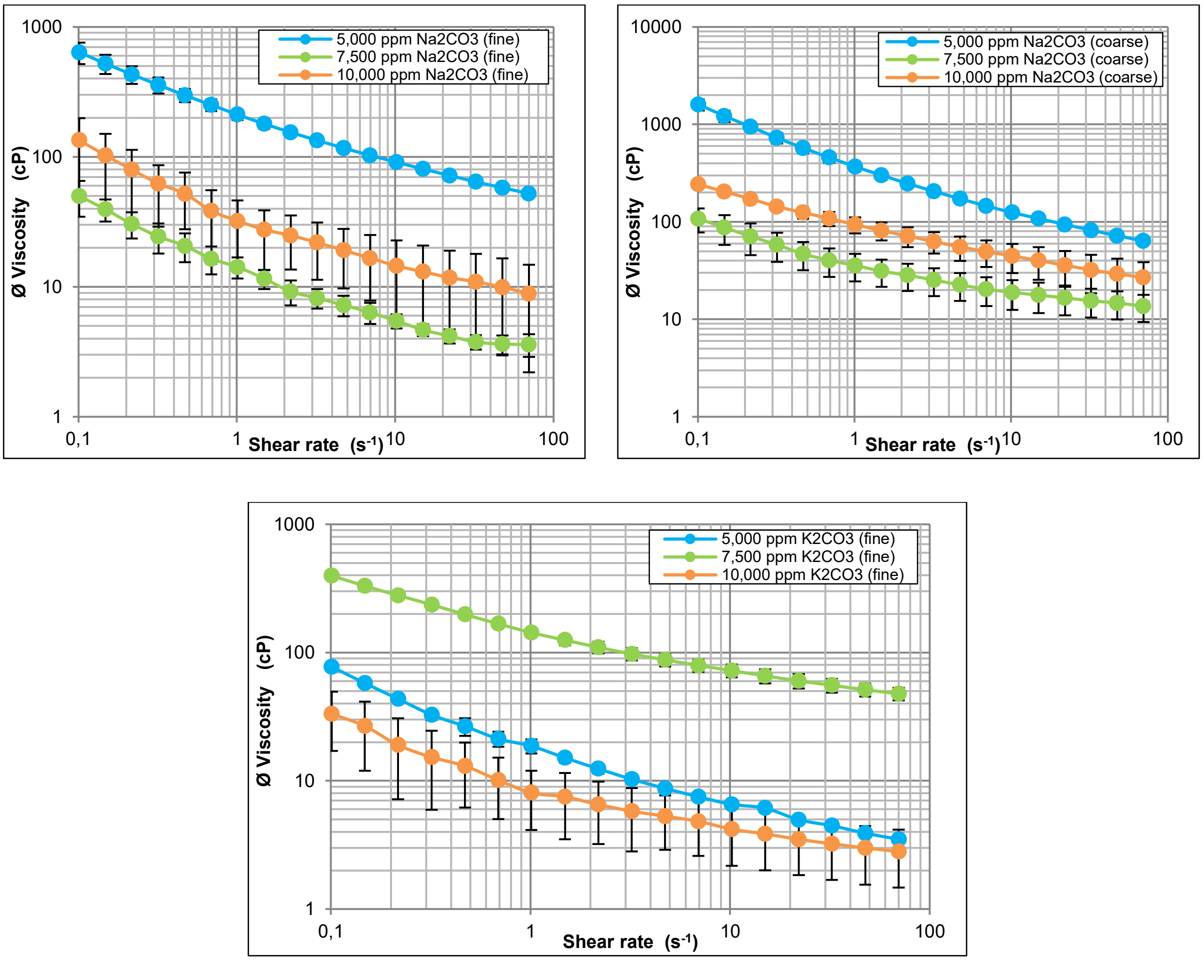


Figure 4-45: Shear plot of softened water mixed with modified Bo 112 (WOR 5:5) comparing technical graded alkalis at 60°C.

The shear plots of the AP samples are displayed in **Figure 4-46**. Shear thinning behavior could be observed in both samples. The sample containing Na_2CO_3 had a viscosity of 6.97 cP and the sample with K_2CO_3 a viscosity of approximately 15.35 cP at a constant shear rate of $7s^{-1}$.

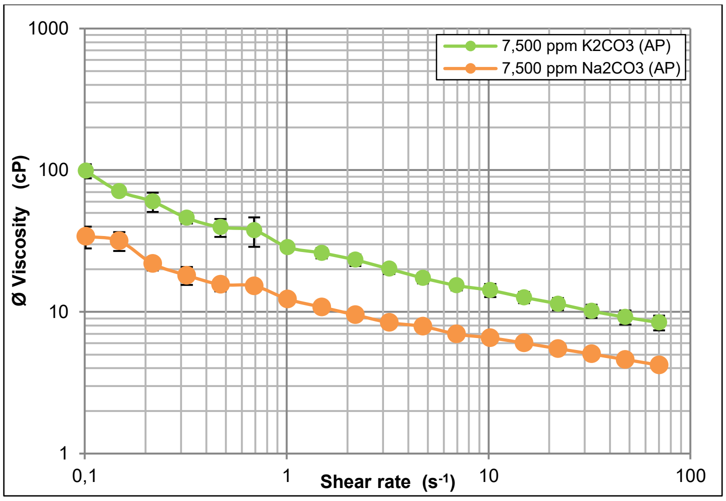


Figure 4-46: Shear plot of softened water mixed with modified Bo 112 (WOR 5:5) comparing technical graded alkalis mixed with HPAM (FP 3630S) at 60°C.

4.3.3.7 Formulation 7a: Alkali + HPAM & Co-Solvents (AP & ACP Slug)

This formulation was prepared with softened water from the outlet hydrocyclones and viscosity-matched Bo 112 oil. Formulation 7a compares the efficiency regarding in-situ soap generation of an AP slug with and without co-solvent 3 (**Figure 4-47**, **A**). As polymer, HPAM (Flopaam 3630S from SNF) was added to the alkali slug. As an outcome of the conducted experiments, the alkali concentration used for further investigations was set on 7,500 ppm. The evaluated polymer concentration was 1,000 ppm and the used co-solvent 3 concentration was 2,000 ppm.

The time dependency plot for AP and ACP shows similar results with both alkalis. In all samples type III emulsions were formed. The emulsion amount was slightly higher for the samples with K_2CO_3 of around 1 ml, whereas the emulsion amount with Na_2CO_3 decreased tremendously over time to almost 0 (**Figure 4-47**). Interestingly, the generated soap amount decreased strongly as soon as polymer was added to the planned slug compared to the achieved in-situ soap amounts with the alkalis alone (**Chapter 4.3.3.2** and **Chapter 4.3.3.3**).

Figure 4-48 represents the shear plot of the prepared samples with AP and ACP. The shear behavior was almost similar between the alkali lyes and AP as well as ACP. The lowest viscosity was achieved with K_2CO_3 and co-solvent 3 of around 4.19 cP at a constant shear rate of $7s^{-1}$. In contrast, the blank had a viscosity of around 6.24 cP. Basically, no huge difference between the AP and ACP samples could be observed regarding viscosity results. Both formulations reached viscosities in the range of 4 to 6 cP.

No significant improvement of the in-situ generation as well as lower viscosities could be observed by the addition of co-solvent 3 to the AP slug.

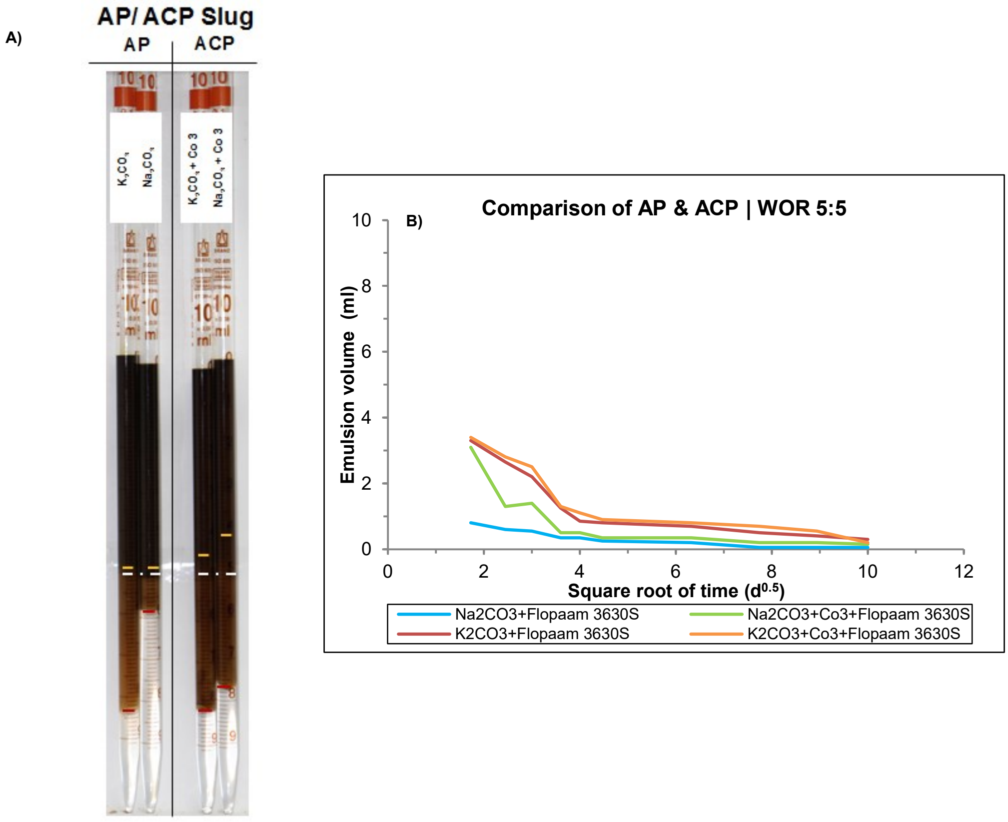


Figure 4-47: Oil scan (A) and time dependency of formulations prepared with softened water and modified Bo 112 oil comparing AP and ACP performance to reach middle-phase microemulsion equilibrium over 100 days at 60°C for WOR 5:5 (B).

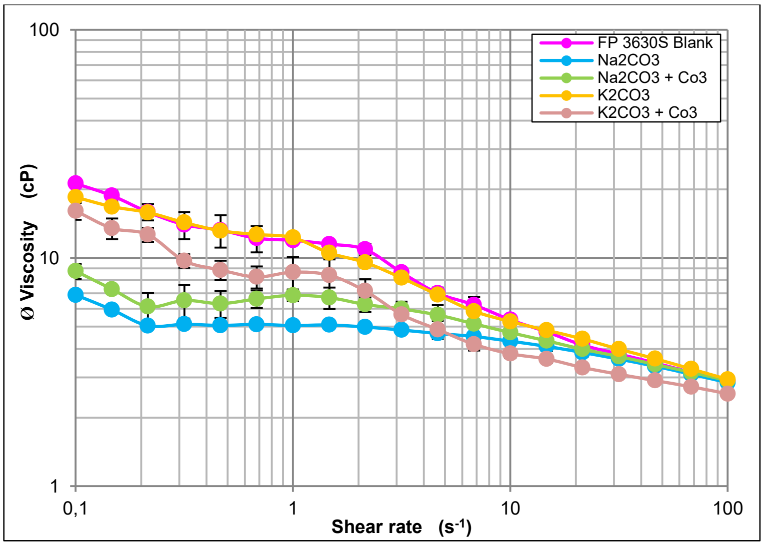


Figure 4-48: Shear plot of softened water mixed with modified Bo 112 (WOR 5:5) comparing AP and ACP performance at 60°C.

Interfacial tension measurements with dead oil and modified Bo 112 oil were performed of the most promising alkali formations. Beforehand, the viscosities of the samples were measured and the results summarized in **Table 4-11**. The alkali concentration was varied between 5,000 ppm up to 17,500 ppm. Prior to the measurement of the samples, the IFTs of following solutions were measured as a baseline (visualized in the plots as dotted lines): softened water from the outlet hydrocyclone, polymer solution (FP 3630S) with a concentration of 1,000 ppm, and co-solvent 3 solution with a concentration of 2,000 ppm prepared without alkali.

Table 4-11: Summary of the measured densities used for IFT measurements. Formulations measured with Anton Paar DMA 5000 and oil samples (*) with Anton Paar SVM 3000 Stabinger Viscometer @ 60°C.

# Sample Number	Sample Name	Concentration (ppm)	Density (g/cm³)		
			1	2	Ø
1	Dead oil (Bo 112)*	-	0.8821	0.8823	0.8822
2	Viscosity-matched Bo 112 (Dead oil + C_6H_{12})*	-	0.8490	0.8488	0.8489
3	Softened formation water outlet hydrocyclones	-	0.9977	0.9959	0.9966
4	Co-solvent 3	2,000	0.9990	0.9970	0.9980
5	Na_2CO_3 solution	5,000	1.0023	1.0014	1.0019
6	Na_2CO_3 solution	7,500	1.0048	1.0048	1.0048
7	Na_2CO_3 solution	10,000	1.0071	1.0071	1.0071
8	Na_2CO_3 solution	12,500	1.0085	1.0086	1.0086
9	Na_2CO_3 solution	15,000	1.0116	1.0116	1.0116
10	Na_2CO_3 solution	17,500	1.0131	1.0133	1.0132
11	K_2CO_3 solution	5,000	1.0016	1.0015	1.0015
12	K_2CO_3 solution	7,500	1.0040	1.0039	1.0039
13	K_2CO_3 solution	10,000	1.0050	1.0049	1.0050
14	K_2CO_3 solution	12,500	1.0051	1.0054	1.0053
15	K_2CO_3 solution	15,000	1.0067	1.0072	1.0070
16	K_2CO_3 solution	17,500	1.0088	1.0090	1.0089
17	HPAM solution (FP 3630S)	1,000	0.9981	0.9980	0.9980
18	HPAM+Na_2CO_3	1,000 / 7,500	1.0053	1.0053	1.0053
19	HPAM+K_2CO_3	1,000 / 7,500	1.0039	1.0039	1.0039
20	HPAM+Na_2CO_3+Co 3	1,000 / 7,500 / 2,000	1.0054	1.0054	1.0054
21	HPAM+K_2CO_3+Co 3	1,000 / 7,500 / 2,000	1.0019	1.0023	1.0021

The IFT was measured between the oil-to-water interface (oil droplet and the surrounding aqueous phase) and between the oil-to-emulsion interface (oil droplet and the formed cloud around the oil droplet) at 60°C reservoir temperature and over time. Cloud formation only appeared with the samples containing K_2CO_3. Thereby, immediately after starting spinning the sample a cloud was formed around the oil droplet (**Figure 4-49**).

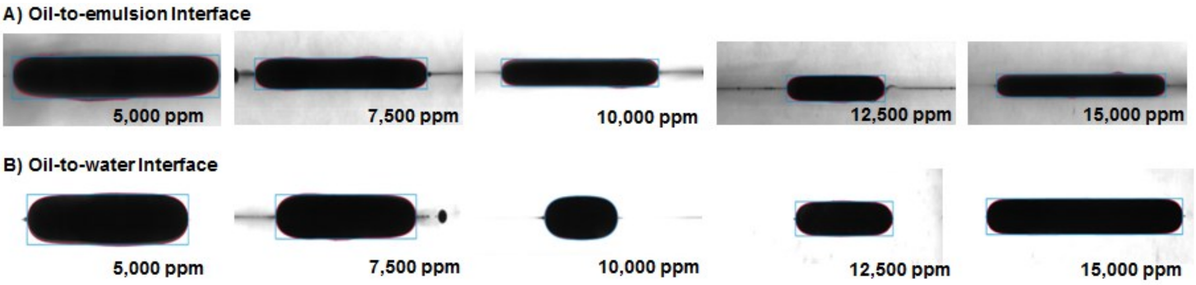


Figure 4-49: Droplet formation of various K_2CO_3 concentrations using modified Bo 112 in the cloud (A) and in the aqueous phase (B). Rotation speed 6,000 rpm and Vonnegut as measuring method.

Figure 4-34 shows the average IFT results from formulations containing potassium carbonate. Viscosity-matched Bo 112 oil was used and Vonnegut was applied as measuring principle. The standard deviation was very small and is therefore barely visible. The IFT values of the HPAM concentration was 4.04 mN/m and 4.24 mN/m from the water of the outlet hydrocyclones. Through the addition of co-solvent 3 (surface-active component) the IFT decreased to 1.63 mN/m. Only at an alkali concentration of 10,000 ppm no cloud was formed. It becomes clear from the plot that a massive difference regarding interfacial tension values occurs depending if the measurements are performed in the aqueous phase or in the cloud phase. Nevertheless, the IFT for the AP and ACP slug (lowest IFT) was just measured for the formulations containing 7,500 ppm alkali. It could be observed that small droplets of the co-solvent 3 surround the oil droplet (**Figure 4-50**). The droplet formation of the AP samples is displayed in **Figure 4-51**.

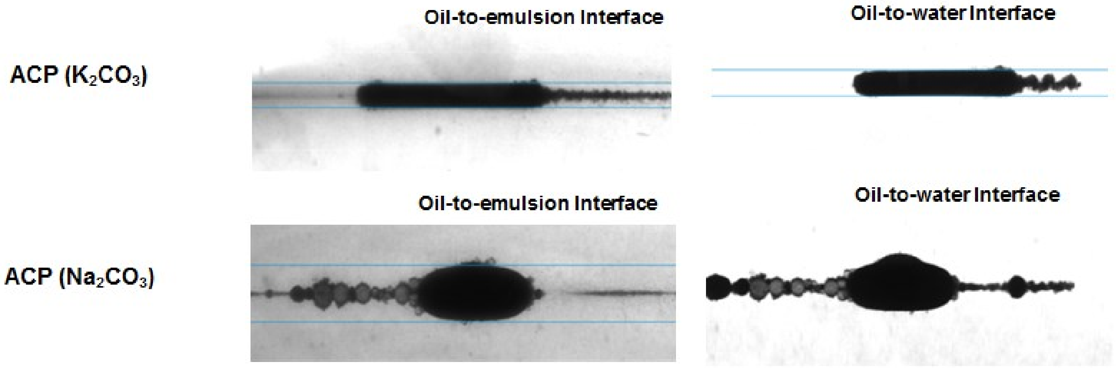


Figure 4-50: Droplet formation of the ACP slug for K_2CO_3 and Na_2CO_3 in the cloud and in the aqueous phase (rotation speed 7,000-8,500 rpm and Vonnegut as measuring method).

The lowest IFT was measured at an alkali concentration of 7,500 ppm with 0.06 mN/m (IFT measurement performed in the cloud). Similar results were achieved by the ACP slug of around 0.08 mN/m. The measurement was performed in the aqueous phase because no cloud formation was observed.

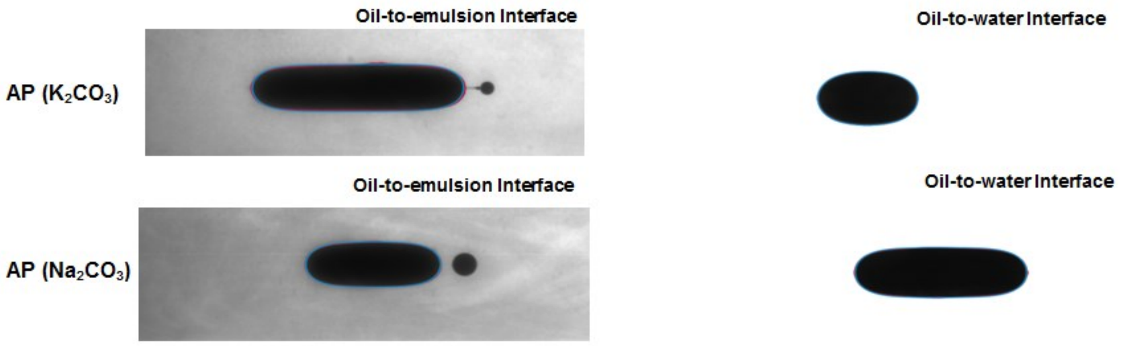


Figure 4-51: Droplet formation of the AP slug for K_2CO_3 and Na_2CO_3 in the cloud and in the aqueous phase (rotation speed 7,000-8,500 rpm and Vonnegut as measuring method).

The AP slug had an average IFT of 1.31 mN/m (aqueous phase). At an alkali concentration of 5,000 ppm the IFT was 0.78 mN/m (measured in the cloud) and in the aqueous phase a similar IFT of 0.84 mN/m was measured. A strong increase of the IFT could be observed at 17,500 ppm (3.03 mN/m measured in the aqueous phase). In addition, the IFT at 12,500 ppm was between 0.31 mN/m (cloud) and 0.73 mN/m (aqueous phase).

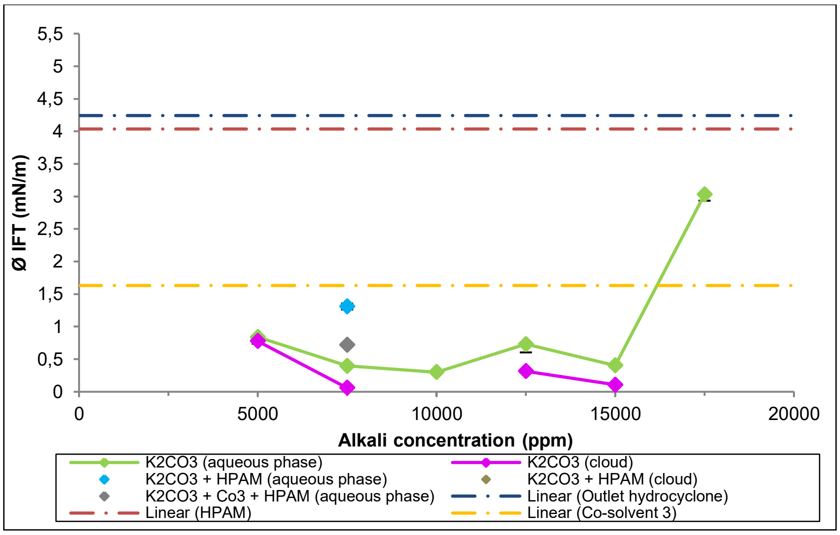


Figure 4-52: Minimum IFT results of K_2CO_3 and modified Bo 112 oil (measuring principle: Vonnegut).

As mentioned before, no cloud formation could be observed for the samples containing Na_2CO_3 (**Figure 4-53**). Only the IFT values measured in the aqueous phase are displayed in **Figure 4-54**. The IFT values with Na_2CO_3 were slightly higher compared to the ones with K_2CO_3. The lowest IFT could be observed of the alkali slug at a concentration of 10,000 ppm with 0.82 mN/m. The IFT values at all other concentrations were in the range of 1.27 mN/m until 1.63 mN/m (15,000 ppm). As observed with K_2CO_3, the IFT increases with the alkali concentration. The peak of the measured concentrations was also reached with Na_2CO_3 at a concentration of 17,500 ppm with around 2.51 mN/m. The lowest IFT was measured in the ACP slug prepared with 7,500 ppm Na_2CO_3 of approximately 0.05 mN/m.

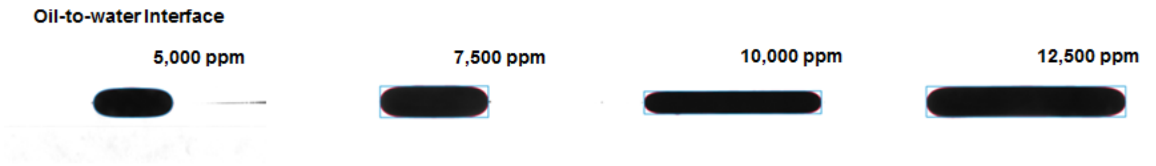


Figure 4-53: Droplet formation of Na_2CO_3 in the aqueous phase (rotation speed 7,000-8,500 rpm and Vonnegut as measuring method).

In addition, IFT measurements were performed with dead Bo 112 oil of the same formulations. The measured IFT of the softened water from the outlet hydrocyclone was 4.11 mN/m, while IFT from HPAM (FP 3630S) was 4.04 mN/m and 0.93 mN/m with the co-solvent 3.

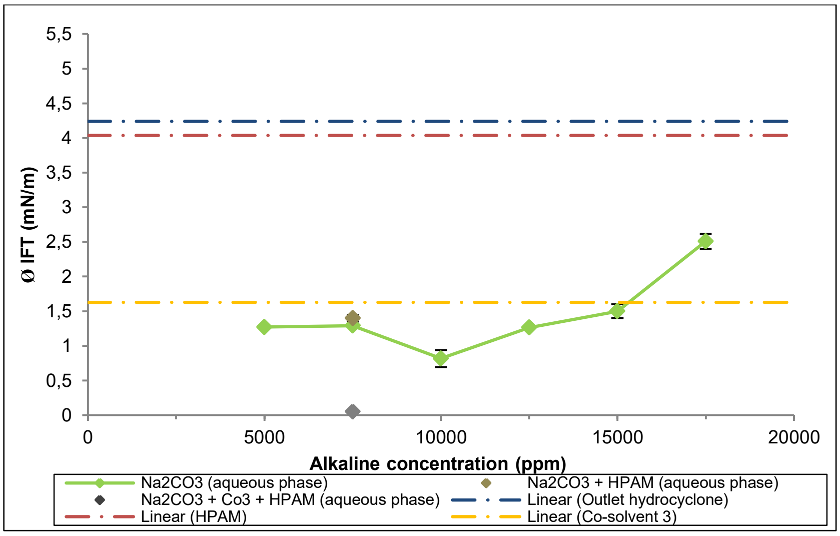


Figure 4-54: Minimum IFT results of Na_2CO_3 and modified Bo 112 oil (measuring principle: Vonnegut).

Figure 4-55 displays the IFT results for dead Bo 112 oil with samples containing K_2CO_3. It could be observed that the IFT values do not vary so strong between the oil-to-water interface and the oil-to-emulsion interface as they did with the modified Bo 112 oil. The lowest IFT with with 0.09 mN/m was measured at the oil-to-emulsion interface with 10,000 ppm K_2CO_3. The IFT of the AP slug was 0.67 mN/m compared to 0.15mn/m of the ACP slug. As observed with modified oil, the IFT increased at alkali concentrations higher than 15,000 ppm. The values were in the range of 0.09 mN/m to 0.25 mN/m for those alkali concentrations.

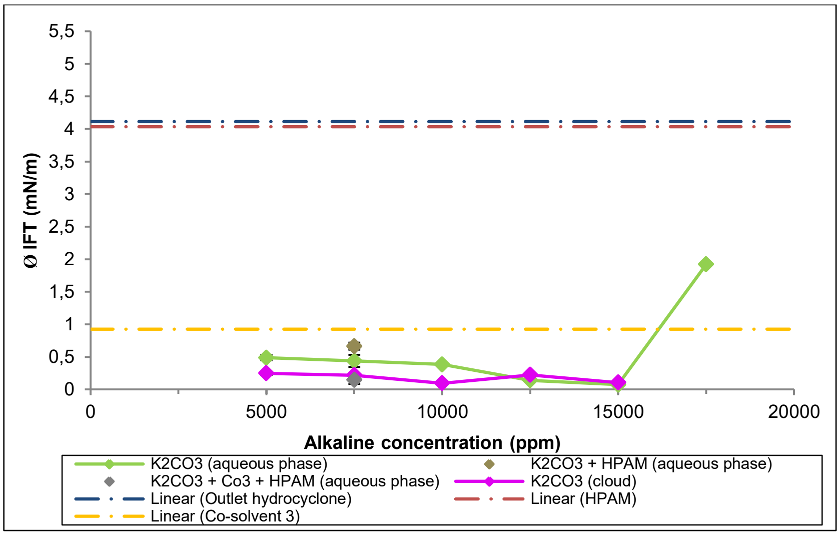


Figure 4-55: Minimum IFT results of K_2CO_3 and dead Bo 112 oil (measuring principle: Vonnegut).

Basically, no cloud formation could be observed with the samples containing Na_2CO_3 alone (**Figure 4-56**). The lowest IFT was measured at 12,500 ppm with 0.09 mN/m and the highest one at 17,500 ppm with 2.14 mN/m. The AP slug had an IFT of 0.62 mN/m. In contrast, the ACP slug had an IFT of 1.03 mN/m.

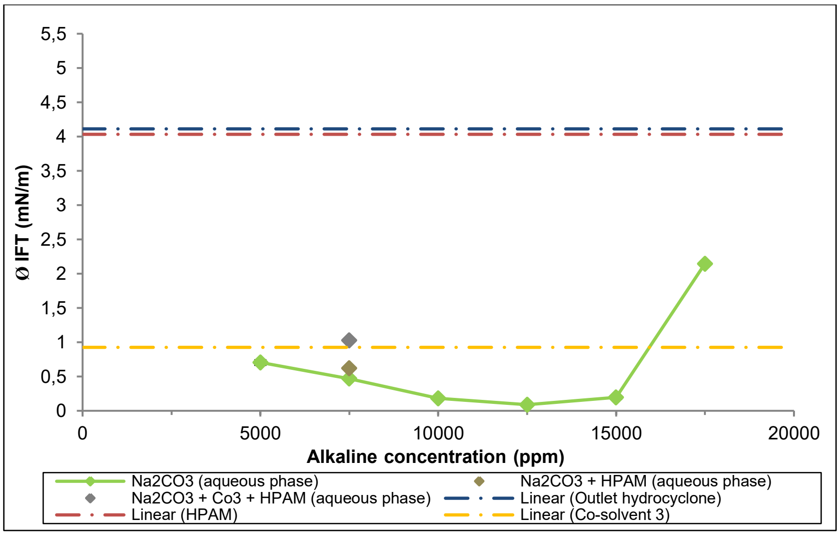


Figure 4-56: Minimum IFT results of Na_2CO_3 and dead Bo 112 oil (measuring principle: Vonnegut).

4.3.3.8 Formulation 8a: Mixture of K_2CO_3 & Na_2CO_3 (Alkali & AP Slug)

This formulation 8a was prepared as mixture using both alkali lyes (Na_2CO_3, K_2CO_3) and their in-situ soap behaviour compared to various prepared mixes. In order to compare the results achieved by the alkali lye alone the alkali concentration was set to 7,500 ppm. Thereby, samples were prepared as 50:50 mixture of both alkali lyes (3,750 ppm of K_2CO_3 + 3,750 ppm of Na_2CO_3). Further samples were prepared in which K_2CO_3 was present in higher amounts as a mix of 5,000 ppm K_2CO_3 and 2,000 ppm of Na_2CO_3. In addition, some samples were prepared in which Na_2CO_3 was in the surplus as mix of 5,000 ppm Na_2CO_3 and

2,000 ppm of K_2CO_3. Softened water from the outlet hydrocyclones and modified Bo 112 oil was used for the sample preparation. In order to compare the in-situ soap generation with HPAM (1,000 ppm) additionally AP slug samples were prepared with the above described alkali mixes.

Interestingly, no emulsion was formed or any interaction could be observed for the sample containing equal amounts of alkalis (a`3,750 ppm of Na_2CO_3 and K_2CO_3).

Good results could be achieved by mixing both alkalis (surplus of one alkali). Thereby, similar results were achieved when one alkali was contained as surplus in the slug (5,000 ppm) and mixed with 2,500 ppm of the other alkali. The generated type III emulsions were stable over time and reached an emulsion amount between 5 ml to 6.5 ml after 100 days observation time for both mixes (**Figure 4-57**, **B**). The formed emulsion amount was slightly decreased to less than 3 ml for the AP samples (**Figure 4-57**, **C**). A comparison of the results regarding the generated in-situ soap amount of Na_2CO_3 or K_2CO_3 with HPAM over time showed that the alkali slug formed more stable emulsion amounts (**Chapter 4.3.3.7**).

The emulsion amount was slightly decreased when HPAM was added to the alkali slug. The aqueous phase showed a high turbidity (loss of soap components into the water phase). Similar results could be achieved when either K_2CO_3 or Na_2CO_3 was in the surplus. Type III emulsions were formed in all samples (**Figure 4-57**, **A**).

Similar shear behavior occurred for both alkali mixes with a viscosity of around 75 cP at a constant shear rate of $7s^{-1}$. Again, the standard deviation was so small that it is barely visible in the plot (**Figure 4-58**). No shear thinning behavior could be observed.

The viscosity values decreased strongly when HPAM was added to the alkali slugs (**Figure 4-59**).

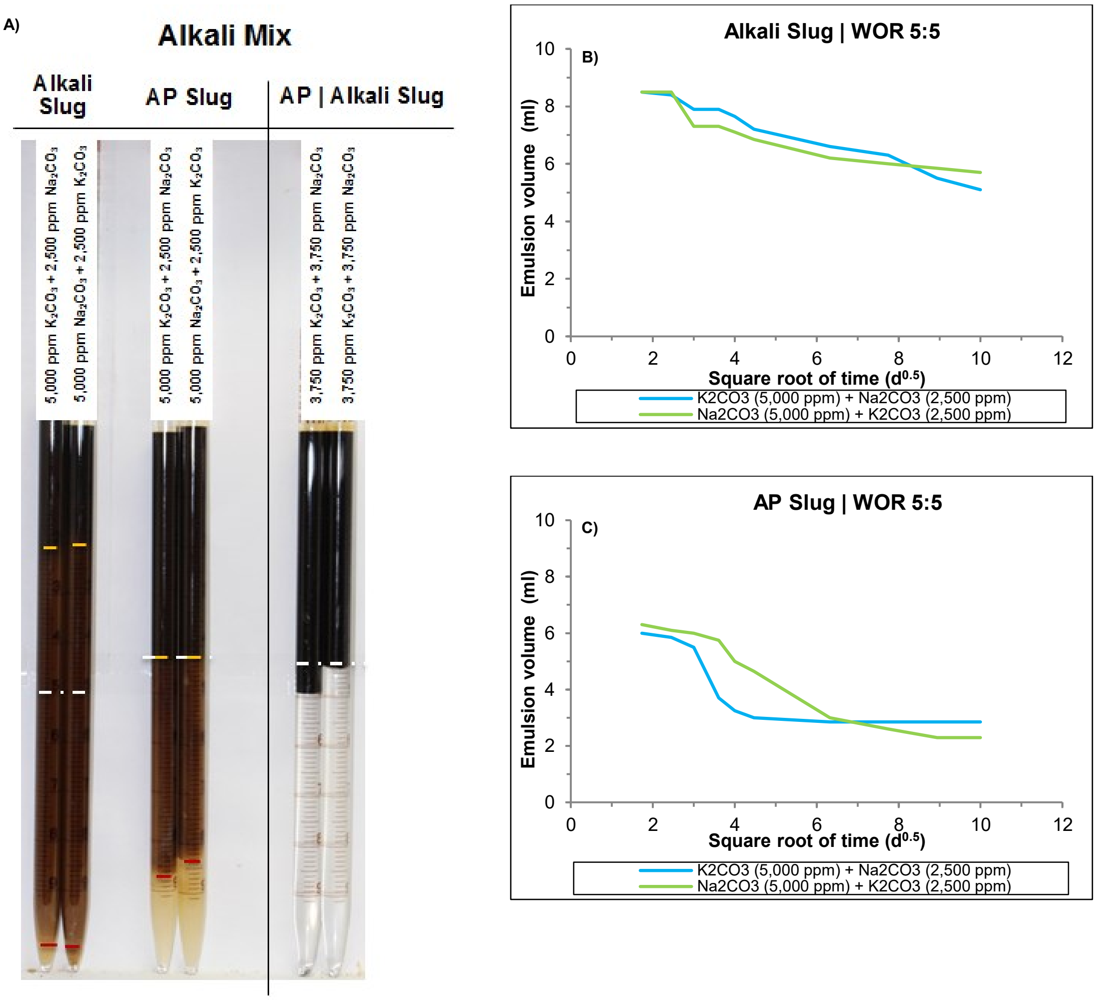


Figure 4-57: Oil scan and time dependency of softened water and modified Bo 112 oil comparing various mixes of Na_2CO_3 with K_2CO_3 at 60°C for WOR 5:5 after two weeks adjusted equilibrium. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface.

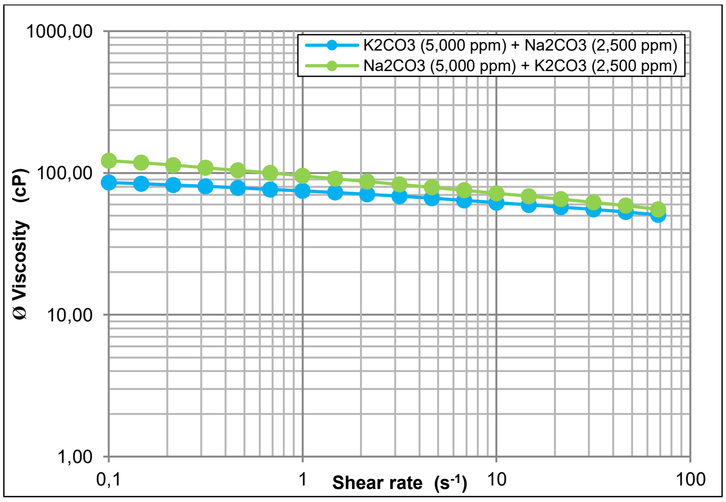


Figure 4-58: Shear plot of alkali mixes at different concentrations prepared with modified Bo 112 (WOR 5:5) at 60°C.

A strong variation of the AP viscosity results could be observed. The viscosity of K_2CO_3 (5,000 ppm) mixed with Na_2CO_3 (2,500 ppm) was 15.5 cP at a constant shear rate of $7s^{-1}$ and the sample in which Na_2CO_3 was in the surplus had a lower viscosity of around 6.9 cP at the same shear rate (**Figure 4-59**).

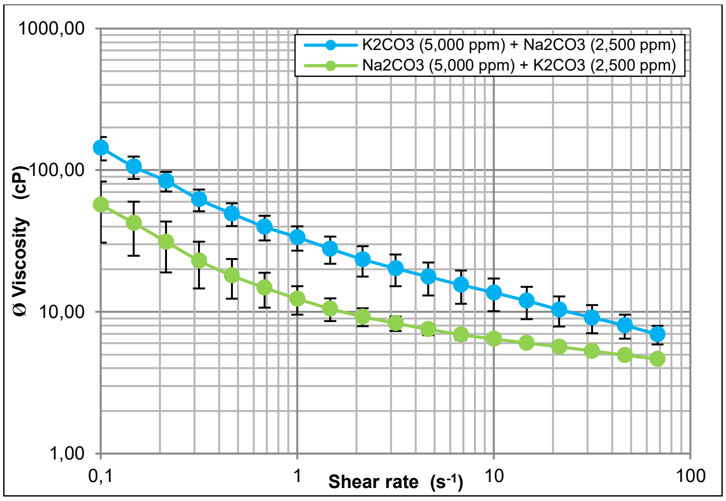


Figure 4-59: Shear plot of AP mixes at different concentrations prepared with modified Bo 112 (WOR 5:5) at 60°C.

4.3.4 Investigated Formulations for the 8th Tortonian Horizon

4.3.4.1 Formulation 1b: Synthetic Make-up Water + Dead S 85 Oil (Alkali Slug)

Formulation 1b was prepared with synthetic make-up water and dead S 85 oil. The samples were stored at 49°C reservoir temperature. The make-up water was prepared regarding the composition of the water from the outlet WTP. The water in the 8.TH has a salinity of 13,400 ppm and an alkalinity of 19 mmol/l. The make-up water was prepared with deionized water, where sodium chloride (NaCl) and sodium bicarbonate ($NaHCO_3$) were added to match the salinity and alkalinity of the real formation water in the 8.TH.

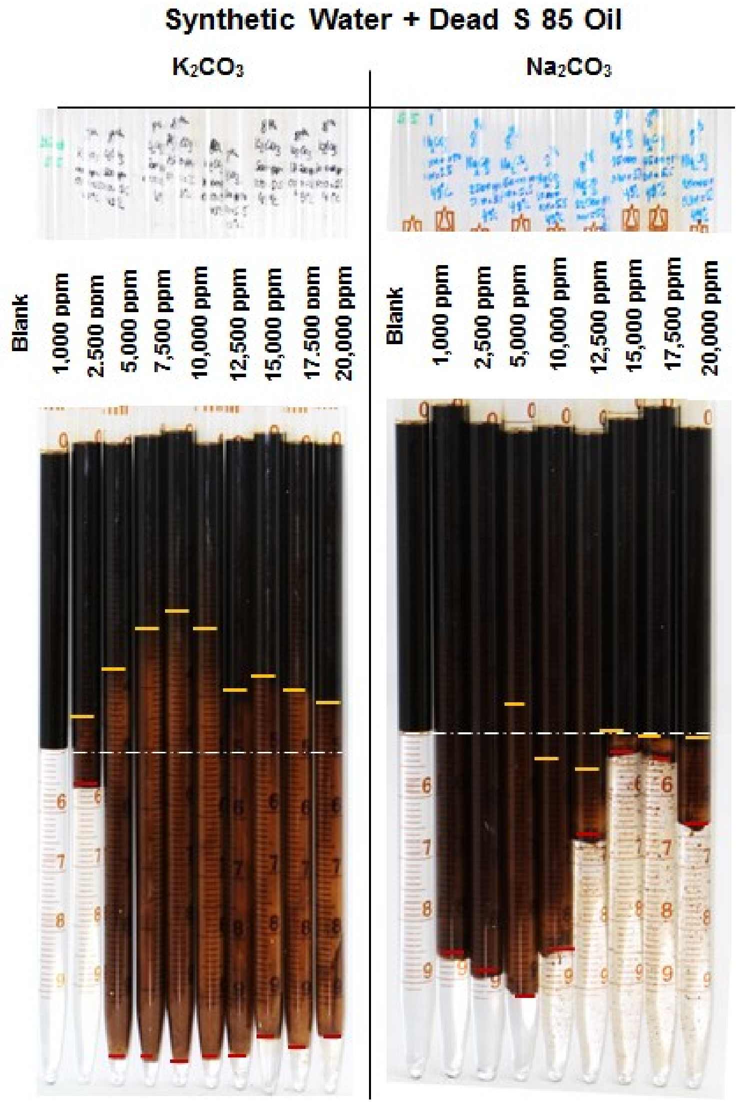


Figure 4-60: Oil scan of synthetic make-up water and dead S 85 oil at 49°C after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

Comparing the results achieved with both alkalis, the results show that K_2CO_3 generated much higher amounts of emulsion than Na_2CO_3 (**Figure 4-60**). Potassium carbonate generated type III middle-phase emulsions over the whole concentration range, whereas Na_2CO_3 formed middle-phase emulsions especially at higher alkali concentrations beginning with 5,000 ppm. At low alkali concentrations, sodium carbonate generated unfavourable upper-phase emulsions, so called type II (+) emulsions, the formed in-situ soap could rather be found in the oil phase than in the water phase. Na_2CO_3 did not show a peak concentration and the emulsion amount was only changing slightly with rising alkali concentration [80].

A peak of the optimal potassium carbonate concentration was found at 7,500 ppm. The emulsion amount decreased slightly with increasing alkali concentration. Even at low concentrations (smaller than 5,000 ppm) no remarkable emulsion amount could be formed. Also the time dependency plot (**Figure 4-61**, **A**) over 100 days proved that K_2CO_3 generated stable emulsions over a broad concentration range (5,000-20,000 ppm). The emulsion volume stayed almost constant over time and reached an overall emulsion amount from 5 ml to 7 ml at equilibrium. Just the 2,500 ppm concentration decreased tremendously over time [80].

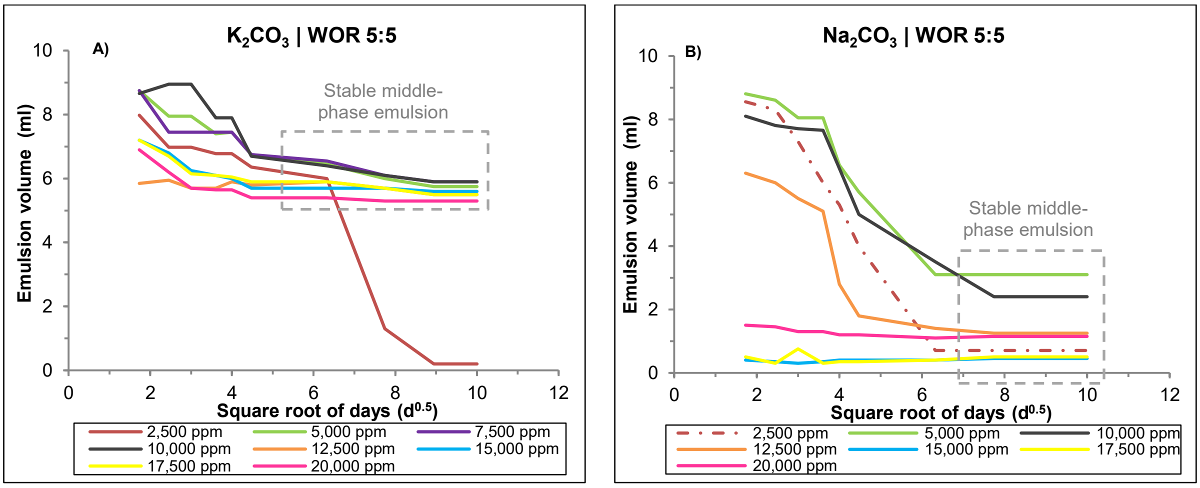


Figure 4-61: Time dependency of formulations prepared with synthetic make-up water containing K_2CO_3 (A) and Na_2CO_3 (B) at different concentrations mixed with dead S 85 oil to reach middle-phase emulsion equilibrium over 100 days at 49°C for WOR 5:5 (Modified from [80]).

The results achieved with Na_2CO_3 in the time dependency plot (**Figure 4-61**, **B**) showed a huge drop of the generated in-situ soap amount. The most stable amount was produced in the range of 5,000 ppm (~3 ml after 100 days observation time) to 10,000 ppm. The sample containing 7,500 ppm Na_2CO_3 broke over the trial time [80].

The emulsion decay of K_2CO_3 was considerably slower compared to Na_2CO_3, which might indicate that this kind of decay is more favorable at reservoir conditions than a faster one. The aqueous phase of both alkalis was clear, no loss of in-situ soap into the water phase could be observed. However, the samples containing Na_2CO_3 indicated adhering oil droplets on the glass tubes.

No viscosity and IFT measurements were conducted with this formulation. Time dependency plots of this formulation are listed in the **Appendix A1**.

4.3.4.2 Formulation 2b: Softened Water + Dead S 85 Oil (Alkali Slug)

Any kind of change in the composition of the chemical formulation can affect the phase behavior. The composition of the real formation water is changing daily, whereby the main components in the brine stay the same. Nevertheless, any kind of production chemicals (e.g. corrosion inhibitors) might affect the phase behavior positively or negatively (**Figure 4-62**). This formulation 2 was prepared with softened water from the outlet WTP in order to reflect the real field properties and dead S 85 oil.

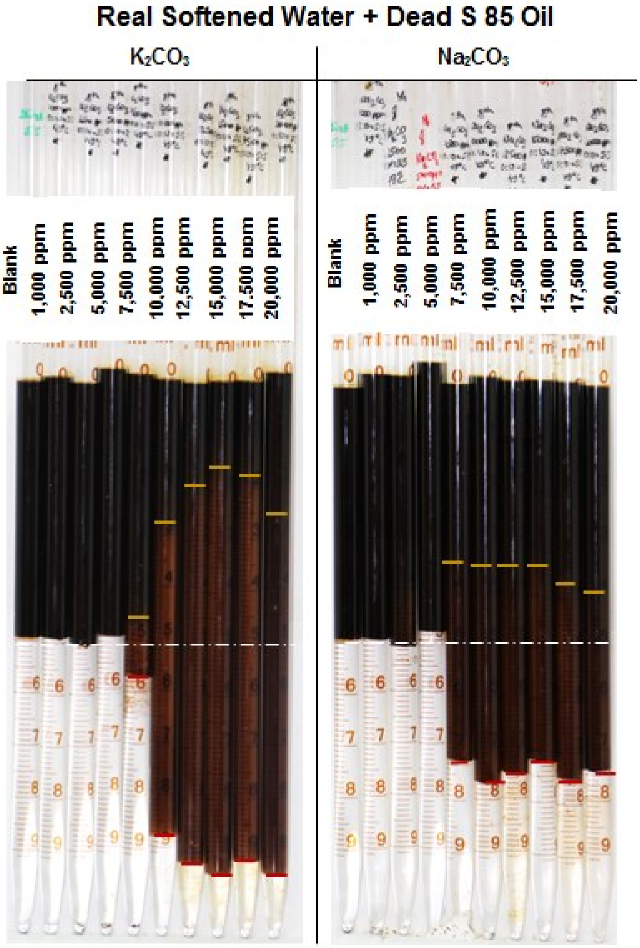


Figure 4-62: Oil scan of softened water and dead S 85 oil at 49°C after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

Comparing the results of the synthetic water with the softened real formation water, it becomes clear that higher alkali amounts are required to achieve a proper soap generation. Interestingly, both alkalis generated type III middle-phase emulsions, starting with 7,500 ppm. The emulsion amount for the samples prepared with Na_2CO_3 stayed almost the same over the whole concentration range from 1,000 ppm to 20,000 ppm [80]. In contrast, the emulsion volumes increased with increasing concentration for the samples containing K_2CO_3. No emulsions could be recognized at lower alkali concentrations. It could be observed that the aqueous phase was clear and no emulsion parts were lost into the water phase in comparison to formulations prepared for the 16.TH. The generated emulsion amount for Na_2CO_3 ranged from 3 to 4 ml and from 1 to 7 ml for K_2CO_3, depending from the tested concentration [80].

In case of using K_2CO_3 as alkali lye, the in-situ soap amount decreased strongly, whereby the concentration 17,500 ppm stayed most stable over time (**Figure 4-63**, **A**). The samples in the concentration range of 12,500-20,000 ppm showed the same trend of emulsion decay. A strong decline over time occurred especially at low K_2CO_3 concentrations (<5,000 ppm). Interestingly, the emulsion decline was much faster and steeper for K_2CO_3 compared to the formulations prepared with synthetic water (stable emulsions). No emulsion equilibrium could be observed for most of the samples [80].

Also, in the samples prepared with Na_2CO_3 a strong emulsion decline occurred over time (**Figure 4-63**, **B**) but stable middle-phase emulsions were formed in most of the concentrations. The emulsion amount declined from initially 8.5 ml to around 3 to 5 ml in most of the samples. Interestingly, no stable emulsions could be formed with the synthetic water containing the sodium carbonate; whereas the effect is controversially with real softened water (K_2CO_3 forms unstable emulsions). The aqueous phase of both alkalis was clear, no precipitations or loss of soap components into the water phase could be observed [80].

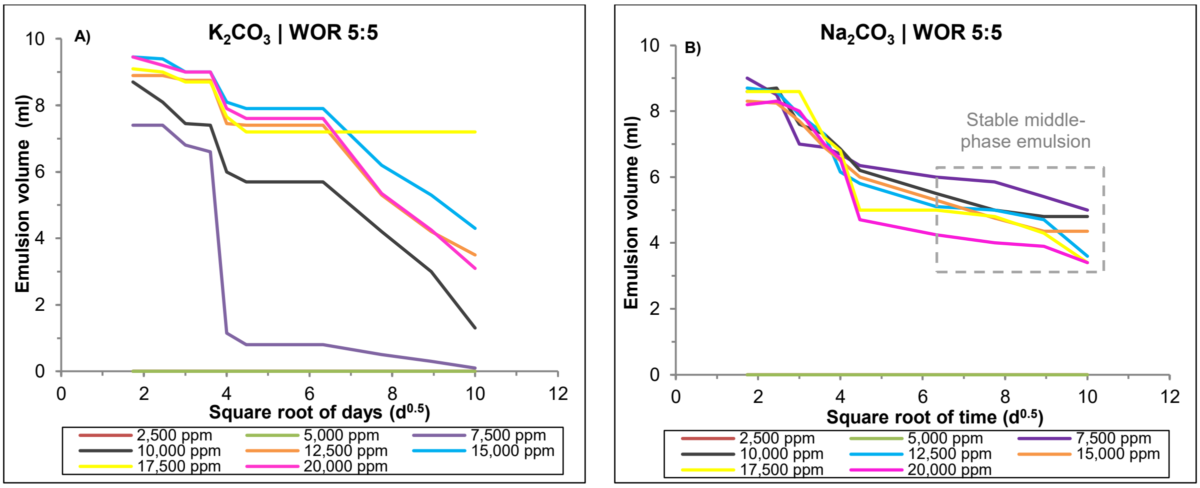


Figure 4-63: Time dependency of formulations prepared with softened water containing K_2CO_3 (A) and Na_2CO_3 (B) at different concentrations mixed with dead S 85 oil to reach middle-phase emulsion equilibrium over 100 days at 49°C for WOR 5:5 (Modified from [80]).

Viscosity measurements for low alkali concentrations were performed in the range of 5,000 ppm to 10,000 ppm. The shear plots displayed average viscosity values, whereby the standard deviation between the measurements was so low that it is again barely visible in the plots. The viscosities for both alkalis were over 250 cP at a constant shear rate of $7s^{-1}$ for 7,500 ppm and 10,000 ppm [80]. The results with Na_2CO_3 showed shear thinning behavior and the viscosities increased with rising alkali concentration (**Figure 4-64**, **B**). At a steady shear rate of $7s^{-1}$ the viscosity of the concentration 5,000 ppm was 272.5 cP, while for 7,500 ppm it was 307.5 cP. With increasing the concentration up to 10,000 ppm the viscosity was already over 378.5 cP. The viscosities of the three alkali concentrations for K_2CO_3 showed almost the same behavior and had a value of 308 cP at 7s^{-1} (**Figure 4-64**, **B**). Also potassium carbonate showed shear thinning behavior.

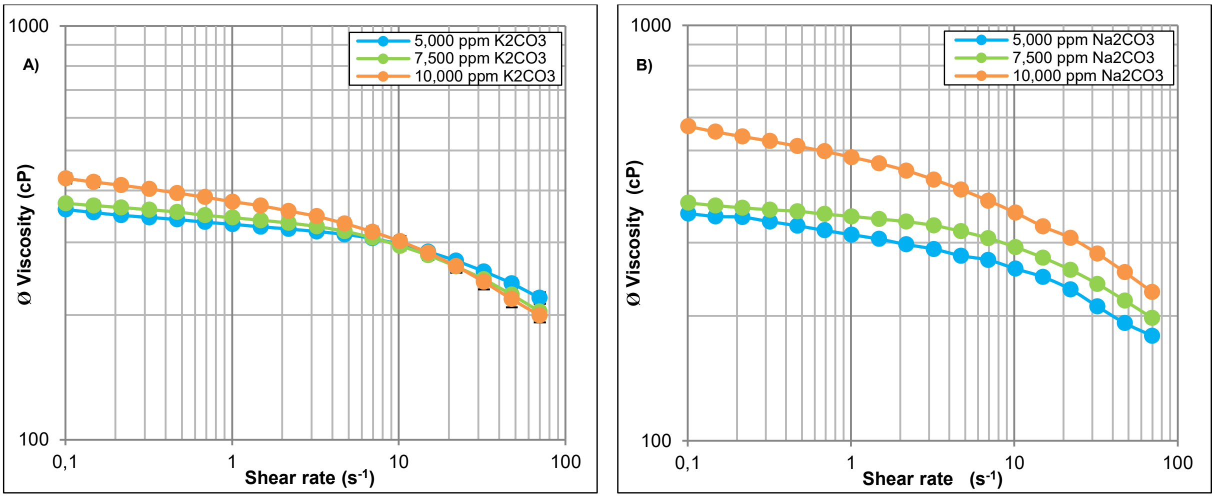


Figure 4-64: Shear plot of softened water from the outlet WTP mixed with dead S 85 (WOR 5:5) at various K_2CO_3 (A) and Na_2CO_3 (B) concentrations at 49°C (Modified from [80]).

In addition, the same alkali concentrations were screened at different WORs. The results are displayed in the **Appendix A1**. Formulations prepared with K_2CO_3 formed significant amounts of type III emulsions in concentration ranges larger than 7,500 ppm and WORs larger than 1.

4.3.4.3 Formulation 3b: Softened Water + Modified S 85 Oil with C_6H_{12} (Alkali Slug)

In this formulation, 89 vol% of dead S 85 oil was mixed with 11 vol% cyclohexane to match the dynamic viscosity of 19 cP at 49°C. Both alkalis formed type III middle-phase emulsions (**Figure 4-65**). Interestingly, the in-situ soap generation started for both alkalis at a concentration of 7,500 ppm. At lower concentrations, no emulsions were formed. K_2CO_3 formed significantly larger and more stable emulsions than Na_2CO_3 within the concentration range of 7,500 ppm to 20,000 ppm. In particular at 7,500 ppm, the generated emulsion amount was significantly lower for the sample prepared with sodium carbonate. No emulsion equilibrium at any concentration was achieved with Na_2CO_3 after 100 days observation time.

In addition, a clear water phase and no precipitations could be observed in any of the samples, no loss of soap components into the water phase.

Over time, the emulsion amount formed with Na_2CO_3 decreased strongly (**Figure 4-66**, **B**). Higher alkali concentrations were required to perform satisfactorily (≥12,500 pm). The time dependency plot of K_2CO_3 showed stable emulsions in the whole examined concentration range (**Figure 4-66**, **A**).

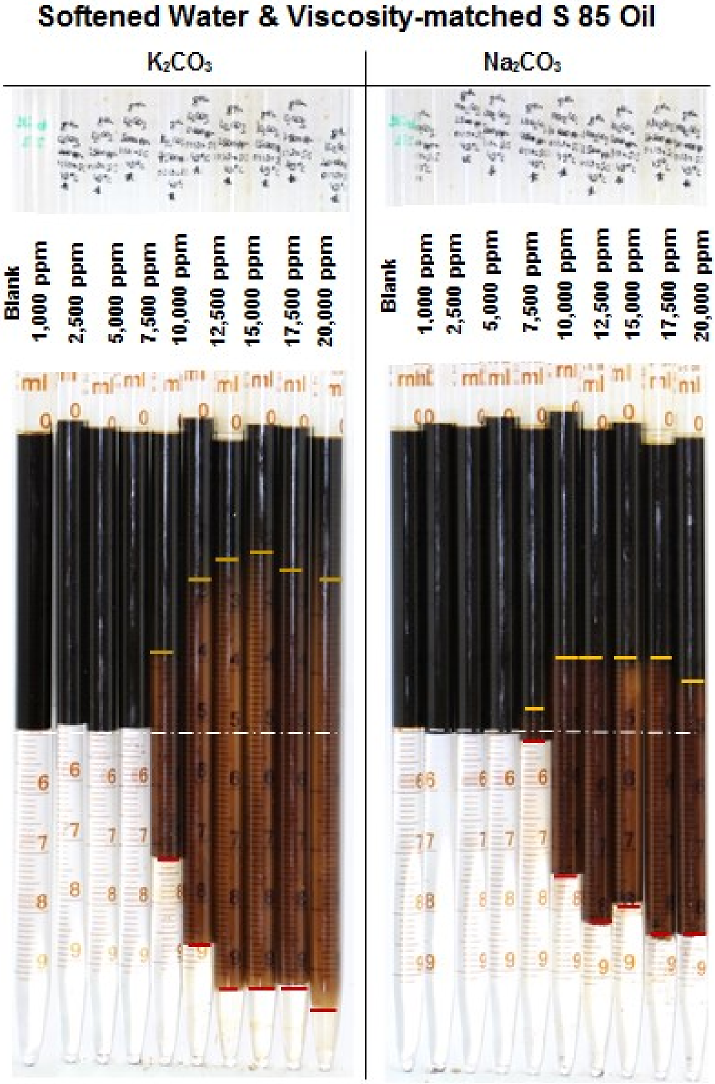


Figure 4-65: Oil scan of softened water and modified S 85 oil at 49°C for WOR 5:5 after two weeks. Yellow lines outline the oil-to-emulsion interface and the red lines the emulsion-to-water interface (Modified from [80]).

The shear plots of both alkalis showed a similar behavior. No shear thinning behavior occurred (**Figure 4-67**). The emulsion viscosities of K_2CO_3 were around 160 cP and massively lower than with dead oil (>200 cP) at a constant shear rate of $7s^{-1}$ (**Figure 4-67**, **A**). The viscosities for Na_2CO_3 emulsions were slightly lower in the range of 120 cP to 160 cP (dependent of the alkali concentration, **Figure 4-67**, **B**).

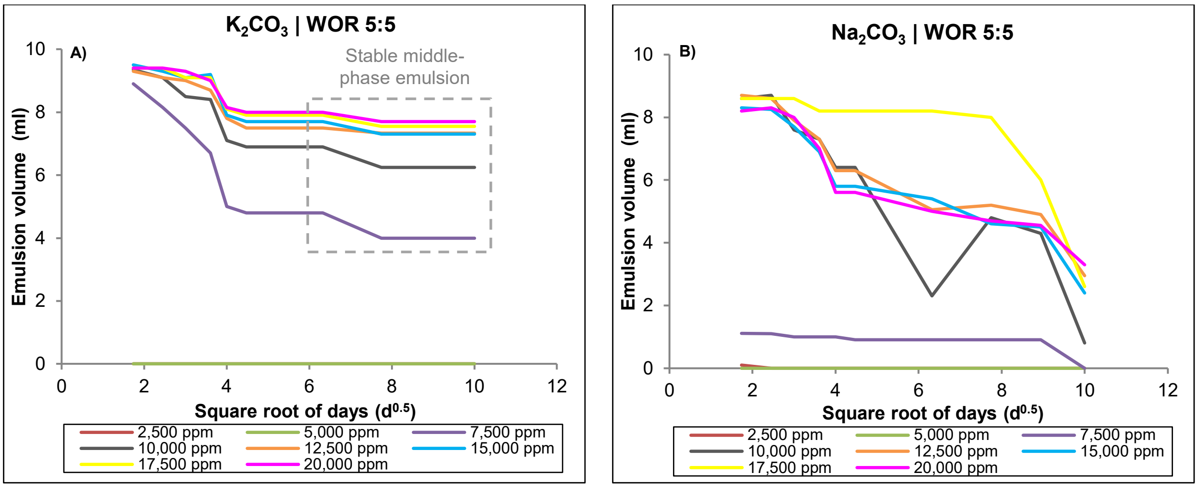


Figure 4-66: Time dependency of formulations prepared with softened water containing K_2CO_3 (A) and Na_2CO_3 (B) at different concentrations mixed with modified S 85 oil to reach middle-phase emulsion equilibrium over 100 days at 49°C for WOR 5:5 (Modified from [80]).

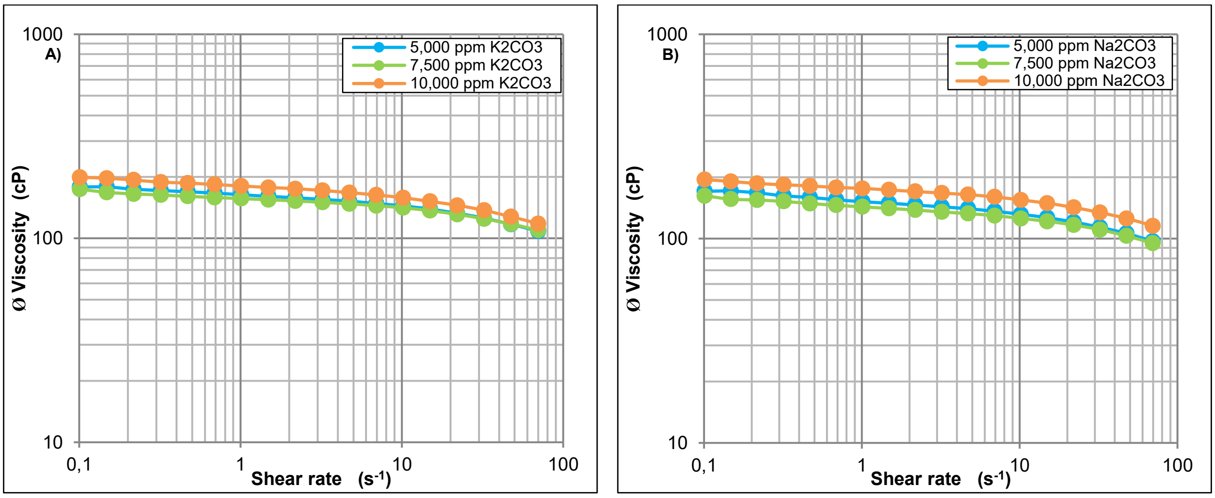


Figure 4-67: Shear plot of softened water from the outlet WTP mixed with modified S 85 oil (WOR 5:5) at various K_2CO_3 (A) and Na_2CO_3 (B) concentrations at 49°C.

The emulsion time dependency plots of additional screened WORs (1:9, 3:7, 7:3 and 9:1) are shown in the **Appendix A1**.

4.3.1 Alkali-Polymer Interaction

The interaction of both carbonate-based alkalis with Flopaam 3630S (expressed as FP 3630S) was investigated in the following experiments. As there was no autoclave box available at the time of the trials, the interaction was tested in oxygen atmosphere. The solutions were prepared with softened real water from the outlet hydrocyclone. A summary of the prepared formulations can be found in **Table 4-12**. The alkali-polymer interaction was investigated for the water from the 16.TH and not for the 8.TH. Viscosity measurements were performed with cone-plate system (CP-60) at 60°C. The technical alkali quality was compared to alkalis with high purity if there can be observed any differences in the results.

Table 4-12: Summary of the prepared formulations for the alkali-polymer interaction experiment.

Prepared Samples	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	Co-Solvent 3 Conc. (ppm)	Flopaam 3630S Conc. (ppm)
#1	x	x	x	x	1,000
#2	Na_2CO_3, K_2CO_3	High quality	7,500	x	1,000
#3	Na_2CO_3, K_2CO_3	High quality	7,500	2,000	1,000
#4	Na_2CO_3, K_2CO_3	High quality	5,000-10,000	2,000	1,000
#5	Na_2CO_3, K_2CO_3	Technical quality	7,500	x	1,000
#6	Na_2CO_3, K_2CO_3	Technical quality	7,500	2,000	1,000

In the first trial, the interaction of Flopaam 3630S with high quality alkalis in combination with and without co-solvent 3 was tested (initial – no aging of the samples). The alkali concentration was kept constant at 7,500 ppm, the FP 3630S concentration at 1,000 ppm and the concentration of co-solvent 3 at 2,000 ppm. **Figure 4-68** displays the average viscosity values of three measurements. At a shear rate of around 7s^{-1} similar results could be observed for all formulations. The viscosity values were in the range of 4.52 cP for K_2CO_3 with co-solvent 3 to 6.24 cP for the blank sample.

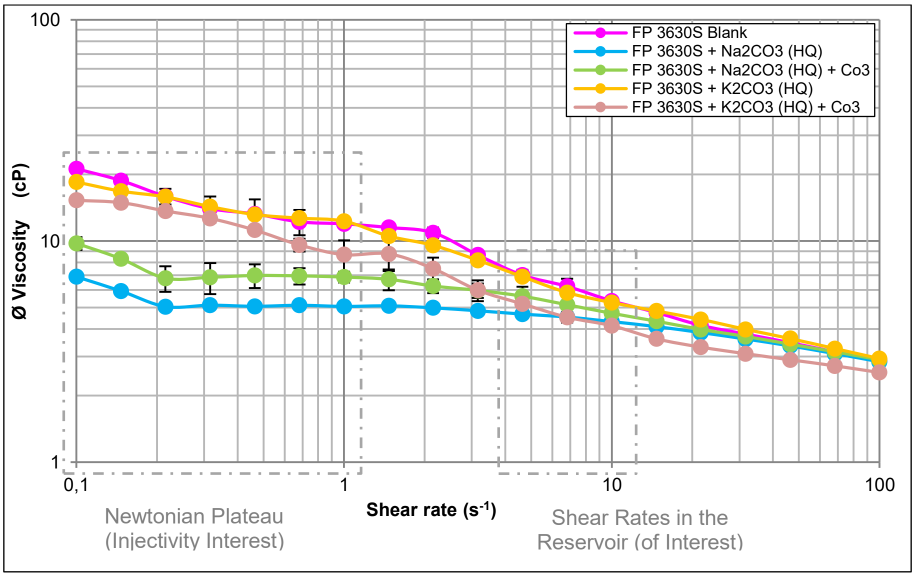


Figure 4-68: Viscosity results showing the alkali influence (high quality) on FP 3630S of various formulations at 60°C initial without aging.

In the next trial the influence of technical graded carbonate-based alkalis at various concentrations (5,000-10,000 ppm) on FP 3630S was examined. The viscosity results are displayed in **Figure 4-69**. All formulations showed a similar shearing behavior at higher shear rates. The sample containing 7,500 ppm K_2CO_3 showed the lowest viscosity at a shear rate of 7s^{-1} with approximately 5.73 cP. In comparison, Na_2CO_3 had a slight increased viscosity of around 6.29 cP at the same concentration. No significant change could be observed by altering the concentration of the alkali lyes.

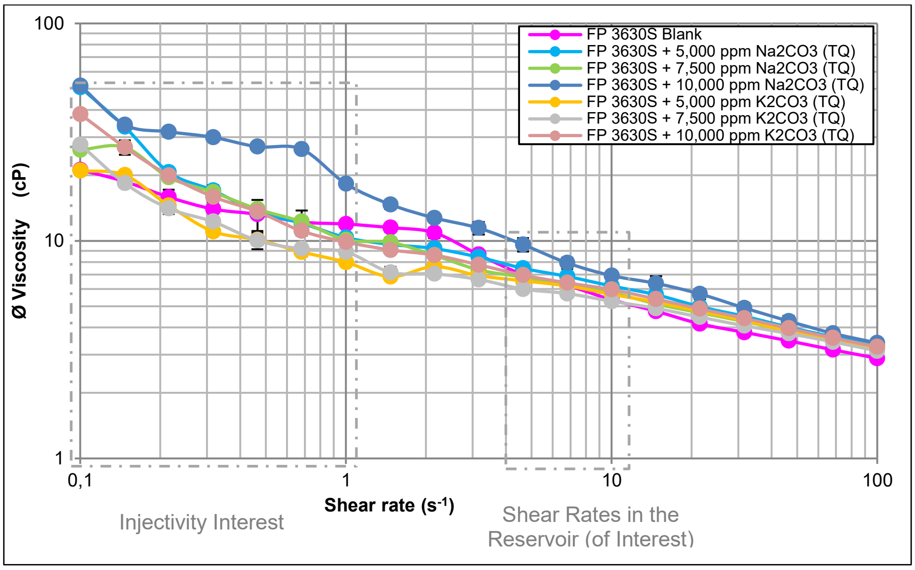


Figure 4-69: Viscosity results showing the alkali influence (technical graded Na_2CO_3, K_2CO_3) on FP 3630S of different alkali concentrations at 60°C initial without aging.

Figure 4-70 compares the influence of the alkali quality (technical and high quality) on FP 3630S without co-solvent 3. The alkali concentration of Na_2CO_3 and K_2CO_3 was kept constant at 7,500 ppm. A huge difference could be observed between the alkali qualities for the samples containing Na_2CO_3. The viscosity of the high quality Na_2CO_3 solution was 4.53 cP and 6.29 cP for the technical quality at a shear rate of $7s^{-1}$. The viscosity results of K_2CO_3 are almost identical for both grades (5.84 cP at high quality and 5.73 cP for the technical quality).

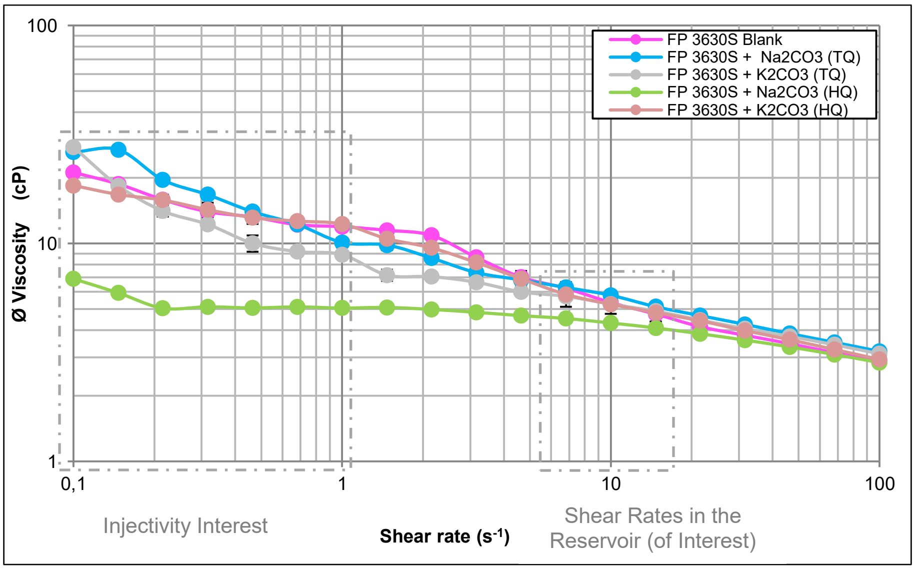


Figure 4-70: Comparison of high quality and technical graded carbonate-based alkalis on FP 3630S at 60°C.

The thermal stability of FP 3630S in alkaline environment was observed over 60 days for high quality and technical graded alkalis. The polymer preparation was performed under aerobic conditions (>1 mg O_2 per liter sample) because no autoclave was available for the experiments. Samples were stored in a convection oven at 60°C. In periodic time intervals samples were taken and the molecular weight measured with SEC. The samples (**Figure 4-71**, **A**) showed a substantial change of the polymer stability. Polymer degradation was already observed after 10 days. All samples were just stable for the first five days. Afterwards, a decrease of the molecular weight was observed, whereby the blank and the AP samples without co-solvent 3 behaved similarly. The ACP samples containing the co-solvent 3 were stable for one week. In the solution, brown small flocculates occurred which precipitated on the bottom of the glass (**Figure 4-71**, **B**).

Figure 4-71: Polymer stability of the chemical formulations (A) at 60°C (settling time: 2 weeks); B) precipitations of the formulations prepared with co-solvent 3.

The results over time for high quality alkalis (Na_2CO_3, K_2CO_3) from the size exclusion chromatography are expressed in **Figure 4-72**. A polymer blank containing 1,000 ppm of FP 3630S, a blank of co-solvent 3 (1,000 ppm) and formulations with the alkalis (7,500 ppm) were prepared as formulations. The concentration of each component was kept constant for all examined formulations. The molecular weight strongly declined over the time from initially 20-MDa to around 10-MDa for the sample containing Na_2CO_3 and for K_2CO_3 to 8.9-MDa. The samples containing a co-solvent 3 had a sharp decline of the molecular weight to less than 5-MDa.

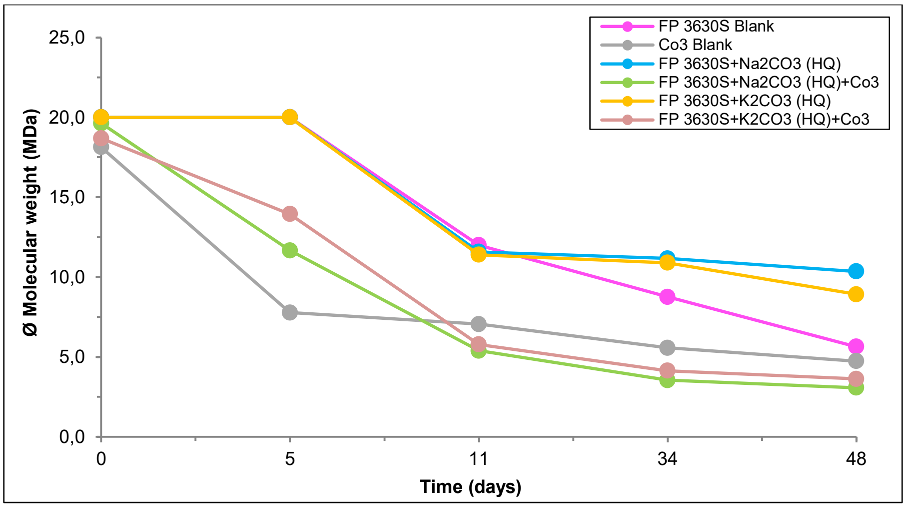


Figure 4-72: Molecular weight distribution over time of FP 3630S in high purity alkali environment.

Figure 4-73 represents the molecular weight distribution for the technical graded alkalis. Samples were taken once per week over a period of 70 days. The same formulations as those for high quality alkalis were prepared and similar results could be achieved. The polymer blank strongly declined from initially 20-MDa to around 6.1-MDa. A strong alteration of the molecular weight could also be observed within the samples containing the co-solvent 3. Values of less than 3-MDa were measured after 70 days aging in the convection oven at 60°C. At the end of the trial, the sample containing Na_2CO_3 had a molecular weight of about 13-MDa compared to the sample with K_2CO_3 which had a molecular weight of around 11.8-MDa.

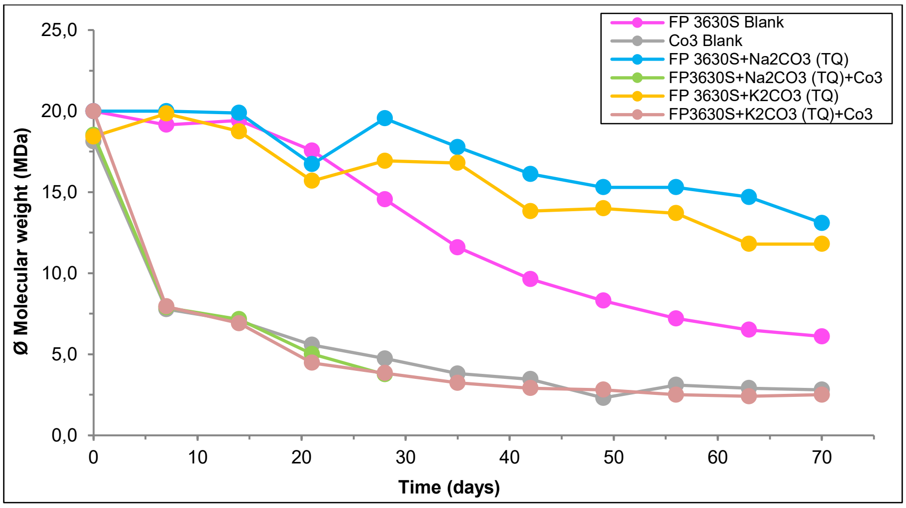


Figure 4-73: Molecular weight distribution over time of FP 3630S in technical graded alkali environment.

4.3.2 Alkali-Crude Oil Interaction

Alkali-based chemical enhanced oil recovery relies on the interaction between alkali lye and crude oil to increase the incremental oil production. Optimizing the chemical formulation depends on screening multiple alkali concentration ranges to maximize the generated emulsion volume as shown in the previous chapters (**Chapter 4.3.1** – **Chapter 4.3.2**). However, the strong chemical variation of the crude oil caused by biodegradation within the reservoirs and its influence on the generation of in-situ soap has never been studied in detail. In this study, organic geochemical oil characterization of different crude oils (slightly degraded, moderate degraded and heavy degraded), excess alkali-equilibrated oil phase and hydrocarbons of the emulsion phase were combined with the gathered phase screening data. Thereby, it was possible to understand the control mechanism for the in-situ soap generation, emulsion types and emulsion stability over time. In addition, alterations caused by the alkali-oil interaction are demonstrated and quantified using organic geochemistry.A complete oil characterization was performed by the use of gas chromatography (GC-FID, GC-MS).

The initial composition of the original oils (dead Bo 112 and dead S 85 oil) resulted in different degradation types. The oil produced from the 8.TH (dead S 85 oil) was classified into degradation rank 3 (heavy degraded oil) and the oil from the 16.TH (dead Bo 112 oil) into rank 2 (moderate degraded oil) according to the Biomarker Biodegradation Scale established by Peters *et al.* (2005) and using data provided by Rupprecht *et al.* (2018). The gathered results fit to the data published by Rupprecht *et al.* (2018) [92].

Both oils were analyzed regarding their composition of saturated, aromatic, resin and asphaltenes components (SARA) as well as NSO-compounds (**Figure 4-74**). The saturated compounds were in the range of 39 to 44%, the aromatic compounds from 15 to 20% and the NSO-compounds (nitrogen, sulfur, oxygen) of 39 to 41%. The oil of the 8.TH differs from the 16.TH regarding its composition. The initial composition of the 8.TH oil consists of 30% saturated compounds, 19% aromatic compounds and 51% of NSO-compounds [114].

Isoprenoides were only detected in the moderately degraded sample of the 16.TH. No n-alkanes were detected in the higher degraded oils produced from both reservoirs. Two major contributing compound groups of the polycyclic aromatic hydrocarbons could be identified in the samples. The first group was formed from mono-, di-, tri-, and tetramethylated naphthalenes which are present in high but varying quantities within all investigated samples. In the moderately degraded oil from the 16.TH methyl-, dimethyl and trimethylnaphthalenes were present. In contrast, methylnapthatlenes were nearly depleted through the degradation in the heavy degraded oil from the 8.TH (**Figure 4-75**). The second group consisted of phenanthrene and methylphenanthrenes. These compounds derived from a variety of non-specific precursor compounds such as steroids and triterpenoids [123].

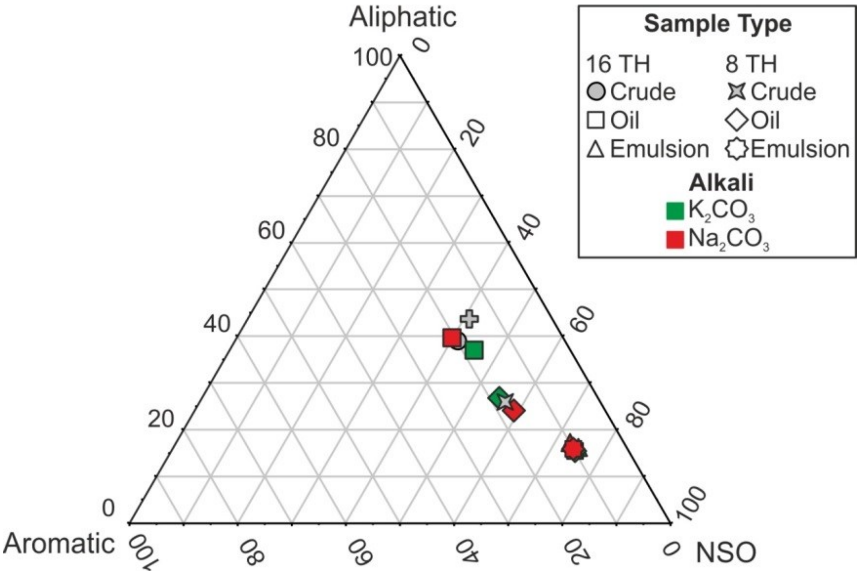


Figure 4-74: Ternary plot showing the composition of the studied crudes as well as alkali-equilibrated oils and emulsions [114].

Furthermore, the alkali-equilibrated excess oil phase of the 16.TH oil showed a slight depletion of the methylnaphthalenes, relative to the dimethyl- and trimethylnaphthalenes. In comparison, the oil of the 8.TH was already depleted of the methylnaphthalenes and no massive change of the composition was observable (**Figure 4-75**). The emulsion phase differed and was heavily depleted of the methyl- and dimethylnaphthalenes (a stronger shift was observed with Na_2CO_3) [114].

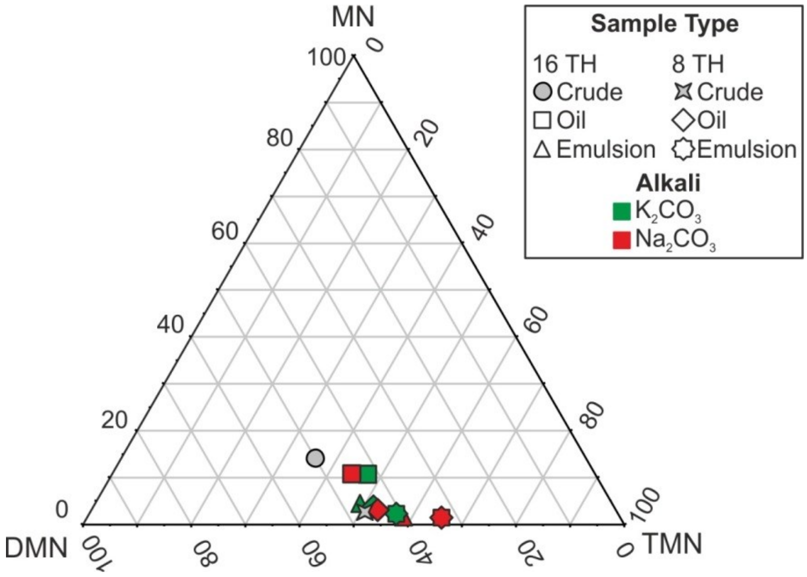


Figure 4-75: Ternary naphthalenes plot (MN: methylnaphthalenes, DMN: dimethylnaphthalenes, TMN: trimethylnaphthalenes) [114].

In contrast to the initial oil composition, the composite of hydrocarbons in the emulsion phase differed significantly. The emulsion phase thereby consisted of around 17% aliphatic compounds, 10% aromatic compounds and 73% of NSO-compounds (**Figure 4-74**). No difference between the two tested alkali lyes (Na_2CO_3, K_2CO_3) could be observed of the emulsion phase from the two degraded oil types. No massive change of the alkali-equilibrated excess oil phase appeared. A significant change of the steroids and hopanoides could be observed in the excess alkali-equilibrated oil phase as well as in the emulsion phase dependent from the used alkali lye. The samples prepared with K_2CO_3 were mildly depleted in the S-isomer, relative to the R-isomer (**Figure 4-76**), whereby the samples with Na_2CO_3 were strongly depleted regarding ααα- and R-isomers [114].

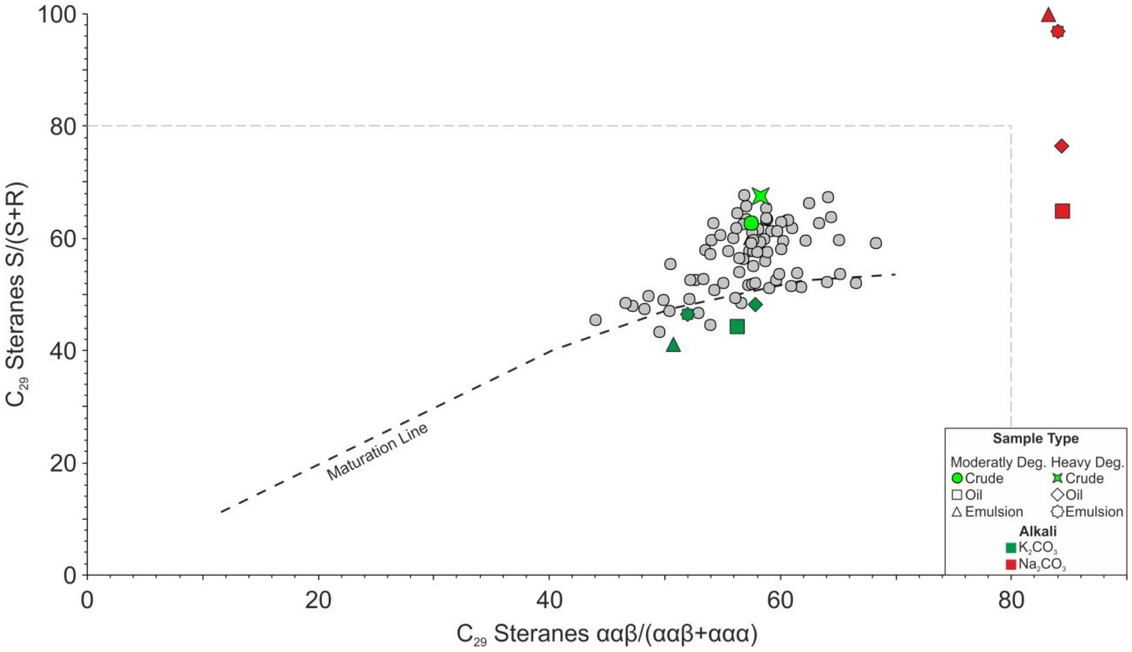


Figure 4-76: Comparison of maturity markers based on the isomerization of the C_{29} steranes (Modified from [124]). Note: the typical axis partitioning was extended in order to plot the composition of the samples equilibrated with Na_2CO_3. Grey symbol represent the data from oils in the Vienna Basin according to Rupprecht (2017) [114].

4.4 Discussion

The results showed that modifications of any parameter, like the alkali type, the water composition, the oil type, the concentration, the temperature etc. already led to slight changes of the phase behavior. Interestingly, the alkali-oil interaction of Bo 112 oil (16.TH) was less strong compared with the S 85 oil from the 8.TH (heavy degraded oil) because almost no non-polar compounds were left in the initial oil. The in-situ soap generation started at much higher alkali concentrations compared to the 16.TH oil as a result of non-soap forming acids which were formed through biodegradation. Adversely, the non-soap forming acids were stronger than the soap-forming naphthenic acids and consumed parts of the alkali lye before the soap generation started. The TAN reached from 1.7 to 2.25 mg KOH/g oil for heavy degraded oils.

According to industry data, moderately degraded oils (e.g. Bo 112 oil of the 16.TH) have a total acid number of 1.5-1.75 mg KOH/g oil. In-situ soaps were formed because the moderately degraded oil interacted with the alkali lye, because the n-alkanes were missing (degradation). The first in-situ soaps with Bo 112 oil were formed with alkali concentrations of 5,000 ppm. Bo 112 oil is rich in non-polar isoprenoids and therefore significant emulsion amounts were formed at higher alkali concentrations. It could also be observed that the excess aqueous phase showed a brownish color with a high turbidity due to dissolved hydrocarbons and loss of in-situ soap components into the water phase. The optimal concentration range for the 16.TH was much narrower than for the 8.TH, regarding the formulations prepared with real softened formation water and dead oil. The optimal concentration range for K_2CO_3 was between 5,000 ppm and 10,000 ppm. At higher alkali concentrations the produced in-situ soap amount decreased stronger over time than those at lower alkali concentrations did. In contrast, Na_2CO_3 formed unfavorable type II (+) emulsions starting at a concentration of over 7,500 ppm. Type III emulsions were only formed at low alkali concentrations (<7,500 ppm), which declined strongly over time and no emulsion equilibrium could be observed.

Especially, the modified Bo 112 oil, with cyclohexane, showed a completely different phase behavior than the one with dead oil. Viscosity-matched oil is widely applied in the industry for core flood experiments. Formulations prepared with viscosity-matched Bo 112 oil showed a significantly reduced emulsion amount. This was most likely a result of adding 23 vol% of non-polar cyclohexane to the crude oil. Like all non-polar compounds, cyclohexane inhibits the alkali-crude oil interaction. Significant lower emulsion amounts were generated with Na_2CO_3 and a strong decline over time could be observed. The formed emulsion did not reach equilibrium and decayed in most samples to initial oil and water conditions (initial WOR).

Interestingly, formulations prepared with heavy degraded oil from the 8.TH (S 85 oil) formed larger emulsion amounts compared to the moderately degraded oil from the 16.TH. It could be observed that in-situ soaps were formed at significantly higher concentration ranges (10,000 ppm). Both alkalis performed satisfactorily and produced reasonable stable type III emulsions over time. In contrast to the 16.TH samples, no significant loss of soap components into the aqueous phase could be observed in the formulations prepared with S 85 oil from the 8.TH (heavy degraded oil). This oil type contains no naphthalene’s because the depletion occurred already through biodegradation. Biodegradation itself resulted in an enrichment of acids in the crude oil. Further it was observed, that a significant amount of in-situ soap was generated only at higher alkali concentrations, beginning at 10,000 ppm for K_2CO_3 and at 12,500 ppm for Na_2CO_3 compared to Bo 112 oil. Therefore, it can be concluded, that the acids generated during biodegradation can be classified as non-soap forming, which interact with the alkali lye prior to the in-situ soap generation (stronger than the acids originally presented in the crude oil).

The oil analysis showed that the excess oil phase of the phase experiment hardly displayed any alteration compared to the initial crude oil composition. In contrast, the emulsion phase was significantly altered. The oil which interacted with the alkali lye in the emulsion phase was enriched in polar organic compounds. No enrichment in the aliphatic and aromatic components could be observed in the oil phase leading to the fact that these compounds must be lost into the water phase (an indicator would be the brownish color of the aqueous phase as well as the high turbidity of same samples). Besides, the relative and absolute naphthalene composition indicated a loss of methyl- and dimethyl variety. The shift in the sterane and hopane concentrations showed a loss of these compounds from the hydrocarbons contained in the emulsion phase to the excess water phase. Furthermore, the brownish color of the aqueous phase from the formulations prepared with moderately degraded oil surely points out a loss of additional NSO-compounds.

The degree of biodegradation proves to be a very important control mechanism. Slightly degraded oils do not interaction with the alkali lye due to a high content of non-polar compounds like alkanes and isoprenoids. Moderately and heavy degraded oils show varying interactions with the alkali solution. The degree of interaction depends on the used degradation type, the alkali type as well as on the used concentration. Moderately degraded oils show interactions in a lower concentration range compared to heavy degraded oils, which display an increased non-soap forming acid content. The performed oil characteristic could be seen as a fast screening method prior to the phase experiments. The crude oil composition has a major influence on the whole in-situ soap generation, whereby higher biodegraded oils represent a higher potential to form in-situ soaps.

With respect to the tested WORs, the alkali concentrations and the used oils potassium carbonate showed more promising results than sodium carbonate. The formed emulsions seemed to be more stable over time than those formed by Na_2CO_3 (higher emulsion amounts). In most of the samples more promising middle-phase (type III) emulsions were formed over time (diffusion process), whereas some formulations mixed with Na_2CO_3 declined massively and separated into their initial phases (WOR).

According to Hill *et al.* (1973), an optimum sodium chloride concentration exists for each crude oil-soap solution system in which the IFT is the lowest [125]. Due to the fact that the salinities of the formation waters from the two investigated reservoirs (8.TH and 16.TH) are relatively high and no salinity scan was performed prior the phase screening (acceptance of the given salinities), the different behavior of the alkali lyes may be attributed to the varying ionic composition. In addition, no ultralow IFT regime could be reached with any of the two alkali lyes. Rudin and Wasan (1992a, 1992b) realized that the salinity and pH show independent effects on the emulsion stability [126, 127]. It can be argued that the addition of sodium carbonate may shift the salinity over the optimal salinity range (ionic strength) and thereof result in the generation of type II (+) emulsions. In comparison, K_2CO_3 does not exceed the optimal salinity concentration range as the initial potassium concentration in the formation water is relatively low. Accordingly, in most of the formulations prepared with potassium carbonate type III emulsions were formed.

Additional performed phase experiments showed that even through the addition of small amounts of HPAM (FP 3630S, 1,000 ppm) the formed amount of in-situ soaps is strongly influenced. Even at concentrations where the alkali slug showed promising results with respect to emulsion amount and emulsion stability a significant decline could be observed. Interestingly, the generated soap amount decreases strongly as soon as polymer was added to the planned slug compared to the achieved amounts with alkali alone (see **Chapter 4.3.3.2** and **Chapter 4.3.3.3**). Shear thinning occurred of the measured emulsions where polymer was contained in the AP slug. Sheng (2017) stated that the interaction of the polymer with the alkali slug leads adversely to a decrease of the polymer viscosity over the time. At the beginning high polymer viscosities can be seen, but through the hydrolysis of the HPAM a decrease of the viscosity appears. Responsible therefore is the alkali, which leads on the one hand to high pH values and on the other hand to an increase of the ionic strength [19].

Various different co-solvents were screened in order to reduce the high emulsion viscosities and to promote Newtonian fluid behavior (removal of shear thinning behavior). Whereby, no promising results were achieved through the addition of co-solvent 1 or 2 to the alkali slug. The generated emulsion amount with co-solvent 1 was less compared to the formulations prepared with alkali alone. The aqueous phase showed a high turbidity (greyish color) through the loss of in-situ soap components into the water phase. Basically, all tested co-solvents showed a massive decline of the emulsion amount over time. Only high concentrations (5,000 ppm) led to stable emulsions over time by the use of co-solvent 2. The addition of co-solvent 3 to the Na_2CO_3 samples led to the formation of type III emulsions. Still a massive decline of the emulsion amount could be observed.

Interestingly, the IFT values were the lowest when the co-solvent 3 was contained into the formulation containing K_2CO_3. A strong increase of the IFT occurred with both alkalis at high alkali concentrations (>15,000 ppm). Normally, ultra-low IFT regimes are preferable for alkali flooding. In this study, no ultra-low IFT regime could be achieved neither by dead oil nor by viscosity-matched Bo 112 oil.

Cooke *et al.* (1974) stated there is a minimum TAN of 1.5 mg/g for a successful alkaline flood process and Chang (2013) defined 0.3 mg KOH per g oil [128, 129]. Sheng (2015) stated that there is no direct correlation between the TAN and the oil recovery. Consequently, there exists no minimum acid number for a successful alkaline flooding process. Due to the fact that the nonaqueous phase titration method is unable to differentiate between acids which are able to produce in-situ soaps and acids that consume alkali modifications to this method may be applied in the future [18].

The micro emulsion viscosity is strongly influenced by varying any parameter such as temperature, salinity, or the concentration of used alkalis which results in a change of the microstructure. For example, increasing the temperature of just 1°C lowers the crude oil viscosity of approximately 10%. Besides, pressure changes lead to viscosity rises. But also salinities below or above the optimum can lead to viscous micro- or macro emulsions due to their strong dependence on the electrolyte environment [109, 110].

Generally, the viscosity changes with the shear rate. Viscous phases can be prevented either through a salinity gradient or by modifying the formulation. For a successful oil displacement high viscosities are unfavorable and require higher polymer concentrations. If the micro emulsion shows continued shear thinning behavior at low shear rates it will lead to a decrease of the sweep efficiency and a raise in surfactant retention [109, 110]. The addition of a co-solvent to the aqueous phase tremendously influences the viscosity and leads to less viscous emulsion phases. Adversely, higher costs and increased complexity can be the consequence [111].

It can be argued that the kind of emulsion decay plays an important role. A slow decline might be more favorable at reservoir conditions than a faster one. Four different breakdown types were identified by the observation of the fluid volumes from the conducted phase experiments of the 16.TH (Bo 112 oil) and visualized in a ternary plot (**Figure 4-77**). The in-situ soaps generated by both alkalis (Na_2CO_3, K_2CO_3) formed middle-phase emulsions.

Type A breakdown (**Figure 4-77**, **a**) is correlated to the degradation of micro emulsions. The trend starts in the corner of the emulsion and displays a straight trend to the corresponding WOR of the experiment. During this process the WOR of the emulsion stays constant. This is supported by the finding of constant WOR in micro emulsions by Yamaguchi (1998) [130]. Therefore, the combination of square root of time plots (**Chapter 4.3.3**) and triplots give information about the decay as well as the overall composition of the sample.

Type B breakdown (**Figure 4-77**, **b**) represents the degradation at a constant aqueous phase volume and an increasing oil volume. Therefore, the WOR of the emulsion increases. This type is maybe indicative for flocculation at which not enough in-situ soap is generated to keep the micelles stable. Type C breakdown (**Figure 4-77**, **c**) represents the decay of an emulsion at a constant oil phase volume. The WOR ratio decreases with increasing decomposition. This breakdown type often follows after an initial occurring type B breakdown. This type can be attributed to creaming were the formed flocs transform into an oil-rich emulsion layer at the upper part of the emulsion.

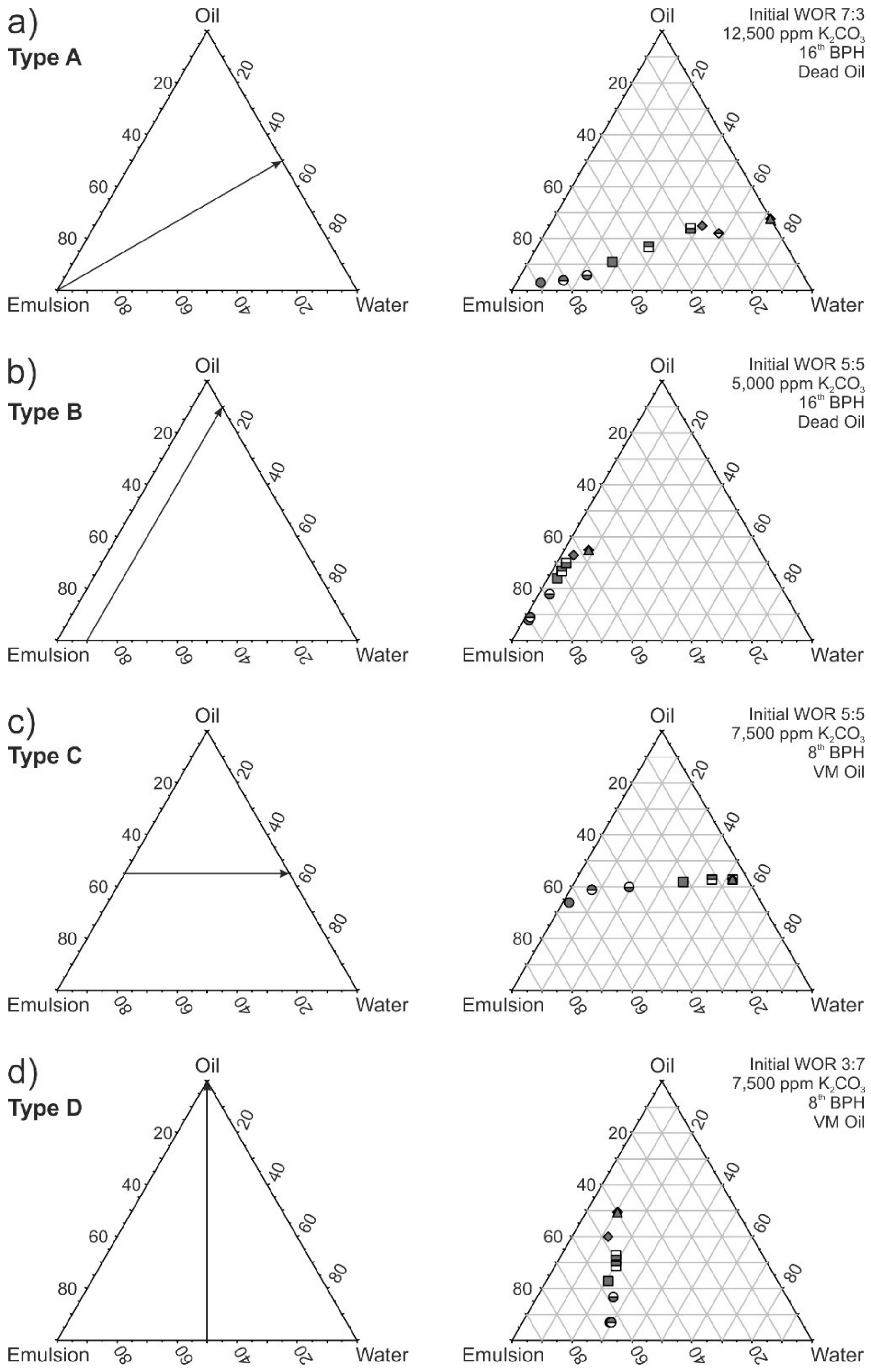


Figure 4-77: Ternary plots indicate the four different types of emulsion breakdowns which could be identified through the phase experiments. The left side displays the idealized breakdown type and the right side visualizes the decay of the phase volumes (VM expresses viscosity-matched oil sample) [114].

Type D breakdown (**Figure 4-77**, **d**) could be observed when the emulsion volume decreases due to the loss of oil from the emulsion into the aqueous phase. Hence, an increasing WOR could be observed from this process. The underlying system is maybe a combination of Ostwald ripening and creaming (**Figure 4-78**). Type B to D breakdowns are indicative for the disintegration of macro emulsions formed by the mixing of the alkalis and oils as changing WOR were observed.

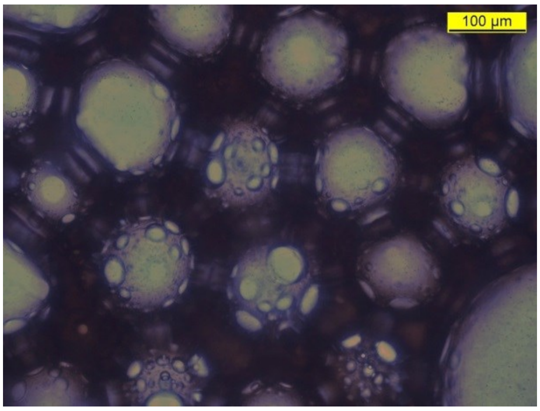


Figure 4-78: Photomicrograph of the sample from heavy degraded dead oil in equilibrium with 7,500 ppm K_2CO_3 solution and an initial 5:5 WOR. Clearly, the bimodal bubble size distribution is attributed to Ostwald ripening [114].

The formulations which were prepared with moderately degraded viscosity-matched oil and K_2CO_3 formed type II (-) emulsions at low WORs (1:9, **Figure 4-79**). This is due to the already high initial oil volume. In addition, emulsions generated with this type of oil typically decay via a type C breakdown. Only emulsions which are formed by formulations prepared with higher WORs initially decay as type B breakdown before changing to type C. In contrast, moderately degraded dead oil samples mostly formed emulsions which decayed as type A at lower concentrated K_2CO_3 samples (≤10,000 ppm). Initial low WORs (3:7), breakdown firstly as type B followed by type C, whereas high WORs (7:3) formed emulsion in all concentration ranges/ oil types (dead and viscosity-matched oil) and decayed via type A breakdown. Interestingly, emulsion stability of formulations prepared with moderately degraded oil at a high concentration of K_2CO_3 and a WOR of 1, showed a lower stability than higher or lower WORs.

Formulations prepared with heavy degraded oil and K_2CO_3 formed significant amounts of stable middle-phase emulsions in concentration ranges larger than 7,500 ppm and WORs larger than 1 (type A breakdown). Lower WORs decayed via type B and C breakdown. The slightly lower stability of the formulations prepared with dead oil may result from traces of demulsifier added to the oil in the separator and transferred to the experiment via the hydrocarbon content of the produced water.

The breakdown of samples prepared with moderately degraded oil and Na_2CO_3 are mainly dependent from the type of used oil (**Figure 4-80**). Samples prepared with viscosity-matched oil decayed as a combination of type A and B. Interestingly, in-situ soap generated with dead oil mostly occured as type II (+) emulsion over a wide concentration range (>10,000 ppm) and at a WOR of 1. All formed emulsions with moderately degraded oil and Na_2CO_3 decayed as type C and are therefore no real “micro emulsions”.

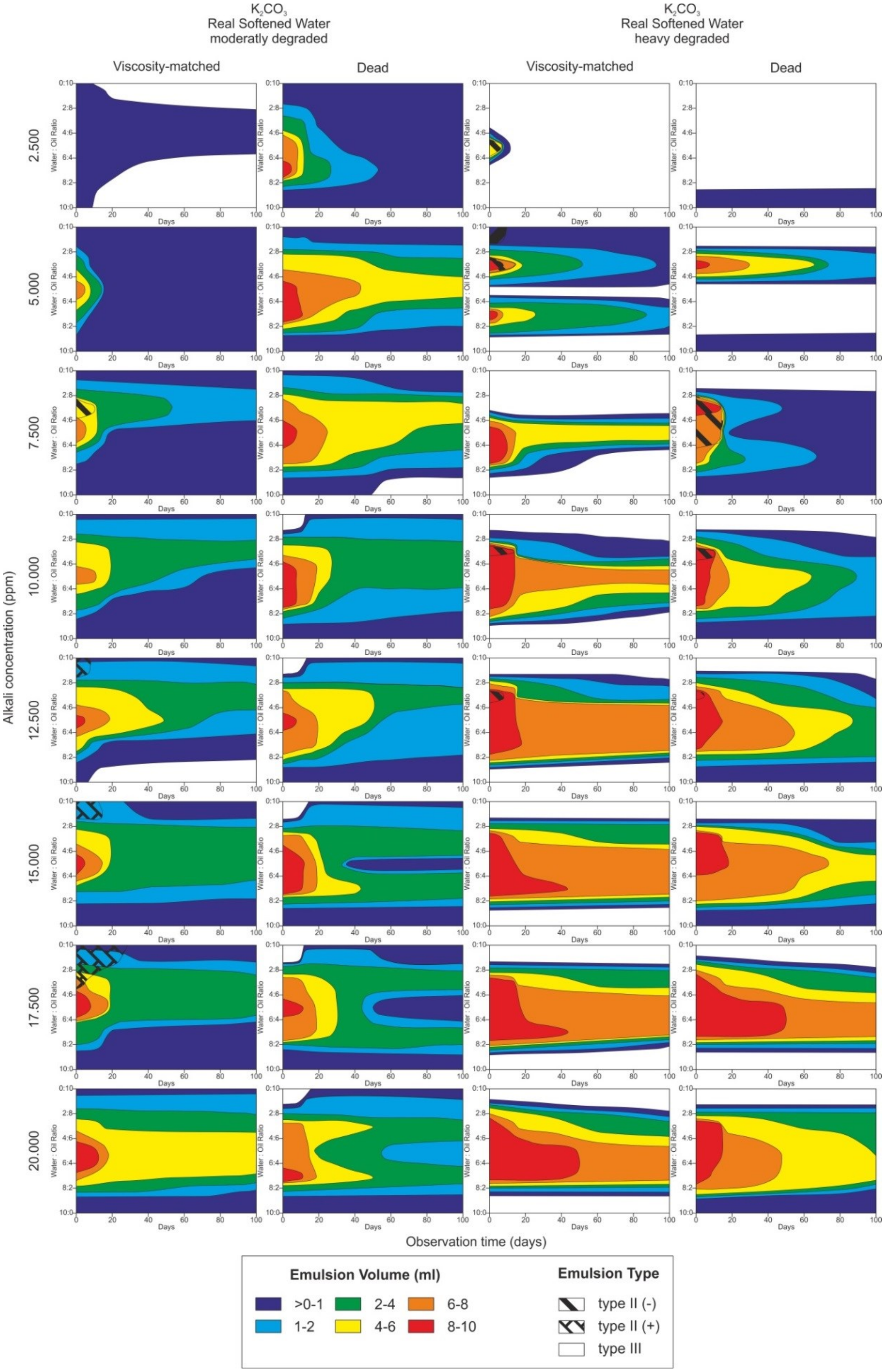


Figure 4-79: In-situ soap generation of K_2CO_3 (x-axis: observation of the emulsion volumes over 100 days). The stability, volumes, oil types and emulsion types vary heavily regarding the alkali lye concentration and the WOR (y-axis) [114].

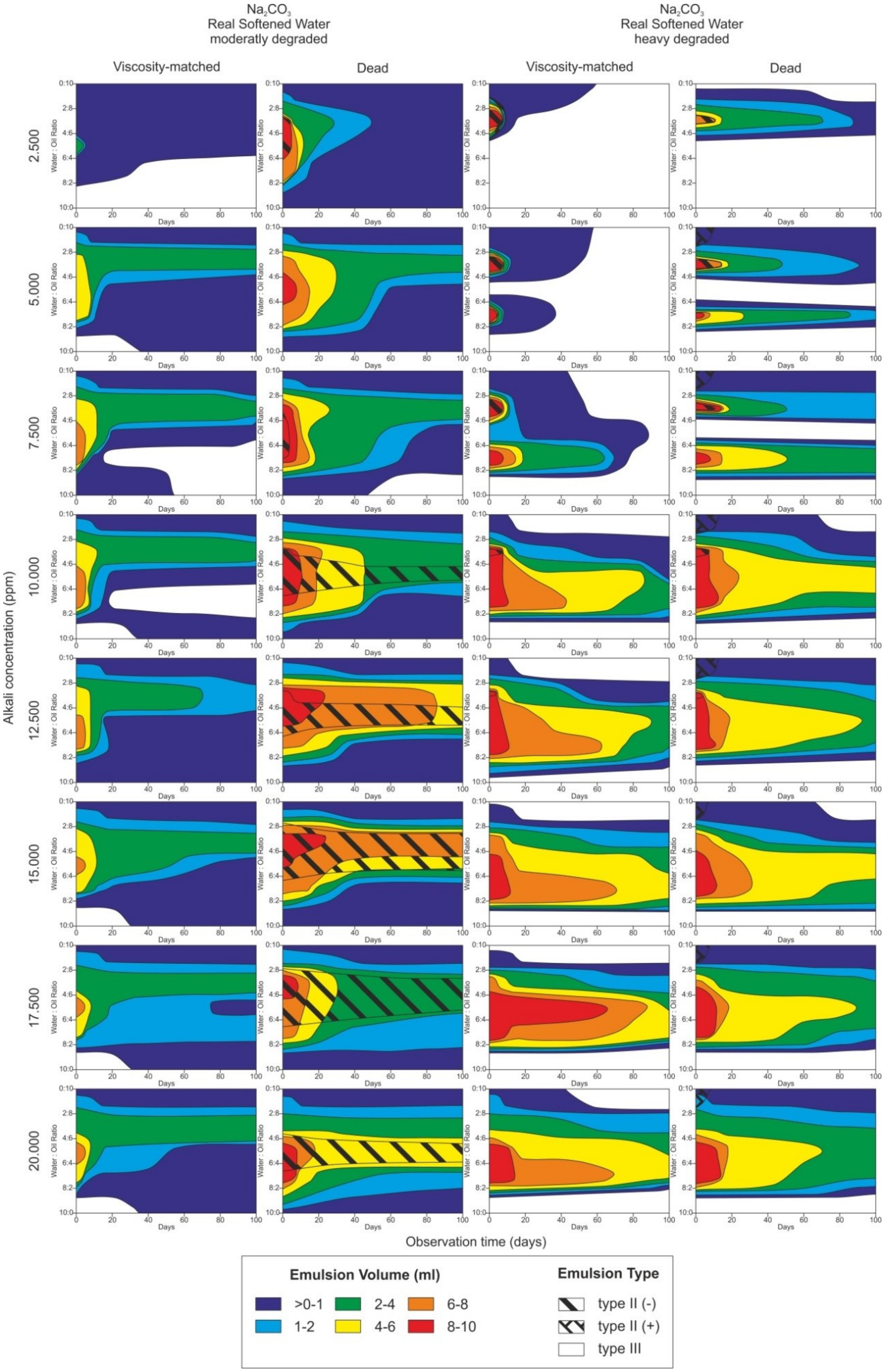


Figure 4-80: In-situ soap generation of Na_2CO_3 (x-axis: observation of the emulsion volumes over 100 days). The stability, volumes, oil types and emulsion types vary heavily regarding the alkali lye concentration and the WOR (y-axis) [114].

Formulations prepared with heavy degraded oil and Na_2CO_3 decayed as type B and C in all concentration ranges with WORs equal or larger than 1. Just the experiment with 12,500 ppm at a WOR of 1 did form a real middle-phase emulsion. Lower WORs formed emulsions indicated by the type A breakdown in all concentration ranges.

In general, lower WORs (<1) seem to form always middle-phase emulsions, regardless of the used alkali or oil type. This is contributed to the surplus of alkali solution in the experiment. In contrast, type II (-) emulsions were only observed in experiments with high WORs (>>1).

Type A emulsion breakdown could only be observed in a small number of experiments (**Table 4-13**). In all other, unlisted experiments only macro emulsions were formed according to their decay types.

Table 4-13: Summary of formulations which formed stable middle-phase emulsions (type A breakdown, x: no emulsion was formed) [114].

Alkali Lye	Moderately Degraded Oil (WOR)			Heavy Degraded Oil (WOR)		
	3:7	5:5	7:3	3:7	5:5	7:3
Na_2CO_3	x	x	x	x	12,500 ppm	≥5,000 ppm
K_2CO_3	x	5,000-10,000 ppm	≥5,000 ppm	10,000-12,500 ppm	≥10,000 ppm	≥7,500 ppm

Viscosity-matched oil shows a completely different phase behavior than dead oil. Especially, formulations prepared with viscosity-matched moderately degraded oil had a significantly reduced emulsion volume but also a reduced emulsion stability. This is most likely a contribution of the addition from 23% of the non-polar cyclohexane to the crude oil. The cyclohexane, like n-alkanes, inhibits the alkali-oil interaction. Viscosity-matched oil is widely applied for core flood experiments. Clearly, it is important to simulate the flow in porous media under conditions close to reservoir conditions to allow the application of the equation of state [131]. In experiments at which no chemical interaction is investigated (e.g. miscible gas injection) no alteration of the experiment will be observed. However, in experiments which are dependent on the chemical interactions, maybe additional effort has to be undertaken to validate these findings.

Phase experiments performed with technical graded alkalis showed differences to the ones performed with high quality alkalis. The sample prepared as a 50:50 mix with both alkali lyes did not show any in-situ soap formation (as the mixture is in the Na_2CO_3:K_2CO_3 eutectic, [132]). Basically, in a chemical reaction where high amounts of energy are released than it means that the reaction products are stable [133]. Although in the 50:50 mix sample, the mixture is more stable than the reaction products and therefore no reaction takes place. Samples in which one alkali is in the surplus represents the opposite, the mixture has an energetic benefit to react. The potential of mixing both alkali lyes in the AP formulation should be further investigated.

Water softening is mandatory in the field to avoid scaling before the alkali lye is mixed to the injection water. No huge difference regarding emulsion amount could be observed between both water sources.

Potassium carbonate is more favorable as alkali lye (K^+ ion > Na^+ ion) for the application of AP flooding in the Vienna Basin (related to the screened 8.TH and 16.TH) based on the phase experiments.

5 Alkali-Reservoir Rock-Interactions

In alkali flooding, not only the alkali-crude oil and alkali-water interactions are from interest, also alkali-rock interactions should be considered and intensively investigated. Alkali-reservoir rock interactions are quite complex; depending on the mineral composition and the used alkalis [134]. Krumrine *et al.* (1984) stated that the injected slug alters the reservoir rock through dissolution, mixing, neutralization, and ion exchange reactions. Flow channels may get blocked through occurring precipitations and even result in fluid diversion [135]. The initial formation wettability and pore geometry play a significant role for a successful alkali flood [136].

In literature, the chemical interaction between alkali solutions and single minerals is well investigated but less research was conducted about the interaction of alkali lyes with porous rocks (mixture of various minerals). Mostly, core flood experiments were executed, which focus solely on the oil recovery.

The main aim of this study is to examine the interaction of different alkali lyes with reservoir rock samples as well as gravel pack material at reservoir conditions (temperature, formation water composition). Thus, possible precipitations of insoluble material in surface facilities as well as severe formation damage can be prevented by the choice of the right alkali lye. Hence, an in-house test procedure was developed to reduce the risk of using inappropriate EOR fluids. The samples were exposed in pressurized batch reactors (autoclaves) to the alkali lyes at reservoir temperature.

The alkali-rock interaction for the 8.TH and 16.TH was studied. The developed in-house method was examined in the beginning by the use of Berea plugs. Further studies were conducted using reservoir plugs from both examined reservoirs. Therefore, the alkali-rock interaction of reservoir plugs in dry, water-saturated and oil-saturated conditions was evaluated. The plugs were exposed to the alkali lye solutions (NaOH, K_2CO_3 and Na_2CO_3) over a certain period of time at the specific reservoir temperature. Furthermore, the interaction on gravel pack material (Carbolite beads and glass beads from Swarco®) was studied.

5.1 Mineral Reactions: Alkaline Consumption, Dissolution & Precipitation

Porous rock consists of various mineral and rock grains which are dependent on the predominant rocks in the hinterland of the sediment deposit. Several chemical reactions, such as adsorption, precipitation and reaction with the reservoir rock minerals, are ongoing when alkali lyes are injected into the formation, resulting in an increased ion content (alkali consumption). The ion exchange and the loss of alkalinity are strongly dependent on the pH value and the temperature but also from the involved mineral type [137, 138]. As a result higher amounts of alkali lyes are required to overcome the high losses of the flow through the porous rock. The need of higher amounts of alkali lyes is an adverse effect in alkaline flooding processes [139]. The injection of a polymer slug afterwards decreases this risk [25].

In principle, the dissolution and precipitation reactions can be divided into five steps. Firstly, the reactants propagate from the aqueous phase (bulk fluid) to the rock surface and adsorb on the reactive sites. Then a chemical reaction is started including the breakup and the creation of bonds. As a next step, desorption of the reaction products and finally a propagation of these products from the rock surface into the aqueous phase can be observed. Compared to the precipitation rates, the dissolution rates are independent from the mineral saturation status [140].

The type of alkali lye tremendously influences the reactivity with the reservoir rock minerals. Especially when minerals/rocks are exposed to alkali solutions with a pH over 10, some of the rock-forming and soil-forming minerals become unstable and start to dissolve. Precipitations depend on the type and concentration of the mineral found within the rock [141]. Especially, the use of Na_2CO_3 is more favourable compared to NaOH, due to its buffer capacity (no pH changes will arise). Furthermore, the interaction of sodium carbonate with sandstone is less severe [10]. Bertaux and Lemanczyk (1987) investigated the interaction of sodium hydroxide on sandstone reservoirs and figured out that the interaction occurs with clay minerals, specifically with kaolinite (migration) and montmorillonite (swelling) [142].

Silicate minerals dissolve into silicate and aluminate ions when they get in contact with alkali solutions and as a consequence of that the ion concentration increases in the aqueous solution. For example the amount OH^- ions increases through the alkali injection, CO_3^{2-} ions increase through the conversion of HCO_3^- into CO_3^{2-} and also the number of SiO_3^{2-} ions rise because of the alkali interaction with the formation material [137, 138].

When alkali lyes interact with hardness ions from the flooding water (divalent cations e.g. Ca^{2+} and Mg^{2+}), precipitations are generated. These precipitations can damage the well equipment (precipitation and deposition) and cause formation damage at the near-wellbore region and in the tubing, resulting in injectivity losses. Adversely, strong alkalis like NaOH, have a higher reactivity with the reservoir rock, resulting in a decline of the permeability and leading to higher alkali consumptions. Besides, extremely high water cuts deteriorate the emulsion severity [143, 79].

In the upcoming subchapters the interaction of some predominant minerals with caustic solutions are described.

5.1.1 Quartz

Texturally mature sandstones consist mostly of quartz (present in crystalline form). Nevertheless, silica can also be available in amorphous form at a lower reservoir temperature and in texturally immature sediments [138]. The dissolution of quartz represents a simple example of the mineral-solution equilibrium (**Eq. 30**). Basically, the dissolution of quartz is driven by pH value, reaction time as well as temperature [144].

Henderson *et al.* (1970) published, that the solubility of quartz is strongly pH value dependent. For example, an increase of the pH value leads to an increase of the quartz dissolution [145]. **Eq. 30** is valid for pH values below 9 and **Eq. 31** as well as **Eq. 32** for higher pH values, whereby H_4SiO_4 dissociates into $H_3SiO_4^-$ and further into $H_2SiO_4^{2-}$. Nevertheless, the overall concentration of dissolved silica or amorphous silica strongly increases at higher pH values [146].

$$SiO_{2\,(quartz)} + 2H_2O = H_4SiO_{4\,(aq.)} \quad \textbf{(30)}$$

$$H_4SiO_4 = H_3SiO_4^- + H^+ \quad \textbf{(31)}$$

$$H_3SiO_4^- = H_2SiO_4^{2-} + H^+ \quad \textbf{(32)}$$

The dependency of the quartz dissolution and the temperature is shown for NaOH and Na_2CO_3 in **Figure 5-1** over time. An increase of the temperature results in an increase of the dissolved silica content. The dissolution process is less severe with Na_2CO_3 (**Figure 5-1**, **B**) than with NaOH (**Figure 5-1**, **A**). Temperature as well as pH massively influences the reactivity of carbonate and silicate minerals [147].

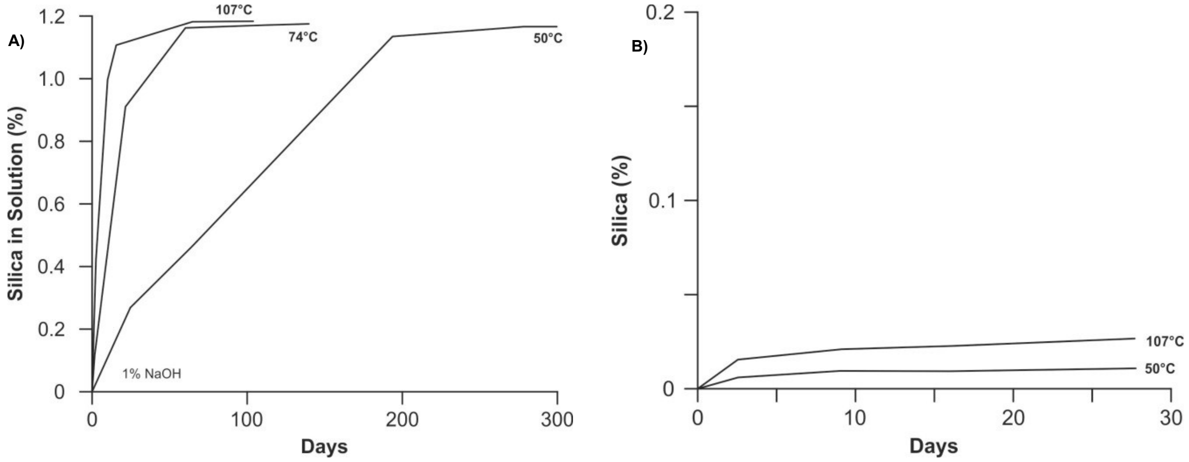


Figure 5-1: Dissolution of quartz with 1% NaOH solution over time (A) and 2.65% Na_2CO_3 (B) solution (After [147]).

Intensive investigations about the interaction of silica with hydroxides were conducted according to the literature. The dissolution of quartz minerals in sodium hydroxide environment (**Eq. 33**) results in the formation of monomeric silica ($Si(OH)_3O^-Na^+$) [148]. Krumrine and Falcone (1988) stated that there is a limit of the increase of SiO_2 in the solution as well as in the decrease of the pH value. Consequently, the quartz equilibrium ratio is approximately 2 ($SiO_2:Na_2O$) [149].

$$\mathrm{SiO_2 + NaOH + H_2O \rightarrow Si(OH)_3O^-Na^+} \qquad \textbf{(33)}$$

The dissolution rate of amorphous silica (**Figure 5-2**, **A**) is higher than of quartz (**Figure 5-2**, **B**) and precipitates first. The concentration of the silicon value is expressed on the y-axis and the pOH on the x-axis [150].

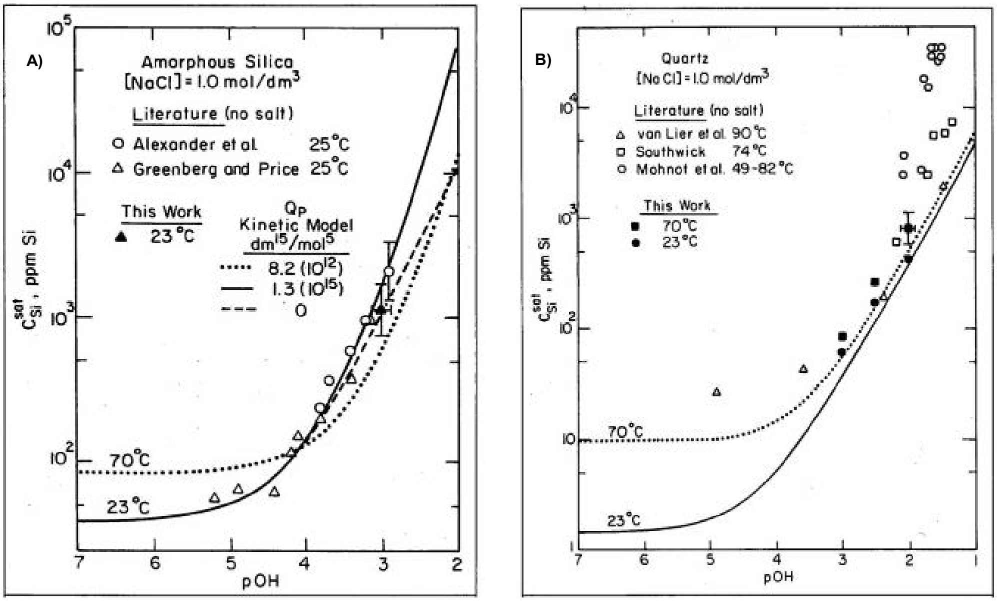


Figure 5-2: Solubility of amorphous silica (A) and quartz (B) in alkaline environment [150].

5.1.2 Calcite

Mohnot and Bae (1989) published, that the alkalinity loss for calcite is so low, that it can be neglected even though in strong basic NaOH solutions. In their trials, no alterations could be observed, even when the minerals were exposed at high temperatures (>80°C) in a 5 wt% NaOH solution for over 8 weeks [151]. According to Mohnot and Bae (1989) even pure calcite minerals do not react with high alkali quantities. Especially in carbonate reservoirs, the impurities of gypsum and anhydrite are responsible for possible alkalinity losses [138]. **Figure 5-3** displays the reaction kinetics of calcite, gypsum and dolomite interaction with 5 wt% NaOH lye.

Choquette *et al.* (1991) figured out in their trials, that already after 28 days in 1 N NaOH solution the calcite crystals showed a strong corroded surface. The experiments were conducted at 23°C [141].

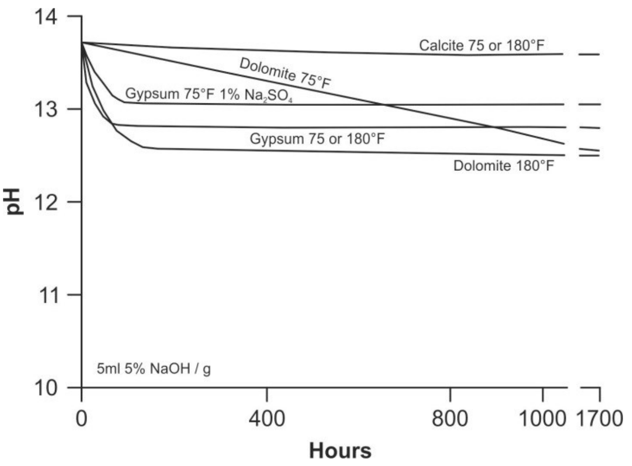


Figure 5-3: Reaction kinetics of NaOH with calcite, gypsum and dolomite over time at room temperature and at 82°C (After [151]).

5.1.3 Dolomite

The occurring alkalinity loss of dolomite ($CaMg(CO_3)_2$) is mainly driven through dissolution and hydroxide precipitations. The dolomite interaction could be observed especially in high alkaline environment (pH>13). As a result dolomite starts to become unstable in solution and breaks into calcite ($CaCO_3$) and brucite ($Mg(OH)_2$). Especially, a long exposure (~265 days) in a 1 N NaOH solution (at a pH of 14) at 23°C showed strong alterations. As a result, calcite and brucite crystals could be observed on the dolomite surface after 28 days interaction time [151].

5.1.4 Feldspar

Feldspars (rock-forming tectosilicates) are, compared to other minerals, less reactive and can be divided into following endmembers: potassium feldspar ($KAlSi_3O_8$) and plagioclase, which can be further subdivided into albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_2O_8$) [152]. Choquette *et al.* (1991) published, that significant amounts of silica were released from feldspar in contact with alkaline solutions [141]. In comparison, Mohnot and Bae (1989) figured out, that the alkalinity loss is relatively low in high alkaline environment. The experiments were conducted at 82°C with a 5 wt% NaOH solution [151].

5.1.5 Clay Minerals

Clay minerals are so called hydrous aluminium phyllosilicates and can be subdivided into kaolin, smectite, illite and chlorite groups [138]. The alkalinity-loss mechanisms of montmorillonite, which belong to smectite and illite clay types, are cation exchange, silica dissolution and the formation of new minerals (**Figure 5-4**). The alkalinity loss of kaolinite (kaolin group) is increased at high temperatures (>80°C) and strong alkali concentrations (5 wt% NaOH). Kaolinites (bilayer structure) have a low cation exchange capacity, compared to montmorillonite and illite, which have a tri-layer structure. The high cation exchange of this two clay types results in high silica and low aluminium concentrations [153].

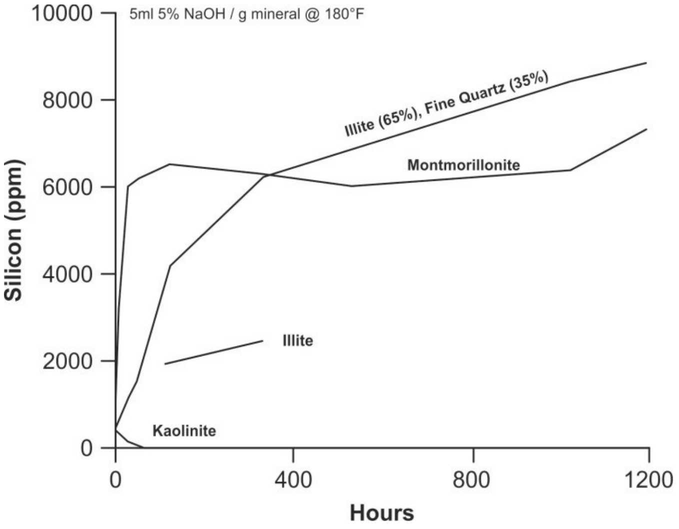


Figure 5-4: Interaction of NaOH with clay minerals (After [151]).

When solid kaolinite, which is the most reactive silicate mineral, interacts with NaOH, it results in a release of silicate and aluminate ions (**Eq. 34**). The alkalinity loss was the greatest with kaolinite at 82°C. The interaction with the alkali lye is strongly temperature driven: the higher the temperature, the faster the reaction [138, 154].

$$(\mathrm{Al_2O_3})_{1/2}(\mathrm{SiO_2})(\mathrm{H_2O}) + 2\,\mathrm{OH^-} + \frac{3}{2}\,\mathrm{H_2O} \leftrightarrow \mathrm{H_3SiO_4^-} + \mathrm{Al\,(OH)_4^-} \qquad \textbf{(34)}$$

According to Thornton (1988), new minerals (zeolites) are formed, when high caustic solutions interact with kaolinites. Precipitations of aluminosilicate minerals are faster compared to montmorillonite [154].

Results published by Mohnot *et al.* (1987) showed, that montmorillonite consumed higher amounts of alkali lye at 49°C than kaolinite. The experiment was performed with a 1 wt% NaOH solution [138]. The alkalinity loss of chlorites is minor, even in high alkaline environment (5 wt% NaOH solution) at 82°C with an exposure time of 11 days [151].

Basically, sodium hydroxide does attack illites, which have a similar structure to montmorillonites. Only a minor amount of SiO_2 is removed by this alkali-mineral interaction [155]. **Figure 5-5** shows, that an immediate alkalinity loss occurred, because of the ion exchange mechanism and through dissolved silica. A further loss arose then through the mineral reaction [151].

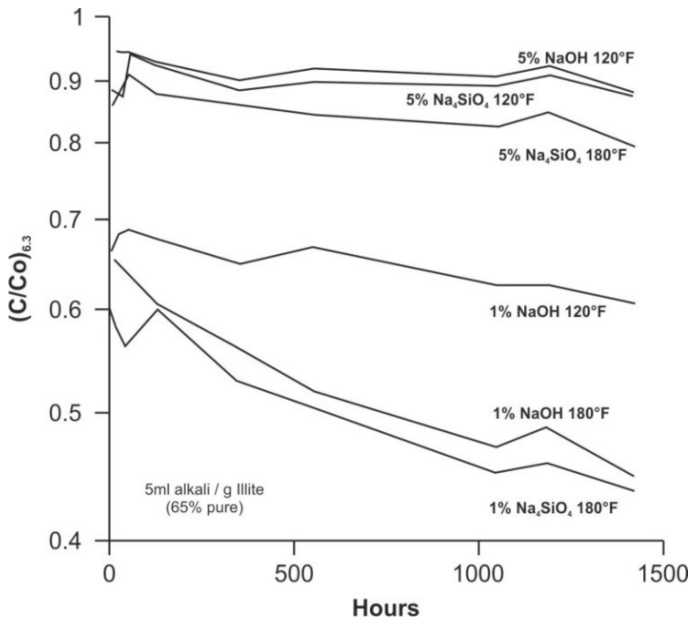


Figure 5-5: Interaction of sodium hydroxide with illite (After [151]).

5.2 Gravel Pack Dissolution

Gravel packs are used in general to avoid sanding issues. Especially, when dissolution of the gravel pack material appears, it leads to a transport of fines into the liner. As a consequence, high maintenance costs arise. A proper selection of the gravel pack type and investigations about the fluid compositions are mandatory beforehand [156]. Several different options can be used as gravel pack material. One option is sand, which consists of relatively high quartz contents (~95-98%). It results in a fast dissolution reaction at high temperature conditions (~177°C) and pH values over 10 [157].

Southwick (1985) published, that it comes to a loss of alkalinity, when silica dissolves from pure quartz (10-20% SiO_2). Nevertheless, the dissolution process stops, because the caustic solution equilibrates with quartz [158].

Athavaley and Sweet (1980) tested several different gravel pack material types such as sands (SiO_2), glass beads and coated sands (SiO_2) with chemical resistant materials like molybdenum, graphite or epoxy. Additional experiments were performed with garnet ($MgFe(SiO_4)_3$), abrasive silicate and carborundum (SiC, abrasive material). Their findings showed that the quartz dissolution is minor for strong caustic solutions at room temperatures (exposure for 7 days). It turned out, that the best results could be achieved with corundum (Al_2CO_3, lowest dissolution rate), followed by sintered bauxite (Al_2O_3). The other gravel pack materials, like bauxite and molybdenum sands, showed a good resistance to caustic solutions (life time of around 20 years). Anthracite (C), known for its chemical resistance, resulted in the formation of flakes and fines; thereof it should be avoided as gravel pack material [156].

5.3 Methods

5.3.1 Alkali Lye Preparation

The preparation of the alkali lyes follows the procedure explained in **Chapter 4.2.1**. Softened real water from the outlet WTP (8.TH) and the outlet hydrocyclones (16.TH) was used to reflect the field conditions. As alkali lyes NaOH, Na_2CO_3 and K_2CO_3 were examined. The concentrations are based on the outcome of the screening study (7,500 ppm and 10,000 ppm). The chemicals used in this study are listed in **Table 5-1**.

Table 5-1: Summary of used chemicals in the alkali-rock study with purity and manufacturer.

Chemical	Purity	Manufacturer
Dowex® Marathon^{TM} C resin, Na^+ form	N/A, strongly acidic, 20-50 mesh, for water softening	Sigma-Aldrich, St. Louis, US
Sodium hydroxide	97%, for resin regeneration & alkali lye	Merck, Darmstadt, Germany
Sodium carbonate	99.9%	Merck, Darmstadt, Germany
Potassium carbonate	99%	Merck, Darmstadt, Germany

5.3.2 Plug Preparation & Saturation

For the experiments, Berea and reservoir plugs from the 8.TH/ 16.TH were used. Homogenous Berea plugs were only used for the evaluation of the experimental setup. The reservoir plugs from the two horizons differed regarding their mineralogical composition.

The reservoir plugs were cleaned before and after the trial by Soxhlet extraction for around 24 hours. Thereby, residual oil and salt were removed. As solvent an azeotrope consisting of 87.4% chloroform and 12.6% methanol was used, to reach a constant boiling point temperature of 53.5°C. Afterwards the plugs were further analyzed through geological and microscopic evaluations.

Petro-physical measurements (porosity, permeability), geological analysis (thin section and x-ray diffraction, XRD) and microscopic evaluations (scanning electron microscope, SEM) were performed for all plugs before and after the experiment. The porosity measurement was based on helium expansion (Boyle-Mariotte Law) according to OMV internal working method (AA D FC 908). The permeability was analyzed at steady state conditions with a radial overburden pressure of 35 bars (according to OMV internal working method AA D FC 906). Out of the measurements the bulk and grain density can be calculated. In order to perform Scanning Electron Microscope (SEM) analysis the samples were broken into pieces and vapor coated with carbon. The sample was fixed to the sample tray and transferred into the instrument (LEO 1450EP SEM). An electron beam was focused on the sample and the composition characterized.

For the plug saturation the setup shown in **Figure 5-6** was applied. The plugs were first fixed in the core holder and then flooded with two different cases according to the OMV internal working method (AA D FC 907). The plugs were saturated with softened formation water (water-saturated plugs). Some plugs were further saturated with crude oil (oil-saturated plugs). The oil-saturated plugs were firstly flooded with softened formation water, then with crude oil and afterwards again flooded by softened water to adjust the residual oil content of the reservoir.

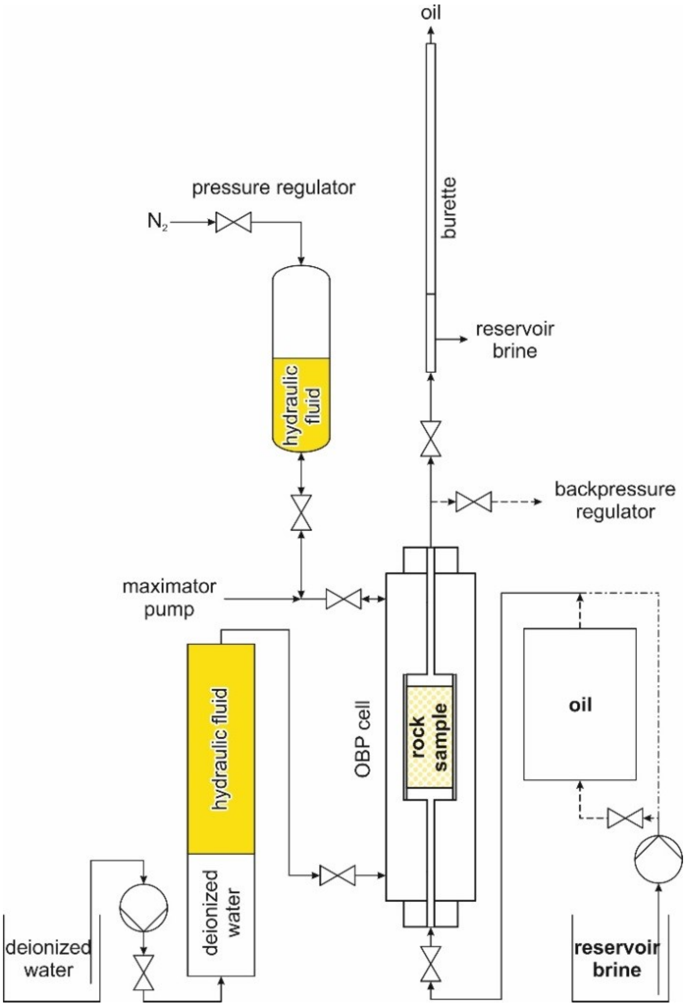


Figure 5-6: Experimental set-up used for plug saturation.

Dead crude oil from the producer well Bo 112 and softened water from the outlet hydrocyclone were used for the cores from the 16.TH. For the 8.TH dead crude oil from the producer well S 85 and softened water from the outlet WTP were applied (**Table 5-2**).

Table 5-2: Description of the used crude oils and characteristic of the used softened water for plug saturation.

Production Horizon	Producer Well	Crude Characteristic	TAN (mg KOH/ g oil sample)	API (°)
16.TH	Bo 112	Nonreactive (dead oil)	1.53	23.29
8.TH	S 85	Nonreactive (dead oil)	1.70	19.22

5.3.3 Autoclave Set-Up

Pressurized vessels, so called autoclaves, manufactured by Berghof, (used as batch reactors) were implemented in the laboratory. Ongoing alkali-rock interactions can be evaluated with this set-up. The Teflon reactors can be pressurized up to maximum 8 bars with a filling volume of 0.28 liters and a maximum possible operation temperature of 100°C. Valves, lines and connections from Swagelok were installed. **Figure 5-7** illustrates the applied set-up. In average six autoclaves were operated in parallel: three at 60°C to simulate the reservoir temperature of the 16.TH and the plugs from the 8.TH were exposed to 49°C.

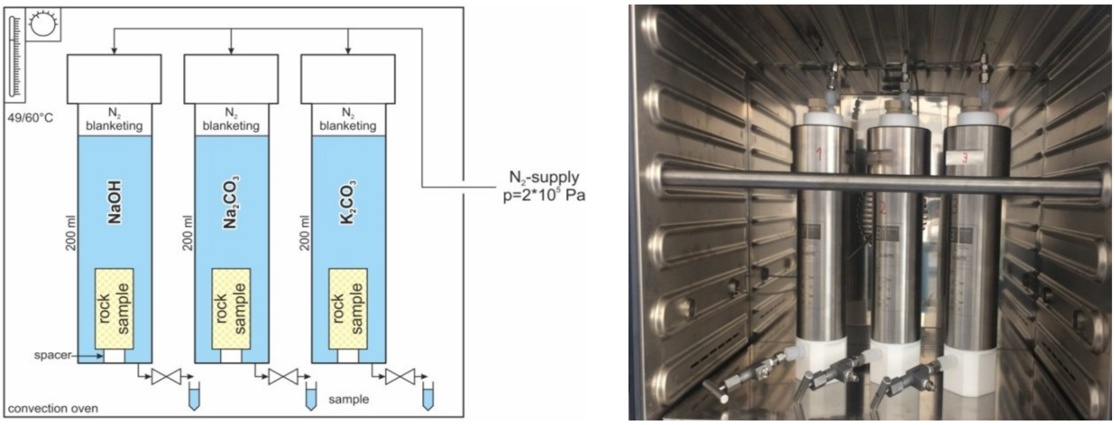


Figure 5-7: Static autoclave set-up used for the evaluation of the alkali-rock-interactions.

Following filling procedure was used for all batch reactors: firstly, every autoclave was opened and equipped with a Teflon spacer, to avoid plugging of the sampling point. Then the rock sample was slowly added with a tweezer and the reactor filled with the prepared alkali lye, up to 0.2 liters. Afterwards the autoclaves were closed, positioned into the convection oven and connected to the gas supply with flow lines. A constant inert gas cap (e.g. nitrogen) of 2bar was set over each fluid level to avoid any oxygen contact (anaerobic conditions). In the end, the temperature of the oven was adjusted (49°C /60°C) and the experiment started. In periodic time intervals samples (5-10 ml) were taken at the sampling point and further analyzed according its ion composition. Every sampling point was rinsed before and after sampling with demineralized water to avoid any errors (e.g. precipitations). At the end of the test, the oven was switched off, the gas connection stopped and the reactors opened. The plugs were then slowly extracted with a tweezer and the autoclaves cleaned with demineralized water for next usage.

For the evaluation of the gravel pack material (Carbolite/ Swarco® glass beads), a flow reactor (**Figure 5-8**, **A**) was used. Pumps from Shimazu (model: LC-20 AD) and valves, lines as well as connections from Swagelok were installed. The gravel pack material was filled into small plastic bags, made of polymer fibers (**Figure 5-8**, **B**). Then the bags were closed and placed in the autoclaves at the top of the Teflon spacer by using a tweezer. The alkali lye was added and the reactor closed. The reactors were then placed in the convection oven, the temperature was set at 60°C and the experiment started. In this set-up, the top of the autoclave was connected to a one liter tank, filled with the alkali lye (NaOH, Na_2CO_3, and K_2CO_3). The alkali solution was pumped through the autoclave, to flush the gravel pack material with lye, at a flow rate of 5 ml/min. In periodic time intervals the alkali tanks were sampled (5-10 ml) and the aqueous phase filtered through a 0.45 µm Millex syringe filter unit and further analyzed regarding its composition.

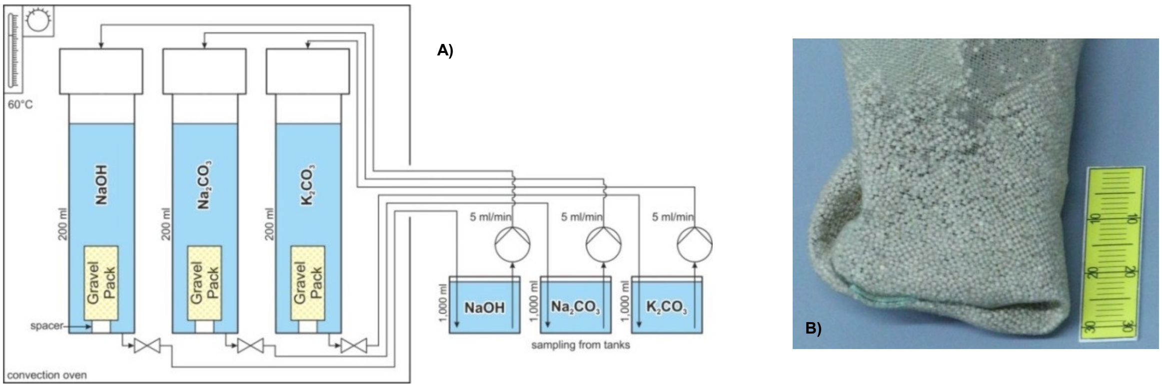


Figure 5-8: Flow reactor set-up used for the evaluation of the gravel pack material (A) and plastic bags to fill with gravel pack material (B).

5.3.4 Qualitative Ion Analysis

As already mentioned, the sampling of every autoclave took place in periodic time intervals (5-10 ml sample volume). The pH value was directly measured after sampling with pH indicator strips (Merck, pH range 7.5-14 and pH range 11.0-13.0). To measure only the dissolved ions of the aqueous phase, the sample was filtered into a plastic vial with a 0.45 µm PTFE membrane filter (Millex syringe filter unit, Ø= 13 mm). Afterwards, the alkalinity (m-value) was determined and the dissolved ions analyzed through ion chromatography (IC) and ICP-OES (inductively coupled plasma emission spectroscopy). Sodium, potassium, magnesium and calcium ions were determined by IC and iron, aluminium and silicon ions by ICP-OES.

For the ICP-OES analysis of the samples containing sodium-based alkalis (NaOH, Na_2CO_3), 1.25 ml of the filtered aqueous phase were diluted with 0.25 ml concentrated HNO_3 (65%) and demineralized water to 50 ml (equal to 1:40 dilution). For the preparation of samples containing potassium (K_2CO_3) 2 ml were diluted with 0.25 ml concentrated HNO_3 (65%) and demineralized water to 50 ml (equal to 1:25 dilution). As measuring method, the in-house formation water method was chosen.

For the IC analysis, the samples containing sodium (NaOH, Na_2CO_3) the ICP-OES samples were directly diluted 1:1 with demineralized water in an IC vial (1:80 dilution). 1.25 ml of the potassium-based ICP-OES samples (K_2CO_3) were diluted with 5 ml demineralized water and directly mixed in the IC vial (1:100 dilutions). As measuring method the in-house formation water method was chosen.

The remaining non-diluted aqueous sample has been used for the volumetric (titration) analysis of the alkalinity (m-value) according to in-house Titrino Method DET 2-1.

5.4 Results

A series of static alkali-rock interaction experiments were performed, using Berea and reservoir plugs as core material and real softened water for the preparation of the alkali solutions. Other conditions such as temperature (49°C/60°C) and pressure of the nitrogen gas cap (2bar) were kept constant during the trials. For the gravel pack material Carbolite beads (grain size: 20/40 mesh) and Swarco® glass beads were studied. The beads were permanently flooded with alkali lye. A summary of the test series can be found in **Table 5-3**.

Table 5-3: Summary of the alkali-rock test series performed in batch reactors.

Test Series	Stratigraphy	Plug Description/ Initial Condition	Experiment Explanation	Test time	Temp. (°C)	Alkali Conc. (ppm)
#T0	-	no plug	leakage test of the autoclaves	7 days	60	10,000
#T1	-	Berea plug (dry)	baseline (static)	7 days	49/60	10,000
#T2	8.TH/ 16.TH	reservoir plug (dry)	preliminary (short-term) study (static)	30 days	49/60	10,000
#T3	8.TH/ 16.TH	reservoir plug (water-saturated)	long-term study (static)	90 days	49/60	7,500
#T4	8.TH/ 16.TH	reservoir plug (oil-saturated)	long-term study (static)	90 days	60	7,500
#T5	-	gravel pack material (Carbolite beads)	permanent flooded with alkali lye	30 days	60	7,500
#T6	-	gravel pack material (Swarco® glass beads)	permanent flooded with alkali lye	30 days	60	7,500

Geochemical reaction modelling was performed, in order to find out how much time it takes to reach a steady-state in the batch reactor system. The kinetics of mineral dissolution and precipitation was investigated more detailed, using rate laws. The used plugs for the 8.TH and 16.TH experiments are summarized in **Table 5-4**.

At the beginning of this study, it was planned to measure the porosity and permeability of all plugs initially and after the exposure, to see ongoing alterations. Due to the fact, that in some trials the plugs disintegrated, it was not possible to measure these values after the experiments. Therefore, no porosity and permeability results are presented.

Table 5-4: Summary of the reservoir plug characteristic used for the alkali-rock study.

Test Series	Stratigraphic Horizon	Producer Well	Depth (m)	Plug Number	Plug Length (cm)	Initial Weight (g)	Alkali Lye
#T2	8.TH	Bo 125	1,292.12	14a	5.1	43.72	NaOH
#T2	8.TH	Bo 125	1,292.12	14b	5.1	43.58	Na_2CO_3
#T2	8.TH	Bo 125	1,292.22	15a	5.1	43.93	K_2CO_3
#T3	8.TH	S 442	1,292.35	18	7	44.27	NaOH
#T3	8.TH	S 442	1,285.33	14	7	44.47	Na_2CO_3
#T3	8.TH	S 442	1,292.03	17	7	43.73	K_2CO_3
#T4	8.TH	S 442	1,291.28	1	7	46.09	NaOH
#T4	8.TH	S 442	1,291.72	2	7	43.58	Na_2CO_3
#T4	8.TH	Bo 125	1,292.22	3	7	44.05	K_2CO_3
#T2	16.TH	Bo 112	1,626.68	11a	7	41.38	NaOH
#T2	16.TH	Bo 112	1,626.97	11b	7	42.90	Na_2CO_3
#T2	16.TH	Bo 112	1,626.97	10a	7	41.55	K_2CO_3
#T3	16.TH	Bo 78	1,651.97	3	7	41.72	NaOH
#T3	16.TH	Bo 78	1,651.97	2	7	42.81	Na_2CO_3
#T3	16.TH	Bo 112	1,619.26	4	7	42.16	K_2CO_3
#T4	16.TH	Bo 112	1,626.05	V3	7	42.11	NaOH
#T4	16.TH	Bo 78	1,654.40	V2	7	37.52	Na_2CO_3
#T4	16.TH	Bo 78	1,654.45	V5	7	38.65	K_2CO_3

5.4.1 16th Tortonian Horizon

The reservoir plugs of the 16.TH consist mainly of quartz with over 80% and smaller amounts of calcite with 6% and potassium feldspar of approximately 4%. The other minerals are present in smaller quantities such as plagioclase, dolomite, ankerite and clay minerals (**Figure 5-9**).

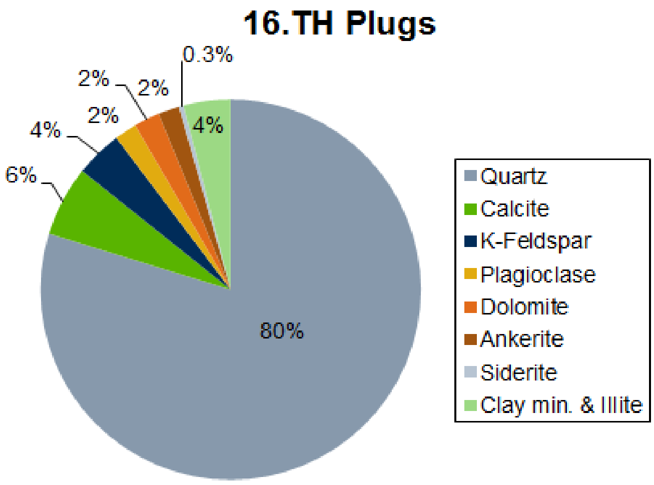


Figure 5-9: Mineralogical composition of the reservoir plugs from the 16.TH.

Trial 1: Short-term Study with Berea Plugs:

In the first trial Berea plugs were used as model plugs because of their uniform material properties. Thereby, the method and the in-house developed setup were evaluated. The plugs were exposed to the alkali lyes (a´10,000 ppm) for 7 days at 60°C (16.TH reservoir temperature). Samples of the aqueous phase were taken on a daily basis. This model plugs did not show a strong interaction with the alkali lye. The Berea plugs, exposed to the carbonate-based alkalis, showed similar results. The silicon value of NaOH tremendously increased, from 10.60 mg/l initially to 123 mg/l, at the end of the trial. Besides, the aluminium value rose from 1.38 mg/l to approximately 6.77 mg/l. The silicon values of Na_2CO_3 and K_2CO_3 did not show any alteration and stayed almost constant over time. The measured values of aluminium, calcium, iron and magnesium declined from the initially measured values over time for the carbonate-based alkali lyes (**Table 5-5**).

Table 5-5: Summary of the measured elements of the Berea plugs initially and after the trial (7 days) exposed at 60°C.

Measured Element	Initial			After the trial		
	NaOH	Na_2CO_3	K_2CO_3	NaOH	Na_2CO_3	K_2CO_3
Aluminium (mg/l)	1.38	0.90	0.56	6.77	0.18	0.18
Calcium (mg/l)	12.90	11.40	14.80	1.70	1.84	2.09
Iron (mg/l)	1.30	0.10	0.32	0.02	0.02	0.02
Magnesium (mg/l)	0.99	12.20	11.80	0.50	1.01	0.71
Silicon (mg/l)	10.60	10.80	10.80	123.00	1.91	1.73

Figure 5-10 shows the results of the dissolved ions in the aqueous phase for Berea plugs. The silicon value of the plug exposed to NaOH increased steadily, whereas for the other two alkalis, no increase could be observed.

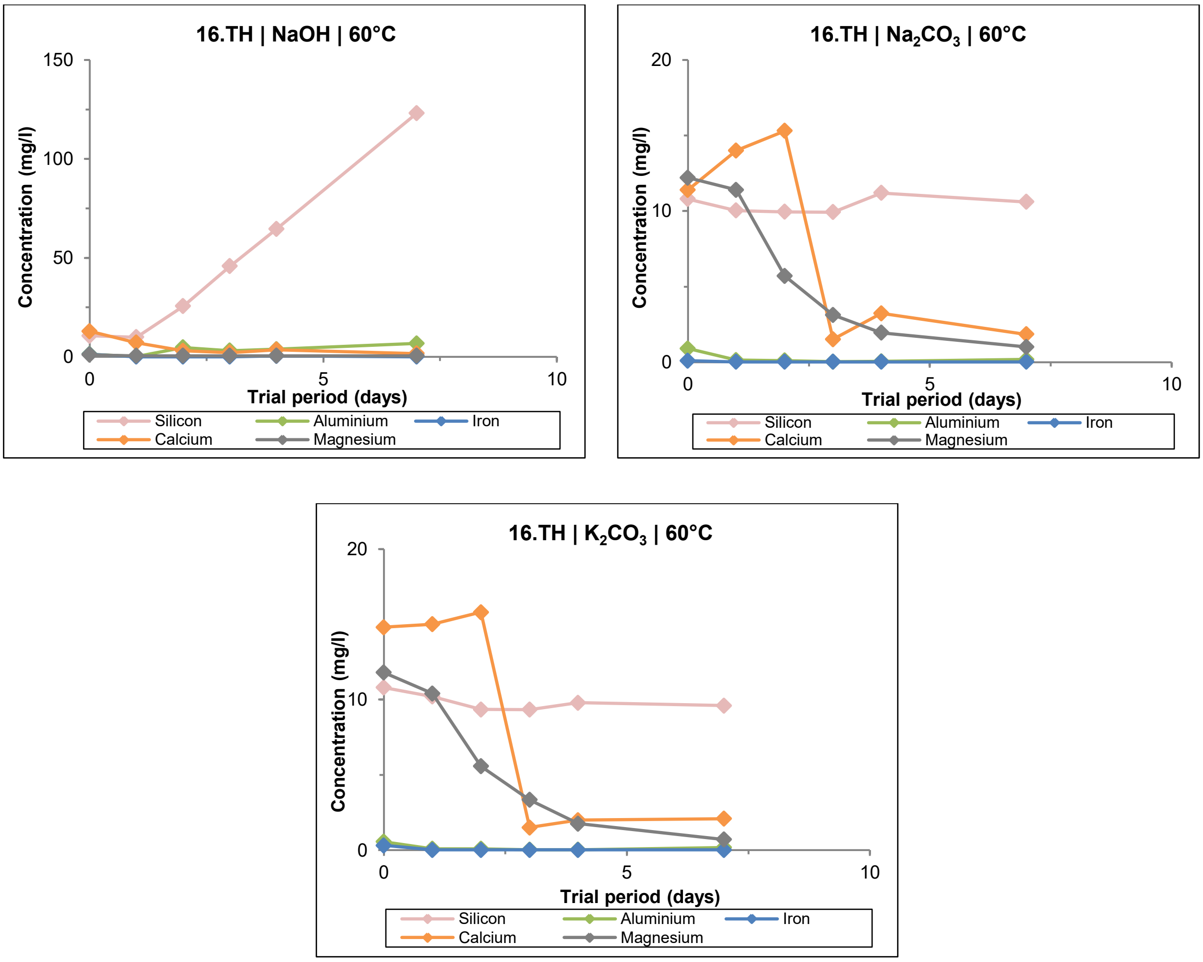
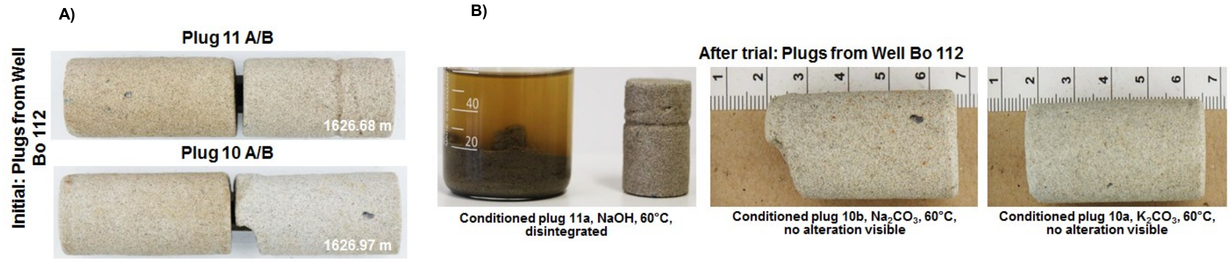


Figure 5-10: Measured dissolved ions of Berea plugs with IC & ICP-OES exposed at 60°C for 7 days.

Trial 2: Short-term Study with 16.TH Reservoir Plugs:

For this study plugs from the well Bo 112 (1,626.68 – 1,626.97 m) were used and the tested alkali lye concentration was 10,000 ppm. The plug 11a was exposed to NaOH, plug 10b to Na_2CO_3 and plug 10a to K_2CO_3 at 60°C reservoir temperature. The plugs were added to the batch reactors in dry condition. The plug 11b was used as reference plug (**Figure 5-11**, **A**). The plugs were exposed in the batch reactors for 30 days. The plug conditioned with NaOH was completely disintegrated after the trial, whereas the plugs exposed to Na_2CO_3 or K_2CO_3 did not show any alteration (**Figure 5-11**, **B**).



Conditioned plug 11a, NaOH, 60°C, disintegrated

Conditioned plug 10b, Na_2CO_3, 60°C, no alteration visible

Conditioned plug 10a, K_2CO_3, 60°C, no alteration visible

Figure 5-11: Reservoir plugs from the 16.TH used for the short-term study: initial (A) and after the trial (B).

The strongest alkali-rock interaction could be observed with NaOH (**Figure 5-11**, **A**). The silicon value increased from 10.5 mg/l initially to approximately 44 mg/l, whereas for the other two alkalis the silicon value decreased from 11 mg/l to around 1 mg/l. All other elements such as aluminium, calcium, iron and magnesium did not show a massive change to the originally measured values (**Table 5-6**).

Table 5-6: Summary of the measured elements of the 16.TH reservoir plugs initially and after the trial (30 days).

Measured Element	Initial			After the trial		
	NaOH	Na_2CO_3	K_2CO_3	NaOH	Na_2CO_3	K_2CO_3
Aluminium (mg/l)	1.00	1.00	1.00	0.95	0.08	0.07
Calcium (mg/l)	12.10	11.60	29.10	2.59	1.55	2.00
Iron (mg/l)	0.10	0.10	0.10	0.10	0.02	0.02
Magnesium (mg/l)	0.50	13.10	14.50	0.50	0.50	0.50
Silicon (mg/l)	10.50	10.80	10.90	43.98	0.98	1.03

A strong increase of the silicon value was observed by the use of NaOH, no plateau was reached after 30 days interaction time. The increase is attributable to the dissolution of quartz. The mineralogy in the 16.TH indicates concentrations of quartz of over 80% and a minor clay amount of around 4%. Some measuring errors of the calcium values from the aqueous phase containing Na_2CO_3 could be observed. No interaction could be seen by the use of K_2CO_3 (**Figure 5-12**).

In order to characterize ongoing alkali-rock interactions the reservoir plugs were examined under the scanning electron microscope before and after the trials (**Figure 5-13**). Compared to NaOH, which showed a strong dissolution of the quartz grains, samples which were in contact with Na_2CO_3 displayed only a weak dissolution. The silica dissolution altered the grain surface. Zeolite precipitations could be realized on the quartz grains of the plug exposed to Na_2CO_3. By the use of K_2CO_3, precipitations in form of silica crusts were formed on the quartz grain surface.

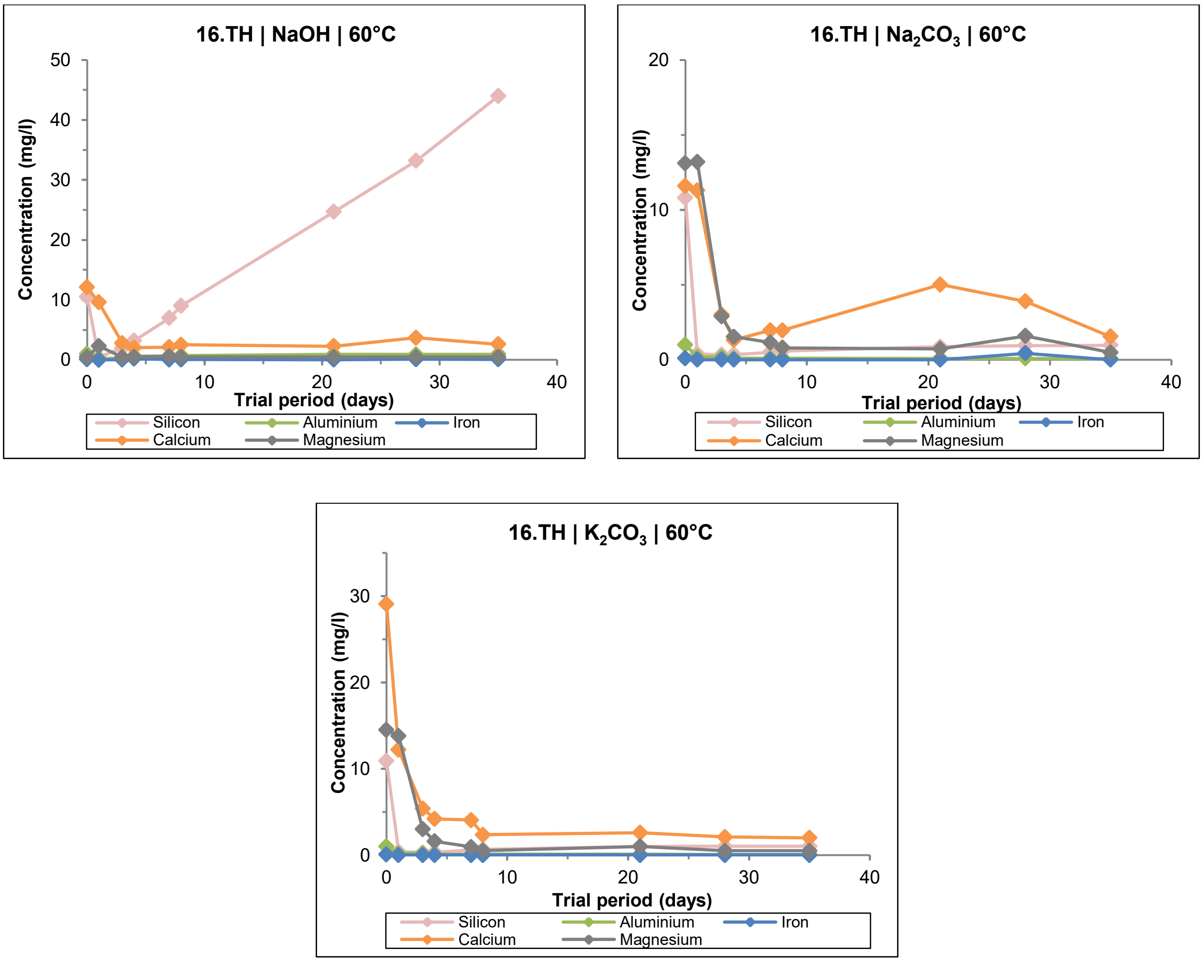


Figure 5-12: Measured dissolved ions of 16.TH reservoir plugs with IC & ICP-OES exposed at 60°C for 30 days.

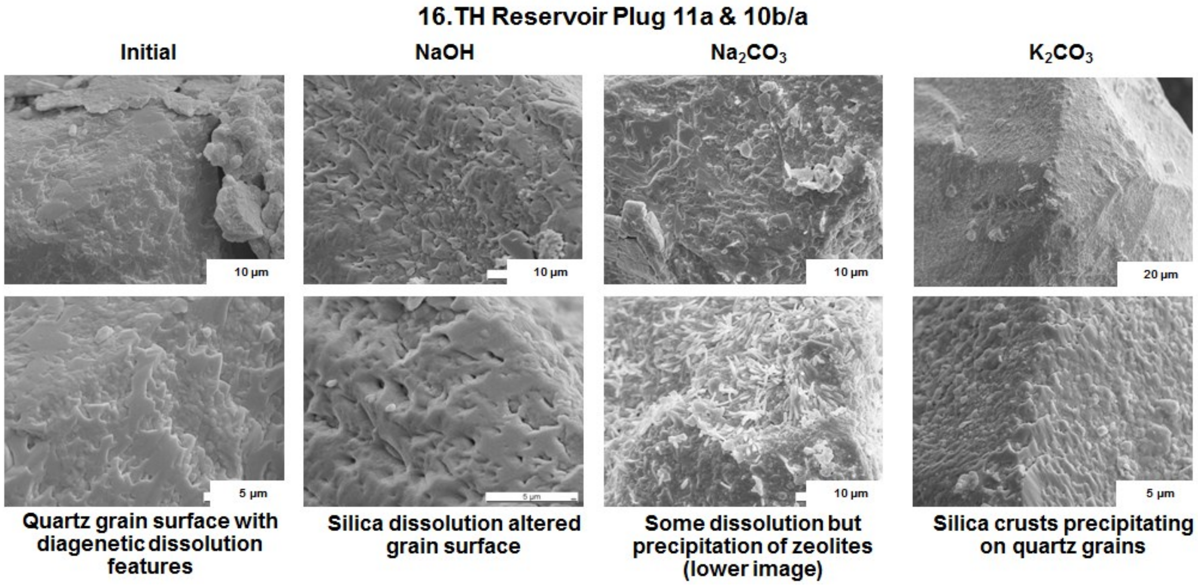
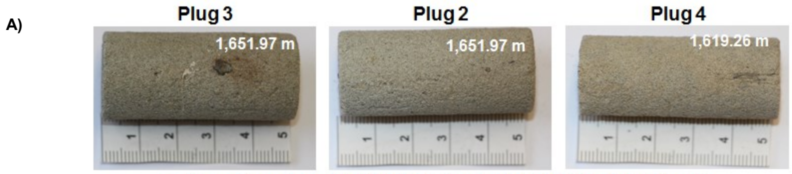


Figure 5-13: SEM micrographs of the 16.TH reservoir plugs used for the short-term study: initial and after the trial (30 days).

Trial 3: Long-term Study with 16.TH Water-saturated Reservoir Plugs:

The plugs were taken from the well Bo 78 (1,651.97 m) and from the well Bo 112 (1,619.26 m). Plug 2 and plug 3 were taken from the well Bo 78 and plug 4 from the well Bo 112. Plug 3 was exposed to NaOH, plug 2 to Na_2CO_3 and plug 4 to K_2CO_3. Plug 1 from Bo 112 was used as reference plug. The plugs were saturated with softened water from the outlet hydrocyclone (**Figure 5-14**, **A**). The water-saturated plugs were then exposed to the alkali solutions (a´7,500 ppm) for over 90 days at 60°C reservoir temperature.



Initial: Plugs from Well Bo78 (Plug 2/3) & Well Bo 112 (Plug 4)

After Trial: Plugs from Well Bo 78 & Bo 112

Conditioned plug 3, NaOH, 60°C no alteration visible **Conditioned plug 2, Na_2CO_3, 60°C no alteration visible** **Conditioned plug 4, K_2CO_3, 60°C no alteration visible**

Figure 5-14: Water-saturated reservoir plugs from the 16.TH: initial (A) and after the trial (90 days, B).

All reservoir plugs were in good condition after the three months test time, no visible alterations could be observed (**Figure 5-14**, **B**). The plugs did not become more friable compared to the initial conditions. The water phase was colored light yellow after the trial and showed a low turbidity. No particles of the plugs got lost into the autoclave set-up.

Table 5-7: Summary of the measured elements of the 16.TH water-saturated plugs initially and after the trial.

Measured Element	**Initial**			**After the trial**		
	NaOH	**Na_2CO_3**	**K_2CO_3**	**NaOH**	**Na_2CO_3**	**K_2CO_3**
Aluminium (mg/l)	0.05	0.01	0.01	0.05	0.00	0.01
Calcium (mg/l)	8.34	8.37	8.69	<1.5	n.d.	n.d.
Iron (mg/l)	0.44	0.36	0.37	<0.05	0.01	0.01
Magnesium (mg/l)	11.24	11.20	7.75	n.d.	n.d.	n.d.
Silicon (mg/l)	10.20	10.20	10.50	>305.00	3.50	3.00

The exposure of the plug 3 in NaOH for 90 days increased the silicon value strongly, from 10.2 mg/l initially to over 305 mg/l. The value declined for the other two alkalis from around 10 mg/l to approximately 3 mg/l (**Figure 5-15**). A measuring error of the silicon value appeared after day 21 for NaOH and for Na_2CO_3 after day 77. Due to the fact that calcium and magnesium values could not be detected, the curve declines to zero for Na_2CO_3 and K_2CO_3 (highlighted in **Table 5-7** as not detected, n.d.). The silicon values for the carbonate-based alkalis declined after the first week and stayed below 6 mg/l over the entire test period (almost constant).

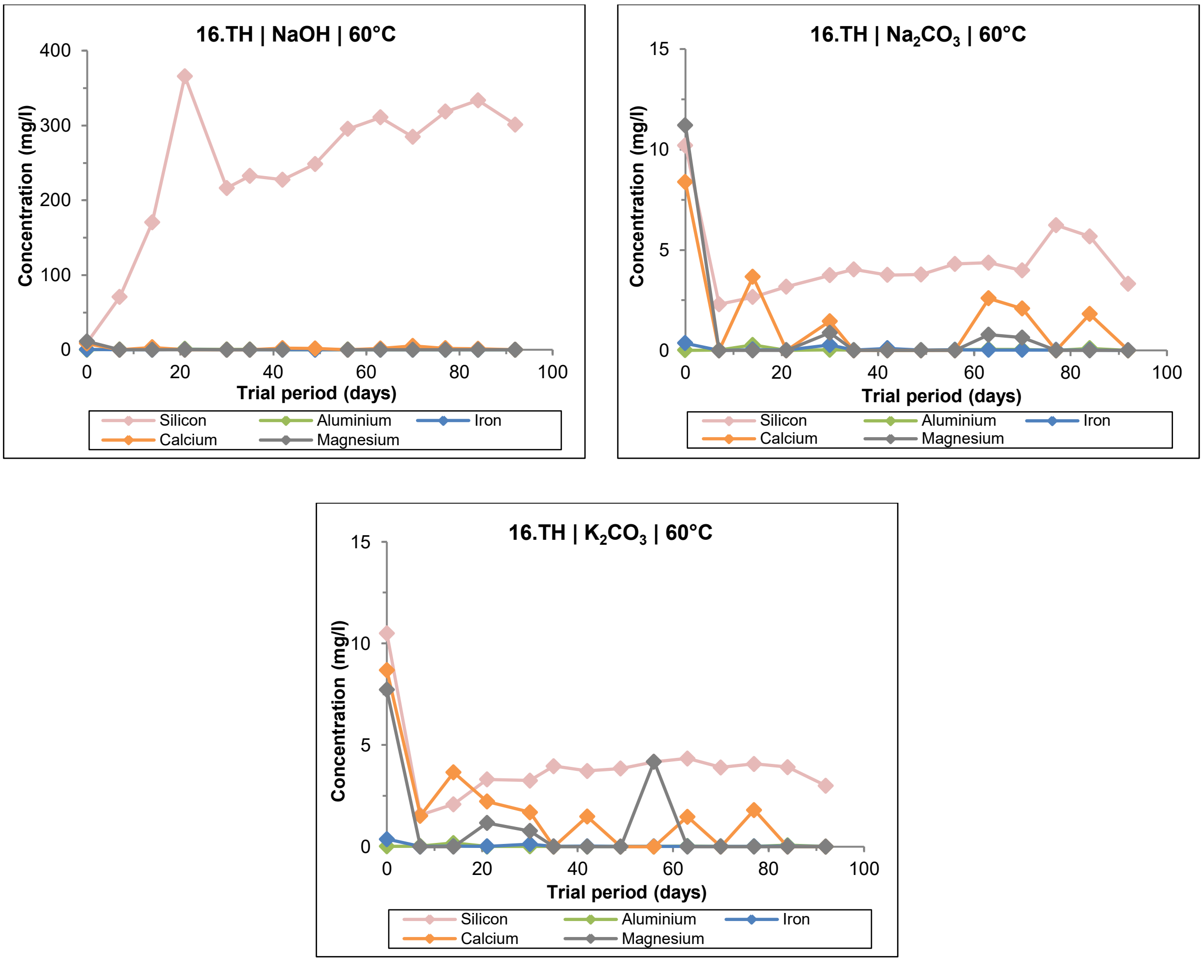


Figure 5-15: Measured dissolved ions of 16.TH water-saturated reservoir plugs with IC & ICP-OES (90 days).

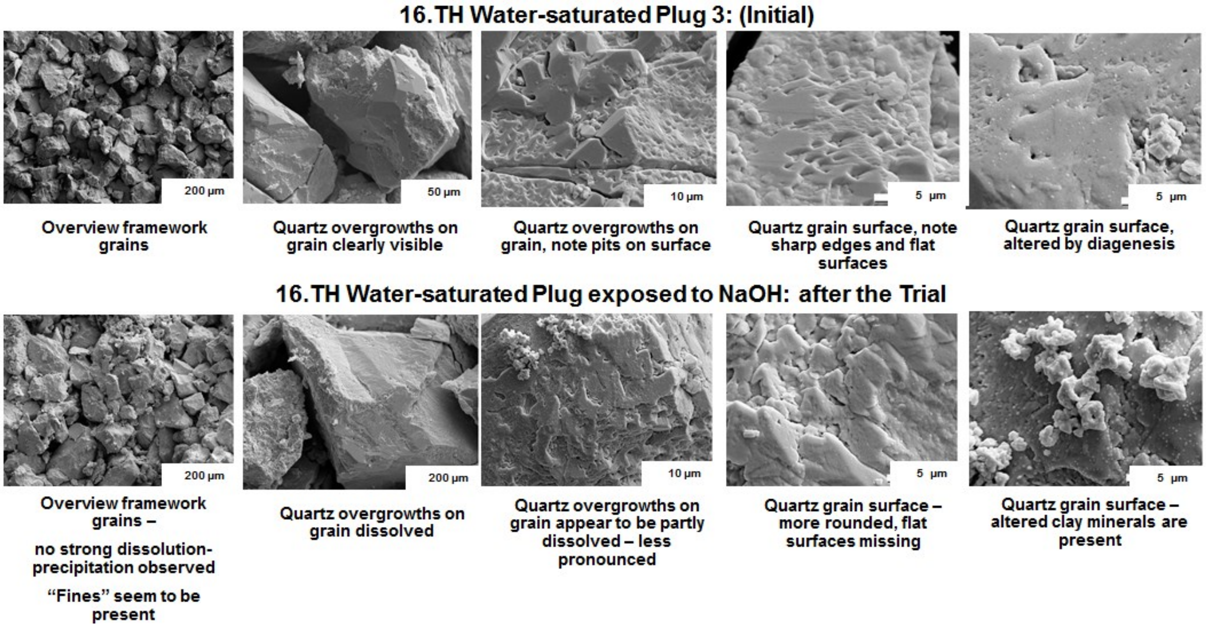


Figure 5-16 shows the SEM results of plug 3 initially and after the trial. The main interaction of NaOH appeared on the quartz grain surface (dissolution reaction). Alterations of the clay minerals could be observed.

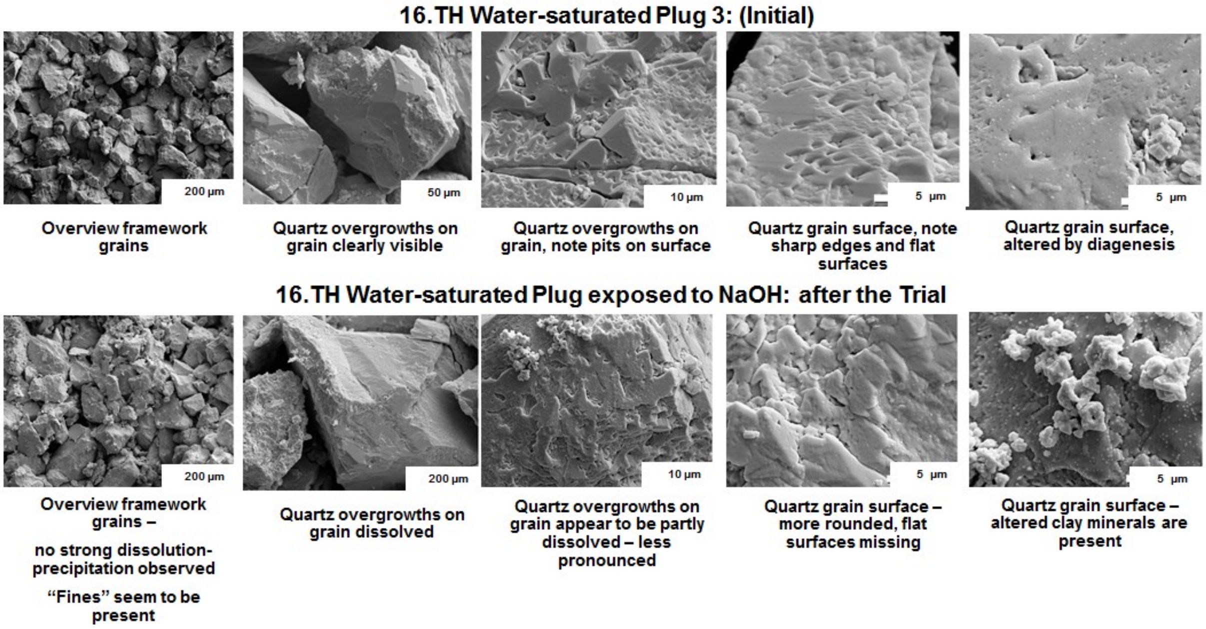
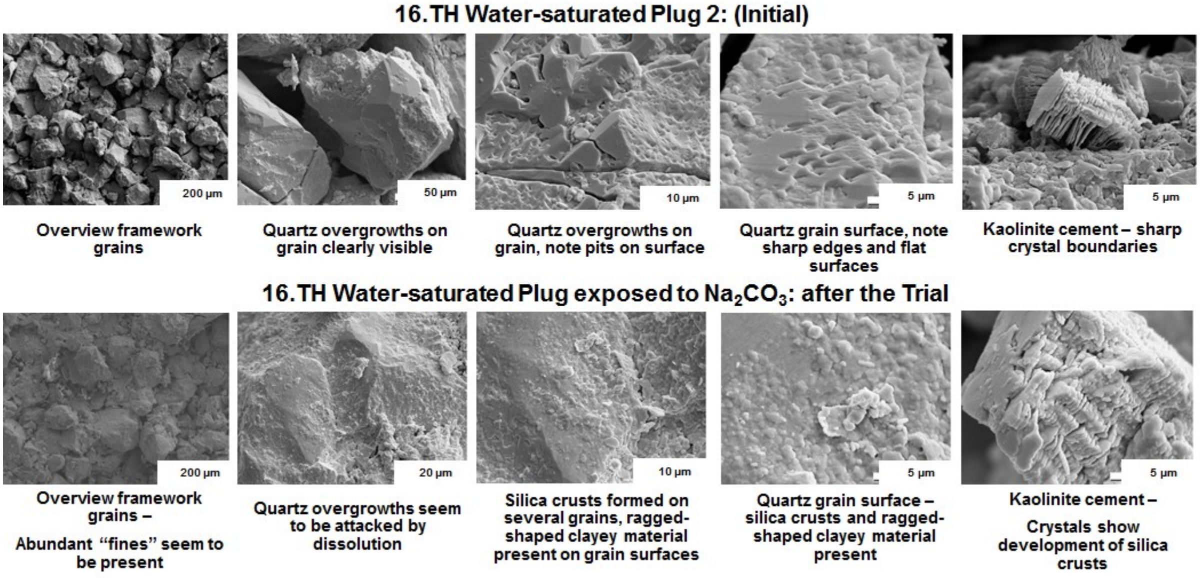


Figure 5-16: SEM micrographs of the 16.TH water-saturated reservoir plugs exposed to NaOH for 90 days.

Figure 5-17 represents the SEM results of the plug 2 exposed in Na_2CO_3. Interestingly, silica crusts were formed on kaolinite cement and in overall on the quartz grain surface.



Overview framework grains

Quartz overgrowths on grain clearly visible

Quartz overgrowths on grain, note pits on surface

Quartz grain surface, note sharp edges and flat surfaces

Kaolinite cement – sharp crystal boundaries

Overview framework grains – Abundant "fines" seem to be present

Quartz overgrowths seem to be attacked by dissolution

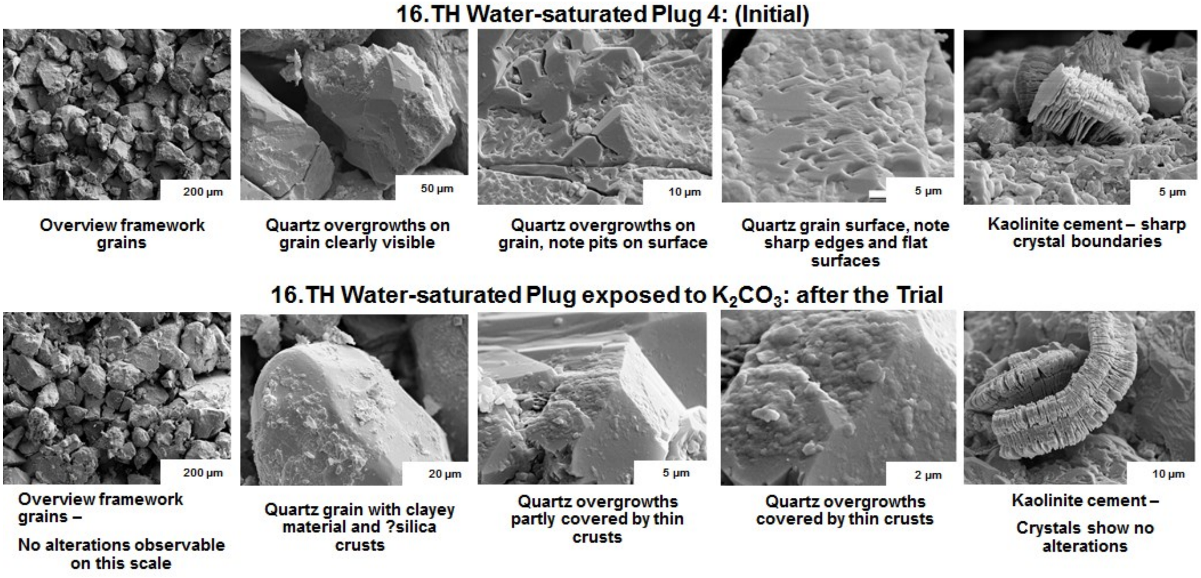
Silica crusts formed on several grains, ragged-shaped clayey material present on grain surfaces

Quartz grain surface – silica crusts and ragged-shaped clayey material present

Kaolinite cement – Crystals show development of silica crusts

Figure 5-17: SEM micrographs of the 16.TH water-saturated reservoir plugs exposed to Na_2CO_3 for 90 days.

In **Figure 5-18** the SEM results are presented for the reservoir plug 4 exposed to K_2CO_3. K_2CO_3 showed no alterations of the kaolinite cement compared to Na_2CO_3. Quartz overgrowths covered with thin crusts could be observed, but in a minor extent than with Na_2CO_3. Replacement of the clay coats by calcite-bearing minerals was observed.



Overview framework grains

Quartz overgrowths on grain clearly visible

Quartz overgrowths on grain, note pits on surface

Quartz grain surface, note sharp edges and flat surfaces

Kaolinite cement – sharp crystal boundaries

Overview framework grains – No alterations observable on this scale

Quartz grain with clayey material and ?silica crusts

Quartz overgrowths partly covered by thin crusts

Quartz overgrowths covered by thin crusts

Kaolinite cement – Crystals show no alterations

Figure 5-18: SEM micrographs of the 16.TH water-saturated reservoir plugs exposed to K_2CO_3 for 90 days.

Trial 4: Long-term Study with 16.TH Oil-saturated Reservoir Plugs:

In this trial, the plugs were flooded before the start with water and crude oil, in order to evaluate the effect of alkali lyes on oil-saturated plugs and to compare the results with trial 3 (water-saturated plugs). The current residual oil saturation in the 16.TH is approximately 30%. The reservoir plugs were therefore initially saturated with softened water; afterwards flooded with dead Bo 112 oil and again with softened water from the outlet hydrocyclones. The plugs were afterwards exposed to the alkali lyes (a´ 7,500 ppm) for around 90 days. NaOH caused too strong alterations as an outcome of trial 3 and will not be used as alkali lye for the planned alkali-polymer flood. NaOH was therefore not considered as possible candidate and tested in this trial 4. The plugs V2 and V5 for this study were taken from the well Bo 78 (1,654.40-1,654.45 m). The two plugs were exposed to Na_2CO_3 (V2) and K_2CO_3 (V5). Plug V2 was used as reference plug.

Table 5-8: Plug saturation details from the reservoir plugs of the 16.TH.

Plug	Initial PV (cm^3)	S_W after Oil Flooding		S_O after Water Flooding	
		PV (cm³)	(%)	PV (cm³)	(%)
V2	6.93	4.33	37.52	2.43	27.42
V5	6.86	3.68	47.60	2.48	17.49

An overview about the initial pore volume (PV), the residual water saturation (S_W) and the residual oil saturation (S_O) of the flooded plugs can be found in **Table 5-8**. The plugs initially and after the trial are shown in **Figure 5-19.**

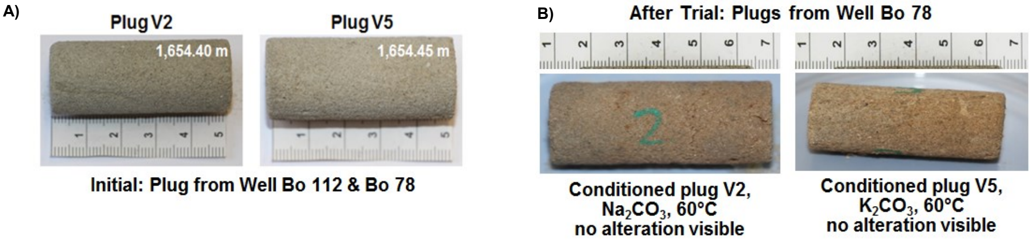


Figure 5-19: Oil-saturated reservoir plugs from the 16.TH: initial (A) and after the trial (90 days, B).

The aqueous phase was sampled once per week, to see ongoing alterations. **Table 5-9** summarizes the measured values of the elements initially and after the trial. The biggest change could be observed from silicon. Initially the value was around 11 mg per liter and declined to around 4 mg/l after the trial. The values of all other elements declined from their initial composition.

Table 5-9: Summary of the measured elements of the 16.TH oil-saturated plugs initial and after the trial.

Measured Element	**Initial**		**After the Trial**	
	Na_2CO_3	**K_2CO_3**	**Na_2CO_3**	**K_2CO_3**
Aluminium (mg/l)	0.38	0.37	0.00	0.00
Calcium (mg/l)	11.00	12.80	1.00	2.00
Iron (mg/l)	11.00	12.80	1.50	1.50
Magnesium (mg/l)	11.10	10.80	<0.70	<0.60
Silicon (mg/l)	10.90	10.60	3.50	3.80

The results of the dissolved ions (silicon, aluminium, iron, calcium and magnesium) measured in the aqueous phase are demonstrated in **Figure 5-20**. The plots show the results of Na_2CO_3 and K_2CO_3. The silicon values declined after the first week and then stayed almost constant over the trial time. It can be argued that silicon is the most predominant alkali-rock interaction. All other elements do not show a massive interaction with the plug (no increase visible). The results of the two carbonate-based alkalis show similar results. In some cases the calcium value was not detected (drop down of the curve to zero). The iron value in all three alkalis stayed below 1.5 mg/l.

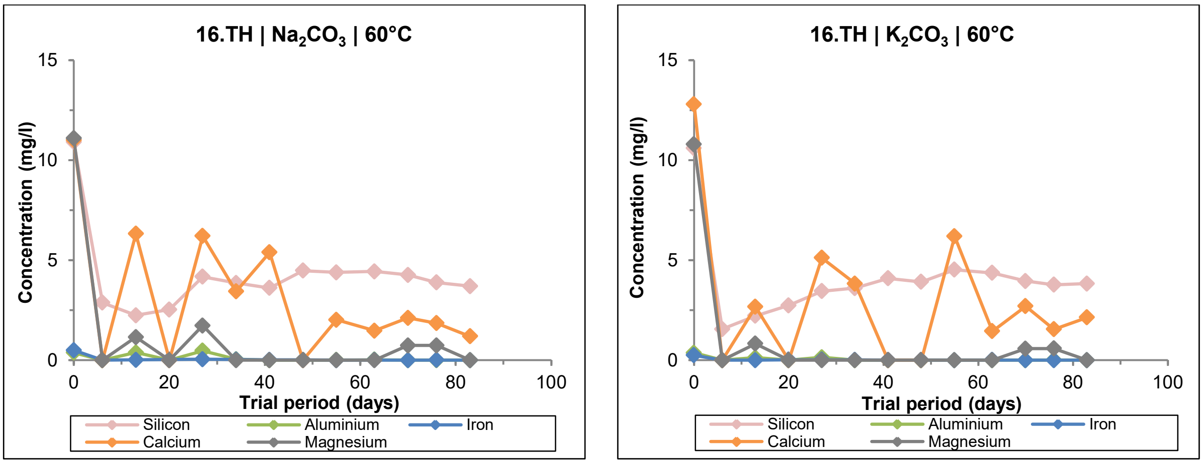


Figure 5-20: Measured dissolved ions of 16.TH oil-saturated reservoir plugs with IC & ICP-OES (short-term study: 90 days).

The SEM pictures of the plug V3, exposed to Na_2CO_3, showed quartz overgrowths on the grains at the initial condition. After the trial, no dissolution or precipitations could be observed. Besides, no silica crusts were formed on the kaolinite cement (**Figure 5-21**). Minor to no reactions of the alkali with the minerals could be observed as long as an oil film is present and covers the grain surface.

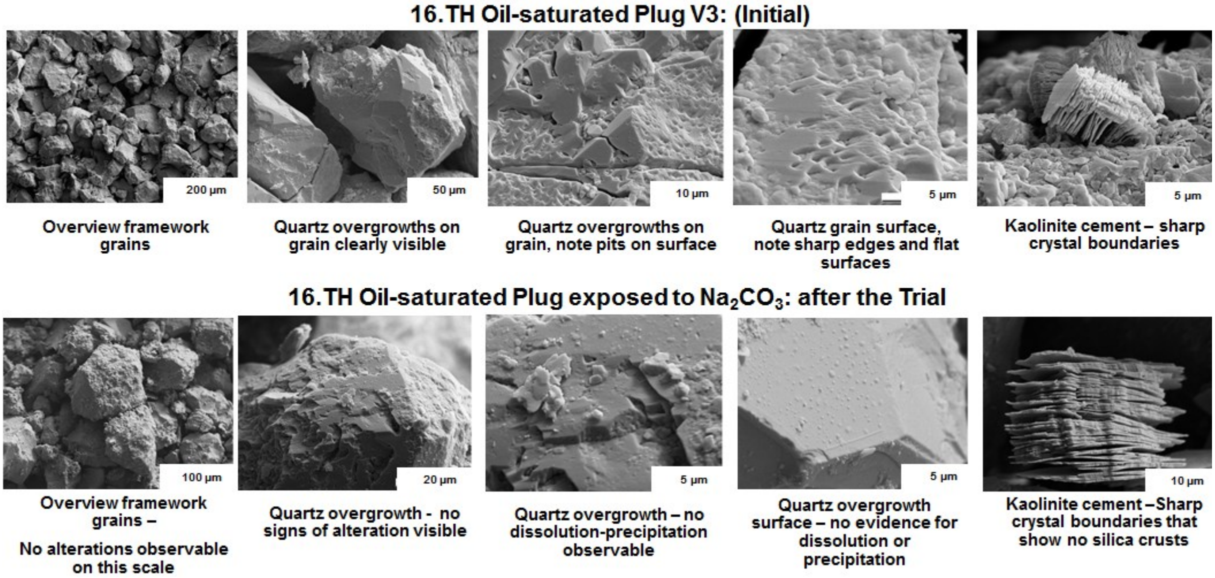


Figure 5-21: SEM micrographs of the 16.TH oil-saturated reservoir plugs exposed to Na_2CO_3 for 90 days.

The K_2CO_3 results of plug V5 are shown in **Figure 5-22** which are similar to Na_2CO_3. Minor to no chemical alterations could be observed by the use of this alkali lye as long as the grains are covered by an oil film. Some silica crusts could be observed only on the quartz grain surface (100 nm scale) at a resolution of 1 µm in a minimal extent as precipitations.

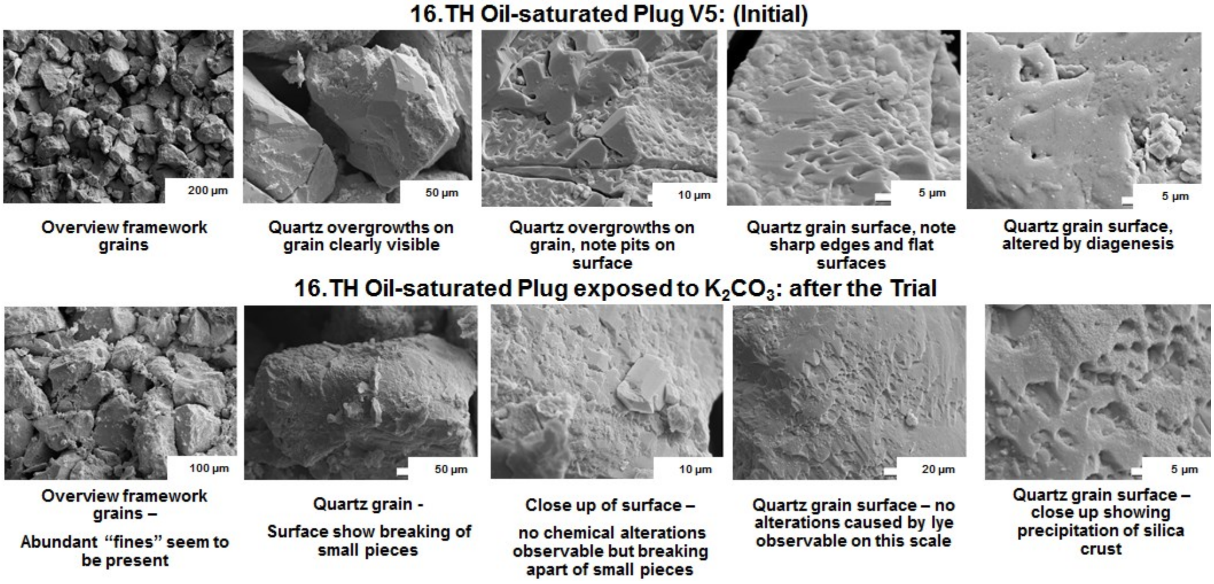
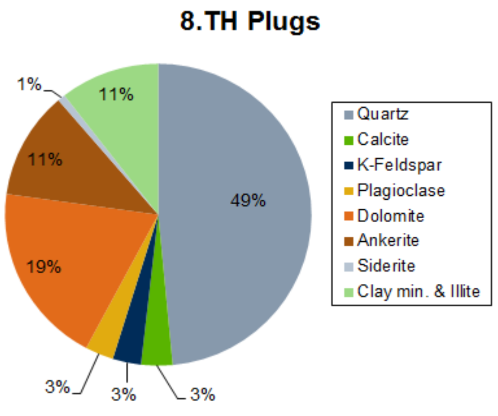


Figure 5-22: SEM micrographs of the 16.TH oil-saturated reservoir plugs exposed to K_2CO_3 for 90 days.

5.4.2 8th Tortonian Horizon

The formation of the 8.TH consists mainly of quartz, with over 49%, and detrital dolomite with 19%. The 8.TH contains high contents of clays of approximately 11% and carbonates (ankerite). All other minerals, such as plagioclase, potassium feldspar (K-feldspar), are present in smaller amounts and calcite with around 3% respectively (**Figure 5-23**).



High amounts of detrital dolomite!

Figure 5-23: Mineralogical composition of the reservoir plugs from the 8.TH.

Trial 1: Short-term Study with Berea Plugs:

The Berea plugs were exposed to the alkali lyes (a´10,000 ppm) for 7 days at 49°C. Samples of the aqueous phase were taken on a daily basis. The measured absolute values demonstrate a certain margin of error through sample dilution of 1:100 for the measuring instrument. The Berea plug exposed to NaOH did not show any alterations of magnesium, iron and aluminium. The plugs exposed to the carbonate-based alkalis show similar trends of silicon, aluminium, iron and magnesium. This model plugs did not show strong rock interactions with the alkali lyes (no massive alterations visible). The measured values are summarized in **Table 5-10**.

Table 5-10: Summary of the measured elements of the Berea plugs initially and after the trial (7 days) exposed at 49°C.

Measured Element	**Initial**			**After the trial**		
	NaOH	**Na_2CO_3**	**K_2CO_3**	**NaOH**	**Na_2CO_3**	**K_2CO_3**
Aluminium (mg/l)	1.06	1.22	1.02	6.26	0.18	0.05
Calcium (mg/l)	20.70	20.50	21.40	3.19	2.52	1.17
Iron (mg/l)	0.10	0.10	0.10	0.02	0.02	0.02
Magnesium (mg/l)	0.50	17.70	15.90	0.50	2.04	2.69
Silicon (mg/l)	10.60	10.70	10.50	52.50	1.54	1.48

The results of the measured dissolved ions of the aqueous phase are shown in (**Figure 5-24**).

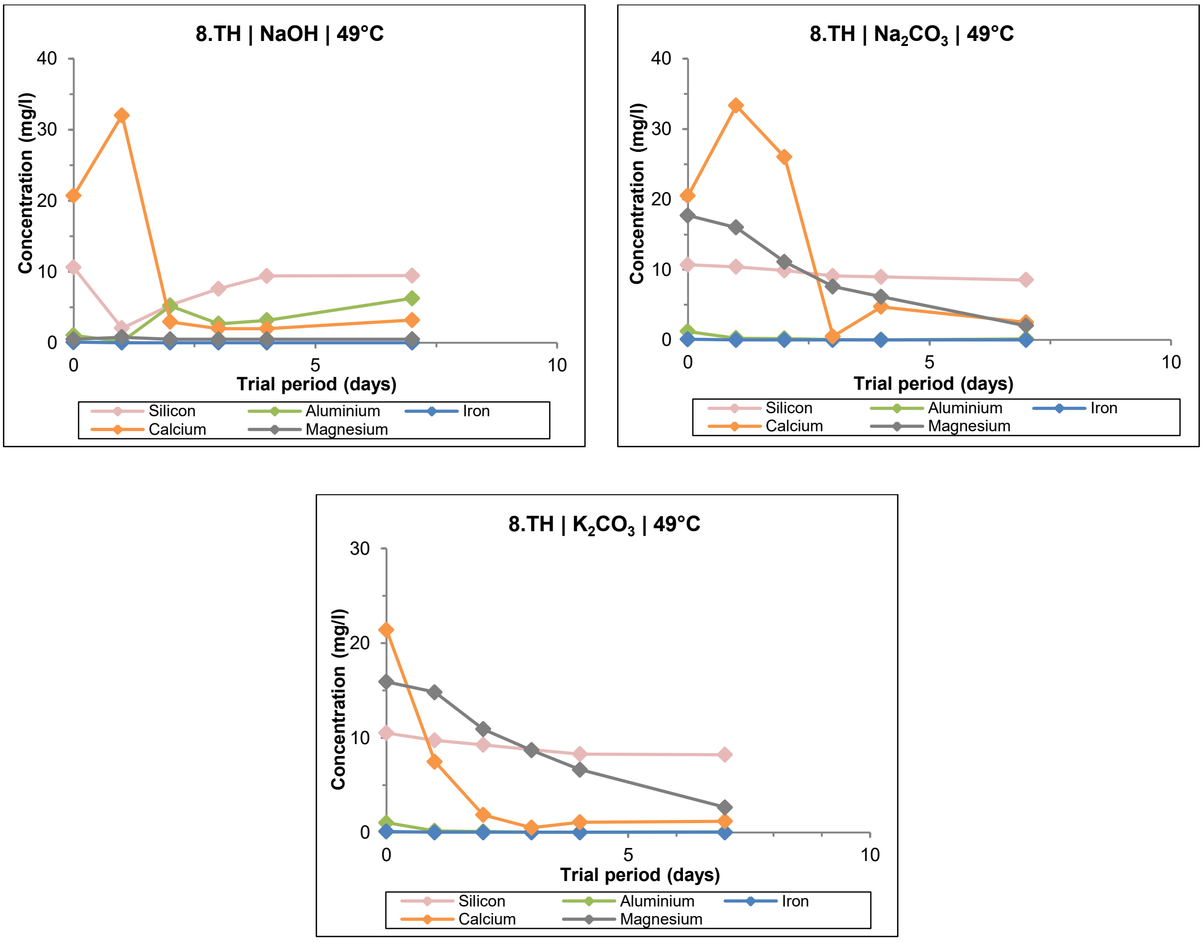


Figure 5-24: Measured dissolved ions of Berea plugs with IC & ICP-OES (short-term study: 7 days) exposed at 49°C.

Trial 2: Short-term Study with 8.TH Reservoir Plugs:

For this short-term study plugs from the well Bo 125 (1,292.12 m – 1,292.22 m) were used. The concentration of the alkali lyes was 10,000 ppm. Samples of the aqueous phase were taken on a daily basis. Plug 14a was conditioned with NaOH, plug 14b with Na_2CO_3 and plug 15a with K_2CO_3. The plug 15b was used as reference (**Figure 5-28**, **A**). The plugs were exposed in the alkali lye for about 30 days at 49°C reservoir temperature. Independent from the alkali lye no visible change could be observed to the initial plugs (**Figure 5-28**, **B**).

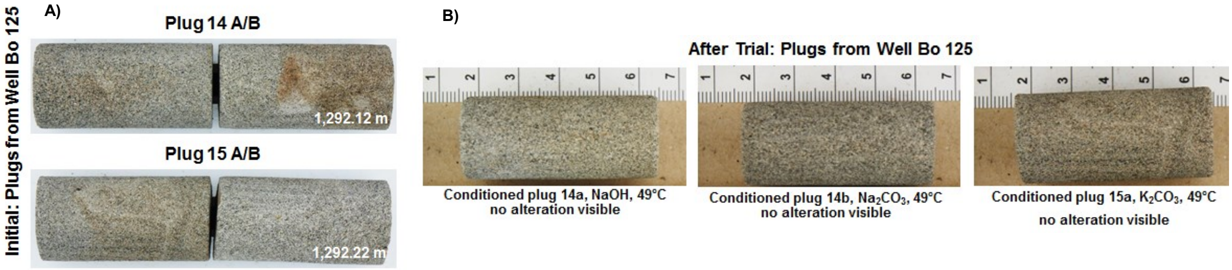


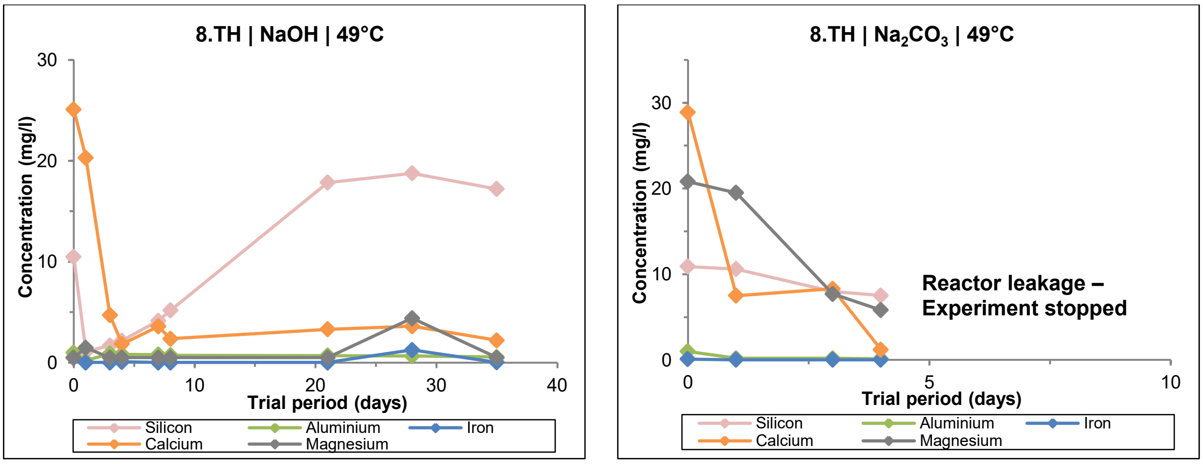
Figure 5-25: 8.TH reservoir plugs initial (A) and after three months test time (long-term study, B).

The silicon value of the plug 14a, exposed to NaOH, showed an increase from 10.5 mg/l to 17.2 mg/l, whereas exposed to K_2CO_3 it showed a decline from 11.2 mg/l to 0.51 mg/l (no interaction with silicon). The sampling valve of the autoclave filled with Na_2CO_3 and plug 14b had a leakage so the experiment had to be stopped prematurely. All elements showed a decline from the initial measured values of the aqueous phase containing K_2CO_3 as alkali lye (**Table 5-11**).

Table 5-11: Summary of the measured elements of the 8.TH short-term plugs initial and after the trial (30 days).

Measured Element	Initial			After the trial		
	NaOH	Na_2CO_3	K_2CO_3	NaOH	Na_2CO_3	K_2CO_3
Aluminium (mg/l)	1.00	1.00	1.00	0.56	Reactor leakage	0.09
Calcium (mg/l)	25.10	28.90	30.70	2.21		2.13
Iron (mg/l)	0.50	0.10	0.10	0.04		0.02
Magnesium (mg/l)	0.50	20.80	21.70	0.50		0.50
Silicon (mg/l)	10.50	10.90	11.20	17.20		0.51

The results of the measured dissolved ions of this study are displayed in **Figure 5-26**. The silicon value of plug 14a exposed to NaOH increased after one week strongly and showed a peak at 18.76 mg/l after 28 days (plateau).



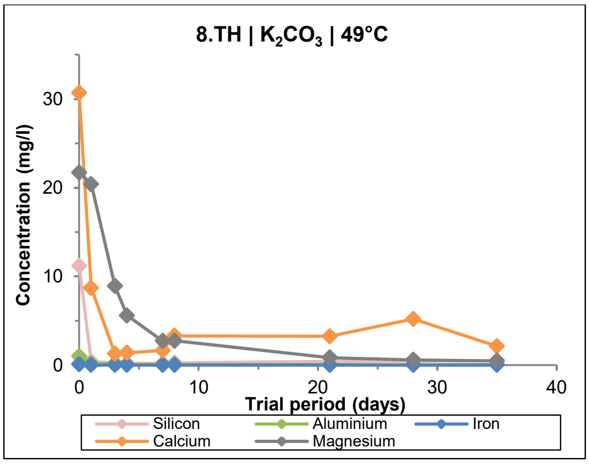


Figure 5-26: Measured dissolved ions of 8.TH reservoir plugs with IC & ICP-OES (long-term study: 30 days).

The plug 14a in NaOH showed a strong dissolution of the quartz grains and also an intense alteration of dolomite. In comparison, the plug 14b (Na_2CO_3) showed almost no dissolution of the quartz grains and only a weak alteration of dolomite could be observed. Plug 15a (K_2CO_3) had a similar behavior to plug 14b and just a very weak alteration of the dolomite could be observed (**Figure 5-27**). No dissolution of the quartz grain surface was visible.

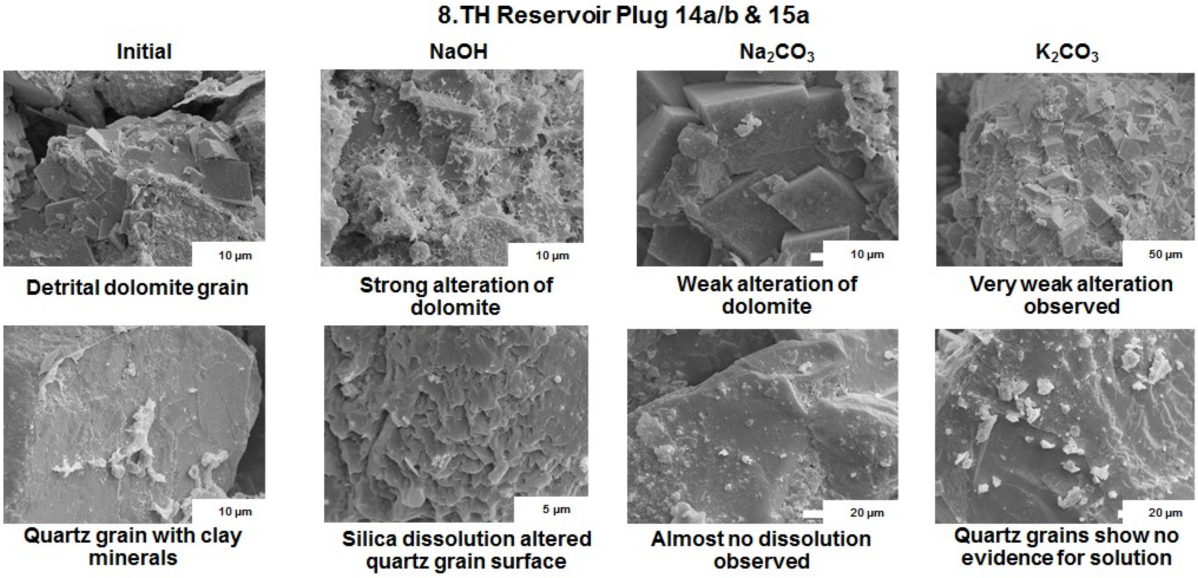


Figure 5-27: SEM micrographs of the 8.TH reservoir plugs used for the short-term study at 49°C (30 days).

Trial 3: Long-term Study with 8.TH Water-saturated Reservoir Plugs:

All three plugs were taken from the well S 442 (1,285.33 m – 1,292.35 m) for this 3 months study. Plug 4 from S 442 was used as reference plug. The plugs were saturated with softened produced water from the outlet WTP. Plug 18 was exposed to NaOH, plug 14 to Na_2CO_3 and plug 17 to K_2CO_3 (**Figure 5-28**, **A**). The alkali lyes had a concentration of 7,500 ppm. At the end of the trial, the water-saturated plugs conditioned with NaOH and Na_2CO_3 were completely disintegrated (no plug fragments left, **Figure 5-28**, **B**).

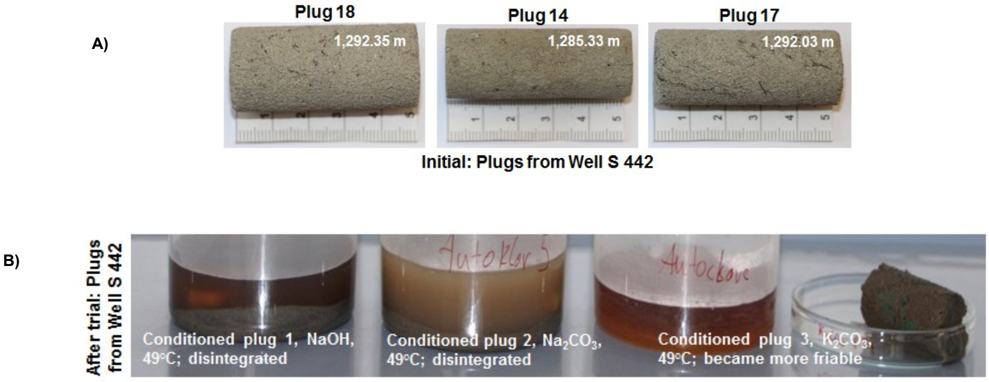


Figure 5-28: Water-saturated plugs initial (A) and after three months test time (long-term study, B).

The plug 18 and the plug 14 were broken and dissolved in the saturated alkali water phase (cracked into single sand particles). The plug 17 exposed to K_2CO_3 could withstand the alkali-reservoir rock interaction (**Figure 5-28**, **B**) and was completely preserved. The plug became more friable compared to the initial plug. A different coloring of the aqueous phase could be realized. The water phase, containing NaOH, was colored dark red to brownish as a reaction of the iron from the dissolution of the clays. The water phase containing Na_2CO_3 showed a high turbidity and the one with K_2CO_3 was clear and showed a light orange to red color.

Table 5-12: Summary of the measured elements of the 8.TH water-saturated reservoir plugs initial and after the trial (90 days).

Measured Element	**Initial**			**After the trial**		
	NaOH	**Na_2CO_3**	**K_2CO_3**	**NaOH**	**Na_2CO_3**	**K_2CO_3**
Aluminium (mg/l)	0.02	0.02	0.37	0.42	0.00	0.00
Calcium (mg/l)	16.50	17.60	13.30	n.d.	n.d.	n.d.
Iron (mg/l)	0.03	0.03	0.25	0.04	0.03	0.04
Magnesium (mg/l)	13.50	15.90	12.58	n.d.	n.d.	n.d.
Silicon (mg/l)	10.10	10.00	10.60	107.38	0.93	0.78

The results of the chemical analysis were similar to the short-term results. The measured dissolved ions in the aqueous phase behaved similar for Na_2CO_3 and K_2CO_3 (**Table 5-12**). The elements aluminium, calcium, iron and magnesium declined for all three alkali lyes and did not show any interaction with the reservoir plug. The silicon value of the aqueous phase conditioned with NaOH increased from the initial value of 10.1 mg/l to over 107.38 mg/l (**Figure 5-29**). No SEM analysis was performed for the water-saturated plugs.

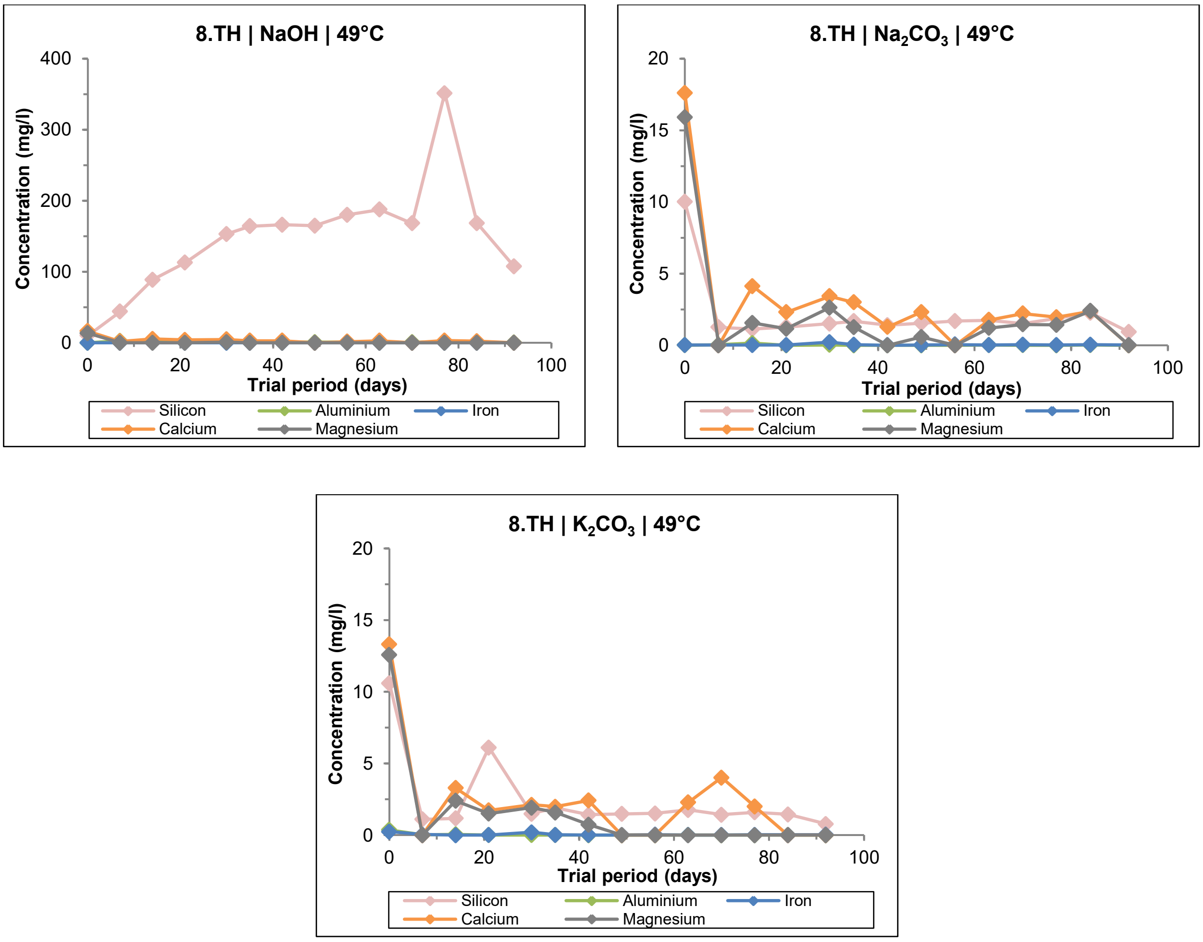
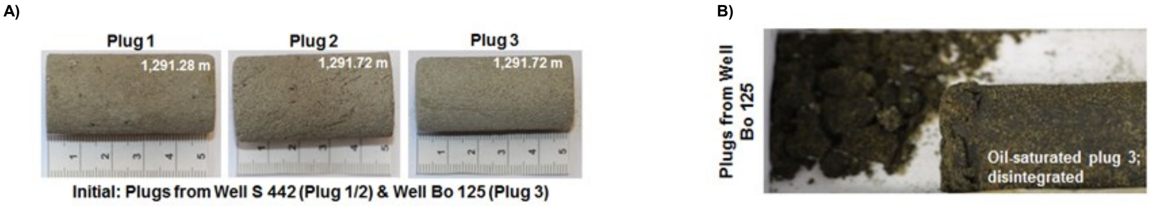


Figure 5-29: 8.TH dissolved ions of water-saturated reservoir plugs (90 days) measured with IC & ICP-OES.

Trial 4: Long-term Study with 8.TH Oil-saturated Reservoir Plugs:

Due to the clay-rich composition and the significant lower permeability of the 8.TH plugs, flooding the plugs with oil was not possible. Immediately after the start of the oil injection the pores plugged and the pressure increases led to a disintegration of the samples (**Figure 5-30**).



Initial: Plugs from Well S 442 (Plug 1/2) & Well Bo 125 (Plug 3)

Figure 5-30: Oil-saturated plugs initial (A) and after saturation (B).

5.4.3 Gravel Pack Material

Carbolite beads (20/40 mesh), consist of crystals in an amorphous matrix (high performance, low density ceramic beads), and reflective glass beads from Swarco® (850/ 1,180 mesh), which are just amorphous, were tested as gravel pack material (**Table 5-13**). According to XRF analysis, Swarco® glass beads consist of 70.5% SiO_2, 10% of Na_2O, 3.3% of MgO, 14.7% of CaO and other elements in smaller amounts. The tested alkali concentration was 7,500 ppm. The plastic bags were constantly flooded in the batch reactors with alkali lye for 30 days. The gravel pack material exposure was just tested at 60°C reservoir temperature because the alkali-polymer flood will be implemented in the 16.TH prior to the 8.TH (at 49°C).

Table 5-13: Summary of the gravel pack trial performed in flow reactors.

Test Series	Gravel Pack Type	Initial Weight (g)	Alkali Lye	Alkali Concentration (ppm)
#T5	Carbolite	40.70	NaOH	7,500
#T5	Carbolite	39.65	Na_2CO_3	7,500
#T5	Carbolite	40.25	K_2CO_3	7,500
#T6	Swarco® glass beads	40.17	NaOH	7,500
#T6	Swarco® glass beads	41.78	Na_2CO_3	7,500
#T6	Swarco® glass beads	41.54	K_2CO_3	7,500

Trial 5: Short-term Study with Carbolite Beads:

Figure 5-31 displays the results initially and after the interaction of the alkalis lyes with the Carbolite beads. At this scale no alterations were visible. All three alkali lyes show cementing of the initial beads after the trial.

Figure 5-31: Carbolite beats after 1 month alkali lye interaction (conditioned before cleaning).

The silicon value of NaOH strongly increased from 22.8 mg/l to 301.1 mg/l (**Table 5-14**). The values of the carbonate-based alkalis did not show a massive alteration and stayed almost constant over time (<20 mg/l). The other elements did not show a massive change (<10 mg/l). A measuring error appeared for K_2CO_3 at day 11 and for Na_2CO_3 at day 6. Some calcium and magnesium values were not detected (highlighted as n.d. in **Table 5-14**). The curve drops down to zero in those cases.

Table 5-14: Summary of the measured elements of the Carbolite beads initial and after the trial (30 days).

Measured Element	Initial			After the trial		
	NaOH	Na_2CO_3	K_2CO_3	NaOH	Na_2CO_3	K_2CO_3
Aluminium (mg/l)	0.03	0.19	0.9	7.49	0.03	0.02
Calcium (mg/l)	9.97	11.0	12.8	n.d.	1.81	n.d.
Iron (mg/l)	1.02	1.0	1.12	0.05	0.05	0.03
Magnesium (mg/l)	9.74	11.1	10.8	n.d.	3.21	3.71
Silicon (mg/l)	22.8	21.8	21.6	301.14	16.95	12.82

Figure 5-32 displays the results achieved with Carbolite beads.

Figure 5-33 shows the SEM results of the Carbolite beads exposed to NaOH. Strong interactions of the alkali lye could be observed. Irregular precipitations and dissolutions were visible on the grain surface. The alterations were visible at all magnifications.

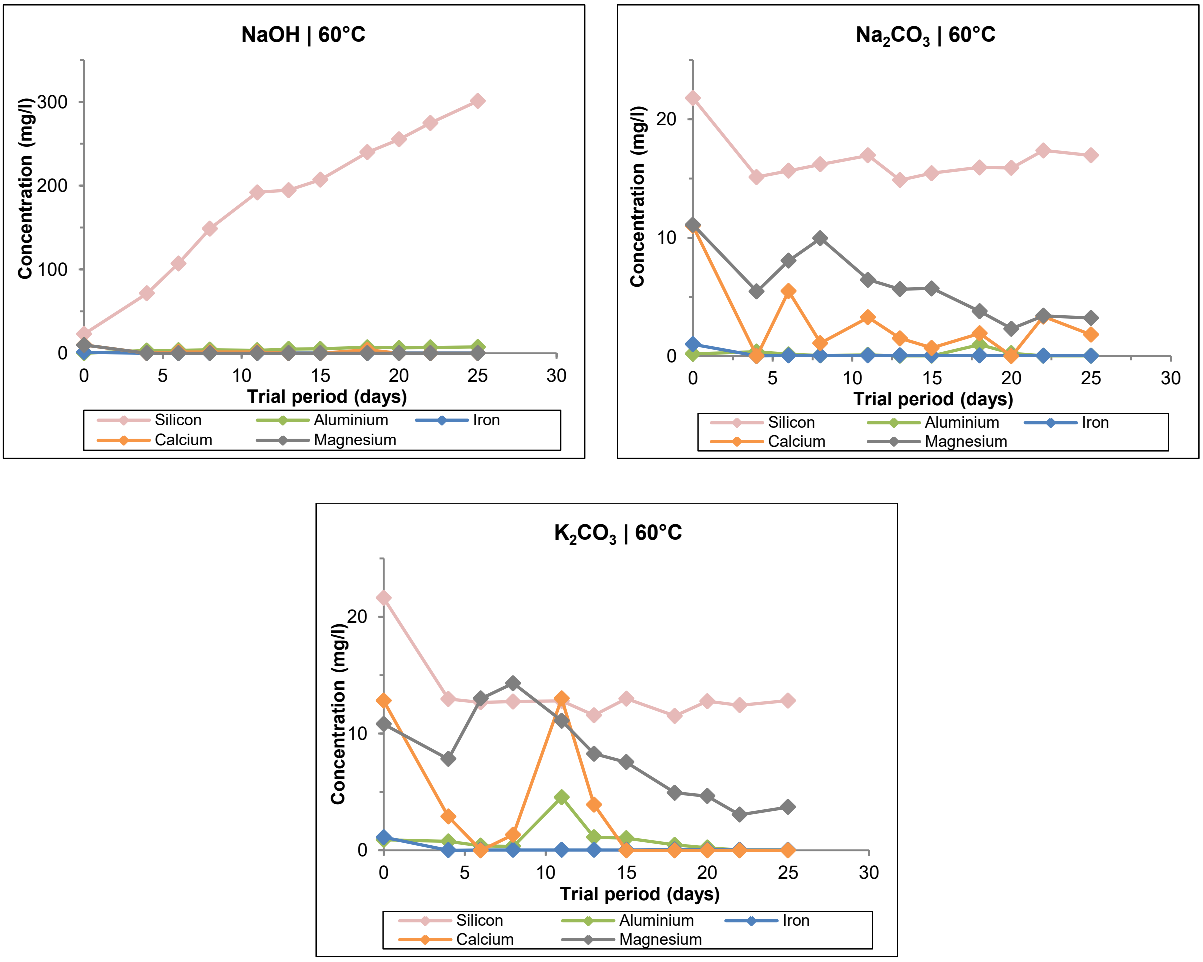


Figure 5-32: Dissolved ions from the water phase of Carbolite beads (30 days) measured with IC & ICP-OES.

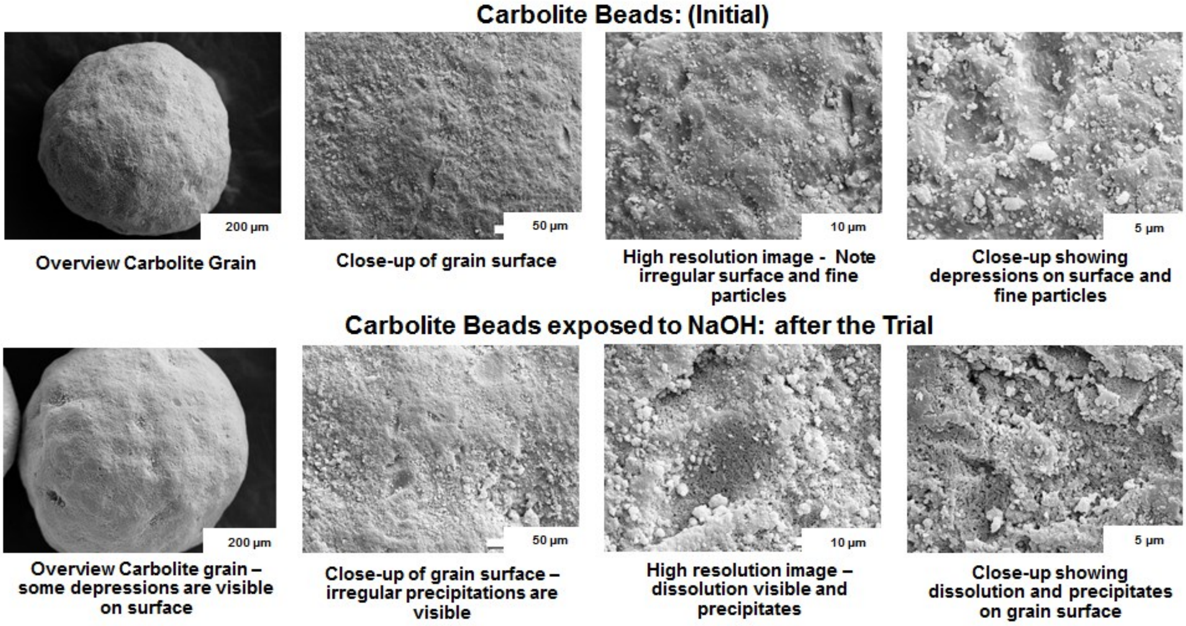


Figure 5-33: SEM micrographs of the Carbolite beads exposed to NaOH (7,500 ppm) for 30 days.

Figure 5-34 represents the SEM results of the Carbolite beads exposed to Na_2CO_3. At a magnification of 50 µm no alterations were visible on the grain surface. At a higher resolution of 10 µm dissolution and precipitations of calcium-silicates were visible on the grain surface. Furthermore, at a higher resolution of around 2 µm depressions could be observed. The degree of dissolution had a lower intensity compared to NaOH.

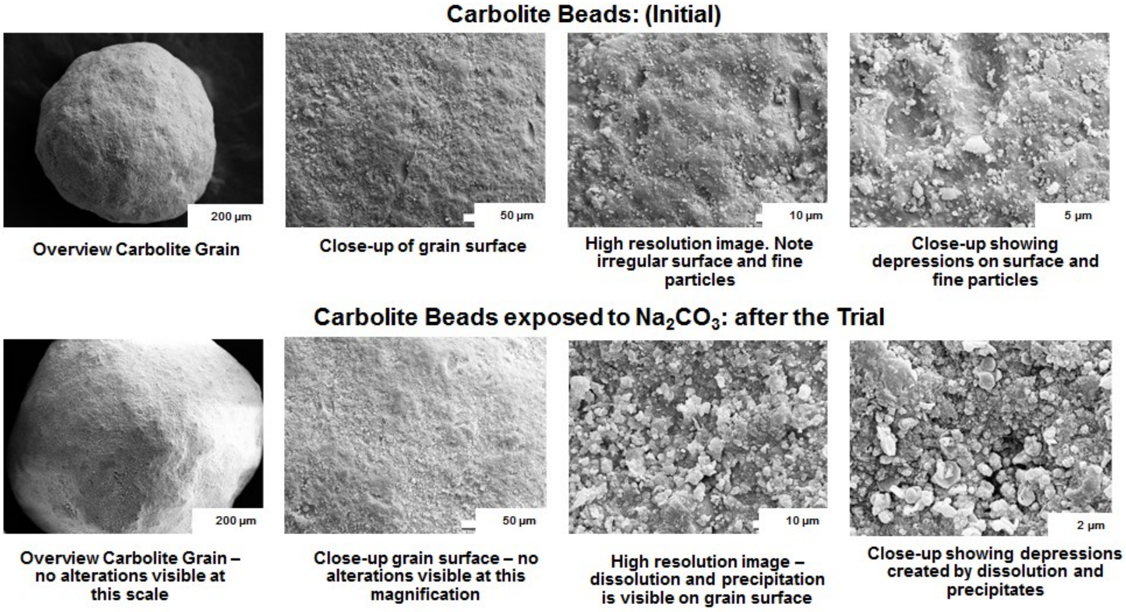


Figure 5-34: SEM micrographs of the Carbolite beads exposed to Na_2CO_3 (7,500 ppm) for 30 days.

Figure 5-35 shows the SEM results of the Carbolite beads exposed to K_2CO_3. No alterations on the grain surface could be observed at a magnification of 50 µm. At a higher resolution (10 µm and 5 µm) crusts of calcium-silicates (precipitations) were present on the grain surface. No dissolution reactions could be observed.

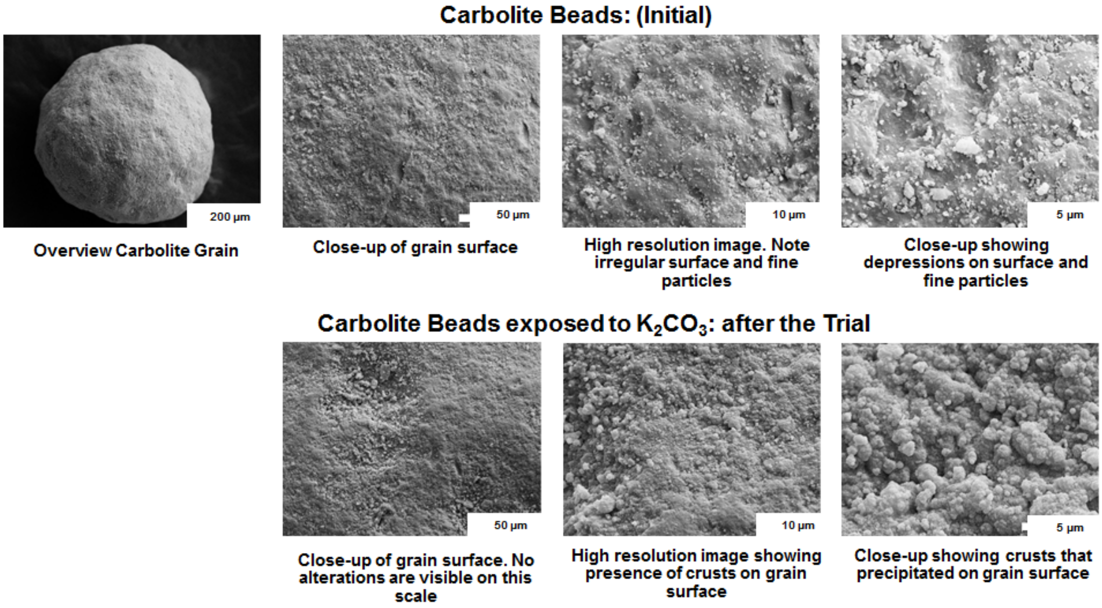


Figure 5-35: SEM micrographs of the Carbolite beads exposed to K_2CO_3 (7,500 ppm) for 30 days.

Trial 6: Short-term Study with Swarco® Glass Beads:

Swarco® glass beads were exposed in the plastic bags made of polymer fibres to NaOH, Na_2CO_3 and K_2CO_3 (a´7,500 ppm) for around 30 days in the flow reactors. **Figure 5-36** shows the initial condition and the condition after one month of exposure to the alkali solutions. Alterations were already visible due to the fact that the glass beads showed a whitish colour.

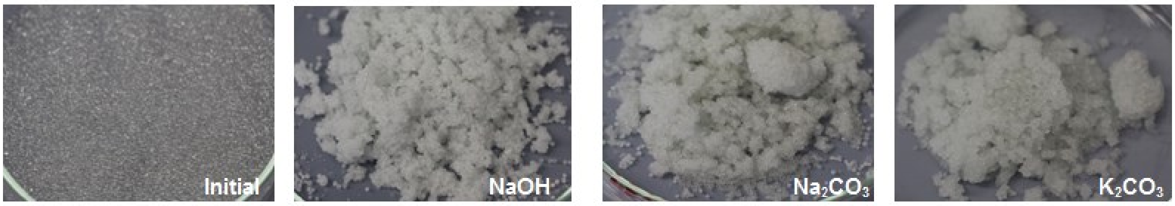


Figure 5-36: Swarco® glass beats after 1 month alkali lye interaction.

The silicon value of NaOH increased whereas for the other two alkali lyes a slight decrease could be observed. Nevertheless, the values stayed almost constant over the trial time. All other elements showed a decline of the initial values. The trial needed to be stopped earlier because of blockage of the valves which lead to pump leakage and pump failure.

Table 5-15: Summary of the measured elements of the Swarco® glass beads initial and after the trial (30 days).

Measured Element	Initial			After the trial		
	NaOH	Na_2CO_3	K_2CO_3	NaOH	Na_2CO_3	K_2CO_3
Aluminium (mg/l)	0.06	0.06	2.12	Pump leakage		
Calcium (mg/l)	28.4	26.9	31.7			
Iron (mg/l)	0.08	0.56	2.26			
Magnesium (mg/l)	1.66	27.9	25.7			
Silicon (mg/l)	28.6	13.9	11.2			

The silicon value strongly increased for all alkali lyes. For NaOH the silicon value increased from initially 28.6 mg/l to over 245 mg/l. Also for the carbonate-based alkalis the value increased from approximately 2 mg/l to over 180 mg/l. All other elements just showed minor interaction with the glass beads (**Figure 5-37**).

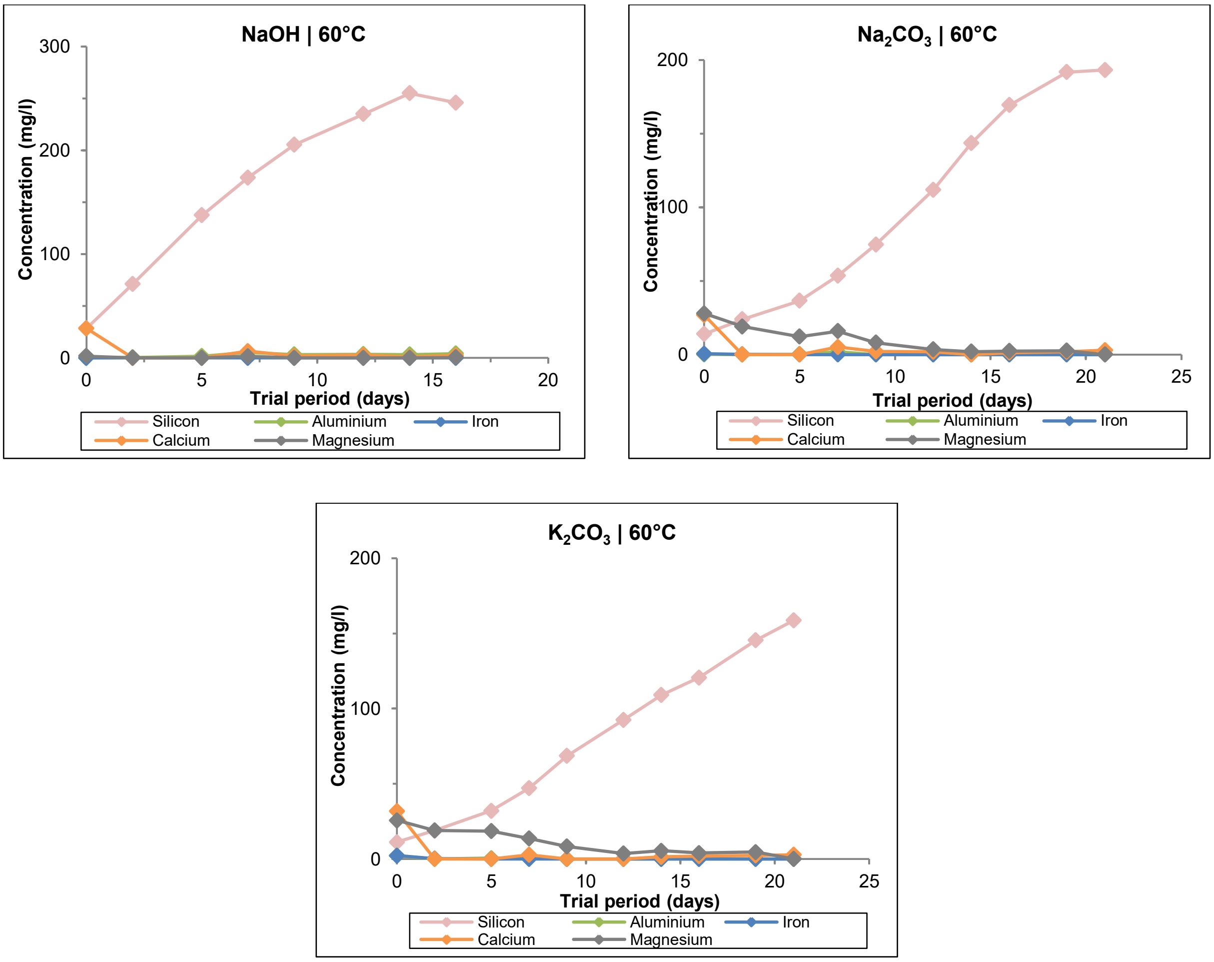
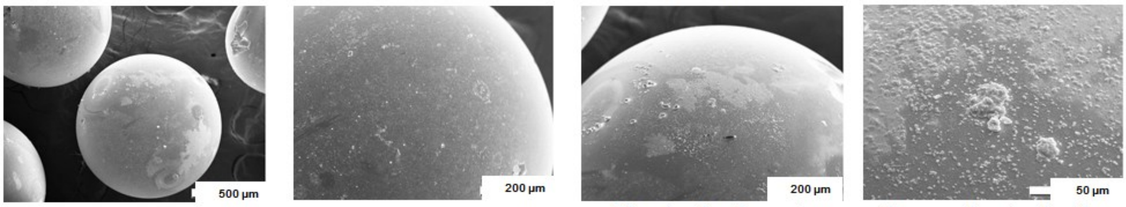


Figure 5-37: Dissolved ions from the water phase of Swarco® glass beads (30 days) measured with IC & ICP-OES.

Figure 5-38 displays the SEM results of the Swarco® glass beads exposed to NaOH. It could be observed that an intense alteration of the glass beads appeared. The uppermost surface of the glass beads was removed and precipitations of calcium-silicates appeared. Furthermore, strong dissolution (fracturing) and precipitations on the grain surface could be observed.

Swarco® Glass Beads: (Initial)



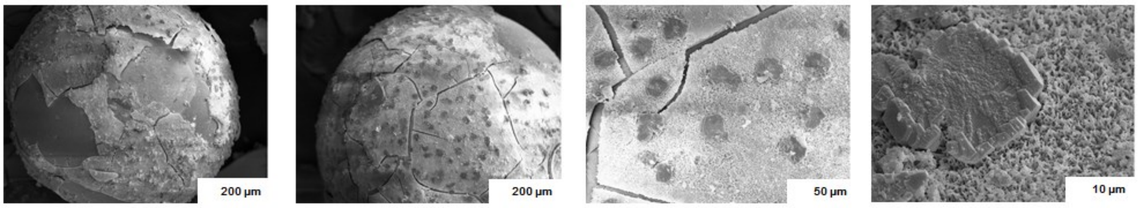
Overview glass-bead

Close-up of smooth glass-bead surface

Glass-bead surface, only minor irregularities are visible

Close-up glass-bead surface, only minor irregularities are visible

Swarco® Glass Beads exposed to NaOH: after the Trial



Overview showing strong alteration of glass-bead

Uppermost surface of glass-bead is removed

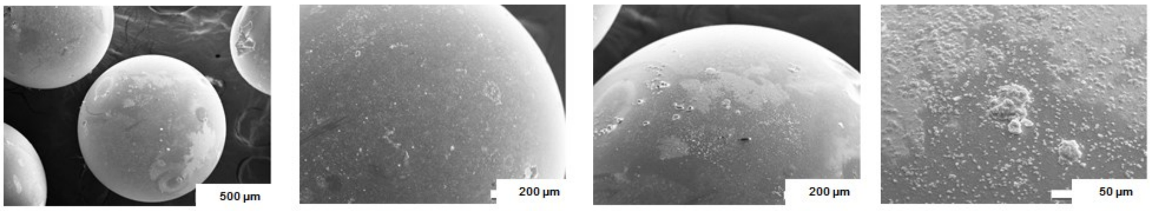
Close-up showing alteration of surface and precipitation of Ca-silicates

High resolution image showing dissolution and precipitates on grain surface

Figure 5-38: SEM micrographs of the Swarco® glass beads exposed to NaOH (7,500 ppm) for 30 days.

Figure 5-39 displays the SEM results of the Swarco® glass beads exposed to Na_2CO_3. The results with Na_2CO_3 showed slight cementation of several glass beads. At a higher resolution of 20 µm fractures and precipitations of calcium-silicates were realized, but less alteration were visible compared to NaOH.

Swarco® Glass Beads: (Initial)



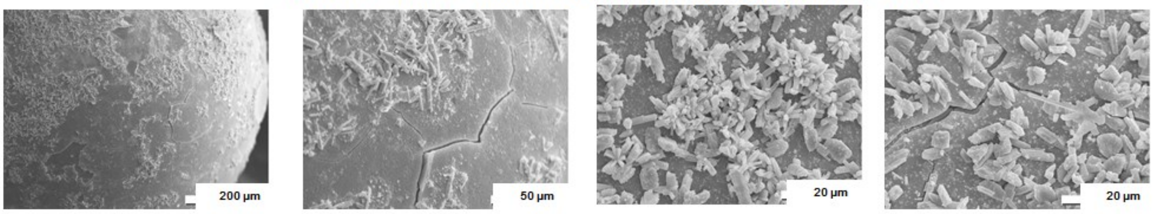
Overview glass-bead

Close-up of smooth glass-bead surface

Glass-bead surface, only minor irregularities are visible

Close-up glass-bead surface, only minor irregularities are visible

Swarco® Glass Beads exposed to Na_2CO_3: after the Trial



Surface of glass-bead shows precipitation and mechanical alteration

Close up of fracture in surface and precipitates

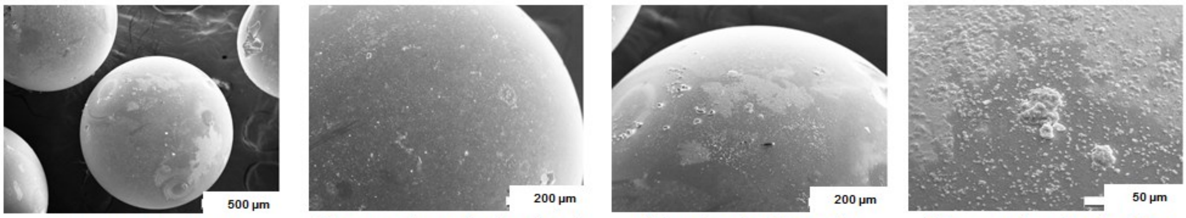
High resolution image of crystal (Ca-Si) that precipitated on glass bead surface

High resolution image of fracture and precipitates

Figure 5-39: SEM micrographs of the Swarco® glass beads exposed to Na_2CO_3 (7,500 ppm) for 30 days.

Figure 5-40 displays the SEM results of the Swarco® glass beads exposed to K_2CO_3. Precipitations of calcium-silicates could be observed on the Swarco® beads surface. At a magnification of 100 µm the glass beads had been cemented by these precipitations.

Swarco® Glass Beads: (Initial)



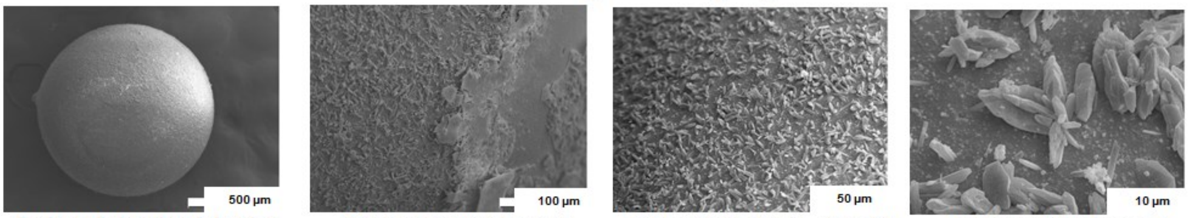
Overview glass-bead

Close-up of smooth glass-bead surface

Glass-bead surface, only minor irregularities are visible

Close-up glass-bead surface, only minor irregularities are visible

Swarco® Glass Beads exposed to K_2CO_3: after the Trial



Surface of glass-bead showing precipitation but no fractures

Close up showing contact between two glass beads that have been cemented by Ca-Si precipitates

High resolution image of crystal (Ca-Si) that precipitated on glass bead surface

High resolution image of precipitates

Figure 5-40: SEM micrographs of the Swarco® glass beads exposed to K_2CO_3 (7,500 ppm) for 30 days.

5.5 Discussion

The developed in-house test set-up (batch reactors) allows analyzing the interaction of EOR fluids and reservoir rocks before conducting a field trial. All experiments were conducted with reservoir rocks and softened produced water at reservoir temperature. The outcome of this study demonstrates issues that might arise from dissolution and precipitations of minerals by the use of different alkali lyes. Nevertheless, just qualitative assumptions about the alkali-rock interaction could be made because an upscale regarding the damage severity is difficult.

No alterations of the alkalinity or pH changes to the initial values could be observed in any of the trials. Basically, the observed alkali-rock interactions include quartz and clay mineral dissolution as well as precipitations. The main controlling factors for the dissolution are the mineralogical composition and the reservoir temperature. The evaluated reservoirs (8.TH and 16.TH) contain highly reactive minerals like dolomite and clay minerals. The 8.TH consists of high amounts of detrital dolomite, ankerite and clay minerals, whereas the 16.TH contains huge amounts of quartz and smaller compounds of calcite and clays.

Trial 1 with Berea sandstones was just performed to evaluate the set-up. The dissolution of silica minerals is the main indicated interaction of the examined alkalis with the reservoir rock of the 16.TH (60°C) and 8.TH (49°C). The temperature difference of 10°C led to an accelerated dissolution process and increased silicon values (especially by the use of NaOH). This trend could be observed in all conducted test series. Amorphous silica, which is a common product of the alkali-silica reaction, has been observed as crusts on quartz cement and kaolinite surfaces.

The following aspects were identified in all performed studies: the use of NaOH will most likely cause formation damage. This strong alkali lye showed the most severe alkali-rock interaction of all three examined solutions. Sodium hydroxide should therefore not be used as alkali lye for the planned EOR prospect, because massive alterations of the reservoir plugs and of both gravel pack material types appeared. The carbonate-based alkalis (Na_2CO_3 and K_2CO_3) showed minor alterations compared to NaOH and behaved almost similar. Na_2CO_3 showed a possible potential for scaling and formation damage, especially through the interaction with highly reactive minerals and also when the exposure of the lye is long enough to the formation. However, K_2CO_3 showed just minor interactions with the formation and was regarding alkali-rock interaction the best candidate to not cause any severe issues. The potential to generate formation damage can be argued as questionable when the exposure to the formation is long enough.

The 8.TH contains a higher amount of clays and is much more reactive than the 16.TH. The water-saturated plugs of the 8.TH exposed to NaOH and Na_2CO_3 were completely disintegrated after the trial. According to the mineralogical composition of the 8.TH, the reservoir is less favorable for any kind of alkali method compared to the 16.TH. Subsequently reservoirs with a similar or comparable composition of the 8.TH are most likely not suitable.

Based on the results and the mineralogical composition, K_2CO_3 might be probably the best candidate as alkali lye in the 8.TH. In the 16.TH both carbonate-based alkalis can be used and might cause just a minor severity of formation damage. However, to decide and give a recommendation in favor of one of these two alkalis, it is relevant to consider various other technical and economic studies and criteria.

Carbolite beads showed just minor alterations by the use of Na_2CO_3 and K_2CO_3. Strong alterations as well as dissolution could be observed with NaOH. It led to dissolution of the uppermost layers (generation of hollows). The initial beads did not show a homogenous surface. K_2CO_3 just formed crusts and did not show any dissolution reaction, whereas Na_2CO_3 caused precipitations and dissolution.

Using Swarco® glass beads as gravel pack material may be unfavorable because really strong alterations could be observed with all tested alkali lyes. NaOH caused severe alterations and Na_2CO_3 led to cracking and caused precipitations of calcium-silicates. Interestingly K_2CO_3 did not create any cracks. Glass beads are a candidate for filter bed materials tested for the treatment of produced fluids. These findings are relevant to consider, when alkali lyes are contained in the produced fluids (pH changes), because it would lead to severe alterations of the glass beads (precipitations). As a consequence, the filter performance is decreased and might even lead to filter blockage.

The test set-up does not enable any fluid flow and the alkali-rock interactions were just evaluated at static conditions. Under reservoir conditions, the fluid flows through the porous rock and precipitations might appear especially by alterations of the temperature, the pressure or the flow regime. As a next step, the test set-up needs to be adapted and further extended in order to test the alkali-rock interaction under dynamic conditions. The plugs should thereby be flooded continuously with fresh alkali lye and the aqueous phase sampled in periodic time intervals. Additionally, the specific surface of the rocks needs to be measured in further studies.

To sum up, the characteristic of every production horizon differs greatly concerning mineralogical composition, formation water composition, temperature, oil characteristic, petro-physical properties, etc. The findings of this study cannot be completely adapted to other horizons. An extensive screening of every reservoir prior a field trial is required to understand and evaluate possible alkali-rock interactions. The reservoir heterogeneity plays a major role. Furthermore needs to be considered that fluctuations of the test results might appear.

6 Influence of EOR Fluids on Surface Facilities

The water cut increases during the production of old and mature oilfields and causes enormous amounts of produced water. Produced water is saturated with hydrocarbons and chemicals (various inhibitors). This entails an intense treatment effort before reuse. The use of surface water for injection is prohibited in Austria, subsurface water sources are rare and limited and the high treatment costs of such waters makes re-injection an attractive and environmental friendly opportunity. Furthermore, the water quality plays a predominant role for EOR applications to ensure an excellent injectivity [160].

The injection of dilute hydrolyzed polyacrylamide solutions after water flooding operations (alone or in combination with caustic solutions) is a promising tertiary recovery method. However, the treatment of produced water, containing breakthrough polymer, is more challenging than the handling of normal oilfield water (viscosity changes). Ensuring good filterability of the produced water for re-injection purposes, pressure maintenance or EOR application is still a critical issue. High polymer loads in the produced water need to be expected, which can massively influence the separation efficiency of the installed water treatment system. Especially, the handling of polymer-containing water streams and finding the appropriate technology for the treatment, chemically or mechanically, has a decisive influence on performing a full-field flood activity [45].

Aim of this study was, to investigate the impact of back-produced polymer on the water treatment process and to find methods to reach the desired injection water quality. A water treatment plant in pilot scale was used, which simulates the main process steps of the WTP Schoenkirchen in the Vienna Basin. The maximum polymer concentration which can be handled within the system was determined. Two different chemical packages of coagulant and flocculant were tested, regarding their oil and solids removal ability, in presence of different HPAM concentrations [45].

The treatment of alkali-polymer solutions was not tested in this study, because artificially generated emulsions in the laboratory do not reflect the real back-produced fluid properties as well as field conditions (e.g. water cut, dilution of the fluids from other producing wells, droplet size). The usage of the same kind of demulsifier, as well as dosing quantity identified in the laboratory, will probably not reflect the field conditions. The demulsifier needs to be adjusted onsite, to suit the field conditions as soon as the first emulsions are produced.

6.1 Impact of EOR Chemicals on the Produced Water Cycle

Most of the published associated technical challenges are related to ASP or polymer flooding. Less is published regarding the treatment of back-produced AP fluids. Through the performance of chemical flooding, it is difficult to predict the breakthrough time as well as the amount and composition of back-produced EOR fluids. Generally, the amount of the back-produced concentration depends on the consumption and the retention time in the reservoir, but also on the injected concentration. Sheng (2013), Alwi *et al.* (2014) and Argillier *et al*. (2014) noticed, that a chromatographic separation of the injected slug could be monitored in the executed AP/ASP floods. Typically, the polymer breaks through as first and leads to changes of the water viscosity followed by the alkali and the surfactant [161, 23, 79]. Dependent on the amount of injected polymer slug, high quantities of back-produced polymer can arise in the produced water [45].

In addition, scale issues, precipitations, and back-produced emulsions must be expected. Alwi *et al.* (2014) published that stable emulsion breakthrough occurred and caused flow assurance problems to downstream facilities. Furthermore, the crude oil quality was affected [162]. Weatherill (2009) mentioned major upcoming operational challenges such as low injectivity, polymer degradation, bacterial growth, corrosion, and pump failures but also difficulties in the water treatment when cEOR flooding (especially ASP) was performed [163].

With regard to the use of alkalis in EOR applications, a cost intensive water handling procedure on the injection and production side is required. Filtration, softening and post-filtration units, as well as a disposal options for process chemicals, have to be evaluated [161, 164, 12].

The use of caustic solutions evokes two challenging aspects: stable micro emulsions and inorganic scale problems (e.g. $CaCO_3$ precipitations) near the wellbore and the production system [165]. The formation of scale is strongly dependent on pH value, temperature, pressure, and ionic composition of the water. Carbonate scale can easily be removed through acidizing or scale inhibitors at the production wells. In comparison, no long-term treatment is available for the removal of silicate precipitations [23]. Krumrine *et al.* (1984) published, that at the Long Beach Unit (California, caustic flood project) calcium carbonate, magnesium silicate, and amorphous silica gel could be found in submersible pumps [135]. In order to avoid severe scaling issues, the investigation of a proper scale inhibitor program for the artificial lift systems and to soften the water prior to the alkali injection is recommended.

Tight emulsions increase the water treatment costs and create operational challenges in the separator (difficulties to separate the water phase from the oil phase) but also in further treatment steps [165]. EOR-based emulsions are completely different in their mechanism than natural occurring emulsions in the crude oil, which are stabilized by resins and asphaltenes. Micro emulsions are formed and stabilized through synergistic effects, created by the injected chemicals. These chemicals lead to ionic, electrostatic, and steric effects. Thermodynamic stable micro emulsions are formed on the oil-water interface, affecting the crude oil quality and further the monetarization/sale of the crude oil [79, 13, 166]. Emulsions (**Figure 6-1**) can be differentiated into stable water-in-oil (W/O), oil-in-water (reverse, O/W) or into multiple emulsions (W/O/W or O/W/O). Like for all emulsions, chemical additives (demulsifiers) and technical equipment is required to resolve or break them, in order to keep the water treatment business in normal operation [161, 23, 79].

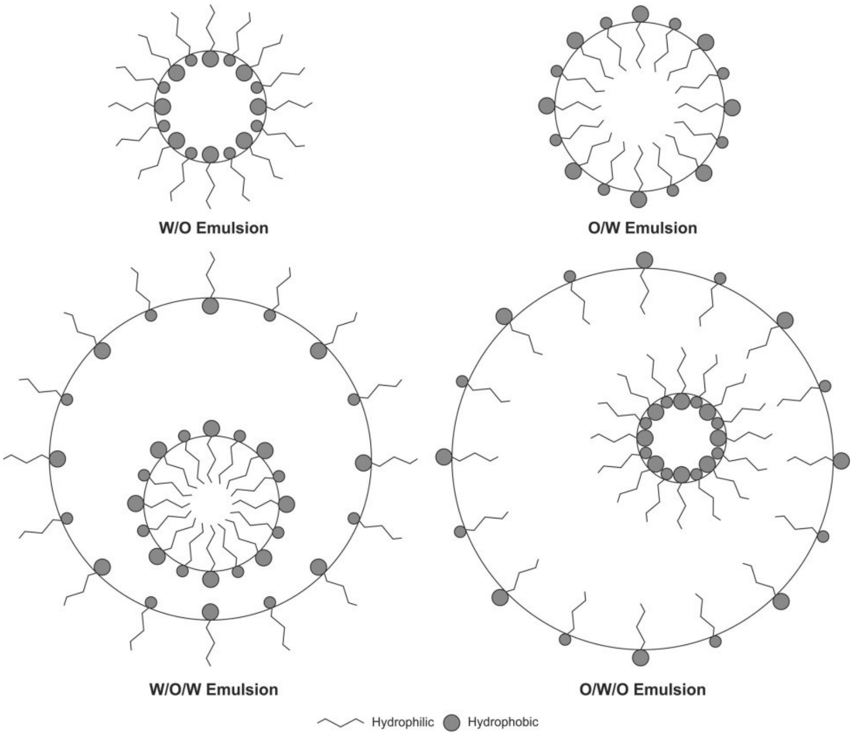


Figure 6-1: Characterization of micro emulsions into water-in-oil (w/o), oil-in-water (o/w) and multiple (w/o/w, o/w/o) emulsions (Modified from [167, 168]).

According to the ASP pilot in the Southern of Oman, Al-Mjeni and Shuaili (2018) stated that the most issues appeared when surfactants were included in the water stream. This field pilot did not recognize any adverse aspects or challenges with alkaline substances alone. Furthermore, the demulsifier requirements (volume, concentration) were adjusted individually at each well. The incremental oil stayed in the water phase. Additionally, non-ionic water clarifiers (did not lead to flocking) were injected at the wellhead (cross-linking). Higher back-produced polymer concentrations did not lead to any adverse effects of the water clarifier. Samples were taken at the wellhead and the WOR, as well as the water quality was checked. Nevertheless, the oil quality changed in some parts of the field (increase of the asphaltenes content) [169].

According to Bryan and Kantzas (2009), it is relevant to establish a cost-effective separation of the produced emulsion, whereby the oil phase should contain less than 0.5 vol% water and the water phase less than 200 ppm of oil [170].

6.2 Water Softening

Several water softening technologies are on the market: frequently ion exchangers, chemical softening with limestone or membrane technologies including reverse osmosis and electrodialysis are used. Chemical softening is mostly applied in the waste water treatment, because of the low hardness levels. However, it is not frequently applied for softening of oilfield water. Reasons for this are the low reactivity, the decreased effectiveness, the high sludge disposal and difficulties to reach the desired softness for alkali flood operations [85].

A big issue of membrane technology is the relatively high price (\$3.7 per m^3 water), fouling caused by dissolved organics and scale deposition on the membrane surface. Fouling massively influences the membrane performance and leads to a reduced water flux and to a decline of the re-injection efficiency. As a consequence, demanding pre-treatment and high membrane replacements are required. Experiments of Muraleedaaran *et al.* (2009) showed, that nano- and ultrafiltration as process steps prior to softening, decrease fouling and enhance the operational lifetime of a membrane [171].

Ion exchangers are mostly applied in the oil industry. The resins used for ion exchangers can be subdivided into strong acid, weak acid or chelating cation ion exchanger resins. Produced water containing high amounts of total suspended solids and hardness ions need a precise selection of the possible resin [172]. Weak acid resins are normally used for water streams containing high amounts of total dissolved solids. They need an expensive regeneration with hydrochloric acid (HCl) and sodium hydroxide (NaOH). Strong acid cation exchangers are simpler, less expensive and only need brine regeneration without acid or caustic solutions. Adversely, they can only be used for water that contains low quantities of suspended solids (≤3,000 mg/l for all pH levels). The conventional softening reaction with a strong acid cation exchanger (expressed as R) is demonstrated in **Eq. 29** and the regeneration reaction in **Eq. 30** [173].

$$\mathrm{CaCl_2 + 2\,RNa \rightarrow 2\,NaCl + R_2Ca} \tag{35}$$

$$\mathrm{2\,NaCl + R_2Ca \rightarrow CaCl_2 + 2\,RNa} \tag{36}$$

By using chelating resins, sub-ppm hardness levels (<1 ppm) in saturated brine solutions can be achieved. The regeneration process requires – like for weak acid resins – hydrochloric acid and sodium hydroxide [173].

New technologies combine strong (SAC) and weak acid cation (WAC) ion exchanger resins. SAC and WAC technology can be applied to soften water with high amounts of salt and total dissolved solids. Thereby, the SAC ion exchanger resin removes most of the multivalent cations, such as calcium, magnesium, and iron ions. The WAC resin is used to purify the water to a total hardness of less than 0.5 ppm. Nevertheless, additional costs for chemicals and water, used for the resin regeneration, need to be taken under consideration [174].The softening unit can be either installed as packed bed system, conventional ion exchanger system, produced water WAC system or as degasifier included to the ion exchanger system. The packed bed system has higher CAPEX but ensures a higher water quality, a lower chemical consumption and less waste volume, rsulting in lower OPEX [175].

In the executed alkali projects described by Garrett *et al.* (1983) ion exchangers were used even though when high hardness levels (≥2,000 ppm $CaCO_3$) were present in the water stream. Zeolite or organic resins were applied to soften water with substituted sodium ions. For the regeneration of the saturated resin sodium chloride brine was used [85].

For the installation of water softening systems, prior to the alkali slicing unit, a redundant operation system is required. Thereby, one unit is under operation to remove the divalent cations from the injection water and one is under regeneration, in which the hardness loads are removed from the resin. In the plant design swelling of the resin needs to be considered.

6.3 Water Quality for Re-Injection

Strong water specifications, such as low contents of dispersed hydrocarbons, total suspended solids and small particle sizes are necessary for tertiary treatment processes. These requirements are mandatory for unconsolidated, shallow sand reservoirs, to avoid plugging of the pore spaces [176, 13].

The desired water quality for re-injection purposes is based on internal defined OMV standards. The parameters correlate with the water quality criteria of the water treatment plant Schoenkirchen (**Chapter 3.3**). The produced water at the plant inlet has a hydrocarbon content of around 300 ppm (fluctuations possible), with approximately 30 ppm of total suspended solids. Before re-injection, the water should have a hydrocarbon content of less than 2 ppm, total suspended solids of less than 3 ppm and good filterability (WBF smaller than 0.7). The water blocking factor (WBF) is an OMV internal index, which gives information about the filterability of the treated formation water. The WBF is just measured at the outlet of the final polishing step. The smaller the WBF, the smaller the risk of blocking the rock pores during re-injection into the reservoir. The WBF is determined by cellulose nitrate membrane filtration under exclusion of air to avoid iron precipitations [45]. The filtered volume is measured over time. In **Eq. 37** the mathematic correlation between volume and time is expressed. The filterability is a result of its derivative to time shown in **Eq. 38** [177].

$$\mathrm{V} = \frac{\mathrm{R_{init}}}{\lambda} * (1 - \mathrm{e}^{-\lambda t}) \tag{37}$$

$$\frac{\mathrm{dV}}{\mathrm{dt}} = \mathrm{R_{init}} - \mathrm{V}\lambda * (\mathrm{V_\infty} - \mathrm{V}) \tag{38}$$

6.4 Methods

6.4.1 Water Treatment Pilot Unit

The impact of back-produced polymer on the water treatment process was studied by the use of a water treatment pilot plant. The pilot unit was built, to simulate the main water treatment steps of the WTP Schoenkirchen in the Vienna Basin (**Chapter 3.3**). The plant in Schoenkirchen is designed as a closed system and uses mechanical as well as chemical treatment steps, including a corrugated plate interceptor (CPI), a dissolved gas flotation unit (DGF), and a nutshell filter (NSF), to treat the produced water. All process steps are blanketed with nitrogen to avoid aerobic conditions. Besides, there are no emissions of carbon dioxide, hydrogen sulfide or volatile organic compounds (e.g. hydrocarbons).

The pilot unit was located at the metering station Schoenkirchen V in the Matzen oilfield. In the station a three-phase separator was installed, where production wells with and without polymer could be tied in. In the separator the formation water was separated from oil and gas, and a side stream, with a volume flow of 5m³/h, was further used for the pilot plant (**Figure 6-2**). All fluid streams were then transferred back to the metering station Schoenkirchen V and further forwarded as commingled stream to the gathering station Matzen [45].

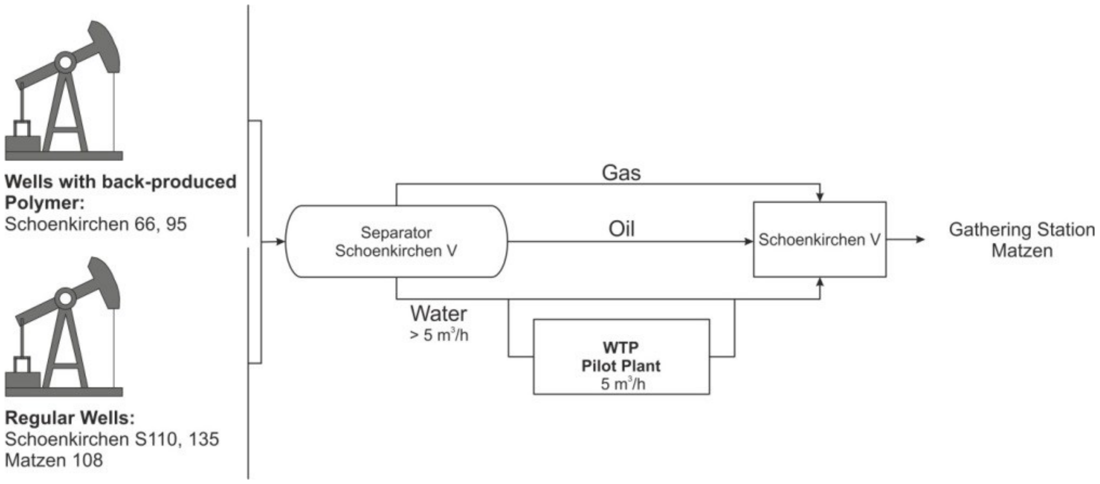


Figure 6-2: Produced water supply at the Schoenkirchen V with the connected production wells (After [45]).

Depending on the producers connected via the manifold, the pilot plant could be supplied with or without polymer-containing water. The average operating flow rate of the unit was 5m³/h. Several production wells, all located in the Matzen oilfield, were combined to reach the desired flow rate. The production data of the wells used in the trials are represented in **Table 6-1**.

Table 6-1: Production dates of the used production wells in the pilot unit to reach the required flow rate [45].

Well	Oil (m³/d), avg.	Gross Rate (m³/d), avg.	Water (m³/d), avg.	Water Cut (%), avg.
S 66	3.1	38.8	35.7	92.1
S 95	5.9	64.0	58.1	90.8
S 110	1.6	54.4	52.8	97.1
S 135	1.0	84.1	83.1	98.8
Ma 108	1.0	21.1	20.1	95.4

Breakthrough polymer was found in the production wells S 66 (37 ppm HPAM) and S 95 (9 ppm HPAM) and used as polymer-containing water for the experiments. The water amount of the other three production wells was used for dilution, to adjust the desired polymer concentration for examination. The concentration of back-produced HPAM can be varied, starting with a baseline of zero ppm. The maximum possible concentration was 30 ppm back-produced polymer; resulting from the combination of both polymer producers and dilution to reach the required flow rate (**Appendix A3**).

In front of the test unit, a tank was installed to buffer upcoming inlet fluctuations and to hold the oil-in-water content below an acceptable limit (outlet <300 ppm). Otherwise the next treatment steps would be overloaded and quickly lead to a reduction in the treatment efficiency (**Figure 6-3**). Consequently, the residence time was prolonged and the hydrocarbon content reduced by gravity separation. The produced water was then transferred to the corrugated plate interceptor, which contains four bundles of horizontal corrugated plates with a plate clearance of 6 mm. It was possible to remove oil droplets down to a minimum size of 43 µm. The oil droplets accumulate on the plate surface (surface coalescence), increase in size and rise through holes within the plates to the surface through density differences. At the surface an oil layer is formed and further transported to the slop (outlet <100 ppm hydrocarbon content). Nitrogen blanketing in the corrugated plate interceptor and in the dissolved gas flotation cell excluded oxygen and prohibited possible aerobic bacterial activities [45].

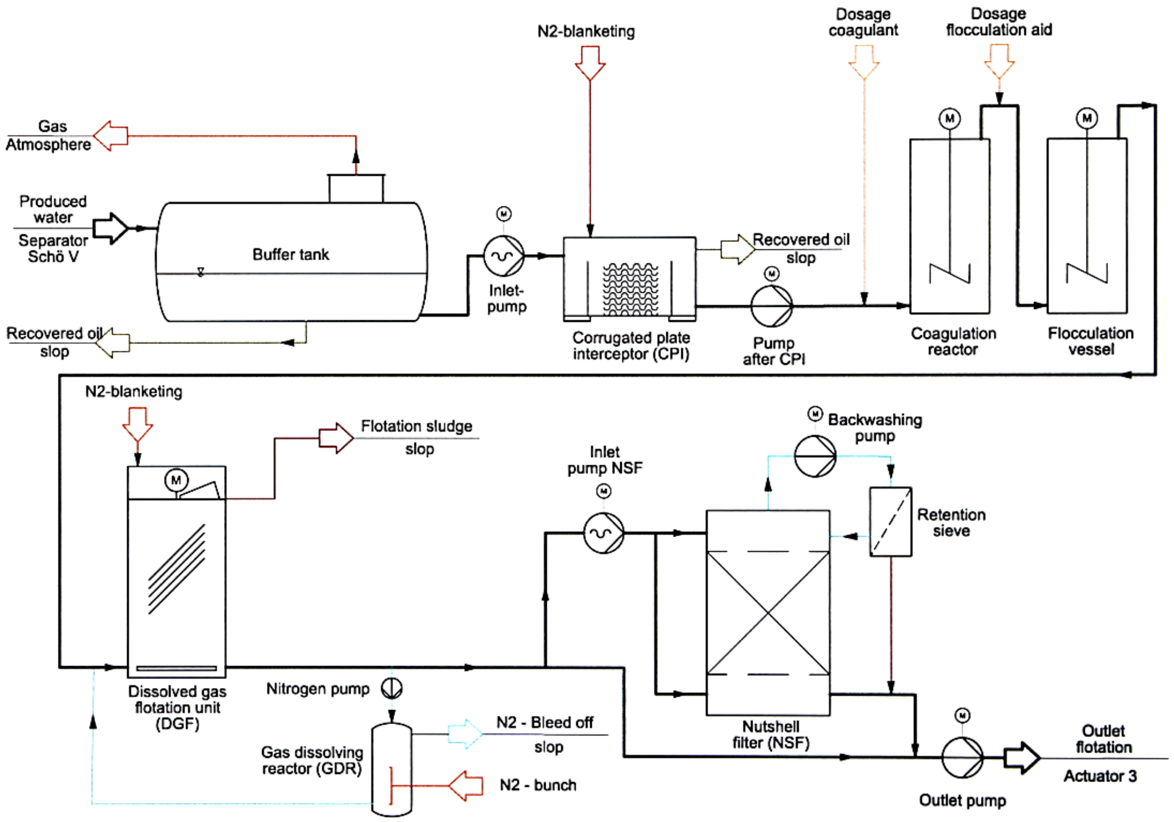


Figure 6-3: Process flow diagram of the water treatment pilot unit [45].

After the mechanical treatment steps, the water was treated within the flotation unit (chemical treatment), consisting of a coagulation reactor, a flocculation vessel, a dissolved gas flotation cell, and a gas dissolving reactor. The flotation unit was operated with a coagulation agent and a flocculation aid, to destabilize and agglomerate the colloidal dispersed particles into larger stable, floatable flocs. The coagulation reactor, designed as a tube reactor, ensured sufficient residence time (3.5 min) for the added coagulant to react with the colloidal dispersed particles and to form micro-flocs. Through adding the flocculation aid the micro-flocs agglomerated to floatable flocs, which took place in the flocculation vessel. It was a cylindrical stirrer vessel, equipped with a three-blade stirrer to provide a homogenous mixing of the flocculation aid. The residence time in the vessel was about 7.5 min. The agglomerated flocs were removed afterwards in the dissolved gas flotation cell. A side stream of the treated process water was pressurized up to 6 bar beforehand, saturated with nitrogen in the cylindrical shaped gas dissolving reactor and fed back into the bottom of the dissolved gas flotation cell. The nitrogen bubbles, generated by rapid pressure reduction of the saturated process water, accumulated the flocs and lifted them to the surface of the cell. At the top, a slug layer was formed, which was periodically removed with a rotating skimmer and transported to the slop. The process water had a hydrocarbon content of less than 20 ppm after the chemical treatment step.

A nutshell filter, designed as a deep-bed filtration, was used as a final polishing step. The oil droplets in the process water adhered to the nutshell granulate surface. Black walnut shells, with a mesh of 12/20, were used as a filter bed material (average filter bed depth of 36 cm). The nutshell filter was operated with a flow rate of 200 liters per hour. Through periodical back-washing cycles was the adsorbed oil removed and the oil receptivity of the nutshell granulate maintained. The filter was operated discontinuously, which is mainly dependent on the water quality. The maximum operating time is 24 hours, to ensure a proper adsorption of the oil droplets. The back-washing cycle started, when the maximum differential pressure of over 1 bar was reached or due to a filter breakthrough. This filtration step further reduced the hydrocarbon content to less than 2 ppm [45].

6.4.2 Flotation Packages

In laboratory scale extensive bottle tests (flocculation tests) were performed, to find appropriate coagulants and flocculants before the start of the field tests with the pilot unit. The chemical packages were evaluated regarding stability, floatability, stickiness, and size of the flocs, as well as the filterability of the water. Out of these preliminary tests, two chemical sets could be identified to be applied in the pilot plant.

Table 6-2 compares the two packages; both sets were able to stabilize colloidal dispersed oil droplets and particles. The coagulant induced floc formation, while the flocculation aid induces floc growth. Through the usage of both chemicals the dispersed oil droplets and the suspended solids were removed from the produced oilfield water. The density of the agglomerated flocs is crucial for further sludge treatment [45].

Prior to the field trial, several mixtures of Set Vb were investigated in laboratory scale and optimized for high HPAM concentrations. Following mixtures were tested 70:30 vol%, 80:20 vol% and 90:10 vol%, whereby the 80:20 vol% mix was the most promising one (consisting of 100 ppm coagulant and 0.6 ppm flocculation aid).

Table 6-2: Comparison of the used chemical packages applied in the DGF unit. (* currently used at the same dosage in the WTP Schoenkirchen, ** dosage determined by prior lab-tests, optimized for high HPAM concentration in produced water streams) [45].

Chemical Set	**Set IIa**		**Set Vb**	
Type	Inorganic coagulant	Organic flocculation aid	Inorganic & organic coagulant	Organic flocculation aid
Substance	PAC	PAM	PAC (80 vol. %) + Epi-DMA (20 vol. %)	PAM
Charge	cationic	anionic	cationic	anionic
Dosage	35*-80 ppm	0.3 ppm*	100 ppm**	0.6 ppm**

Set IIa, which is normally used for conventional oil-water separation in the water treatment plant Schoenkirchen, has been analyzed if it is also able to treat polymer-containing water.

Set IIa persists of the inorganic coagulant poly-aluminium chloride (PAC) and flocculation aid polyacrylamide (PAM). PAC is designed for the flocculation of oil and suspended solids. The chemical dosage used in the water treatment plant Schoenkirchen is 35 ppm PAC and 0.3 ppm of PAM. During the trials the dosage of the coagulant was varied from 35 ppm up to 80 ppm. Earlier performed experiments with spiked polymer showed that with Set IIa, polymer concentrations below 6 ppm can easily be treated. The separation efficiency decreased at higher polymer loads.

Set Vb, normally pre-selected for the treatment of polymer-containing water (flocculation of HPAM), showed that it was able to treat water with higher polymer loads in the bottle tests. In the laboratory scale good results were achieved up to 100 ppm HPAM with constant dosage. Set Vb consists of two different coagulants, the inorganic PAC and the organic epichlorhydrine-dimethylamine (Epi-DMA). Epi-DMA, a cationic polymer, is also a common used coagulation agent. Favorable of cationic electrolytes is the reduction of the produced sludge amount and the low sensitivity to varying pH values [178]. Furthermore, the combination of metal salts and cationic polymers (used as coagulant) leads to an improved size as well as stability of the generated flocs [179, 45].

6.4.3 Hydrocarbon Content

For the measurement of the total hydrocarbon content in the produced water, solvent extraction, using mid-infrared laser spectroscopy, was applied after ASTM D7678-11. The method focuses on the determination of the hydrocarbon content in the water, which can be extracted through cyclohexane from the acidified sample. The infrared absorption is measured in the range of 1,370 cm^{-1} to 1,380 cm^{-1} [180].

6.4.4 Polymer Concentration

For the determination of back-produced HPAM in the produced water, size exclusion chromatography was used (API RP 63-5). The measuring principle is based on the chromatographic separation of high-molecular-mass polymer molecules from low-mass interferences. The quantification is accomplished by ultraviolet detection [181].

6.4.5 Water Blocking Factor

The water blocking factor (WBF) is an OMV internal index to evaluate the filterability of the injection water and demonstrates the injectivity of the water. The water quality at the outlet of the nutshell filter plays an important role for a successful re-injection and for further usage in EOR operations. The sample was taken under anaerobic conditions, in a 5 to 10 liter pressure vessel, to avoid iron precipitations. After the sampling, the sample is filtered over a 3 µm cellulose nitrate filter. The volume of the filtrate is recorded over time and the blocking factor calculated. In the ideal case it should be around zero. For injection water a satisfying factor is below 0.7 [45].

6.4.6 Total Suspended Solids

The determination of the total suspended solids (TSS) was performed parallel with the WBF evaluation. Before usage, the filter was dried at 105°C and weighed. After the filtration, the filter was washed oil- and salt-free with 2-propanol, white spirit and distilled water. Subsequently, the filter was dried at 105°C to a constant weight and after cooling down weighed again. The difference to the empty filter is calculated and recalculated to the filtered volume. An optimal value of TSS should be below 1 mg/l [45].

6.5 Results

Two different chemical packages were tested in the pilot plant. The dosage of Set IIa was varied from 35-80 ppm of the coagulant and mixed with 0.3 ppm of the flocculation aid. In the pilot plant different back-produced polymer concentrations were investigated to evaluate the defined flotation sets concerning their treatment efficiency. The feed concentration of HPAM (**Table 6-3**) was varied during the examination of the two chemical packages. The trials were started with a baseline (0 ppm HPAM) and then increased stepwise to higher polymer loads. The maximum possible and available back-produced polymer concentration was 30 ppm. In the trial with Set Vb the plant was operated with the same dosage identified in the laboratory, because promising results could be achieved with 100 ppm of the coagulant and 0.6 ppm of the flocculation aid at all tested HPAM concentrations.

Table 6-3: Combination of producers used for the experimental trials, * wells contain breakthrough polymer [45].

# Test Series	Tie-in of Producers	Flow Rate, calc. (m^3/h)	HPAM Concentration, calc. (ppm)
1	S 110, S 135, Ma 108	6.5	0
2	S 95*, S 110, S 135, Ma 108	8.9	6
3	S 95*, S 135	5.9	8
4	S 66*, S 110, S 135	7.3	20
5	S 66*, S 95*, S 110	6.1	30

The different concentrations of back-produced polymers in the two production wells were (S 66 and S 95) dependent on a chromatographic effect in the reservoir and on possible polymer losses in the formation through mechanic, thermal, or chemical degradation. Besides, adsorption in the porous medium and dilution effects influenced the back-produced polymer amount. Furthermore, the slug composition (polymer concentration and injection volume) played a considerable role.

Table 6-4 expresses the results of the measured HPAM concentrations with size exclusion chromatography. The results show that the added chemical agents in the flotation unit significantly influenced the removal of back-produced polymer. The removed HPAM was contained in the flotation sludge, which changed the sludge composition. This could affect the further sludge treatment, which needs to be investigated in additional trials. Also higher polymer concentrations could be removed through the flotation process, leading to the fact that the polymer does not adversely affect the nutshell filter [45].

Table 6-4: Results of the measured HPAM concentration from the main treatment steps [45].

Measured HPAM concentration (ppm)		
CPI Inlet	**DGF Inlet**	**DGF Outlet**
6	6	< 1
9	8	< 1
19	19	< 1
29	29	< 1

The mechanical treatment steps, buffer tank and corrugated plate interceptor, showed no negative impact on the separation efficiency in presence of back-produced polymer in the water stream [45]. **Figure 6-4** shows the hydrocarbon removal efficiency of the mechanical step at different HPAM concentrations. Over the trial time the removal efficiency was 78% in average. A higher gross rate through combining several wells resulted in reduced residence time and decreased the removal efficiency.

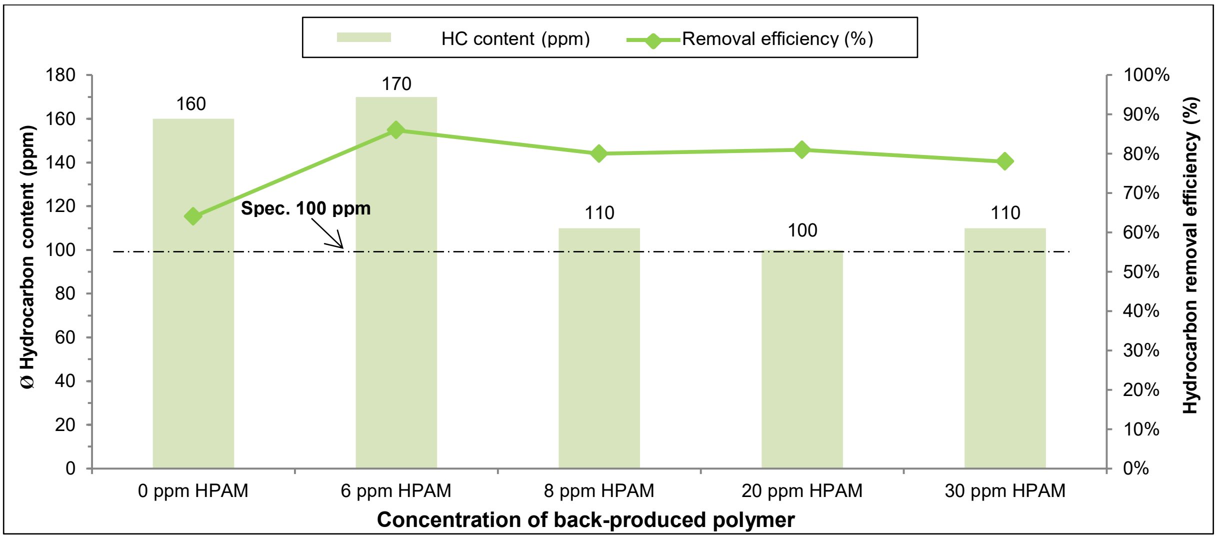


Figure 6-4: Hydrocarbon removal efficiency of the mechanical treatment step at tested HPAM concentrations (Modified from [45]).

Through the addition of coagulant and flocculent the colloids in the produced water (containing back-produced HPAM) were removed (**Figure 6-5**). The addition of a positively charged coagulant (cationic) led to the generation of micro flocs (compensation of the negative surface charge). The flocculent agglomerates then destabilized these particles into larger stable flocs (floatable). In the flocs, oil and suspended solids were contained (adsorption) [182].

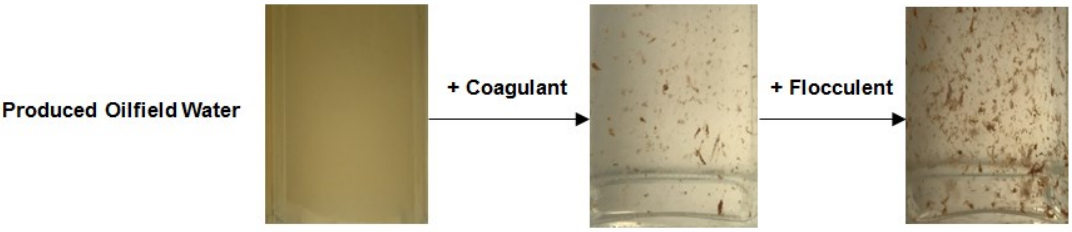


Figure 6-5: Floc formulation through the addition of coagulant (micro flocs) and flocculent (macro flocs).

The separation efficiency of the chemical treatment step (dissolved gas flotation unit) was tremendously influenced by the used coagulant and flocculation aid. Following dosage rates of the Set IIa were tested:

- 20 ppm PAC and 0.15 ppm PAM for the baseline (0 ppm HPAM)
- 35 ppm PAC and 0.3 ppm PAM for 6 ppm HPAM

For 8 ppm HPAM, the same dosage of 6 ppm was tried but the results were sobering. Therefore, the dosage rate was further increased to 80 ppm PAC and 0.3 ppm PAM, but still no improvements were achieved. Set IIa was not able to perform satisfactorily, even with an increased dosage. **Figure 6-6** demonstrates the hydrocarbon removal efficiency of both chemical packages. A significant trend that the effectiveness of Set Vb is much better than Set IIa can be seen in the figure [45].

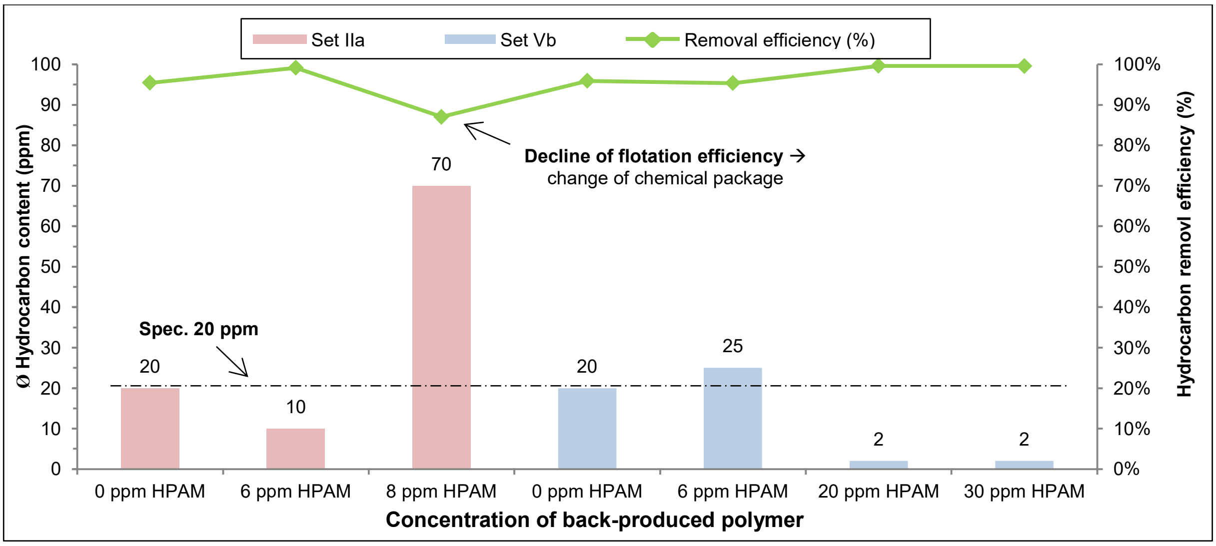


Figure 6-6: Hydrocarbon removal efficiency of the dissolved gas flotation unit compared with both chemical sets at tested HPAM concentrations (Modified from [45]).

The hydrocarbon removal effectiveness at 6 ppm HPAM was 78% with an average hydrocarbon content of 10 ppm. An increase of the polymer concentration to 8 ppm showed already a massive influence on the performance of the flotation unit, the efficiency decreased to 45% with an average hydrocarbon content of 70 ppm. However, from the **Figure 6-6** it is evident, that the usage of the Set IIa for polymer-containing water streams is limited. The maximum possible polymer concentration is approximately 8 ppm back-produced HPAM. These results correspond with the findings of earlier trials with spiked polymer. Furthermore, the required dosage rates are higher compared to the necessary dosage rate of produced water without polymer [45].

Particularly, Set Vb can be used for higher polymer loads, as it was able to clear water with a polymer content of around 30 ppm back-produced HPAM. The hydrocarbon removal efficiency at higher polymer concentrations was still 99%. Additions of up to 100 ppm of spiked HPAM were tested successfully in the laboratory scale with the same dosage rates (100 ppm coagulant and 0.6 ppm flocculation aid) and good cleaning efficiency could be achieved. Over the trials the dosage was kept constant. The necessary quantity of the chemicals increased in portion of eight parts treatment chemicals per one part HPAM. Moreover, Set Vb was cheaper than Set IIa, which should be further taken into consideration. Besides, for lower HPAM concentrations the dosage of Set Vb could be further optimized [45].

Figure 6-7 compares the floc formation of both chemical packages at their maximum tested polymer concentration. The floc formation of Set IIa was substantially affected by the negatively charged back-produced polymer. Whereby, the Set Vb generated different flocs reasonable through the different mechanism. Set Vb created polyelectrolyte complexes, when HPAM (polyacid) was mixed with the Epi-DMA (polybase) [183]. Consequently, HPAM was complexed through the organic coagulant and the negative surface charge of the HPAM. PAC (metal salt) agglomerated the oil droplets as well as solid particles [45].

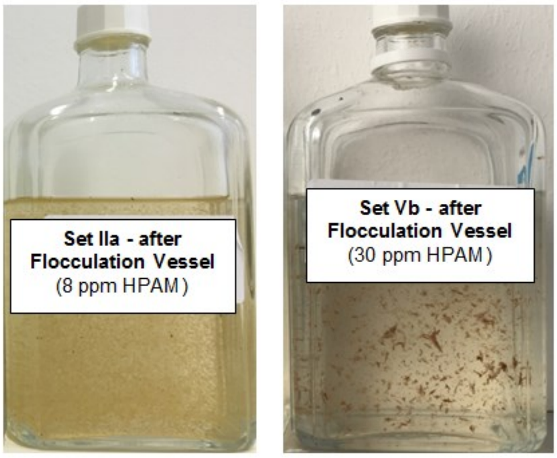
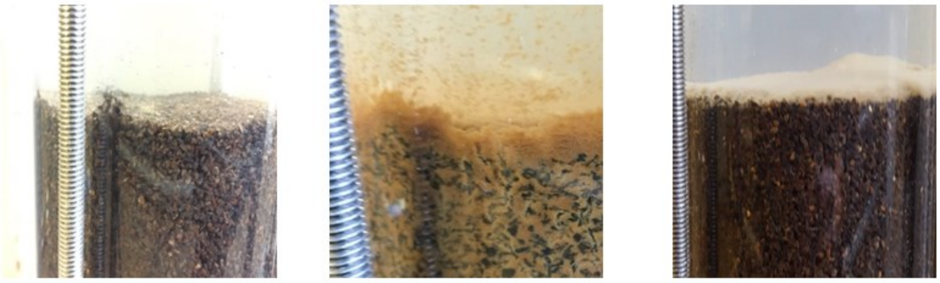


Figure 6-7: Comparison of the floc formation of the two chemical packages at their maximum tested HPAM concentration [45].

The generated sludge in the flotation cells differed from the two tested chemical packages. By the usage of Set IIa, high volumes of water were included (highly liquid) and with Set Vb a compact/ denser sludge was produced.

The filterability of the treated water after the flotation unit plays an important role for the final polishing step. The operational behavior of the nutshell filter is strongly dependent from the performance of the flotation unit. Part of the filter bed agglomerated when the water quality of the flotation unit was poor. All flakes, including the polymer amount, entered the nutshell filter. This effect just appeared with Set IIa. **Figure 6-8** displays the nutshell filter performance at 6 ppm and 8 ppm HPAM concentration [45].



Filtration
6 ppm back-produced polymer in the water → >12 h filter runtime possible

Filtration
8 ppm back-produced polymer in the water → after 3 h bulk amount of flakes visible

After 19 h Downtime
8 ppm back-produced polymer in water → white layer of flakes on the nutshell granulate surface visible

Figure 6-8: HPAM influence on the nutshell filter by the use of Set IIa [45].

At 6 ppm polymer concentration, the water after the filtration was completely clear (hydrocarbon content <5 ppm). An increase of the polymer load of around 2 ppm HPAM already led to problems in the chemical treatment step and resulted further in an unfavorable filtration process (no measurement of the hydrocarbon content possible). The filter was overloaded and created an enormous bulk amount of flocks, visible after three hours filter runtime. Besides, also the hydrocarbon removal efficiency decreased from 98% to 87%. The regenerative back-washing cycle was also affected by the agglomeration. **Figure 6-9** shows the plugging of the nutshell granulates, as a consequence of the produced water containing the flakes and the residual polymer. A suboptimal operation of the filtration step leads to an increased number of back-washing cycles [45].

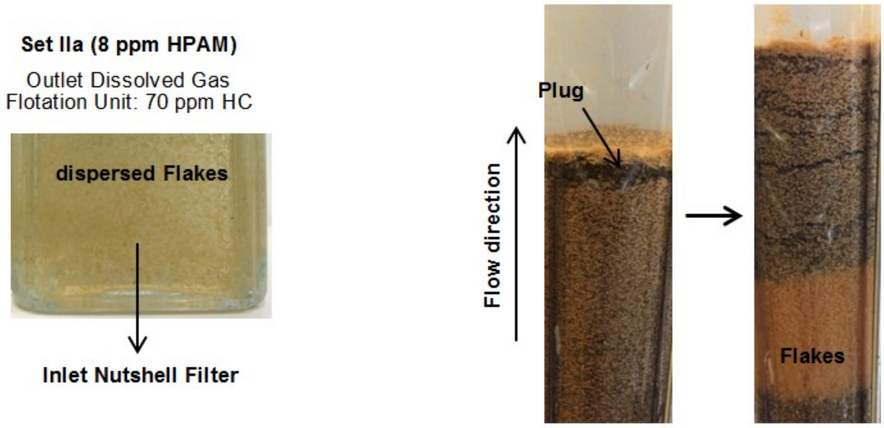


Figure 6-9: Impact of the polymer interfering on the back-washing cycle of the nutshell filter (HC: hydrocarbon content) [45].

With the Set Vb really good results could be achieved and the hydrocarbon removal efficiency was around 99%, with an average hydrocarbon content of less than 1 ppm and the water quality criteria for re-injection could be easily achieved. **Figure 6-10** demonstrates the operation efficiency of the nutshell filter [45].

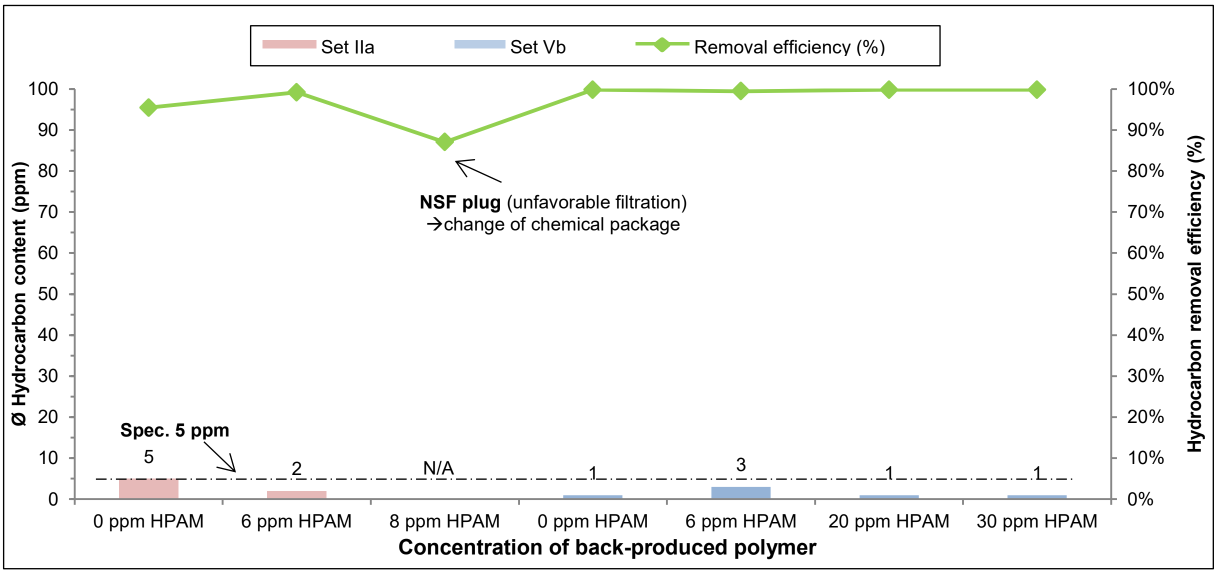


Figure 6-10: Hydrocarbon removal efficiency of the final polishing step (nutshell filter): comparison of both chemical sets at the tested HPAM concentrations (Modified from [45]).

The results of the performed WBF and TSS experiments are shown in **Table 6-5**. The injection water quality criteria were achieved at varying polymer concentrations. Just in the 8 ppm HPAM case, no WBF measurement was performed due to the poor water quality at the outlet of the flotation unit. In all trials the total suspended solids were less than 1 mg/l [45].

Table 6-5: WBF and TSS results at different HPAM concentrations [45].

DGF Inlet HPAM (ppm)	NSF Outlet HPAM (ppm)	WBF (-)	TSS (mg/l)
0	<1	<0.7	<1
6	<1	0.8	<1
19	<1	0.7	<1
29	<1	1.6	<1

6.6 Discussion

The produced oilfield water is not equal in its composition (e.g. hardness, salinity, and alkalinity) in the whole basin. The water which is transferred to the treatment facilities can change and be different than the defined inlet specifications. Therefore, it is relevant to choose the proper treatment system to handle breakthrough EOR water streams.

As seen from the titration curves, (**Chapter 4.3.3**) precipitations occurred when alkalis and multivalent hardness ions, which are present in the injection water, interacted with each other. In order to prohibit these precipitations at the injectors and in near-wellbore region the injection water needs to be softened before further usage (prior to the alkali-polymer slicing unit). According to the fact, that high hydrocarbon loads are present in the produced water, a deoiling step (chemically, mechanically) prior to the softening unit is mandatory.

Produced water containing breakthrough polymer is more difficult to treat than conventional produced water. There are several different options to degrade, destroy or eliminate the water-soluble polymer, chemically and/ or mechanically, in order to enhance the filterability of the polymer-containing water. In this pilot study, the HPAM was removed through the chemical treatment step (contained and removed through the flotation sludge). Higher flotation sludge amounts could be realized when polymer was contained in the water stream compared to normal oilfield water handling.

Especially, when back-produced EOR fluids are contained in the water, the oil-water properties are changed and treatment steps massively influenced. In this study, the results of the mechanical treatment steps (corrugated plate interceptor) showed no adverse effect when HPAM was contained in the inlet water stream. The water quality was strongly influenced by performed changes in the field (e.g. workover programs, pigging) and lead to fluctuations of the hydrocarbon content. Also, the different production well combinations lead to different inlet quantities.

The chemical treatment step (flotation) and the filtration step were relatively sensitive to polymer concentrations at the inlet stream (smaller than 2 ppm HPAM). The presence of polymer tremendously affected the filterability of the water.

There was a difference in the sludge composition of the two tested chemical packages. By the usage of Set IIa, high volumes of water were included (highly liquid) and with Set Vb a compact/ denser sludge was produced. As a result, it is important to adjust the skimmer regarding the sludge properties in the pilot plant. This could be either achieved through a change of the skimming depth or an increase of the filling level. Otherwise no proper sludge removal is possible, which results in a spill of the flotation cell. Further investigations about the sludge treatment are relevant and should be conducted.

At the end of the field study, one of these chemical sets was found, having a hydrocarbon removal efficiency of around 99% in presence of 30 ppm HPAM inlet concentration. Using this set, good removal efficiency and no plugging of the nutshell filter was observed even at high polymer concentrations. The other set led to plugging of the filtration system at relative low polymer concentrations (~8 ppm HPAM). As a consequence, the removal efficiency of hydrocarbons as well as polymer was poor. Based on these results, it can be assumed that the evaluated treatment steps are not negatively affected in presence of up to 30 ppm HPAM load at the inlet water stream.

Artificially prepared micro emulsions do not absolutely reflect the real field conditions because it is difficult to predict the composition of the back-produced fluids. Still it makes sense to evaluate the worst case in laboratory scale beforehand. As a next step, the concentrations of the alkali/ polymer/ co-solvent as well as the softened injection water (same properties) which will be injected can be used and further investigated. Through this evaluation it is possible to understand the emulsion characteristic (oil-in-water or water-in-oil emulsion) but also if there are any demulsifiers on the market to handle the back-produced fluids. A proper screening needs to be performed in the field at the breakthrough because the oil quality changes. After finding the appropriate mixture online monitoring might be useful.

For EOR field applications, it is major to handle oilfield water containing EOR fluids in a decentralized treatment facility. Otherwise the whole field processing might be influenced when treatment difficulties arise.

7 Economic Assessment of R&D Projects

Research & development (R&D) projects become more and more important in the upstream business. As a part of this study/thesis an economic model for R&D projects based on an exploration & production (E&P) model was developed. All required components for the R&D economic evaluation are highlighted, whereby life cycle assessments (LCA) represent an important part of the evaluation. The developed R&D model was tested on a practical case study of chemical enhanced oil recovery (cEOR). Different injection scenarios and formulations were simulated based on the technical studies of alkali-polymer (AP) flooding by the use of Palantir® Cash software and compared regarding the defined R&D key performance indicators. The LCA evaluates the environmental impacts of the chemical injection water containing alkali and polymer used for this EOR application. The applied methodology follows ISO 14044:2006. The LCA highlights the chemical amounts, waste streams and energy requirements for the injection water, regarding the overall injection volume. The CO_2 footprint of the delivery of goods (chemicals) is highlighted.

7.1 Divisions of the Oil & Gas Industry

Basically, the businesses of oil and gas industry are subdivided, according to their value-added chain, into upstream, midstream and downstream [184]. The upstream segment, exploration and production (E&P), includes exploration for oil and gas, drilling and operation of wells, recovery and production of oil and natural gas through the transfer of fluids to surface facilities. Over the production lifetime the oil cut decreases and the water cut increases. As the operational costs do not change over the production time, it will result in an unattractive economic production (incremental costs per barrel increase) and well abandonment will be started. Upstream projects are characterized through high risks (safety and environmental aspects, unpredictable success of a well…) and returns as well as high initial investment costs. In most of the cases, the period from exploration until production is rarely lower than five years (first marketable production, cash inflow) [185, 186]. In addition, upstream projects are technology intensive and highly regulated through the country's local political environment (price controls, laws, tax regimes, regulations, political instability…), but also influenced through global politics including supply and demand, crude production, economic growth, etc. [185].

The midstream segment represents the interface between the upstream and downstream business. It includes required facilities (storage, pipelines) and processes to transfer the produced fluids to the refineries (ships, tanker) [184, 185].

The downstream segment includes the oil refinery, the supply and trading but also the product marketing and retail. After the crude oil is transported to the refinery, it is further processed into different end products, such as gasoline, diesel, jet fuel, lubricants, heating oil, plastics, synthetic rubber, fertilizers, pesticides and asphalt. The process steps include fractional distillations, cracking, reforming, but also other conversion and purification processes. The downstream segment also includes the service-station business. Downstream is mainly influenced by the crude oil prices and capacity utilization but also the composition of end products (yield; high content of light and middle distillates is favorable) [187, 186].

7.2 Economic Project Evaluation

Economic analyses are already performed at an early stage of a project, to support the project team regarding relevant decisions from an economic point of view (value contribution, **Figure 7-1**). Typically, economic analysis is based on the discounted cash flow (DCF) concept, which provides a quantitative and systematical approach (state-of-the-art concept). DCF method is applied in most industries. It considers relevant economic factors, which might influence the economic potential of planned investments [188, 189]. DCF puts all investments on an evaluation basis and considers the time value of money with a discount rate. Different discount rates influence the results [189, 188]. Often the weighted average cost of capital (WACC) is used as discount rate (reflecting the risk of the cash flow), which represents the average cost a company pays for capital by borrowing or selling equity [190].

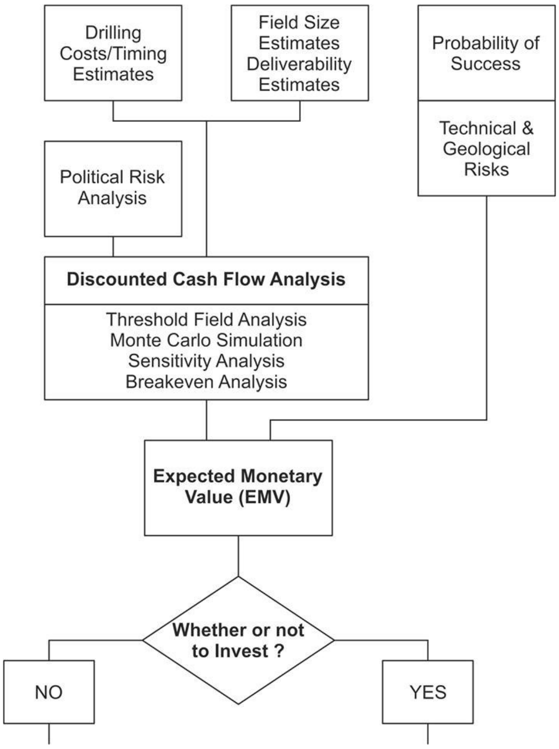


Figure 7-1: Decision making of exploration projects (After [191]).

The net present value (NPV), which is gained through the DCF method, is risked with the technical and geological aspects (including the probability of success) and called the expected monetary value (EMV). EMV is a quantitative risk parameter which allows quantifying and comparing projects (decision whether or not to invest) [192].

7.3 Exploration & Production Methodology

Economic analyses in E&P are performed for acquisition, exploration, development/re-development, production, maintenance, safe guarding and abandonment [193]. Typical upcoming costs are exploration, development, and operating costs (**Figure 7-2**). In general not all executed exploration ventures are successful, which means that the profit margin needs to be large enough to compensate for failures. The government tries to capture as much of the economic rent as feasible by bonuses, royalties, taxes and levies. Additionally, the exploration acreage is characterized through lack of information and uncertainties [191].

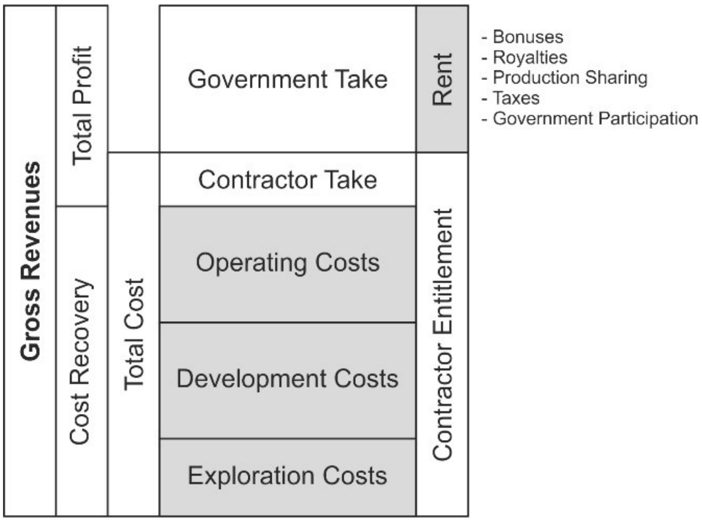


Figure 7-2: Division of revenues from the production. The total costs reflect the perspective of the government (After [191]).

Petroleum economics is a continuous activity, whereby exploration economics start prior to any discovery. As soon as oil and gas is found, economic analyses are relevant to justify appraisal drilling. Furthermore, petroleum economics are required to commit large funds for field developments (final investment decision) [194].

Each E&P business differs tremendously concerning its economic perspective. The main aspects in terms of risks, bonuses, work commitments, royalties, reserves, field size, capital requirements, operational expenditures (OPEX), sunk costs, contractor take and cost recovery limit for exploration, development, production and R&D prospects are summarized in **Table 7-1**. Research and development economics are worked out, which focus on developing and testing new technologies, as the focus on R&D projects becomes more important in the upstream segment.

Table 7-1: Summary of the key considerations of economic perspective from exploration, development, production and R&D projects.

	Exploration Economics [191]	**Development Economics** [191]	**Production Economics** [191]	**Research & Development Economics**
Focus	Risk Analysis, Farm-in/ Farm-out Bidding	Feasibility, Exploitation, Development Economics	Ongoing Production, Acquisitions	Products, Services, Technologies
Risk	Drilling/ Finding very high	Costs, Timing, Prices moderate	Mostly price risk lower	Technology risk high
Bonuses	Signature Bonus very sensitive	Startup Bonus Usually not sensitive	Production Bonus Usually not too sensitive	Not applicable
Work Commitment	Very important part of risk capital	Huge but not as risky as exploration	Usually not applicable	Can be included
Key Capital Requirements	Exploration Capital, Seismic, Bonuses G&G, Drilling	Development Costs, Drilling, Facilities, Transportation	Operating Costs	Development and Testing Costs
Operating Costs	Economics not sensitive	Moderately sensitive	Very sensitive	Moderately sensitive
Sunk Costs	Not yet created	Positive impact on development decision	Flow through cost recovery and have present value	R&D recovers costs – no sunk costs
Threshold Field Size	Huge 100-500+ MMBBLS	Moderate 5-50+ MMBBLS	Economic Limit Threshold	Not applicable
Contractor Take	Critical concern	Important concern	Important concern	For rollout not applicable
Royalties	Can be very regressive and discourage exploration and development, and cause premature abandonment			
Cost Recovery Limit	Important concern	Very important concern	Not so important	Not so important
Reserve Values	Expected Monetary Value	Discounted Cash Flow	Discounted Cash Flow	Expected Monetary Value

Exploration economics focus on risk analysis, farm-in and farm-out bidding and distinguish from development economics regarding threshold field size, bonuses, work commitments and cost recovery limit. Furthermore, exploration, as well as drilling of new wells, is associated with high risks. Work commitments play an important role and are part of the risked capital. The expected monetary value (EMV) is used for project rankings as main key performance indicator. Besides, the reserve values are purely hypothetical and the cost recovery limit constitutes a significant aspect in exploration prospects. The main capital requirements are driven by seismic, bonuses, and drilling [193].

Development economics focus on feasibility studies, exploitations, and evaluations. The upcoming risks are classified as moderate and include costs, execution time and prices. The capital requirements consist of development and drilling costs but also necessary expenses for facilities and transportation. Moreover, work commitments are huge but not as risky as for exploration prospects. Sunk costs have a beneficial influence on the development decision and bonuses are not that sensitive as for exploration projects. Other important aspects are contractor take and cost recovery limit. The reserve values for development prospects are low and discounted cash flow is used as key performance indicator [193].

Production economics distinguish from the other two types and focus on ongoing production as well as acquisitions. In production projects, the price risk is lower and the reserve values higher compared to exploration and development projects. The key cost drivers are the OPEX. Here, an economic limit of the threshold field size is relevant [193].

Research and development economics focus on improving current technologies by means of maximizing revenues through improved production. The risks of investing in R&D projects can be quite high, as the risks and uncertainties of the new technology may not be fully understood. The de-risking should occur through a pilot before implementing the technology to the field [195]. In contrast to classical E&P projects, no bonuses are typically associated with developing and testing new technologies, but could probably be deducted from taxes (depending on the fiscal regime). R&D projects can be included in a work program suggested to authorities during the application process for a license (studies of the local geology). The key capital requirements for R&D projects are mainly associated to development, testing and pilot costs [196]. R&D projects cannot be characterized by threshold field size, as well as contractor take, as the costs of a successful R&D project will be recovered through an increased production of other E&P projects [197]. The recoverable reserves for planning and economic evaluation can only be estimated as the performance of the pilot cannot be assessed in advance.

Projects which should be implemented in an already existing field, asset or area, need to be calculated through incremental economics, regarding a defined base case. Thereby, aspects which influence the value, such as sunk costs, opening balances, carry repayments or adjustments, need to be considered. The individual planned project needs to be evaluated by the use of differential cash flow method. The differential cash flow is gained through the subtraction of the cash flow from a defined base case scenario for the planned investment case [193].

7.3.1 Uncertainties, Risks & Chance of Maturation

In principle, discovery, acquisition and development of new reserves, construction of facilities and drilling are capital intensive. The nature of exploration projects is always associated to high risks and uncertainties [198]. Depending on the type of E&P project, different risks and uncertainties can arise before and during investing in such projects and therefore require a proper understanding of the petroleum system, occurring drilling hazards, production from the target reservoir, sale of produced fluids, etc. [189]. Nevertheless, changing oil and gas prices are also becoming an increasingly important aspect [194].

The terms uncertainty and risks have a different meaning and need to be defined: uncertainties describe the fact, that a possible outcome of a decision/ event is unknown. In addition, uncertainties cannot be measured, controlled or minimized and are not assigned to probabilities. In contrast, the outcomes of risks are known; they are controllable and can be minimized. Risks are assigned to probabilities and have a possibility that economic loss occurs or the economic value is reduced, whereas uncertainties reflect future events that might occur [199, 194].

The evaluated uncertainties are clustered in an uncertainty matrix (level of impact vs. degree of uncertainty, **Figure 7-3**, **A**) and the risks in a risk matrix (impact vs. likelihood, **Figure 7-3**, **B**). According to the risk matrix, high-risks are defined by the chance that a high loss occurs even though the probability is very small. Risks can vary from technical (reservoir, geological, development, production, infrastructure, maintenance, safety…), economic (cost estimate, exchange rates, regulation, price and pricing, taxes, royalties…), commercial (regulation, energy prices, legal, insurance, customers…), organizational (supply chain, project management, internal and external experience…), and political (stake holders, environmental issues, regulatory environment, government involvement…) as well as social risks [194].

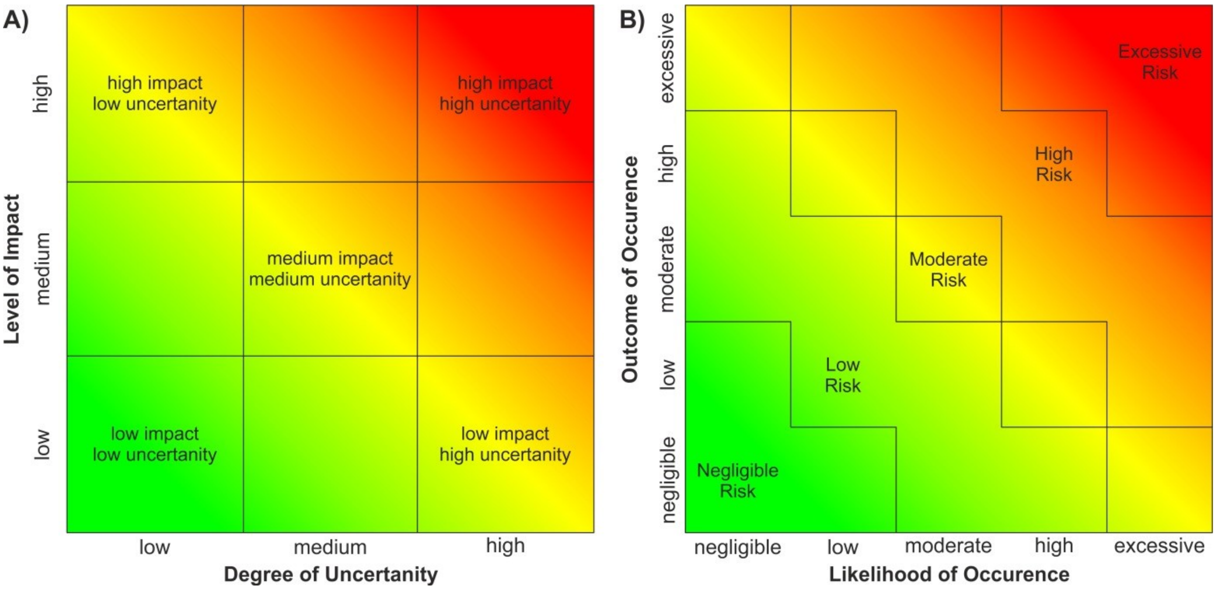


Figure 7-3: Comparison of uncertainty (A) and risk (B) matrix (After [200, 201]).

However, as such qualitative descriptions cannot be used for economic analyses; these informations are transferred into the Chance of Maturation (CoM). The CoM method makes the associated project risks transparent and enables a project comparison. The arising risks and uncertainties are clustered into four quadrants, representing the hydrocarbon chance (geology), the recovery chance (reservoir), the skills and technology chance and the authorization as well as market chance [202]. Slight differences between the project types exist, whereas for exploration projects the greatest uncertainties are related to the working petroleum system and recoverability of hydrocarbons. In contrast, uncertainties of a project, which occur later in the field lifetime, are different and are more related to recovery, skills/ technology and authorization/ market aspects [203].

The Chance of Maturation (CoM) concept is applied to allow a risking for economic analysis, to compare projects and to provide a base for decision making. CoM is a chance factor (**Figure 7-4**) and describes quantitatively the probability of a project success in percent [202]. Each quadrant can be quantified by answering and quantifying a series of standardized questions, whereby a peer group can assist [203].

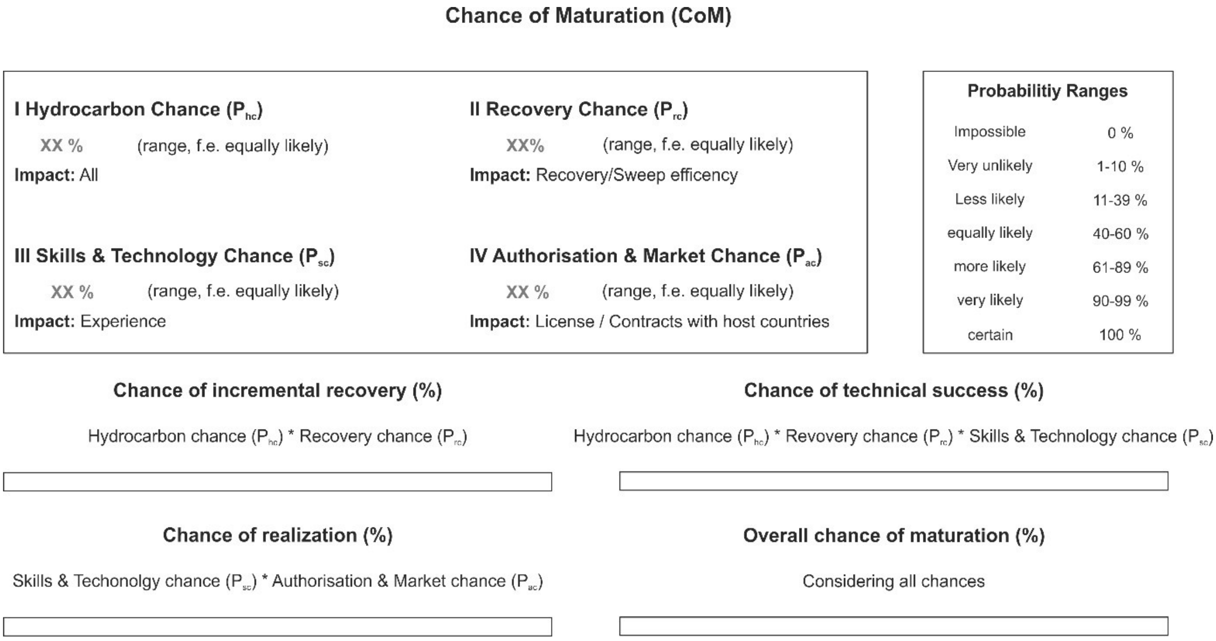


Figure 7-4: Elements of the chance of maturation process (Modified from [204]).

The hydrocarbon chance (P_{hc}) describes the chance that hydrocarbons are generated from a sufficient rich and thermally mature source rock and have migrated into a trap structure (working hydrocarbon system is present; P_s), that a reservoir formation is present and has sufficient reservoir quality (porosity, permeability and volume; P_r), that a sufficient seal rock is sealing (P_{seal}) a proposed trap structure (P_t) and that the hydrocarbons are capable of sustained production (included in P_s; low viscosity and no contaminations, **Eq. 39**) [203]. Uncertainties may arise in frontier basins as the presence of a working hydrocarbon system is unclear, the presence of reservoir rocks in suitable stratigraphic and structural positions is unknown, the properties of the seal rock may vary and the trap structure may not be present due to invalid seismic processing [205].

$$P_{hc} = P_s * P_r * P_t * P_{seal} \qquad \textbf{(39)}$$

The active recovery mechanism (water drive, gas drive, depletion drive…), reservoir volume, sweep efficiency and production method are risked in the recovery chance (P_{rc}) [203]. If the reservoir is not connected to a conducting aquifer and the gas-oil ratio of the hydrocarbon is low, a reservoir may be initially only produced via depletion drive, which causes a significant drop of the reservoir pressure and ultimately results in a decreased recovery factor. Furthermore, compartmentalization on sub-seismic scale may limit the reservoir volume and reduce the efficiency of any flooding mechanism applied. Also, an unsuitable production technique may cause significant decreases in the overall production.

Issues regarding the capability of the staff (are specialists required?), nature of the project (deep-water, unconventional…), availability of the required technology, obtainability of skills and technology and timeframe are treated within the skills and technology chance (P_{sc}) [203]. For example exploration and production, for and from deep-water reservoirs (turbidities), is challenging and requires geologists, which have already experience with such targets. Furthermore, sinking deep wells may require cutting edge heavy rigs and steering equipment, specially trained drilling engineers and micro seismic monitoring.

The authorization and market chance (P_{ac}) describes all risks associated with eco-social or environmental hurdles, uncertainties with contracts for ownerships, possible time delays and the availability and commerciality of a hydrocarbon market [203]. For example, sinking an offshore well close to a protected marine sanctuary may cause unfavorable press coverage and increased environmental restrictions. Time delays and the availability of a hydrocarbon market may become important issues when projects are carried out in remote areas or zones with questionable infrastructure.

By multiplying the individual chance factors the chance of maturation of a project can be calculated using **Eq. 40**:

$$\mathrm{CoM} = P_{hc} * P_{rc} * P_{sc} * P_{ac} \qquad \textbf{(40)}$$

The failure case (Cost of Failure, CoF) is the inverse of the CoM and can be calculated with **Eq. 41**:

$$\mathrm{CoF} = 1 - \mathrm{CoM} \qquad \textbf{(41)}$$

To account for the different uncertainties and risk scenarios during project maturation the different elements of the CoM are used. For exploration projects the main uncertainties and risks are related to the geology and the reservoir. The geological chance of success (P_g, product of the hydrocarbon and recovery chance) is used to evaluate such projects (**Eq. 42**). The associated chance of geological failure (P_{gf}) is expressed in **Eq. 43.**

$$P_g = P_{hc} * P_{rc} \qquad \textbf{(42)}$$

$$P_{gf} = 1 - P_g \qquad \textbf{(43)}$$

Also, the volumetric estimates of a potential reservoir in exploration projects are relatively hard to estimate due to the great amount of uncertainties. Therefore, the P_{10}, P_{50} and P_{90} volume estimates are averaged into a mean volume, prior to economic evaluation. This concept reflects the degree of uncertainty in the estimates which are not covered in over-exact calculation methods [206].

If a commercial field has been discovered during exploration and a field size has been established during appraisal, the economics of the development project can then be based on the individual volumetric estimate chances. For the calculation of the $P_{mean,}$ typically Swanson´s 30-40-30 approach is used. This method is a good estimate for the P_{mean} value of a skewed distribution (field size distribution, **Figure 7-5**) under certain conditions [207].

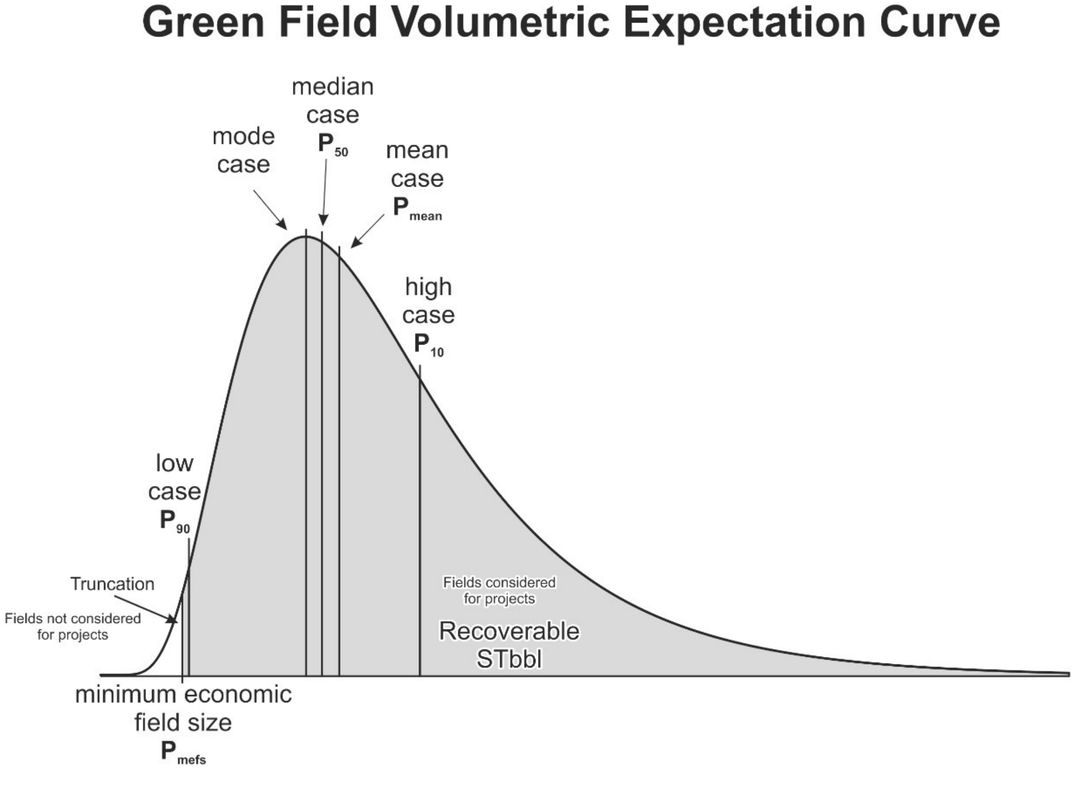


Figure 7-5: Volumetric skewed distribution (After [208]).

When a development project is mature enough (CoM has been assigned, reserve probabilities (P_{10}, P_{50}, P_{90}) and cost estimates are available) a decision point is reached (**Figure 7-6**). Thereby, the available options are clustered in a decision tree and ranked regarding their expected financial gains.

The associated risk to undertake a project is considered in the expected monetary value (EMV). Expected monetary value is a risked NPV. The EMV of the "Execute Project" branch within the decision tree can be calculated in two ways, either using P_{mean} or Swanson´s P_{mean}. The received mean NPV is then multiplied with CoM to get the EMV [193]. The "Execute Project" branch can be divided into a success case (calculation through CoM) and failure case (calculation through CoF). The decision tree illustrated in **Figure 7-6** is based on the NPV discounted at hurdle rate according to company regulations and not discounted at WACC.

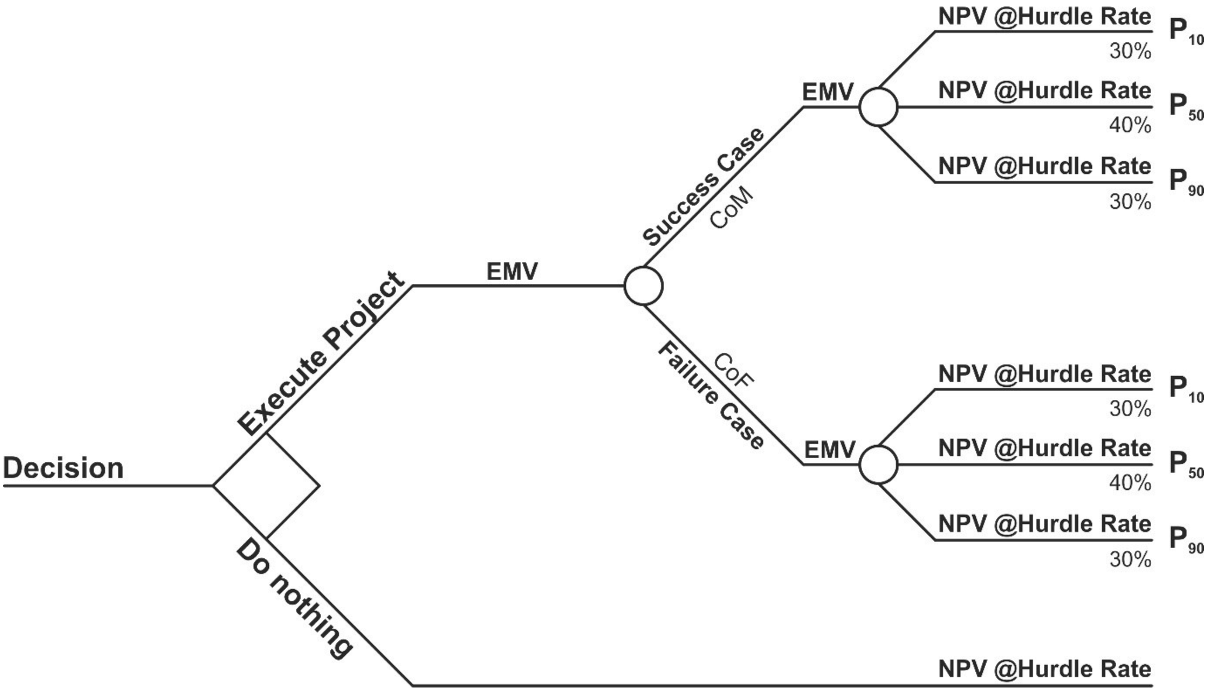


Figure 7-6: Illustration of chance of maturation decision tree (Modified from [202]).

Generally, the chance of commercial success (P_c, considers only positive part of the curve) and economic success (P_e) is obtained by truncating the prospects reserves distribution at some reserves size threshold [207]. To calculate the probability of an economic success (P_e, **Eq. 44**), P_g considers also the negative part of the curve and is multiplied with the chance to discover a field larger than the minimum economic field size (P_{MEFS}). The minimum economic field size (MEFS) represents the minimum required volume of recoverable oil and gas to develop a field in order to reach a positive NPV at country hurdle rate. In a mature hydrocarbon bearing basin, where surface facilities are already in place, the minimum required field size is smaller as development costs typically only include the well and pipeline costs. Therefore, the minimum commercial field size (P_{MCFS}) is defined as the quantities of oil and gas required to recover the drilling and completion costs (**Eq. 45**).

$$P_e = P_g * P_{MEFS} \qquad \textbf{(44)}$$

$$P_c = P_g * P_{MCFS} \qquad \textbf{(45)}$$

In a hydrocarbon province few large fields can be found next to many smaller traps. As defined above, a minimum field size is required to produce hydrocarbons with an economic success. Therefore all smaller fields are uneconomic and will not be considered as valid targets for exploration and production wells. This applied truncation shifts the volumetric cases (P_{90}, P_{mean}, P_{50} and P_{10}) to higher values (**Figure 7-7,** to the right).

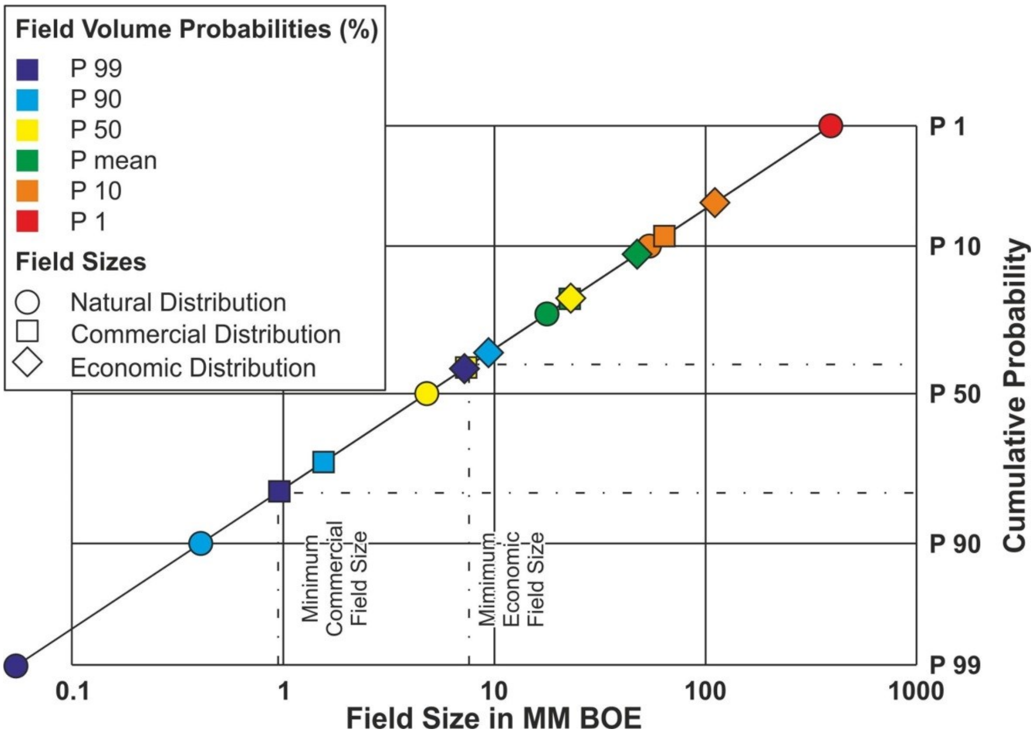


Figure 7-7: Field size distribution and truncations for commercial and economic success (Modified from [207]).

7.3.2 E&P Key Performance Indicators (KPIs)

In order to perform a successful and final investment decision it is relevant to calculate, evaluate and compare different key performance indicators (KPIs). KPIs can be divided into tangible and intangible. A tangible KPI can be thoroughly measured, calculated and allows a direct comparison of a specific aspect of two projects. For example, the discounted cash flow or the capital expenditures are directly measurable. In contrast, intangible KPIs may not be measured directly and can´t be compared straight between two projects. The impact of a project on the local communities could be an example of an intangible KPI. KPIs are used to assess the economic impact of a project and allow project comparison [209, 193]. **Table 7-2** summarizes the selection of KPIs, which OMV uses for project evaluations considering net present value (NPV), internal rate of return (IRR), expected monetary value (EMV), payback period and discounted profitability index (DPI).

Table 7-2: Economic decision criteria for E&P projects used by OMV (Modified from [210]).

KPI	Definition	Investment Decision Influence	Disadvantage
NPV	*major assessment criterion for projects *useful for project rankings *absolute value in monetary terms of discounted payment surpluses indicate project attractiveness	*positive NPV= project is profitable *negative NPV= project is not profitable *for rankings: project is preferred if NPV is higher than NPV of alternate investment	*uncertainty of CF *reinvestment premise at DR *for project comparisons: requirement of identical life time of all alternates
EMV	*risk-adjusted (probability adjusted) NPV	*positive EMV= project is profitable *negative EMV= project is not profitable	*accuracy of probabilities *reinvestment premise at DR *for project comparisons: requirement of identical life time of all alternates
IRR	*IRR in % of a CF profile *indicates DR at which CF profile has an NPV=0	*higher than hurdle rate= project is profitable *lower than hurdle rate= project is not profitable *for rankings: project is preferred if IRR is higher than IRR of alternate investment	*reinvestment premise at IRR *cannot always be calculated *not additive *doesn't consider (total) investment volume *for project comparisons: requirement of identical life time of all alternates
Payback Period	*number of periods (years) needed to recover the invested capital *useful for single investment decisions	*the shorter the payback period the better *shorter payback indicates a lower risk exposure	*reinvestment premise at DR *ignores occurrences after breakeven point in time *doesn't provide info about total profit of the investment project
DPI	*ratio indicating how many money units are earned per 1 monetary unit of cash out (CAPEX) *useful for project rankings	*the higher the DPI, the more attractive a project appears	*reinvestment premise *different ways of calculations *not additive *doesn't consider (total) investment volume

Net present value (NPV) is the most common used decision criterion. It measures the project regarding the shareholder value. In case of a successful outcome, the incremental NPV is positive at a fixed discount rate for a chosen application. The chosen discount rate influences the economic outcome of a project. When several projects are compared, the one with the highest NPV will be the best option. If just a single project needs to be evaluated, the NPV should be zero or greater. The discount rate at which the NPV becomes zero is called the internal rate of return (IRR) [189, 188]. Nevertheless, this would mean to invest automatically in all positive NPV opportunities. In practice, there are other factors like associated risks, resources (money, personnel) which influence the outcome and which need to be considered before making an investment decision. In order to get a bigger picture about a planned prospect it makes sense to have a deeper look besides the NPV on IRR, discounted payback (time to recover an initial investment that ignores the cash flow after payback), investment efficiency and associated sensitivities [189]. Sensitivity analyses are performed to figure out the influences of the economic input to the economic indicator (NPV). Mostly a Spider diagram or a Tornado sensitivity plot is used (sensitivities range from -75% to +100%). Thereby, the project economics are analyzed on how strong they are affected through deviations from the base case assumptions. Possible sensitivities, for example oil/ gas price assumptions, alternative reserve estimates, different production behavior, OPEX changes, increased CAPEX, etc. might be different [194].

The internal rate of return (IRR) is a widely used profit indicator. It is a more realistic profitability criterion, including the time value of money compared to payout time and/ or profit-to-investment ratio. It can be calculated on a before-tax and after-tax basis. IRR is independent of the cash flow magnitude and is typically expressed through the breakeven prices (NPV=0). By using the IRR different project sizes can be easily compared. Adversely, this indicator cannot be specifically used to consider risks (probability numbers) and uncertainties [211].

The discounted profitability index (DPI) is very useful, when constraints are defined and investments are ranked according to it. It refers to how much value is created per unit of constraint like money (NPV per dollar of the initial CAPEX), engineering capability (NPV per engineering man year utilized), etc. The DPI is defined through the division of the NPV through the discounted cumulative CAPEX (NPV and CAPEX discounted at country WACC) The NPV calculation also considers the abandonment costs, which are often excluded in the CAPEX [189].

Another important KPI represents the discounted payback period in years, which reflects the time that is relevant to recover the investment costs and all expenditures until this point (break-even point). This KPI is based on the discounted accumulated cash flow using the country WACC [193].

As additional KPI the maximum exposure, which defines the highest negative cumulative undiscounted cash flow over the project runtime, is commonly used [193].

Furthermore the spent CAPEX and OPEX can be referred to one produced barrel; thereby the gross CAPEX (without considering abandonment) or gross OPEX are divided through the gross production over the calculation period [193].

In addition, specific KPIs need to be considered for the royalty/ tax regime such as total liquids (commercially recoverable oil and NGL from the field over the calculated period), total gas (commercially recoverable gas from the field over the calculated period) and total equivalents (commercially recoverable oil and gas from the field over the calculated period) [193].

7.3.3 E&P Maturation Funnel

E&P projects follow the independent project analysis (IPA) benchmark to execute upstream projects (inclusive E&P projects within OMV). It supports the improvement of capital projects performance and is a standardized database providing data about the entire project life cycle from concept until realization [212]. All upstream capital projects and opportunities follow the OMPD (opportunity maturation and project delivery process) regulation and run through six tollgates were risks are reduced throughout the project (expressed as TG). This maturation funnel is company specific (OMV approach) and was used as a discussion base for further considerations. Hence, it is not universally applicable as TG phases may vary from company to company. It is an integrated management process and highlights details as well as upstream characteristics of the capital project management (CPM) policy. Thereby, a standardized approach is established to support management decisions regarding the maturation and delivery of capital projects. OMV's OMPD requirements apply to all planned opportunities, whereby for minor projects (5-20 MM EUR) the relevant deliverables and events are scalable and must not follow the OMPD TG funnel. Major projects (>20 MM EUR) require the full OMPD TG funnel [213].

Every tollgate has a different degree of complexity, whereas the early TGs represent a readiness check and later ones become highly detailed. The spread of evaluated parameters becomes less wide and the weighting of parameters changes throughout the funnel. For every phase of the maturation process an economic assessment is performed. Every passed tollgate typically releases budget for the project.

Opportunities are planned concerning costs, time, volumes and risks from the business idea to early operation with the aim of value optimization. The process is segmented into six phases (**Figure 7-8**): identify (understand what is planned), assess (look wide enough, reduction of uncertainties), select (best and optimal concept), define (control if everything is done to ensure success, readiness check for final investment decision), execute (operations/ facilities ready and safe for takeover, secure hydrocarbon introduction) and operate (steady state of facilities, record of lessons learned) [213]. Opportunities should be prioritized in the early phase including progress reviews, resource allocations and relevant management decisions in order to implement the prospect as soon as possible. Projects perform more satisfactorily if front-end-loading is done [214, 213].

Identify: In the identify phase the opportunity is framed. The scope of the project including purpose, perspective, project drivers, trade-offs, and possible exit criteria is defined. Cost estimates in this phase are parametric and include owner's costs, wells, decommissioning, escalation and phasing. The end of this phase is marked by TG 0, which is the project initiation note [215, 216, 217, 213].

Assess: In the assess phase, further options for continuing the project are considered. The most promising concepts are chosen and put forward. The same cost estimation process as in the identify phase can be applied. The phase ends after a peer review with TG 1 (Executive Commission, ExCom 1), where the question "Is the project justifiable?" is answered [215, 216, 217, 213].

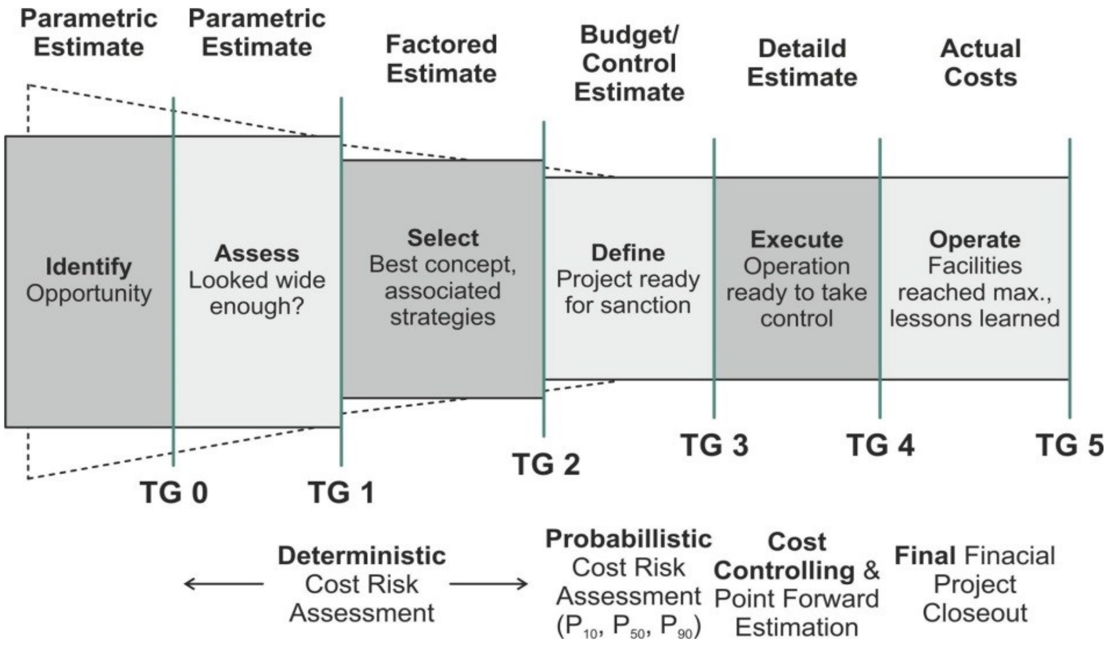


Figure 7-8: E&P project concept funnel (Modified from [213]).

Select: In the select phase the concepts are further evaluated and the most promising one is chosen. The cost estimate is a concept study and includes factored costs for wells, decommissioning and escalation (including commitments). After an opportunity framing workshop the phase ends with TG 2 (ExCom 2), where it is decided, if the project has the potential to increase the existing portfolio [215, 216, 217, 213].

Define: In the define phase the specifications for the project are matured and finalized. The target of the economic analysis in this phase includes the creation of a budget plan and a controlled estimate of the costs. Also in this phase an opportunity framing workshop is performed before TG 3 (ExCom 3), where it is answered if the project is mature enough for execution. This TG includes the final investment decision [215, 216, 217, 213].

Execute: In the execute phase the selected and defined option is implemented to the field. Detailed cost estimates are the basis for detailed economic evaluation of this project phase. After an action review, the implemented project is handed over to asset [215, 216, 217, 213].

Operate: In the operate phase, steady-state operation is conducted and lessons learned are captured. The costs need no longer be estimated as actual costs are available. Basically, lessons learned workshops should be performed in specific time intervals during the running operation [215, 216, 217, 213].

Projects executed in assess and select phases (exploration and appraisal projects) are based on deterministic economic evaluations due to the high degree of uncertainties. Whereas development projects (define phase) are based on probabilistic economics.

7.4 Research & Development Methodology

Nowadays more investments are executed in the oil and gas industry in research & development projects. Thereby, sophisticated technologies are established, to meet the energy demand and to ensure value creation from petroleum activities in the future (production of the retarded oil) [218]. The development as well as the successful application of R&D technologies, strengthens the strategic position of the upstream portfolio, enhances the competitiveness as well as boosts the innovative character of a successful E&P company. In addition, it tries to maximize the recovery of oil and gas, enhances the competitiveness of the company and boosts the innovative character [219, 220].

R&D projects have a major value contribution to the overall outcome of a company, which can be divided into tangible and intangible values. As tangible values increased volumes, an increase of the total recovery rate, acceleration of the production, reduced costs, enabling additional production, creation of access to special funds, reduction of environmental impacts, etc. can be mentioned. The application of R&D technologies raises the reputational level (intangible values allow additional access to project opportunities, reduced cost of capital, and attraction of outstanding employees…) as well.

7.4.1 R&D Chance of Maturation

R&D projects are a special case of E&P projects. Therefore the overall concept of clustering, evaluating and quantifying the risk and uncertainties in the four quadrants is still valid. However, all quadrants can be impacted by additional R&D risks. As for E&P projects, the chance factors of the four quadrants are based either on literature values, experimental data or on an expert panel recommendation (transfer of a subjective value to an objective value). Depending on the chosen approach the values may vary. In order to calculate the EMV for risked economics it is important to characterize the R&D chance of maturation process.

Skills and technology chance is an important factor of R&D projects. Little to no experience with the technology needs to be developed and practically tested by the R&D team. Considerations about the width of application in the industry, how long the technology is going to be used (new entry versus established product), reliability of the planned technology and assessments regarding occurring issues, must be undertaken. For example the sleep-sweep approach for seismic acquisition is widely and reliably used since years in the industry. The implementation of this technology in a seismic survey is less risky, than for example the implementation of a microbubble flotation unit, or the application of softening systems for oilfield water handling, which are new entrants in the oil market. The assessment should also include a realistic estimate of the own skills, as these tend to be overestimated [221]. However, this parameter will strongly increase through gained experience with the pilot for further implementation projects.

The authorization and market chance is strongly impacted by developing and testing new technologies either. As R&D projects can become very complex, time delays, which are covered in this chance factor, are impending. Uncertainties about the technology ownership (possible patent violations) must also be accounted for. Another uncertainty may arise from the acceptance of the technology by the local communities in the deployment area and impacts on the environment, which is covered through life cycle assessments. Sizeable plant installations, increased traffic for continuous supply with goods or the application of sensitive unconventional hydrocarbon production techniques may be good examples for possible opposing company and residence targets. Furthermore, unfavorable public opinions may arise, if environmental unfriendly or harming technologies are applied.

The recovery chance describes risk and uncertainties associated with hydrocarbon production from the reservoir to the surface. R&D projects with an impact on the reservoir or production equipment will also affect this chance factor. For example, increasing the sweep efficiency, by flooding the reservoir with chemicals and oil-miscible CO_2, may also cause precipitation of carbonates with Ca^{2+} and Mg^{2+} in the formation water. The reservoir volumes may be significantly increased by the application of radial drilling to connect previously unproduced compartments. However, the chance of damaging a good producing well has to be accounted for. Testing new pump designs may lead to longer mean time between failures, but the chance of failure through design flaws is not negligible. Anyway, if an R&D project has no impact on the reservoir or production it can be argued that this parameter can be considered as unnecessary. However, to be consistent with E&P projects, and to allow the application of standard procedures and software applied for project evaluation, this chance should be assumed as 100% in such cases.

Risks and uncertainties which are related to the geology are described in the hydrocarbon chance. Impacts on the individual constitutes, which have to be considered for this chance factor (P_s, P_r, P_{Seal}, P_t), must be assed critically. R&D projects cannot impact the presence of a seal rock, reservoir rock and source rock as well as the presence of a hydrocarbon trap. R&D projects may focus on artificial maturation of an immature source rock in-situ (application of the In-situ Conversion (developed by Shell) or Electrofrac (ExxonMobil)) to produce unconventional hydrocarbon [222, 223]. If R&D projects do not impact the hydrocarbon chance it should be assumed as 100% to be able to apply standard software and assessment methods.

7.4.2 R&D Key Performance Indicators

Historically the defined business objectives of a company were reached through quality, time and costs (project management triangle/ triple constraints) [224]. Nowadays the eco-social aspects are becoming more relevant. Therefore, companies include environmental and ecological factors already into their management decisions (**Figure 7-9**). Especially for R&D projects eco-social aspects are an important driver, which have an impact on the value as well as on the sustainability of new processes, services or products throughout the life cycle. It is relevant to integrate environmental aspects already into the R&D strategy. Thereby, the development of new processes/ technologies can be measured and ranked regarding their sustainability [225].

In order to perform an economic analysis of R&D projects, the defined E&P key performance indicators are valid (based on the OMV Economic Standard) and should be additionally augmented by life cycle assessments (delivering quantitative information), to assist and support management decisions with regards to eco-social aspects. The concern for environmental protection becomes more severe and leads to the importance of evaluating new products, services or processes regarding possible environmental impacts [226].

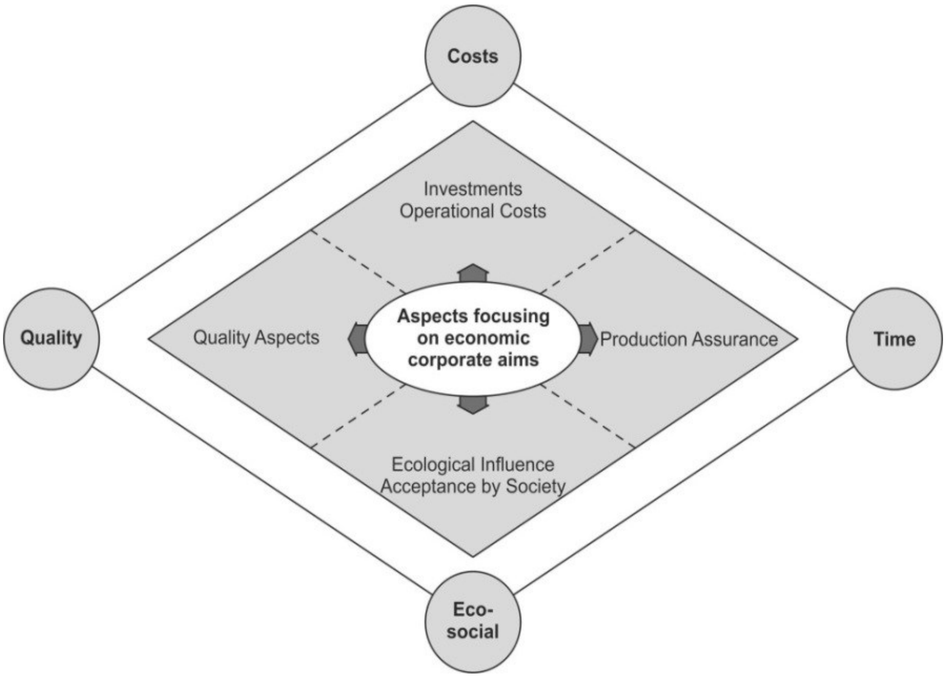


Figure 7-9: Constraint polygon: costs, quality, time and eco-social aspects influencing the management decisions (Modified from [186]).

LCAs need to be considered prematurely as additional KPI into the R&D strategy to support management decisions not only from a technical and economic point of view.

In principle, costs as well as the project time can differ over the project life cycle from the initially planned cost curve (**Figure 7-10**). In the beginning, the ability to influence changes is relatively high, cost-effective and easy to perform. The cost curve can be influenced less and less over time when more project details are set [227]. Therefore, it is relevant to include LCAs as early as possible into project evaluations to avoid upcoming additional life cycle costs at a later stage of a project. LCA provide additional information, that might influence management decisions at the early stage of a project (whether to invest or not).

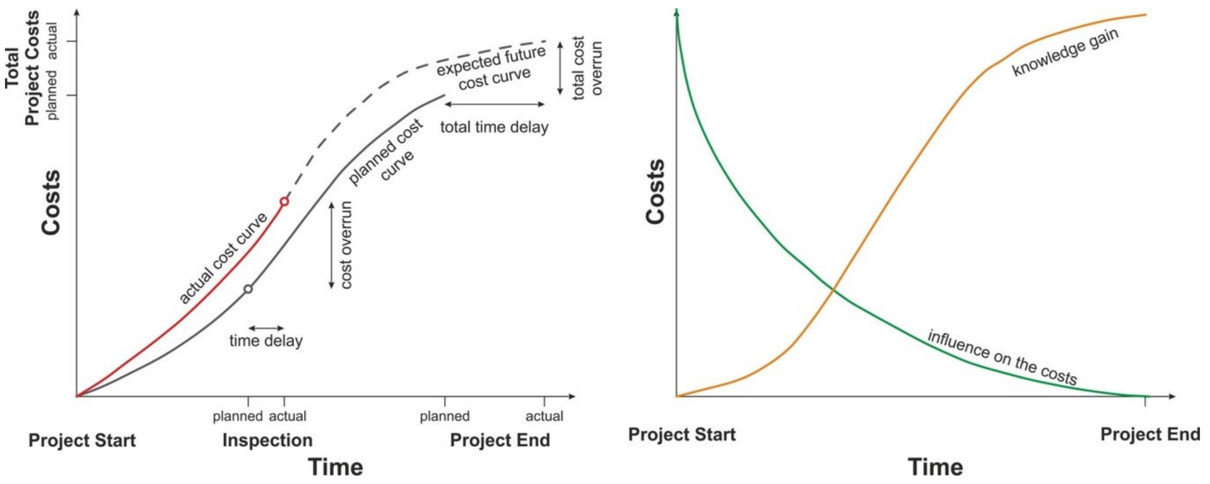


Figure 7-10: Left) Expected cost curve over the project life cycle; Right) Impact of knowledge and costs on the project (Modified from [227]).

Life cycle assessment (LCA) method belongs to environmental management and is a standardized tool to assess sustainability. LCA is governed by ISO 14040 (principles and framework)/ ISO 14044 (requirements and guidelines) and can be used to evaluate a whole life cycle from "cradle-to-grave" (production, usage, and disposal). According to ISO 14044:2006, a LCA can be divided into four key elements: goal and scope, inventory analysis of the in- and output of energy/ material through modeling, potential environmental impact analysis and interpretation of the results [228]. There are several different methods which can be used to assess upcoming impact categories such as ABC analysis, CML method, eco-indicator 99, environmental priority system, critical volumina method, sustainable process index and verbal assessment [229].

As a first step, the life cycle inventory of a new process/ technology is assessed regarding input and output of the material/ energy balance. Then the inventory aspects are allocated in a two-step process via impact categories to damage categories. For each impact category an environmental relevance and a reporting unit is predefined in ISO 14044:2006. A single inventory item may affect multiple environmental impact categories. Furthermore, inventory items must be scaled via factors to the reporting unit. For example 1 kg of CH_4 is equivalent to 23 kg of CO_2 in terms of its greenhouse gas potential, whereas 1 kg of N_2O is equivalent to 296 kg of CO_2 [230]. Such evaluations have to be done for each item of the life cycle inventory. Not every impact category must be present in an individual R&D project. For example, if a R&D project does not emit any greenhouse gases, no global warming potential can be assessed as damage category. After assessing each occurring environmental impact factor, they are clustered into six pre-defined damage categories (resource depletion, land use ecological impacts, impacts from greenhouse gases and black carbon, emissions linked to regional environmental impacts, emissions linked to human health impacts and untreated hazardous waste impacts).

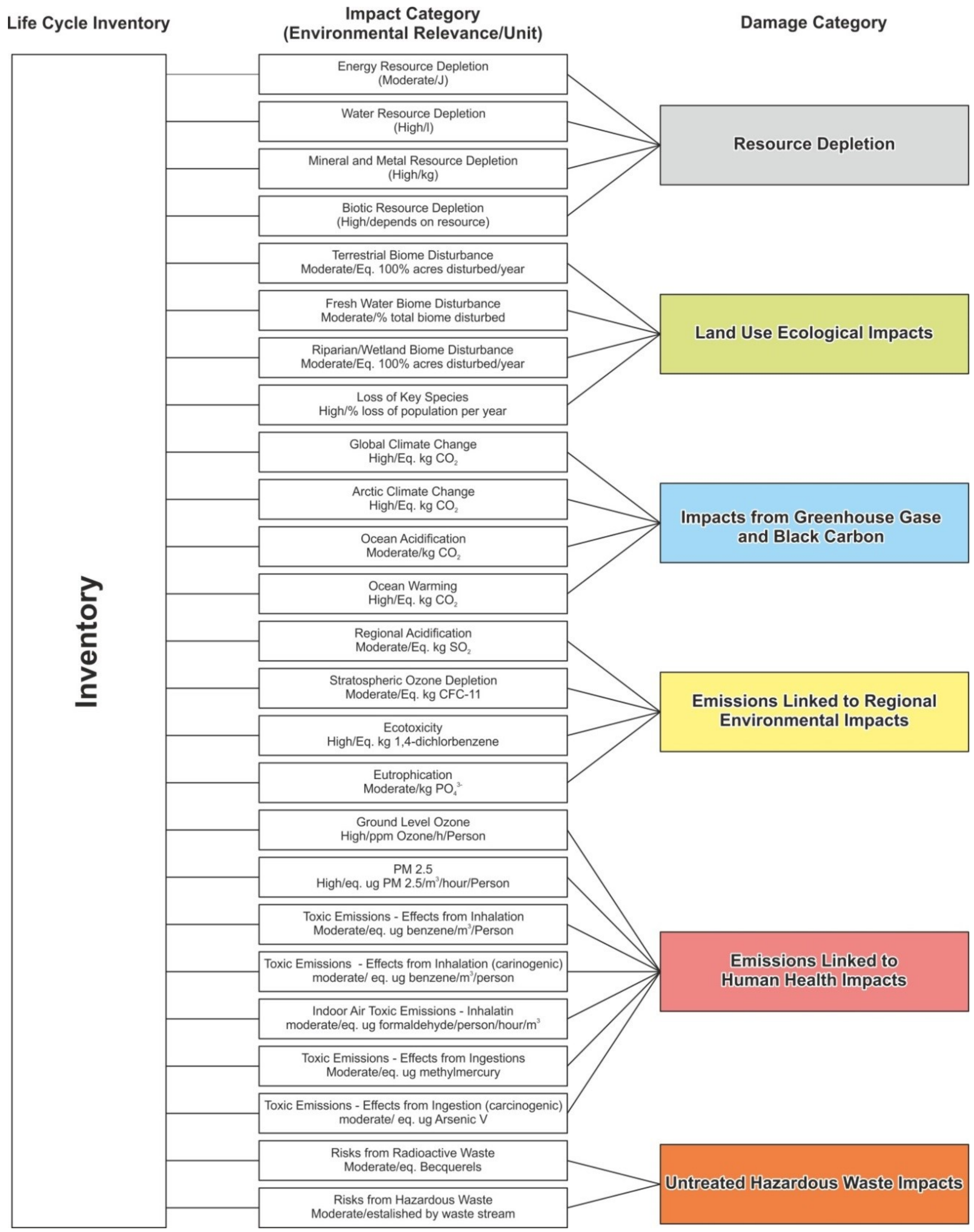


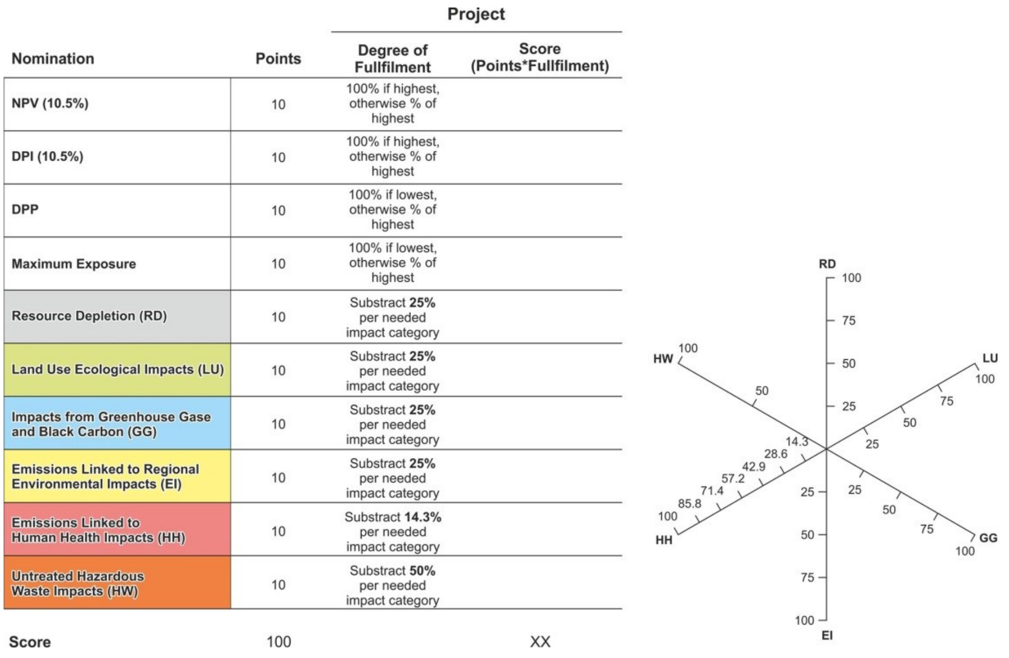
Figure 7-11: LCA methodology showing the inventory analysis, the associated environmental impacts and clustered damage categories (Modified from [231]).

Based on the potential environmental impact analysis, the LCA impacting KPIs are defined and listed as in **Figure 7-11**. In the end, the outcome of an LCA should support the management decision, whereby benefit-analysis represents a useful non-monetary assessment method. It supports the decision making between different options. The degree of fulfillment of each option is expressed by reaching sub goals. Each damage criterion from the LCA is weighted (sum should be 100%) and a valuation standard needs to be defined (**Figure 7-12**)

[232, 233]. Within a damage category each triggered impact category subtracts the percentage of the weighing factor. For example, if a damage category can be subdivided into four impact categories, each impact category has a weighing factor of 25%, whereas when a damage category, like emissions linked to human health impacts, has seven impact categories the weighing factor is 14.3%. As a next step, the points of each category are multiplied with the degree of fulfillment (set on 10 for each damage category) and summed up for its total score. The option with the highest points represents the best alternative (most environmental friendly option). In order to visualize and allow an easy comparison of several R&D options the results can be plotted in a spider diagram. If two or more options have an equally high score (same amount of triggered impact categories) the one with less triggered damage categories and then the one with less overall impact (lower overall emissions and land use) is the better option.

Dependent on the type of R&D project, the LCA KPIs need to be assessed individually in order to identify if all environmental impacts occur or not. Besides, it is relevant to define exact system boundaries for each R&D project where the LCA considerations start and where they end.

In order to combine the LCA KPIs with the economic KPIs a scoring was established for NPV, DPI, DPP and maximum exposure. These KPIs were selected because they represent the size of the project, the required payback time and the maximum financial risks. The economic indicators are scored to its best occurring value. Through the scoring of the economic KPIs and the LCA KPIs a total scoring of the project is enabled. Different R&D options can so be easily compared and ranked.



		Project	
Nomination	Points	Degree of Fullfilment	Score (Points*Fullfilment)
NPV (10.5%)	10	100% if highest, otherwise % of highest	
DPI (10.5%)	10	100% if highest, otherwise % of highest	
DPP	10	100% if lowest, otherwise % of highest	
Maximum Exposure	10	100% if lowest, otherwise % of highest	
Resource Depletion (RD)	10	Substract **25%** per needed impact category	
Land Use Ecological Impacts (LU)	10	Substract **25%** per needed impact category	
Impacts from Greenhouse Gase and Black Carbon (GG)	10	Substract **25%** per needed impact category	
Emissions Linked to Regional Environmental Impacts (EI)	10	Substract **25%** per needed impact category	
Emissions Linked to Human Health Impacts (HH)	10	Substract **14.3%** per needed impact category	
Untreated Hazardous Waste Impacts (HW)	10	Substract **50%** per needed impact category	
Score	100		XX

Figure 7-12: Project evaluation: score card for occurring damage categories (LCA KPIs) combined with economic KPIs (Modified from [234]).

7.4.3 R&D Maturation Funnel

The purpose of this R&D maturation funnel (model), was to define a standardized approach, how to execute future innovations which have an impact on the E&P value chain. The model was developed on the basis of the described opportunity maturation and project delivery process (E&P model), which is currently used for all other exploration and production projects. All further planned R&D prospects shall follow this model to enable a project ranking (**Figure 7-13**).

In general, R&D projects can be started and linked in any E&P project phase (exploration, appraisal, re-development…) and follows a classical project funnel with tollgates. However, the project phases are more flexible than in the E&P funnel. The implementation of the tested and proven technology of an R&D project can be done in any E&P project phase, fulfilling the requirement of cascading projects lined out in the EPMS (exploration production management system).

Following aspects are identical to the previous described E&P model:

- Gathered opportunities (ideas) are pre-selected to focus on the most valuable activities.
- The project phase identify and assess can be put together (TG 0 & TG 1)
- A R&D project can be started at any point in the maturation of the field lifetime.

The following conditions differ from the E&P economic model:

- Project duration as well as project phases are shorter compared to the E&P model.
- Model consists of three phases from the idea to the pilot implementation.
- No long-lead items are ordered before the pilot design has been approved during TG 2.
- The R&D model ends with TG 3. There it should be decided whether the R&D project should be implemented to the field or not.
- Field implementations should be defined as own projects and executed with the classical E&P economic model.
- For all new implementations a LCA study following the latest valid ISO norm is recommended as additional project decision criterion (according to the defined R&D KPIs).
- The economic R&D evaluation is based on the same KPIs which are used for the E&P model evaluation and augmented by R&D KPIs (LCA).

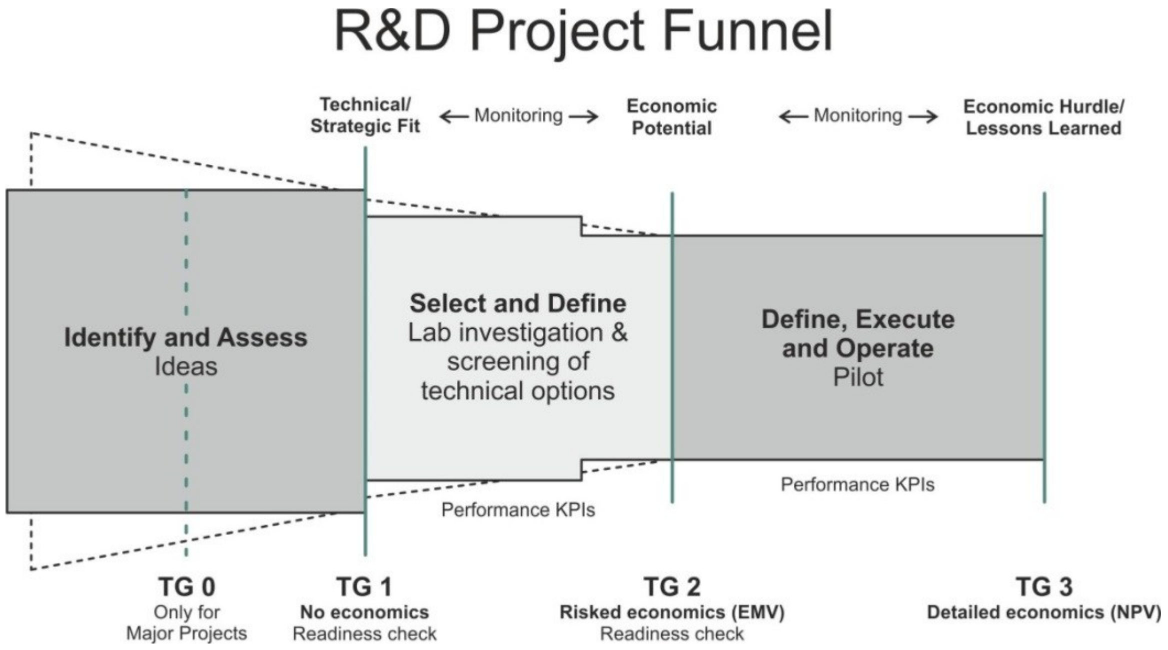


Figure 7-13: Developed conceptual funnel for R&D projects (green lines represent the tollgates) [235].

Identify and assess: R&D projects start exactly like E&P projects with the identify and assess phase, where the research idea is formulated and a team consolidated. The team is tasked with reviewing possible technical options, screening their applicability and deciding which options should be further investigated. An item list which contains the identified opportunities, threads, risks and uncertainties of a "technology-to-be-tested" should be worked out in a series of opportunity framing workshops and be presented at the TG 1. Depending on the impact a dedicated TG 0 can be hold (a TG between identify and assess is not mandatory,). The TG 1 (ExCom 1) is held after a peer review and represents a readiness check if the project fits technically and from a strategic point of view. Therefore, no economic evaluation is required to move on to the next step.

Select and define: In this project phase, the team is tasked with small scale testing (laboratory scale and small scale field tests if laboratory scale tests are inapplicable (e.g. water treatment pilot)), simulations, specifying the pilot design and performing a risked economic analysis. All aspects of the project must be closely examined and intensively evaluated to de-risk the pilot. Furthermore, the pilot is designed based on the findings from all conducted technical and economic studies in this phase. In contrast to the E&P model, no long-lead items should be ordered prior to the TG 2 decision. Before the TG 2 can be passed a peer review of the gathered data, the designed pilot and the risked economic analysis has to take place. The EMV is the major economic KPI next to KPIs from the LCA to evaluate the economic potential of the planned pilot.

Define, execute and operate: In the define, execute and operate phase the pilot design is finalized and long-lead items are ordered. Then, the required equipment is installed, operators trained, technical safety checks are performed (HSSE) and commissioning commenced.

Afterwards, the pilot is operated under multiple operating scenarios. All tasks are monitored by actual operating costs to allow a detailed deterministic evaluation and forward predictions for future applications of the tested technology. During the operation, execution reviews are held. The gained experience and know-how should be compiled in a lessons learned workshop and used for other upcoming R&D studies as well as for the implementation. Through the pilot phase the associated risks and uncertainties are reduced and it gets proven that the technology works well in practice. Furthermore the economic analysis focuses on testing, if the technology can increase the revenues of a project beyond the economic hurdle.

The R&D maturation funnel ends after the pilot phase because additional investigations about the upscaling need to be undertaken. The implementation of the tested technology needs to be reviewed, if it fits with the strategic company targets and eco-social aspects [235].

7.5 Case Study: 16.TH Alkali-Polymer Flood

The planned AP project is a so called redevelopment opportunity of managing assets and belongs to the upstream portfolio. It is based on subsurface field data and production forecasts including assumptions and upcoming costs for the R&D implementation. Besides, the installation of required surface facilities, the drilling of new wells and planned workovers are considered. Upcoming technical and operational uncertainties are assessed based on laboratory investigations (no risk evaluation). The established R&D model is applied and the defined formulations (cases) compared according to the specified R&D KPIs. Thereby, realistic considerations regarding injection volumes (OPEX profile), CAPEX, CoM assumptions, and production profile forecasts were used to calculate the economic potential of this case study.

7.5.1 AP Project Funnel

A study was conducted to screen possible options of field interventions in the Vienna Basin, prior to this doctoral thesis, to further boost the oil production and to prolong the field lifetime (identify & assess phase). Thereby, chemical EOR (as AP flooding) turned out to be the best choice. After screening, the AP project moved on to the select and define phase. Detailed investigations were started before upscaling this new R&D technology from the laboratory to field scale (parts were performed through technical studies within this PhD thesis).

Laboratory methods needed for the purpose of alkali-polymer flooding were selected, introduced and successfully tested. In this thesis, extensive laboratory experiments were performed, to understand the fluid-fluid but also fluid-rock interactions of various chemical formulations. Furthermore, the treatment of breakthrough polymer water streams was examined in pilot scale. Besides this thesis, additional investigations such as softening trials to find the proper resin (regeneration, different oil-water-solids loads including alkali and alkali-polymer quantities), core flood and micro model experiments were conducted.

Different studies regarding the water handling were performed to choose the right design and technology of the surface facilities (micro bubble filtration, dissolved gas flotation, multi-media filter…). Besides, proper scale and corrosion inhibitors need to be selected in additional studies. Lastly, investigations regarding the production behavior of currently installed artificial lift systems (sucker rod pumps, electric submersible pumps and gas lift) needs to be examined.

As a further step, this R&D project will move on to the define, execute and operate R&D project phase (implementation). The main target is to drill new vertical injectors which require new pipelines and electrical grids as additional installations. Besides, new surface facilities, such as an AP unit, are mandatory to be constructed and operated. The AP unit consists of a de-oiling unit (micro-bubble flotation, MBF), filter systems (multimedia filter), water softening unit (redundant operation), alkali mixing and polymer slicing units, storage tanks for the chemicals and pipelines to the disposal wells for the process water streams (softening unit).

7.5.2 Economic Simulation of possible 16.TH Cases

Based on the technical studies, different cases were defined to compare them regarding the developed R&D model. At present, the alkali-polymer project is in the select and define phase (according to the R&D project funnel). Therefore, it was impossible to face all relevant costs for the cost estimate. Still several studies are ongoing, which might give additional insights about the chemical requirements for scale and corrosion inhibitor as well as of the demulsifier (influence on the OPEX profile ignored in this economic simulation). Carbonate-based alkalis were preferred for the preparation of the injection slug instead of strong alkali lyes, such as sodium hydroxide. According to the technical studies, following formulations were promising:

- **AP formulation 1:** using 7,500 ppm of Na_2CO_3 and 1,000 ppm of HPAM (Flopaam 3630S) for the AP slug
- **AP formulation 2:** using 7,500 ppm of K_2CO_3 and 1,000 ppm of HPAM (Flopaam 3630S) for the AP slug
- **ACP formulation 3:** using 7,500 ppm of Na_2CO_3 mixed with 2,000 ppm of co-solvent 3 and 1,000 ppm of HPAM (Flopaam 3630S) for the ACP slug

The two alkalis differ mainly regarding their chemical costs (influence on the OPEX profile) and their in-situ soap generation (efficiency). K_2CO_3 showed more promising results than Na_2CO_3 in terms of emulsion amount and emulsion stability over time. Formulation 3 provides an alternative to improve as well as to stabilize the formed in-situ soap of sodium carbonate. Although it is associated to additional chemical costs. In all cases the same hydrolyzed polyacrylamide from SNF is used. The assumptions of the pre-flush, polymer flush and post-flush remained the same for the economic simulation of these three formulations (cases).

7.5.3 LCA Goal & Scope

The R&D installation represents, as mentioned before, a new technology/ process within OMV. Environmental impacts of the alkali-polymer injection water were evaluated, because high loads of process chemicals are required for its operation (**Figure 7-14**). The system boundary for the evaluated AP injection water stream starts at the outlet of the three-phase separator, which represents the first treatment step after the production wells. This purification takes place without chemicals and no adverse environmental impact can be recognized. Additionally, the handled flow rate in the separator is much higher compared to the inlet water stream used for the AP trial and would not reflect the real conditions.

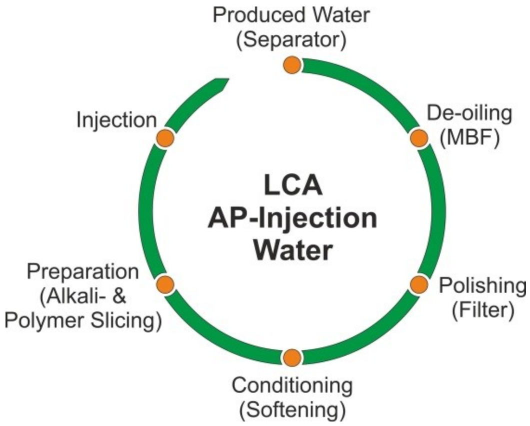


Figure 7-14: Life cycle assessment of the required alkali-water injection water.

This LCA focuses on the main treatment steps required for AP injection water, but does not consider the production of relevant process chemicals (alkali, polymer, regeneration chemicals…) as well as the treatment of generated waste streams (sludge). In this LCA, the transport distance from the chemical manufacturer to the pilot unit was assumed with 1,000 km (500 km per ride). No differentiation was applied on the three possible AP injection formulations due to current unknown aspects of individual impacts such as mining the alkalis, alkali lye and co-solvent processing and disposal of the generated sludge.

Mayer and Alteneder (2017) argued that softening systems are relatively sensitive to the presence of oil, leading to fouling or a reduction of the efficiency. Additional de-oiling steps are mandatory right after the separator. Water side streams, containing high quantities of hardness ions and operation chemicals, need to be expected. The application of ion exchangers requires considerably more chemicals for the regeneration of the resin compared to membrane technologies [236].

The relevant process water stream starts at the outlet of the separator (first water treatment step), which is further transferred to the micro bubble flotation (second water treatment step) and to the media filter (final polishing step). Afterwards it enters the softening unit (water conditioning) and then the alkali-polymer slicing units. In the end, the conditioned water is transferred to the injectors. The relevant water streams for the AP project will not enter into the actual existing hydrocyclones (bypass).

The LCA highlights the chemical amounts, waste streams and energy requirements for the injection water. It does not consider any breakthrough chemicals (alkali, polymer). Furthermore, the CO_2 balance for the delivery of goods (chemicals) was considered.

7.5.4 Uncertainties Evaluation

Based on the technical studies only uncertainties were assessed; no risk evaluation was performed because the occurring probability is unknown. Possible arising uncertainties in this R&D project can be classified into subsurface, well site, surface aspects as well as in uncertainties of other businesses.

- **Subsurface Uncertainties**

The 16.TH is a relative heterogeneous reservoir where possible uncertainties can occur because of reservoir property distributions and connectivity faults. Different or improper assumptions of the production forecast can influence the recovery factor, as well as the economic success of the project.

As discussed in previous chapters, two alkali lyes were tested to find the optimal chemical formulation for injection. Sodium carbonate is mostly applied in the industry and its efficiency in EOR applications is well proven, whereas potassium carbonate is a new entrant in this market. Na_2CO_3 is a cheaper option compared to K_2CO_3, which is even three times as expensive but more efficient and environmentally friendly (compostable, acts as a corrosion inhibitor). The technical studies demonstrated, that no stable middle-phase emulsions were generated for Na_2CO_3 at 7,500 ppm (type II (+) emulsions were generated based on the formulation prepared with dead oil). The emulsion amount decreased strongly over time. Compared to Na_2CO_3, K_2CO_3 generated stable middle-phase emulsions (type III emulsions). It is uncertain, how the alkali lyes will behave at reservoir conditions. Furthermore, it is unknown which quantities are really required to achieve the optimal flooding effect with the AP technology.

Most of globally performed alkali-polymer floods (**Figure 1-2**) were carried out by the additional use of surfactants in order to stabilize and maximize the amount of generated soap (independent of the oil characteristic). Nevertheless, high surfactant costs would tremendously influence the economics of this 16.TH project.

Another uncertainty is the transfer of static laboratory results into dynamic reservoir conditions (modeling).

- **Well Site Uncertainties**

Attention should be paid to the integrity of existing wells, to new wells and to the lifetime of the existing well stock.

As already mentioned in previous chapters, water softening is required in order to reduce precipitations at high pH values and to minimize scale tendencies. In principle, higher scale amounts at the wells need to be expected compared to normal water floods. A scale inhibitor treatment program is required. Through the individual scale monitoring of each well, the inhibitor volumes as well as concentrations can easily be adjusted, regarding the amount of produced fluids.

- **Surface Uncertainties**

On the surface side, a proper selection of the materials used for the construction of the facilities as well as a proper selection of the corrosion inhibitor is required. Scaling tendencies need to be expected in the production wells.

The expected time of the polymer breakthrough influences the injection scheme which is relatively difficult to predict. Water softening as well as alkali injection is stopped when back-produced polymer is contained in the produced fluids.

One of the major challenges in this business case is the water softening process due to the required low amount of hydrocarbons in the inlet water stream. Nevertheless, the really required water quality is uncertain. ASP floods in Canada operated the softening unit with much higher oil loads (>50 ppm) [237] than recommended by the resin producers (<5 ppm) [236]. According to the literature, high oil contents might lead to fast plugging of the resin and result in more back-washing cycles (higher operational demands) [236]. The maximum ion exchange tolerance concerning oil and polymer load needs to be further verified through pilot studies. Nevertheless, a de-oiling step prior to the water softening unit will handle upcoming fluctuations and provide the necessary inlet water quality.

Possible interferences of used chemicals (demulsifiers, scale inhibitors, etc.) need to be analyzed. Waste water handling is important, because additional water streams from regenerating the resin of the softening unit will accrue. Attention should also be paid to the sludge treatment which contains the back-produced fluids.

It is difficult to predict the viscosities and compositions of the back-produced fluids (emulsion, polymer) for the treatment in the surface facilities. In the technical study

(**Chapter 6**) the treatment of back-produced polymer was tested with a pilot plant to get a better understanding of the water handling process.

Generally, “green” chemicals are preferred for the choice related to HSSE issues. Good logistic and infrastructure is required for the delivery of goods. Moreover, new machines and facilities should carry the CE mark.

- **Other Uncertainties**

Like for every other EOR prospect, the oil price tremendously influences the success of the planned opportunity. Other aspects are the time schedule, procurement process, communication (internally, externally) and of course the costs (economics).

The identified uncertainties were as a next step clustered in an uncertainty matrix as represented in **Figure 7-15**. The level of impact and the degree of uncertainty were split into low, medium and high. The clustered uncertainties were graded regarding their outcome of the technical studies. Especially, the handling of back-produced fluids and the conductivity of the formation represent the highest impacts and uncertainties of this case study (continuous field monitoring required). The assumptions for the chance of maturation are influenced by these uncertainties.

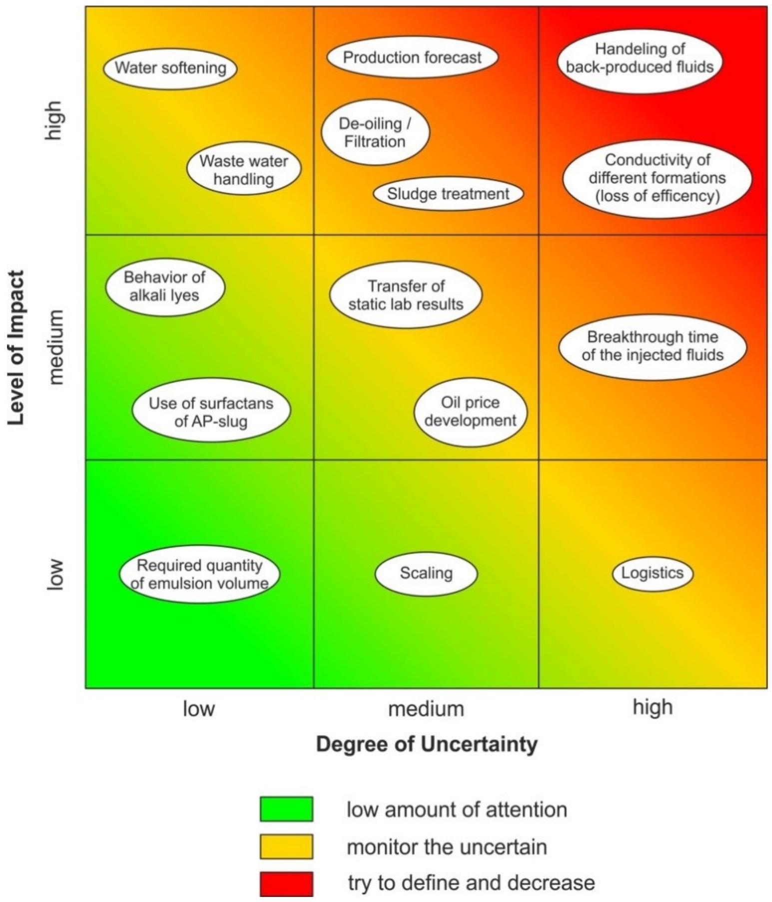


Figure 7-15: Uncertainty matrix of the 16.TH prospect.

As a next step, the hydrocarbon chance, recovery chance, skills and technology chance as well as market and authorization chance were adjusted according to the uncertainty matrix.

7.5.5 Simulation Model Input

Various input data are mandatory for appropriate modelling such as geological information about the reservoir, fluid data, engineering data for the design of surface facilities, chemical requirements as well as concentration ranges. All relevant cost positions influencing the net cash flow are represented in **Figure 7-16**.

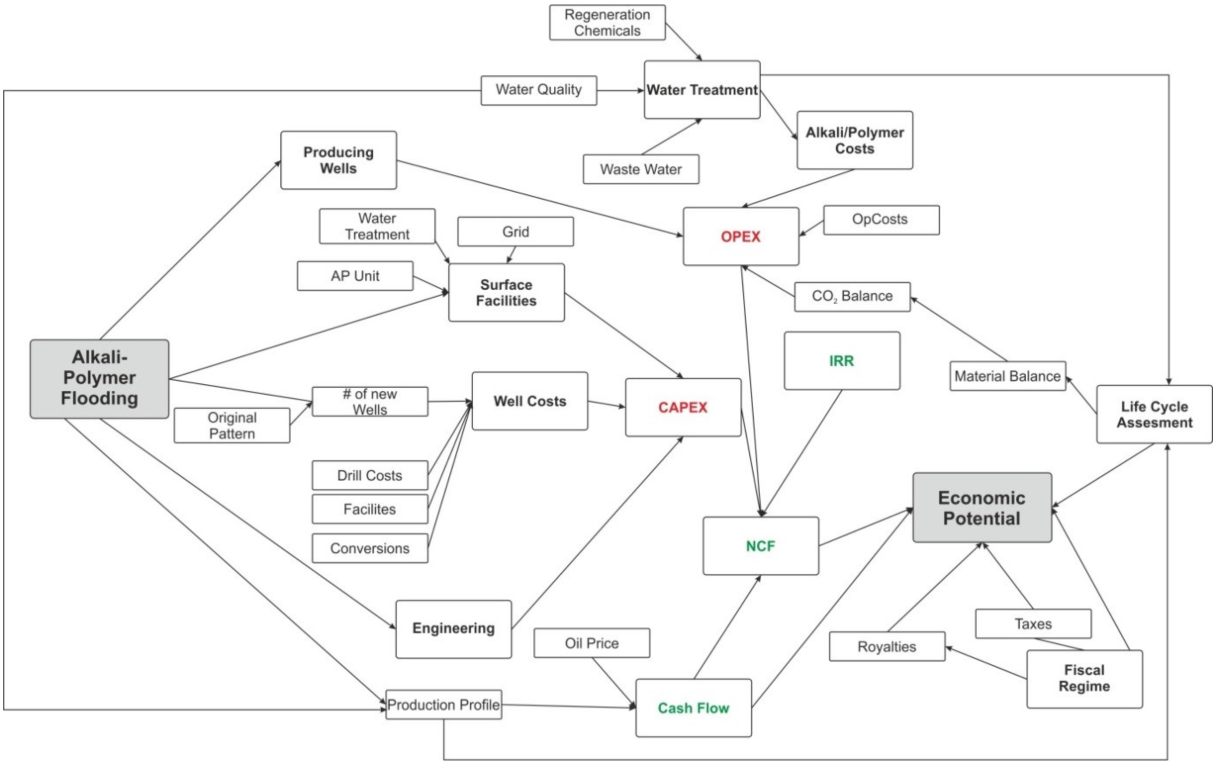


Figure 7-16: Influence of upcoming cost positions on the net cash flow (Modified from [238]).

7.5.5.1 Projects Assumptions

The following general project assumptions were chosen for this case study:

- The AP project is planned in the 16.TH in Sector 1.
- The injection volume makes up 5,000 m^3 per day.
- Start of the pre-flush injection (softened water) is in September 2021 and the closure of the AP project with the post-flush (water injection) is in December 2040. The well abandonment is assumed for 2040 with 10% of the CAPEX (20 MM EUR).
- Project duration will be 22 years.
- Project start year: 2018 and inflation date start: 01/01/2019.
- The used production profile is based on the described forecast in **Chapter 7.5.5.2**.
- A gas-oil ratio for the sale of oil and gas was assumed with 0.6.

7.5.5.2 Production Forecast

The original oil in place was 12.23 MM tons in the 16.TH. Over field lifetime the oil production declined strongly and water flooding was started. Currently, the water cut is already relatively high with 96.4% and only 210 tons of crude oil are produced on a daily basis. The cumulative oil production is 7.49 MM tons and the associated/ non-associated gas production 583.99 MM sm^3. Currently, approximately 5,600 m^3 of water are re-injected into the 16.TH per day.

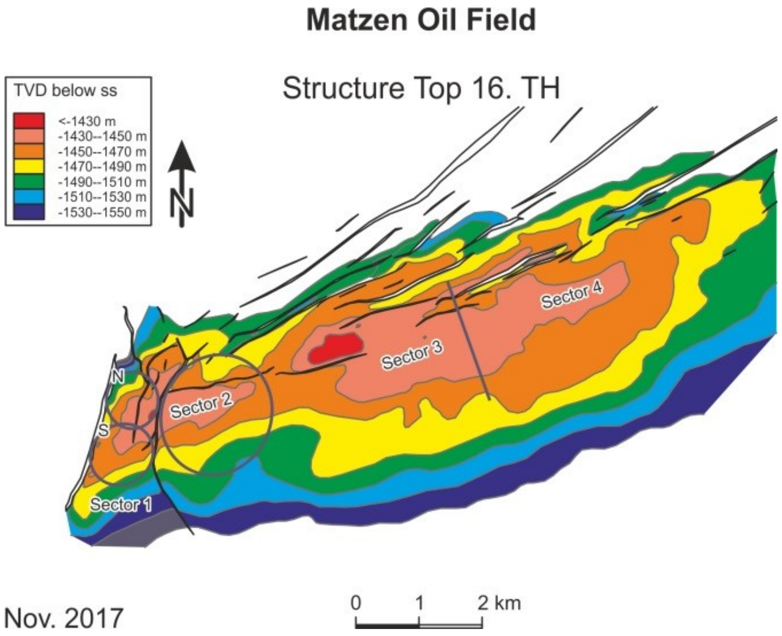


Figure 7-17: Structural map showing the planned AP prospect in the 16.TH (Adapted from [239]).

On current figures, the produced oil volume in the 16.TH will significantly decrease over the upcoming years without any additional field intervention (**Figure 7-18**). As a result, higher production costs than produced oil quantities would lead to uneconomical conditions (shut down of the field). Therefore, different EOR technologies like thermal, chemical, gas, or microbial flooding were screened beforehand in order to enhance the field lifetime as well as to boost the production. It turned out, that chemical flooding will be the best choice (further details about the Vienna Basin and screening of EOR options can be found in **Chapter 3**). Through the planned EOR prospect in the 16.TH West (Sector 1, **Figure 7-17**), the incremental oil production will be further increased. The reservoir produces moderately degraded oil (**Chapter 4.3.2**).

Alkali-polymer flooding is planned to be used as cEOR method. According to the performed phase screening, three different possible chemical formulations could be identified which would be promising (**Chapter 4**). **Figure 7-19** represents the oil production forecast of AP flooding (perform cEOR, success case), polymer flooding (representing the failure case if AP injection fails) and water flooding is shown as base case (do nothing case), when no further field activity would be planned (significant oil production decline). Typically, an AP flood is divided into different injection phases. In this case, a softened water pre-flush, an alkali-polymer flush, a polymer flush and a water post-flush are chosen as injection scheme. For each injection phase 5,000 m³ per day are assumed as injection volume in this case study. The injection should start in 2021 and increase the recovery factor until 2025 before the water post-flush starts.

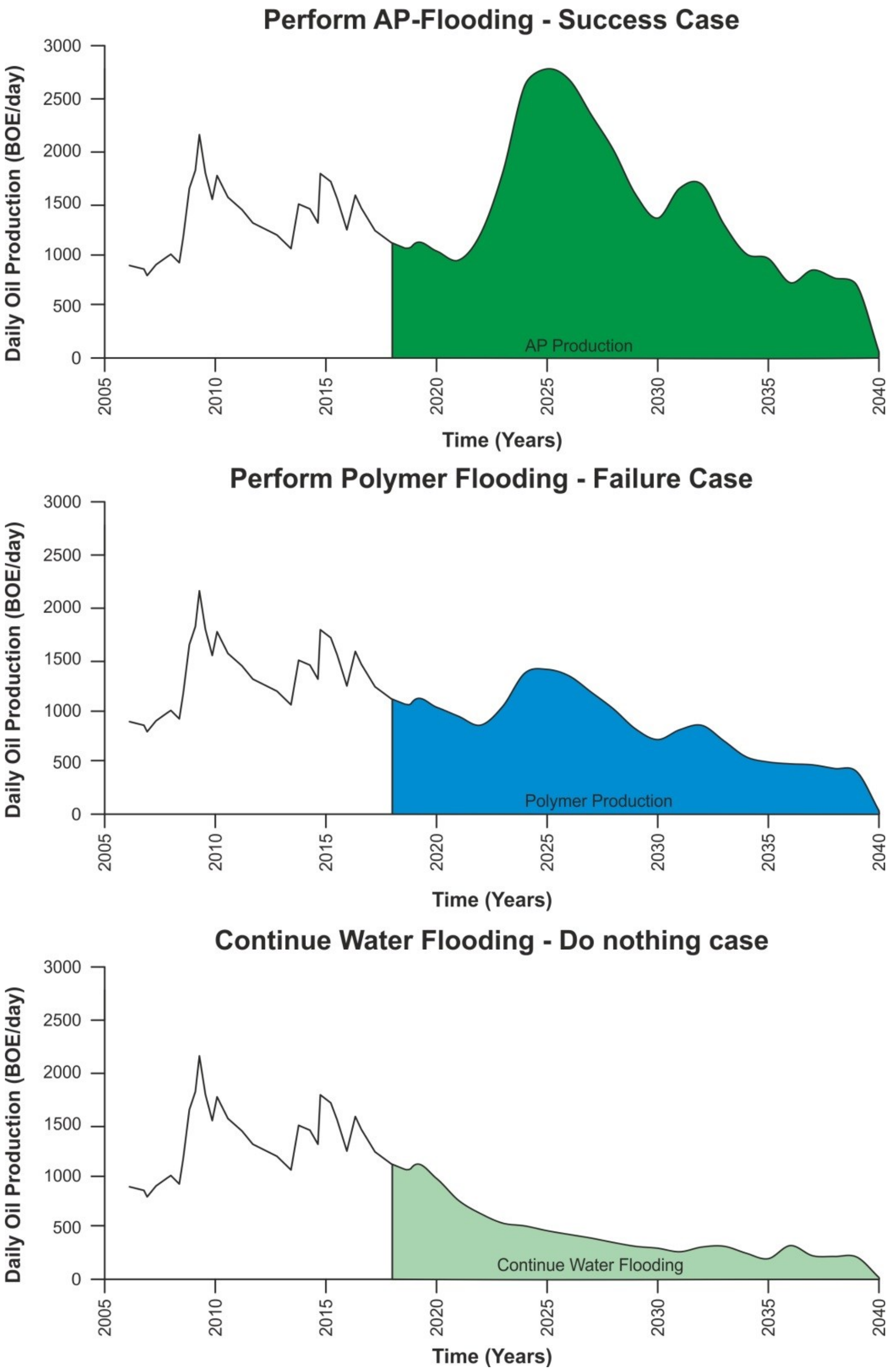


Figure 7-18: Production profile of the 16.TH showing the success case (perform AP flooding), failure case (perform polymer flooding) and do nothing case (continue water flood without any field intervention, data provided by OMV).

The production forecast is based on simulation data of the Na_2CO_3 case, provided by OMV, and includes the performance of the phase screening (**Chapter 4**). The expected recovery efficiency of the AP slug containing sodium carbonate leads to an ultimate recovery of 74% after water flooding and with potassium carbonate to around 82%. The formulation containing Na_2CO_3 and co-solvent 3 lead to a total recovery of 76%. The expected oil production forecast for the AP slug containing K_2CO_3 shows slightly higher performance compared to the other two options (numbers are based on laboratory investigations). Only production forecast for the volumetric P_{50} case was available, therefore no P_{10}, P_{90} and P_{mean} cases are shown.

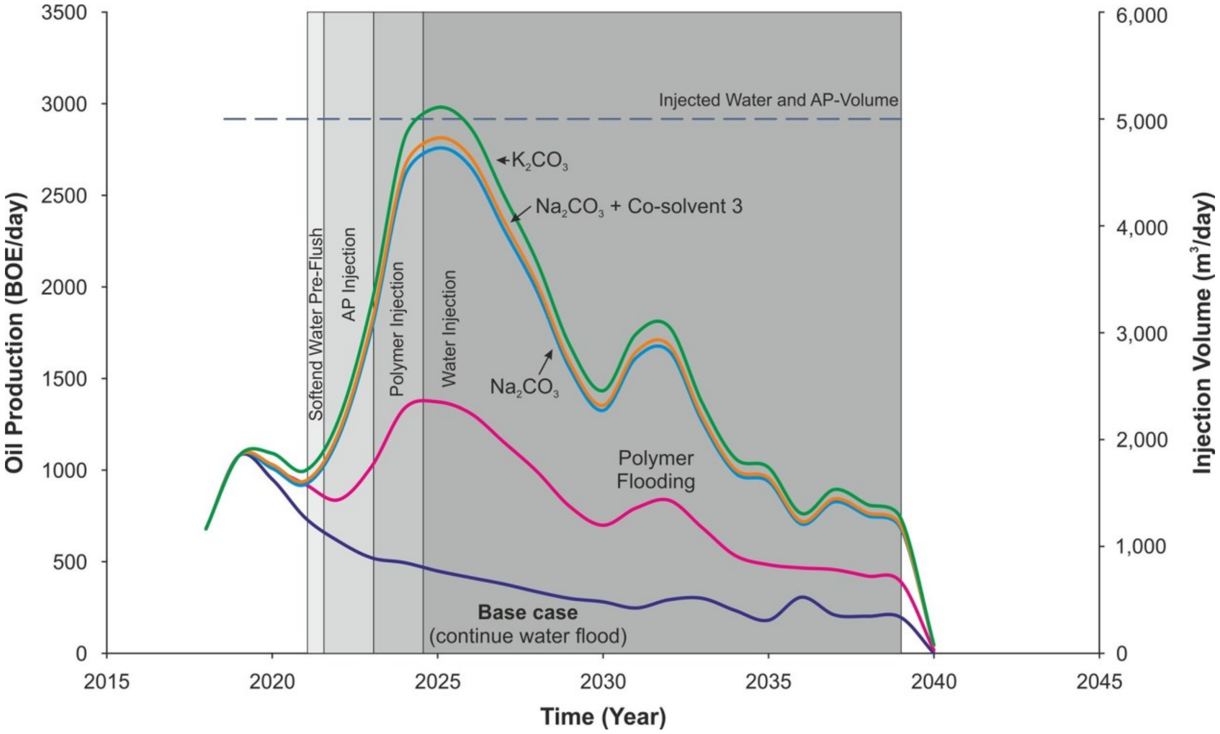


Figure 7-19: Oil production profile forecast showing the volumetric P_{50} case of the normal water flood without any field intervention and the production forecast with alkali-polymer flooding (data provided by OMV).

7.5.5.3 Input Settings in Palantir® Cash

All relevant input data for this project were put into a PAS considering P_{50}. Palantir® Cash software was used to perform the calculations. As input, the defined chance of maturation (CoM), production and sales (marketable production) volumes, production costs, CAPEX, OPEX, development capital expenditures, abandonment but also specific commercial, contractual and fiscal regime terms were entered.

As A-oil (asphaltenes-based crude oil) is produced in the 16.TH West and no P-oil (paraffinic-based crude oil), A-oil was chosen for the Palantir® Cash settings.

The fiscal regime represents a major economic success impact. Austria belongs to the concessionary system and has a simple hydrocarbon tax regime. Thereby, the oil company pays royalties and corporate income tax (20% royalty on oil and 15% on gas). Sliding-scale royalties were assumed according to the tax law (oil price related). This means, the royalty rate is low when the oil price is low; the royalty will rise with increasing oil price [241].

According to the fact, that the implementation will be performed in Austria, royalty/ tax was set as contract type and the fiscal regime Austria-RT 3.3 chosen. The calculation was performed incrementally because the AP project will be implemented in an already existing field. As ring-fence input was set PRL Austria Corporate Tax and PRL COP. The company working interest is 100% and the carried interest 0%.

In addition, all inputs were included in “nominal” term basis including inflation, escalation and contingency according to OMV standards. The inflation factors and correlated nominal exchange rates are provided through the MTP planning assumptions [193]. The discount of the project starts basically with 1st of January of the year in which the calculation starts [193].

The two scenarios, base and stress case were calculated based on OMV planning price assumptions. The base price scenario was related to the country hurdle rate and the stress price scenario to the country WACC. For the base scenario, the oil price scenario MTP2019 v06 2018 and the currency scenario MTP2019 v06 2018 was used. For the domestic gas the price scenario Rev 09 2016 – MTP2019 v06 2018 was applied. For the oil price stress scenario MTP2019 v06 2018 Stress was applied. The same currency scenario like for the base scenario was used (MTP2019 v06 2018). For the domestic gas the price scenario Rev 09 2016 – MTP2019 v06 2018 Stress was applied.

7.5.5.4 Chance of Maturation (CoM) & Cost of Failure (CoF)

The chance of maturation (CoM) and the cost of failure (CoF) were assumed for the three formulations, based on their performance in the technical studies (**Figure 7-20**). The identified uncertainties influence the probabilities of the four quadrants (CoM). The observed results were transformed into the individual chances. The hydrocarbon chance (P_{hc}) was assumed for all formulations as 100%.

Based on the performed phase experiments, massive differences concerning the emulsion amount and emulsion stability were observed (**Chapter 4**). Slightly better results were achieved with the co-solvent. Consequently, the recovery chance (P_{rc}) massively differs: Na_2CO_3 was assumed with 65%, K_2CO_3 with around 73% and the formulation with Na_2CO_3 containing the co-solvent with approximately 70%. Sodium carbonate is mostly applied in any kind of alkali flood project, whereas potassium carbonate is, as mentioned, a new entrant as EOR fluid. The skills and technology chance (P_{sc}) was therefore assumed with 60% for Na_2CO_3, 55% for K_2CO_3 and for the formulation with the co-solvent. The P_{sc} is furthermore influenced by the handling of back-produced fluids (might cause operational challenges), but also by the fact that AP flooding represents a new technology within OMV.

The authorization and market chance (P_{ac}) was assumed with 75%, for Na_2CO_3 80% for K_2CO_3 and around 70% for Na_2CO_3 mixed with the co-solvent. Uncertainties may arise from residence or land owners and environmental authorizations. The percentage for K_2CO_3 was assumed slightly higher, because it is environmental friendly and also used as fertilizer or corrosion inhibitor.

The estimated chance of incremental recovery was around 75% for K_2CO_3 and Na_2CO_3 mixed with the co-solvent and 65% for Na_2CO_3 (more likely probability range). In addition, the technical success for K_2CO_3 was calculated with approximately 41%, 39% for Na_2CO_3 and 38.5% for the formulation with co-solvent. The chance of realization was equally likely for both alkali lyes (K_2CO_3: 44% and Na_2CO_3: 45%) and less likely for the ACP case with 38.5%.

The calculated chance of maturation for all three cases was ranked to a less likely probability, whereby Na_2CO_3 was around 29%, K_2CO_3 around 33% and the CoM of Na_2CO_3 mixed with co-solvent 3 approximately 27%.

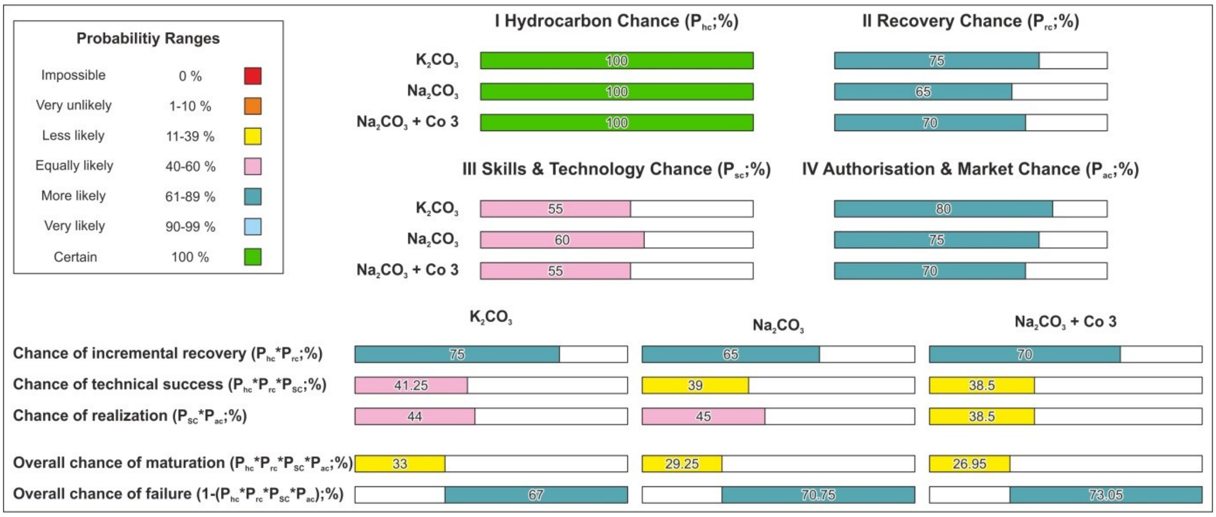


Figure 7-20: Assumption of the chance of maturation for the case study (Modified from [204]).

7.5.5.5 Capital Expenditures (CAPEX)

According to the current stage of the project, the final plant design was not finally chosen. Therefore, slight changes might be possible from the assumed AP plant design. As mentioned, wells need to be drilled, pipelines are required to the injectors and necessary adaptions of existing artificial lift systems (producers) need to be taken into account. The production concept was planned as three-well cluster. The therefore used costs reflect real term numbers (**Table 7-3**) and calculated as nominal.

Table 7-3: CAPEX details for the case study (data provided by OMV).

CAPEX (real term numbers)	Description	Units #	Price per unit (MM EUR)	Total amount (MM EUR)
Wells	Drilling (incl. well site)	20	1.44	28.8
	Pipelines – injectors	20	1.20	24
Workovers	Adaptions on existing producers	40	0.12	4.80
	Downhole ESP scale inhibition test	1	0.14	0.14
Facilities	Grid	1	1.68	1.68
	Alkali-polymer unit	1	46.00	46.00
	Water treatment	1	12.23	12.23
Project management	Engineering & owner costs			25.39
Total CAPEX				**143.04**

The following CAPEX spending was applied for the AP case study:

- Seven wells were drilled in 2019, 12 in 2020 and one in 2021.
- 14 workovers were performed in 2019, 24 are planned in the year 2020 and two further in 2021.
- Basically, 6 MM EUR were spent on pipeline construction in 2019, 14.4 MM EUR in 2020 and 3.6 MM EUR in 2021.
- The surface facilities were acquired from 2019 until 2021. The spent capital expenditures were 38.4 MM EUR in 2019, additional 16 MM EUR in 2020 and 5.1 MM EUR in 2021.
- Additional upgrades (project management) costed 3 MM EUR in 2019, further 6 MM EUR in 2020 and 8.1 MM EUR in 2021 as well as in 2022.

7.5.5.6 Operational Expenditures (OPEX)

An alkali-polymer flood is divided into four main injection schemes leading to different OPEX phases. At the beginning, a softened water pre-flush is used, followed by the alkali-polymer injection, the polymer injection and closed by water injection as post-flush. As injection target 5,000 m³ per day were chosen for this case study, which requires the treatment of 6,458 m³ water per day (based on mass balance data) in order to reach this target. **Table 7-4** summarizes the input data used for setting up the OPEX model.

Table 7-4 represents the operational expenditures for the injection phases. As soon as the polymer breaks through the alkali injection stops. The daily waste water consumption (related to 5,000 m³/d) includes the generated flotation sludge of the MBF, the filtration waste and the waste of approximately 20% from the softening unit (according to NathansTech, 2018), which is only relevant for the first three injection phases. In the last phase (water post-flush) only MBF waste is considered (no water softening). In order to reach the injection target the treatment of additional 1,458 m³ water per day need also be taken into account for the calculation. Therefore, the upcoming extra costs for the treatment are listed in **Table 7-5** and expressed as additional water costs.

Table 7-4: OPEX model input data (real term data, reservoir data provided by OMV).

Reservoir Data	**Amount**	**Unit**
Pore volume Sector I	6,500,000	m³
Pore volume Sector II	4,500,000	m³
Total pore volume	11,000,000	m³
Injection Data		**Unit**
Injection rate for softened water	5,000	m³/d
Injection rate for alkali lye	5,000	m³/d
Injection rate for polymer	5,000	m³/d
Injection rate for water	5,000	m³/d
Pore volume for softened Water (injection ~ 6 months)	20	%
Pore volume for alkali-polymer (injection ~ 18 months)	60	%
Pore volume for polymer (injection ~ 18 months)	60	%
Pore volume for water flush (injection >15 years; according to the calculated production profile)	600	%
Concentration of alkali	7,500	ppm
Concentration of polymer	1,000	ppm
Concentration of co-solvent	2,000	ppm
Backwash Data		**Unit**
Regeneration amount (NathansTech proposal, 2018)	0.2	m³/m³
HCl consumption (Whitecap Canada data + 50% due to higher hardness loads, DOW proposal)	1.309	kg/m³
NaOH consumption (Whitecap Canada data + 100% due to higher hardness loads, DOW proposal)	0.418	kg/m³
Waste water (Whitecap Canada data)	0.024	m³/m³
Cost		**Unit**
Alkali (Na_2CO_3, technical graded, price offer Brenntag 2018)	0.240	€/kg
Alkali (K_2CO_3, technical graded, price offer Brenntag 2018)	0,745	€/kg
Polymer (SNF, price offer March 2018)	2.550	€/kg
Co-solvent 3 (Clariant, price offer March 2018)	2.000	€/kg
HCl (35 %-solution, based on WTP price 2017)	0.110	€/kg
NaOH (50%-solution, DOW quotation, price offer March 2018)	0.260	€/kg
Incremental water treatment (overall costs for water treatment doubled cost from actual WTP costs, 2018)	0.240	€/m³
Waste water treatment	0.720	€/m³
Inclusive Costs		**Unit**
Incremental electrical power consumption, labor, maintenance, inhibitor, corrosion and scaling inhibitor (included in incremental water treatment costs)	incl.	€/m³

In the softening unit NaOH und HCl were used to regenerate the resin. Additionally, the generated waste streams from the softening unit need to be neutralized before disposal, therefore additional NaOH amounts are required. The daily waste water costs were related to all treatment steps. The monthly rate was calculated with 30 injection days. The overall costs were related to the injection duration and the daily costs of each chemical.

For the economic calculation, occurring costs regarding delivery of goods as well as costs for the disposal of hazardous waste were not considered. Nevertheless, their impact on the environment was taken into account and analysed within the LCA study.

Table 7-5: OPEX calculation divided into the different injection phases (*according to the mass balance 6,458 m³ water are required to inject the target of 5,000 m³/day (therefore, the required HCl, NaOH, water & waste water costs are calculated from this 1,458 m³ water which are mandatory to treat extra per day)).

Item	Unit	Softened Water (Phase 1, Pre-Flush)	Alkali-Polymer/ ACP Injection (Phase 2, Main Flush)			Polymer Injection (Phase 3)	Water Injection (Phase 4, Post-Flush)	
			Na_2CO_3	K_2CO_3	Na_2CO_3+Co 3			
Reservoir data								
Flush volume Sector 1	m³	1,300,000		3,900,000		3,900,000	39,000,000	
Flush volume Sector 2	m³	900,000		2,700,000		2,700,000	27,000,000	
Total flush volume	m³	2,200,000		6,600,000		6,600,000	66,000,000	
Injection data								
Injection rate	m³/d	5,000		5,000		5,000	5,000	
Injection duration	d	183		550		550	5,500	
Volumes								
Daily HCl consumption	kg/d	6,739		6,739		6,739	0	
Daily NaOH consumption	kg/d	2,153		2,153		2,153	0	
Daily alkali consumption	kg/d	0		37,500		0	0	
Daily polymer consumption	kg/d	0		5,000		5,000	0	
Daily co-solvent consumption	kg/d	0	0	0	10,000	0	0	
Daily waste water consumption	m³/d	118		118		118	118	
Daily costs								
HCl	€/d	741		741		741	0	
NaOH	€/d	560		560		560	0	
Alkali	€/d	0	9,000	27,983	9,000	0		0
Polymer	€/d	0		12,750		12,750	0	
Co-solvent	€/d	0	0	0	20,000	0	0	
Water treatment	€/d	1,200		1,200		1,200	1,200	
Waste water	€/d	85		3,600		3,600	3,600	
Additional water costs*	€/d	754		754		754	0	
Sum daily costs	**€/d**	**3,340**	**28,605**	**48,605**	**47,543**	**19,605**	**4,800**	
Sum monthly costs	**€/m**	**101,878**	**872,458**	**1,482,458**	**1,450,052**	**597,958**	**146,400**	
Sum yearly costs	**€/a**	**1,219,196**	**10,440,888**	**17,740,888**	**17,353,086**	**7,155,888**	**1,752,000**	
Overall costs								
HCl	€	131,760		407,700		407,700	0	
NaOH	€	102,425		307,834		307,834	0	
Alkali	€	0	4,950,000	36,877,500	4,950,000	0	0	
Polymer	€	0		7,012,500		7,012,500	0	
Co-solvent	€	0	0	0	11,000,000	0	0	
Water treatment	€	219,600		660,000		660,000	6,600,000	
Waste water	€	15,572		1,980,000		1,980,000	19,800,000	
Additional water costs	€	138,019		414,811		414,811	0	
Sum overall costs	**€**	**607,375**	**15,732,845**	**26,148,486**	**26,732,845**	**10,782,845**	**26,400,000**	

7.5.5.7 LCA Inventory Analysis

The assessed process in this LCA is shown in **Figure 7-21**. The flow chart includes all relevant inlet and outlet streams, as well as process parameters. As target, 5,000 m³ conditioned water should be injected per day. Therefore, an inlet flow rate of 6,458 m³ per day is required, because additional water amounts are needed for the generation of the bubbles in the MBF (side stream), regeneration of the softening unit, and also water volumes are lost into the flotation sludge.

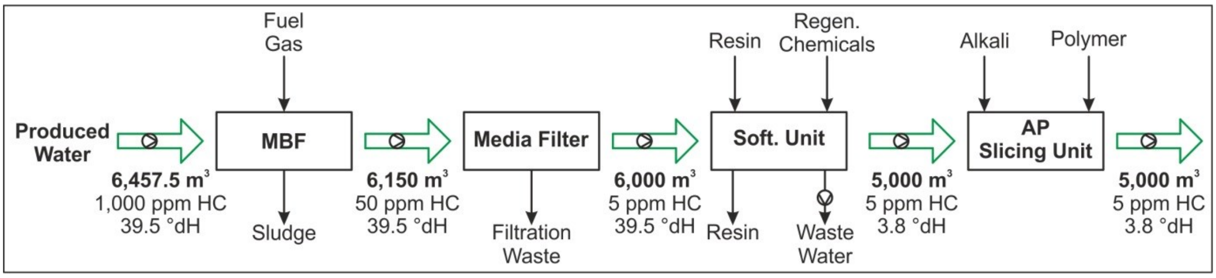


Figure 7-21: Flow chart for the AP injection water LCA.

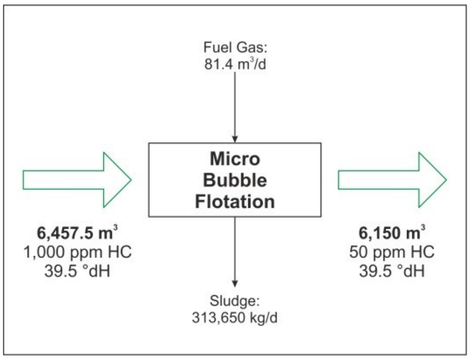
The hydrocarbon content at the inlet of the micro bubble flotation is assumed with 1,000 ppm (fluctuations possible) which are reduced through the MBF to around 50 ppm. After the filtration step the hydrocarbon content should be further decreased to less than 5 ppm. A multimedia filter (back-flushable nutshell granulate) will be applied. The inlet water has a hardness of 39.5°dH, which should be reduced to 3.8°dH at the outlet of the softening unit. The water is then conditioned with alkali (7,500 ppm Na_2CO_3/ K_2CO_3) and polymer (1,000 ppm HPAM) and finally injected into the 16.TH West (Sector 1). The requirements of each process step are summarized in **Table 7-6**.

Table 7-6: Description of the LCA process steps.

Process step	Description	Requirements
Outlet separator	First treatment step (de-oiling step)	Separation of the produced streams into oil, gas and water; the generated gas is used to generate the microbubbles in the MBF
Micro bubble flotation	Second treatment step (de-oiling step)	HC removal from 1,000 ppm (inlet water) to 50 ppm (fluctuations possible); MBF η=95%
Filter	Final polishing step	Reduction of HC to ≤5 ppm; filter η=90%
Softening unit	Conditioning of the water	Hardness removal of divalent cations to ~ 4°DH
Alkali & polymer slicing unit	Mixing of alkali & polymer to the treated water	Na_2CO_3/ K_2CO_3: 7,500 ppm HPAM: 1,000 ppm
Injection	End-of-life	5,000 m³/d slug injection

The efficiency of the MBF (**Table 7-7**) was assumed with 95% for normal oil-in-water separation. The MBF is operated under normal conditions without any flotation chemicals. The efficiency decreases for the treatment of polymer-containing water streams to approximately 80-85% (case not considered in the LCA). In this case study, fuel gas was considered to generate the micro-bubbles for the MBF, which is a produced side stream of the separator (treatment step before the MBF). Under normal conditions MBF can also be operated with N_2 bubbles like a dissolved gas flotation unit (**Chapter 6.4.1**). Both options were evaluated in this LCA.

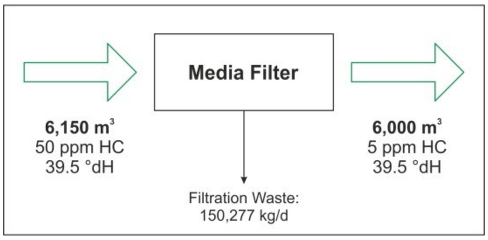
Table 7-7: Process parameters from the MBF.



Process item	Calculation	Assumptions
Flotation chemicals	0 kg/d	MFB is operated without chemicals (data provided by OMV MBF trial 2017)
Fuel gas supply	81.36 m^3/d	30% side stream of the inlet water stream requires 1.2 cF/min in 10 m^3/h (recirculation stream of the MBF, based on the gas consumption of the OMV MBF trial 2017)
Sludge	313.7 t/d	5% of the MBF inlet water stream (data provided by OMV MBF trial 2017)

A back-washable media filter using nutshell granulate (12/20 mesh, **Chapter 6.4.1**) is assumed to be applied as final polishing step right after the MBF (**Table 7-8**). The filter has an operational efficiency of 90% (reduction of 50 ppm to 5 ppm hydrocarbon load).

Table 7-8: Process parameters from the filtration step.



Process item	Calculation	Assumptions
Filtration waste	150.3 t/d	2.5% from the inlet water amount (containing oil, fines and water)

The water stream flows then into the softening unit. The hardness of the inlet water stream will be decreased in this step by around 91%. Currently, the most promising resins on the market are SAC (strong acid cation) and WAC (weak acid cation, possible alternative) exchanger. Nevertheless, SAC and WAC differ tremendously regarding the required regeneration chemicals, chemical types but also in terms of generated waste. For softening the process water in the technical studies a SAC exchanger was used (**Chapter 4**). Due to the fact that the final plant design of the softening unit was not defined yet, SAC and WAC exchanger were compared in this LCA. The outcome of this LCA might support to choose the optimal resin for the field implementation. The operation of the WAC process is designed for 11 hours and 4 hours for the resin regeneration **Table 7-9**).

Table 7-9: Process parameters for the softening unit using WAC.

Process item	Calculation	Assumptions
Regeneration chemicals	7,854 kg/d HCl	1.309 kg/m³ (based on Whitecap Canada data + 50 % due to higher hardness levels, DOW proposal); 35% solution
	2,508 kg/d NaOH	0.418 kg/m³ (based on Whitecap Canada data + 50 % due to higher hardness levels, DOW proposal); 50% solution
	1,000,000 kg/d Regeneration water	Backwash ratio (0.2 m³/m³; based on Whitecap Canada data + 25 % due to higher hardness levels)
Waste water	1,007,713 kg/d Water 4,679 kg/d Hardness load	Includes backwash & regeneration water (waste water 20%, NathansTech proposal for strong cation exchanger)

SAC was used in the technical study as resin for softening the produced water (**Chapter 4.2.1**). The softening step of the SAC was performed with NaCl and in the WAC with HCl and NaOH (**Figure 7-22**). The daily amount of a resin change in a WAC exchanger is less than <1g/m³. It is so low (65 kg resin/day) compared to SAC (702 kg/day) that it was ignored in the in- and output material balance.

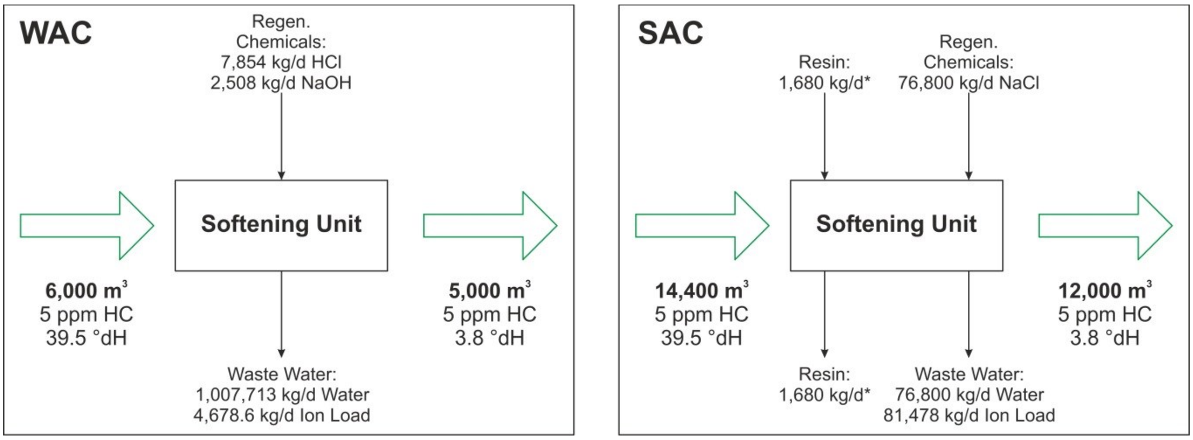


Figure 7-22: Comparison of the required amounts for SAC and WAC.

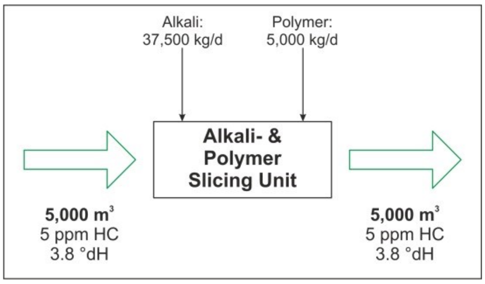
In comparison to WAC, SAC requires a higher amount of chemicals (**Table 7-10**). The doubled resin amount was assumed for the design (*) because of redundant operation (softening, regeneration).

Table 7-10: Process parameters for the softening unit using SAC.

Process item	Calculation	Assumptions
Regeneration chemicals	76,800 kg/d NaCl 1,000,000 kg/d Regeneration water	15.36 kg/m³ (based on DOW proposal) Backwash ratio (0.2 m³/m³; based on Whitecap Canada Data + 25% due to higher hardness levels)
Resin waste	1,680 kg/d*	1,440 tons/day required for an operation cycle (resin change once per year, 10 g resin/100 ml water based on DOW proposal)
Waste water	76,800 kg/d Water 81,478 kg/d Hardness load	Includes backwash & regeneration water (20% waste water, NathansTech proposal for strong cation exchanger)

For the design of the alkali- and polymer slicing unit, the proposed alkali and polymer concentrations from **Chapter 4.3.3** were used and summarized in **Table 7-11**.

Table 7-11: Process parameters for the alkali- & polymer slicing unit.



Process item	Calculation	Assumptions
Alkali	37,500 kg/d	7,500 ppm (based on phase screening study **Chapter 4.3.3**)
Polymer	5,000 kg/d	1,000 ppm (based on phase screening study **Chapter 4.3.3**)
Co-solvent 3	10,000 kg/d	2,000 ppm (based on phase screening study **Chapter 4.3.3**)

7.5.6 Simulation Model Output

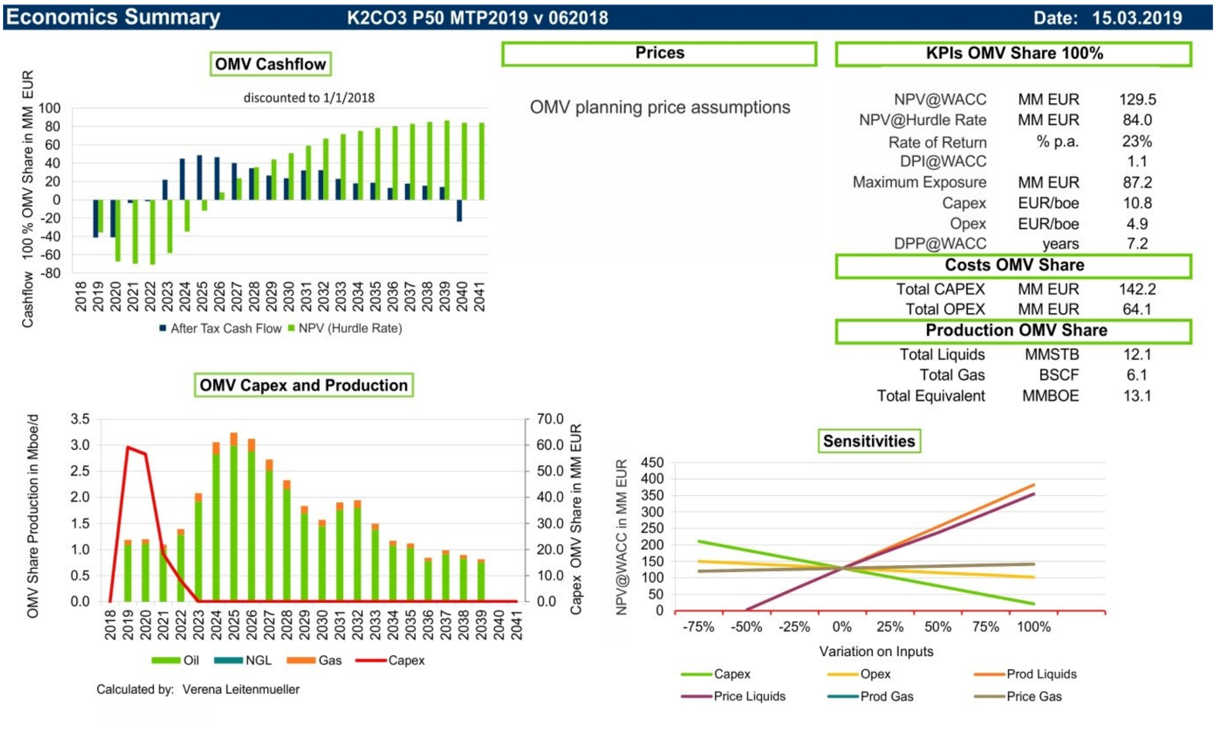
The three formulations which were promising, as an outcome of the technical studies, were calculated, based on different price scenarios (MTP @ WACC and country hurdle rate, MTP Stress @ WACC – see **Appendix A4**). The defined R&D key performance indicators were compared for the three cases. The water flood case was assumed as base case (no further field intervention planned), which was compared to the possible AP cases (field intervention).

Based on the flow chart expressed in **Figure 7-1** (**Chapter 7.1**) the expected monetary value (based on P_{50}) was calculated to compare the three possible formulations regarding their economic potential.

7.5.6.1 Economic Results of the 16.TH Cases

The economic conditions of the influencing oil price based on the mid-term price scenario were worked out for the P_{50} cases of the three formulations. The result reports generated from Palantir® Cash represent the discounted cash flow, relevant KPIs, the production profile and the sensitivities for each case.

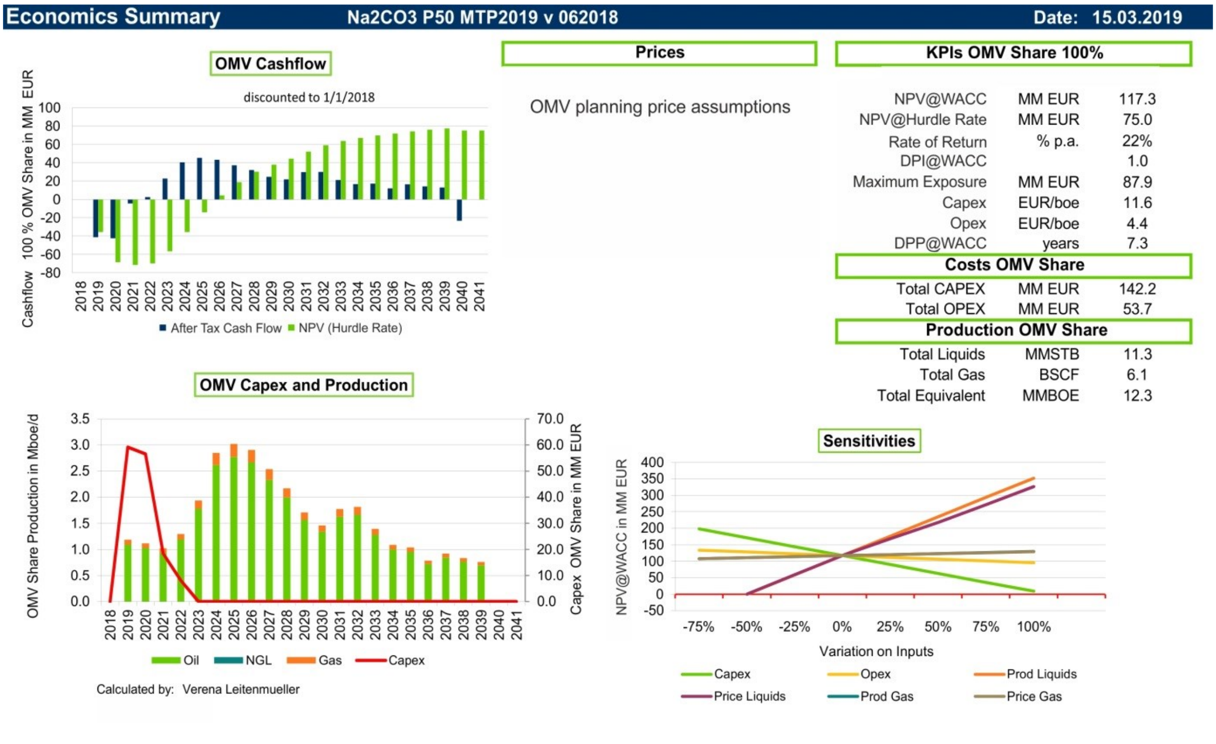
The achieved results of K_2CO_3 are shown in **Figure 7-23**. With K_2CO_3 13.1 MM BOE total equivalents will be produced during the project lifetime. By the use of K_2CO_3 for the AP injection slug 64.1 MM EUR operational expenditures will be required.



KPIs OMV Share 100%		
NPV@WACC	MM EUR	129.5
NPV@Hurdle Rate	MM EUR	84.0
Rate of Return	% p.a.	23%
DPI@WACC		1.1
Maximum Exposure	MM EUR	87.2
Capex	EUR/boe	10.8
Opex	EUR/boe	4.9
DPP@WACC	years	7.2
Costs OMV Share		
Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	64.1
Production OMV Share		
Total Liquids	MMSTB	12.1
Total Gas	BSCF	6.1
Total Equivalent	MMBOE	13.1

Figure 7-23: Results of the economic simulation of the P_{50} case from K_2CO_3.

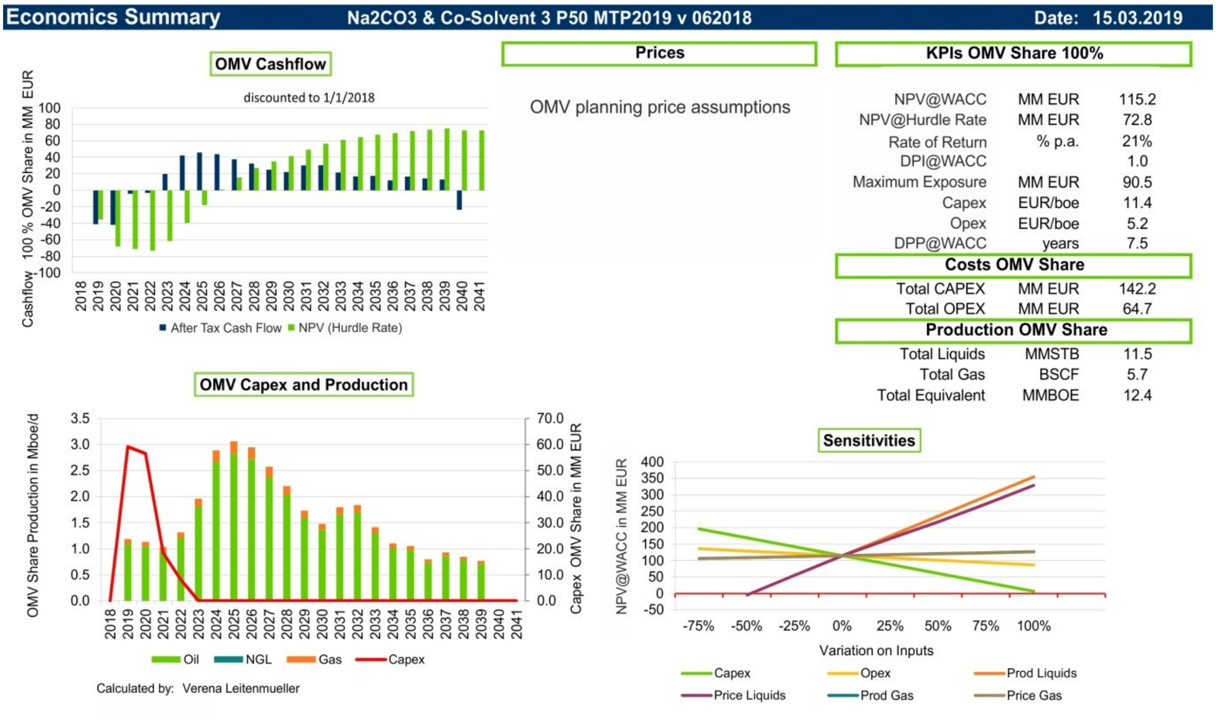
The gathered results with the formulation based on Na_2CO_3 are shown in **Figure 7-24**. By the use of Na_2CO_3, 12.3 MM BOE total equivalents will be produced. This formulation generates the lowest operational expenditures, with 53.7 MM EUR, compared to the other two formulations (Na_2CO_3 cheaper alkali lye than K_2CO_3).



KPIs OMV Share 100%		
NPV@WACC	MM EUR	117.3
NPV@Hurdle Rate	MM EUR	75.0
Rate of Return	% p.a.	22%
DPI@WACC		1.0
Maximum Exposure	MM EUR	87.9
Capex	EUR/boe	11.6
Opex	EUR/boe	4.4
DPP@WACC	years	7.3
Costs OMV Share		
Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	53.7
Production OMV Share		
Total Liquids	MMSTB	11.3
Total Gas	BSCF	6.1
Total Equivalent	MMBOE	12.3

Figure 7-24: Results of the economic simulation of the P_{50} case from Na_2CO_3.

Figure 7-25 represents the results of Na_2CO_3 mixed with co-solvent 3. This formulation generates 64.7 MM EUR operational expenditures (highest OPEX compared to the other two options) and will produce 12.4 MM BOE total equivalents.


Economics Summary Na2CO3 & Co-Solvent 3 P50 MTP2019 v 062018 Date: 15.03.2019

Prices

OMV planning price assumptions

KPIs OMV Share 100%

NPV@WACC	MM EUR	115.2
NPV@Hurdle Rate	MM EUR	72.8
Rate of Return	% p.a.	21%
DPI@WACC		1.0
Maximum Exposure	MM EUR	90.5
Capex	EUR/boe	11.4
Opex	EUR/boe	5.2
DPP@WACC	years	7.5

Costs OMV Share

Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	64.7

Production OMV Share

Total Liquids	MMSTB	11.5
Total Gas	BSCF	5.7
Total Equivalent	MMBOE	12.4

Calculated by: Verena Leitenmueller

Figure 7-25: Results of the economic simulation of the P_{50} case from Na_2CO_3 with co-solvent 3.

As indicated by the sensitivities, shown in the Spider diagrams based on the volumetric P_{50} case, the major influence of the project occurs through the capital expenditures, liquid production and price of the produced liquids. The economic outcome of the project reacts sensitive to these parameters, which means underestimating the CAPEX will result in a decrease of the NPV (@WACC) of the project. Still, CAPEX are slightly more sensitive in all three formulations. In contrast, an overestimate of the liquid production or liquid sales price will also result in a decreased NPV (@ WACC). The smallest variations are caused by a wrong estimate of the gas production and sales prices. In general, the biggest impact for cEOR to increase the NPV stems from CAPEX and production volumes as well as oil price assumptions. However, the easiest element to influence as well as to optimize is the spent capital expenditures.

As a next step, the EMV was calculated for each possible decision path (success and failure case of performing cEOR) to quantify each option regarding monetary terms (quantitative risk analysis). A decision tree was developed for the 16.TH case study and represented in **Figure 7-26**. The defined decision tree can be split into the development of cEOR and continue water flooding (current situation in the 16.TH). Performing cEOR (AP flooding) in the 16.TH was defined as success case. Polymer flooding was chosen as failure case (lower production profile, **Figure 7-18**), especially when the alkali injection fails through poor water quality (alkali softening, de-oiling…) or other occurring technological issues. Normally, EMV calculations are based on P_{mean} or on Swanson's mean calculations. As P_{mean}, P_{10} and P_{90} data were not available for the success and failure case, the EMV calculation is based on P_{50} production data to allow a comparison of both cases. Normally, the NPVs of P_{50} and P_{mean} cases are similar and distinguish only minor.

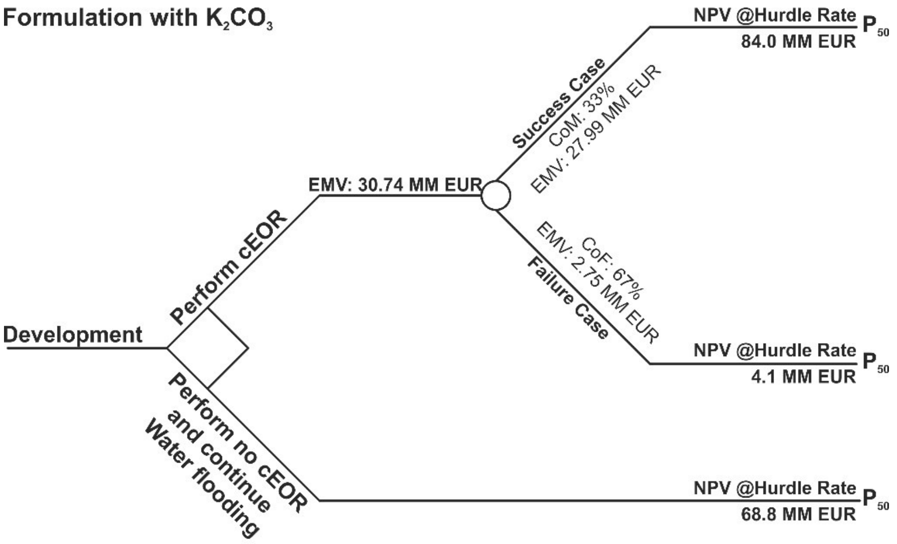
The assumed CoM for K_2CO_3 was 33%, 29.25% for Na_2CO_3 and 26.95% for Na_2CO_3 mixed with co-solvent (**Figure 7-20**). The NPV is based on the country hurdle rate. The EMV of the success case calculated for K_2CO_3 is 27.99 MM EUR and for the failure case 2.75 MM EUR. In contrast, the EMV of Na_2CO_3 from the success case is 21.94 MM EUR and from the failure case 2.88 MM EUR. Besides, the EMV of formulation 3 with co-solvent is for the success case 19.61 MM EUR and for the failure case 2.99 MM EUR.

The EMV for performing cEOR (including success and failure case) differs for the three formulations (**Figure 7-26**). The EMV for implementing cEOR with K_2CO_3 is 30.74 MM EUR and in contrast with Na_2CO_3 it is 24.8 MM EUR. The expected monetary value for the formulation prepared with Na_2CO_3 mixed with co-solvent 3 is 22.6 MM EUR.

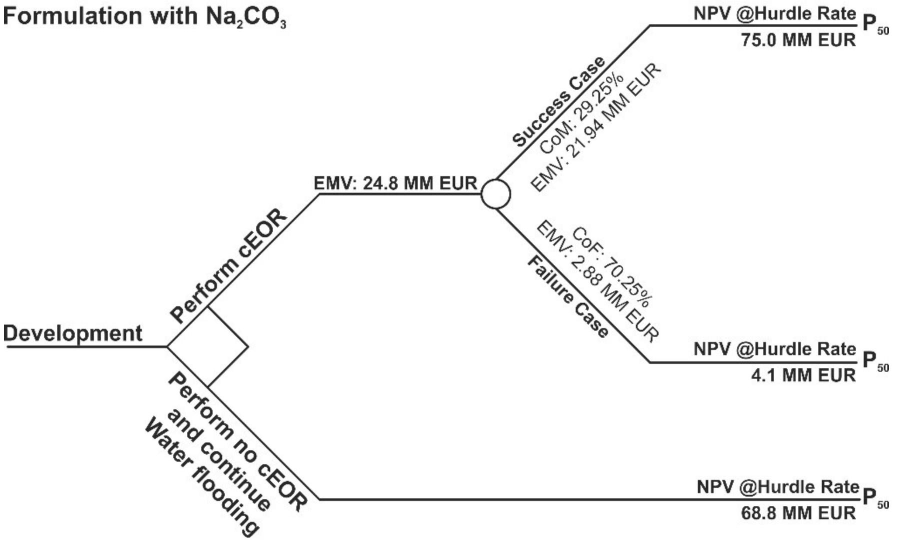
As mentioned before, the EMV represents the major economic KPI and evaluates the economic potential of the planned pilot. The EMV results indicate that the economic best option is reached by continuing the current water flood. However, additional non-tangibale values (gain of knowledge, strategic company position) may influence the final management decision to still perfom cEOR. In this case K_2CO_3 seems to be the best option among the three chemical formulations.

As an outcome of the study, it is recommended to upscale alkali-polymer flooding as a next step from the laboratory to pilot scale. Thereby, the chance of success will be significantly increased and the planned prospect further derisked prior to a field implementation.

Formulation with K_2CO_3



Formulation with Na_2CO_3



Formulation with Na_2CO_3 and Co3

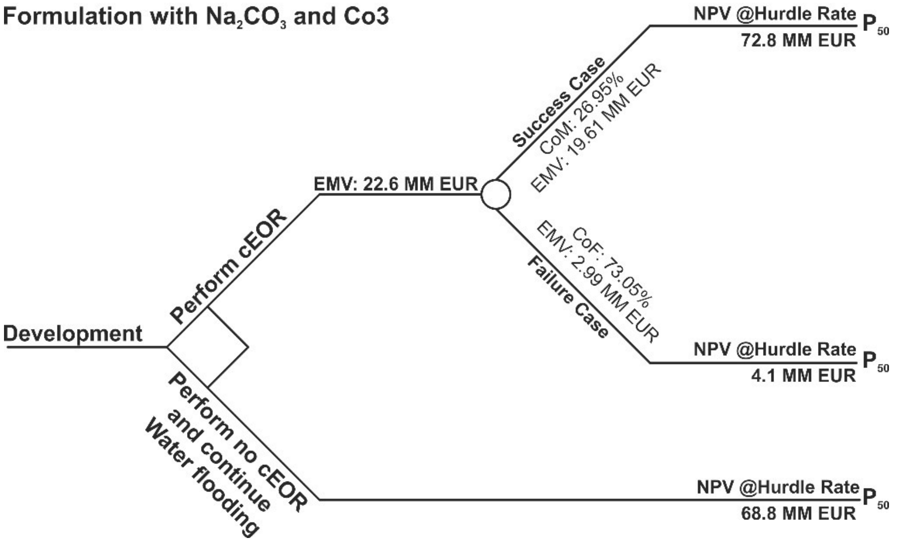


Figure 7-26: Decision tree: EMV calculation comparing the three possible formulations.

7.5.6.2 Environmental Impacts

Based on the inventory analysis, possible environmental aspects were assessed. The impact and damage categories were defined after ISO 14044:2006. The identified inventory aspects of this case study were then assigned to these impact categories (**Figure 7-27**). In the end, the impact categories were clustered to the damage categories, which can be subdivided into resource depletion, land use ecological impacts, impacts from greenhouse gases and black carbon, emissions linked to regional environmental impacts, emissions linked to human health impacts and untreated hazardous waste impacts (**Table 7-12**).

Table 7-12: Used weighing factors for the environmental impact categories [230, 242, 226].

Damage Category	Parameter	Weighing Factor	Source
Impacts from greenhouse gases and black carbon	CH_4	23:CO_2	IPCC, 2001
Emissions linked to regional environmental impacts	Benzen Benzen	0.5: dichlorobenzene 1.7% contained in crude oil	Heijungs, 1992 Verma&desTombe, 2002
Emissions linked to human health impacts	Benzen	1.7% contained in crude oil	Verma&desTombe, 2002

Based on the identified environmental impact categories, the impact of each category was calculated and the results demonstrated in **Figure 7-27**. As a next step, the damage categories were assessed according to the CML method [235].

The highest impact was generated in the MBF unit and in the filtration treatment step through emissions linked to regional environmental impacts, emissions linked to human health impacts and untreated hazardous waste impacts (produced sludge). The type of gas (N_2 or fuel gas) used to generate micro-bubbles has a significant environmental impact. By the usage of fuel gas an enormous global warming potential arises, as 1 kg of CH_4 is equal to 23 kg CO_2 [243]. In addition, it generates an explosive atmosphere and is a potent greenhouse gas. It can also lead to bacterial activities and corrosion. In contrast, nitrogen (N_2) is environmental neutral as it is an inert gas. The softening unit has an impact on resource depletion (operation and regeneration) and impacts on greenhouse gases and black carbon (delivery of regeneration chemicals). Impacts on greenhouse gases and black carbon as well as on resource depletion were identified (, **A**) in the alkali- and polymer slicing unit through the delivery of goods and for the preparation of the alkali lye (mining operations) [235].

The MBF has a 95% influence on the untreated hazardous waste. The alkali- and polymer slicing unit has a 60% impact on the greenhouse gas emissions and on black carbon as well as on resource depletion with around 84%. Based on the fact that the process cannot be optimized in terms of resource depletion (water and alkali consumption), emissions linked to regional environmental and human health impacts (oil from purification) and untreated hazardous waste impacts (sludge), a study was undertaken to show the potential of minimizing greenhouse gas and black carbon impacts (, **B**). No influence on the land use is shown as the final plant design is not ready[235].

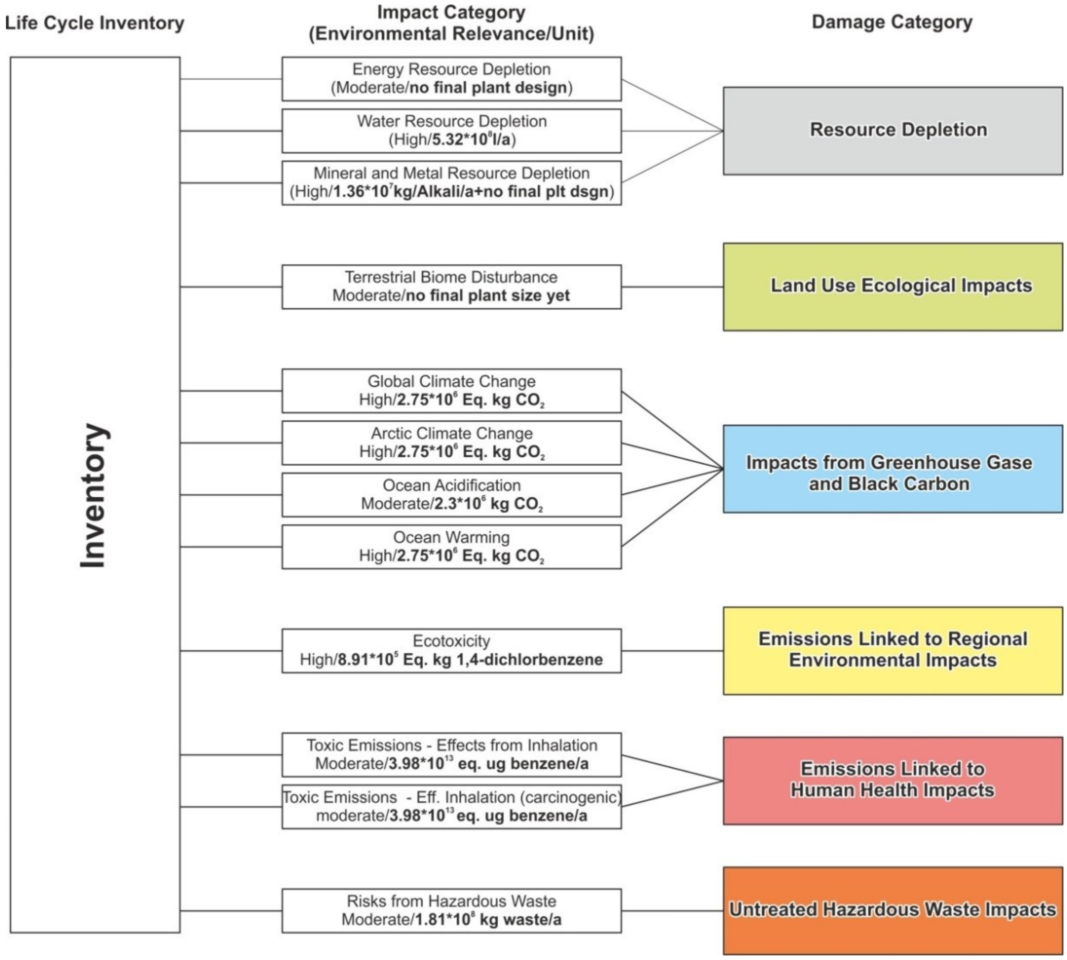


Figure 7-27: Environmental impact factors assessed for the 16.TH case study (Modified from [231]).

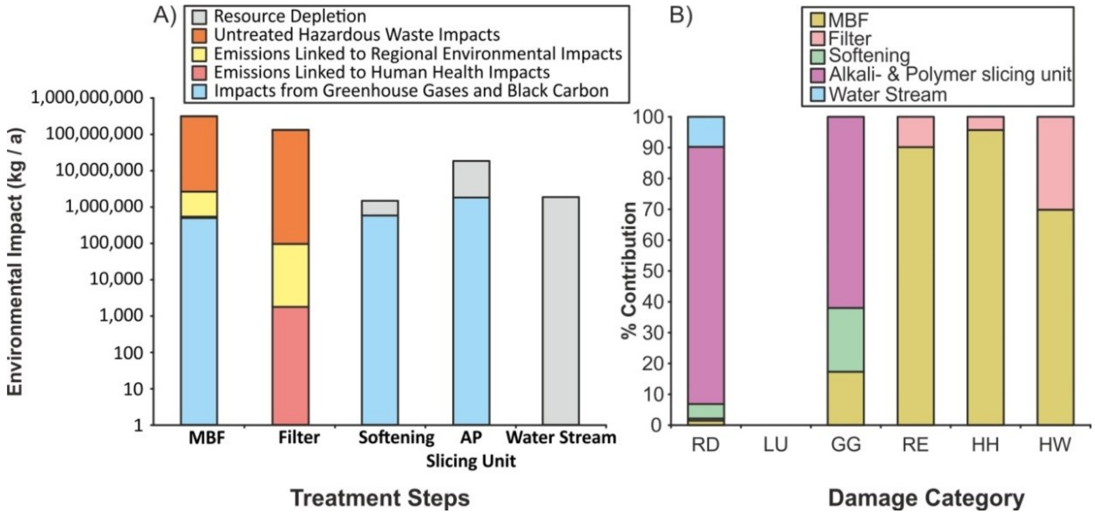


Figure 7-28: Calculated environmental impacts based on the inventory data of each treatment step (A, absolute values) and process step drivers of the assessed damage categories (B, relative values) [235].

Through the developed scoring system, all screened options trigger the same impact categories and therefore represent the same results (**Figure 7-29**). Reasonable high scores were achieved in the land use ecological impacts and in the emissions linked to regional environmental impacts, followed by emissions linked to human health impacts. Strong impacts on the environment were identified in resource depletion, impacts from greenhouse gases and black carbon as well as from untreated hazardous waste [235].

		K_2CO_3		Na_2CO_3		Na_2CO_3 + Co-solvent 3	
Nomination	**Points**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**
Resource Depletion (RD)	10	25	2.5	25	2.5	25	2.5
Land Use Ecological Impacts (LU)	10	75	7.5	75	7.5	75	7.5
Impacts from Greenhouse Gase and Black Carbon (GG)	10	0	0	0	0	0	0
Emissions Linked to Regional Environmental Impacts (EI)	10	75	7.5	75	7.5	75	7.5
Emissions Linked to Human Health Impacts (HH)	10	71.4	7.14	71.4	7.14	71.4	7.14
Untreated Hazardous Waste Impacts (HW)	10	50	5	50	5	50	5
Score	60		29.64		29.64		29.64

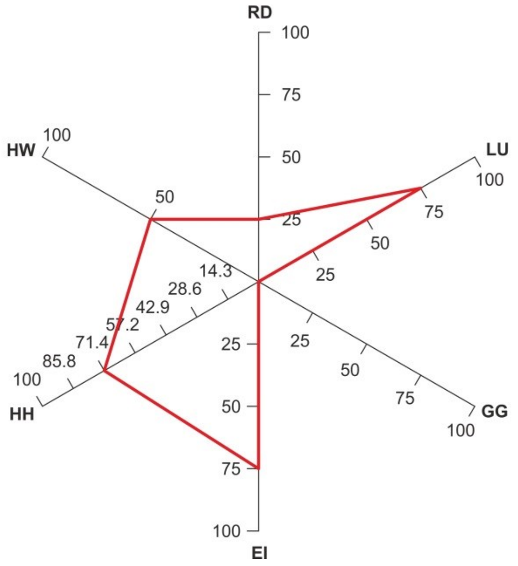


Figure 7-29: Scoring of the occurring environmental aspects of this AP case study (Modified from [235]).

The global warming potential is mainly driven by occurring CO_2 emissions through the delivery of goods. As an outcome of the inventory analysis, various chemicals and high amounts are required per day. Therefore, a CO_2 balance for the delivery of goods was calculated. Per injection phase the required quantities of goods, which need to be transported were calculated in kg per day. In the calculated values the amount of injection chemicals (alkali, polymer) and regeneration chemicals were included. Additionally, the amounts were calculated with and without a co-solvent. SAC and WAC resins are two possible options for the softening step but require significant differing quantities of regeneration chemicals.

Therefore, both options were listed separately in **Figure 7-30**. The total amount was calculated based on the injection volume (kg/day). It was assumed that the resin is changed once per year when the overall capacity is reached. The resin is loaded (conditioned) with hydrocarbons and needs to be treated as hazardous waste and handed to an authorized disposal facility (~55 € per ton).

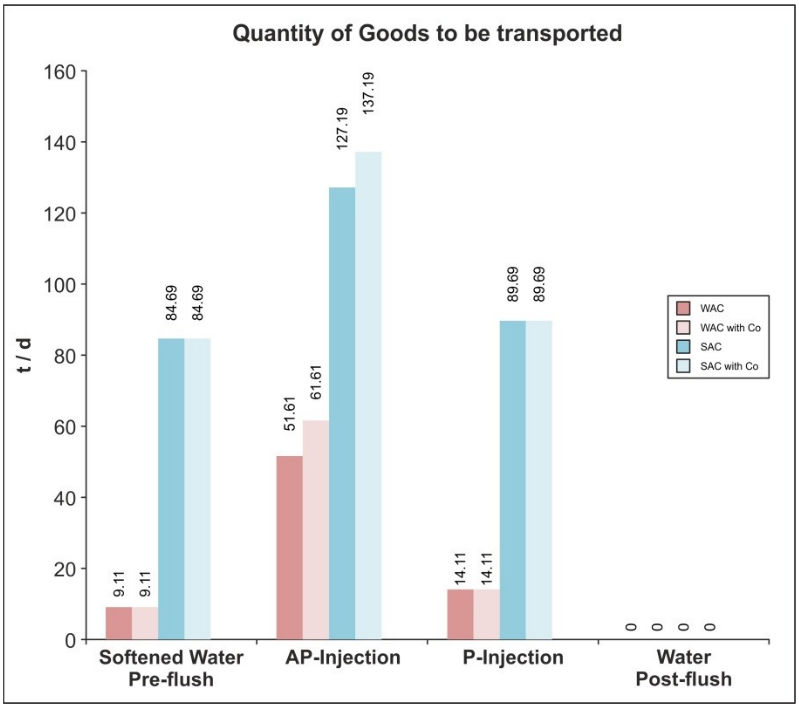


Figure 7-30: Logistic impact of the delivery from the required goods (chemicals).

As a next step, the impact of transporting the chemicals through the local villages (Deutsch-Wagram, Bockfliess and Auersthal located in Lower Austria) and communities was assessed, by calculating the required trucks, which must be used to deliver the goods to the AP unit. Clearly, a rail-based solution would be the best option. Especially, by using SAC technology around five trucks were required and for WAC technology two trucks (**Figure 7-31**). It was assumed that each truck can transport 30,000 kg (max. load) per ride (500 km). The total amount of chemicals will be purchased not only inside Austria, but also from other countries. Therefore, a maximum distance of 1,000 km was assumed.

The occurring CO_2 emissions are demonstrated in **Figure 7-32**. Clearly, the delivery by train represents the most environmental friendly option for all injection phases. In addition, high quantities of regeneration salt (NaCl) required for the SAC resin led to an unfavorable CO_2 balance. For the calculation of the CO_2 emissions, 104 g/ton per driven km were assumed for the trucks according to the Deutsches Umweltbundesamt (2018) [244]. In comparison, the train delivery is much more ecological, with just 20 g CO_2 emission per day. The emissions from train transport are so small that they are barely visible in the plot. Furthermore, it can be mentioned, that in the first phase less than one train will be sufficient (less chemicals are required)[235].

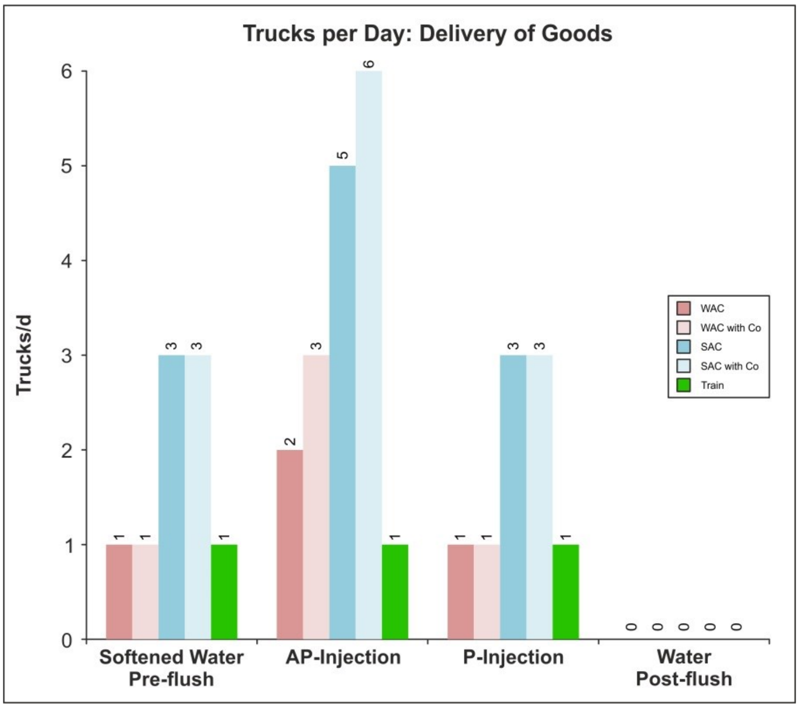


Figure 7-31: Delivery of goods: comparing truck and train service.

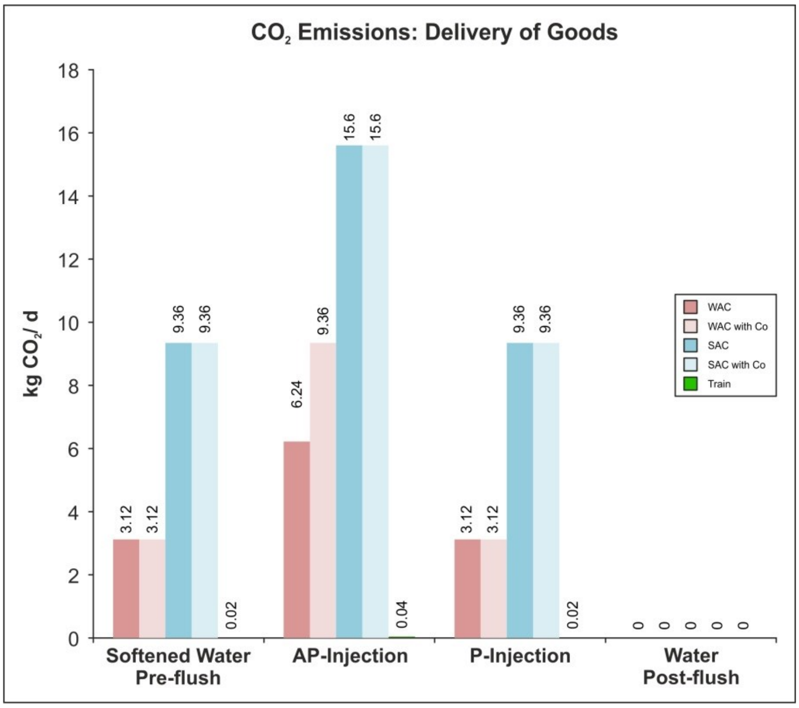


Figure 7-32: CO_2 emissions: comparing truck and train service.

7.5.6.3 Comparison of possible 16.TH Success Cases

Figure 7-33 represents the occurring costs for 1 m³ injection slug based on the different injection phases (softened water pre-flush using WAC, AP injection, polymer injection and water post-flush) for the three screened formulations. Basically, the lowest operational costs arise for the Na_2CO_3 formulation with 4.35 €, for K_2CO_3 with 8.13 € and for ACP 8.35 € are needed. For the polymer injection phase 2.55 € will occur. The normal treatment of the formation water costs 0.24 € per m³. For the softening of the formation water 0.362 € additional costs arise.

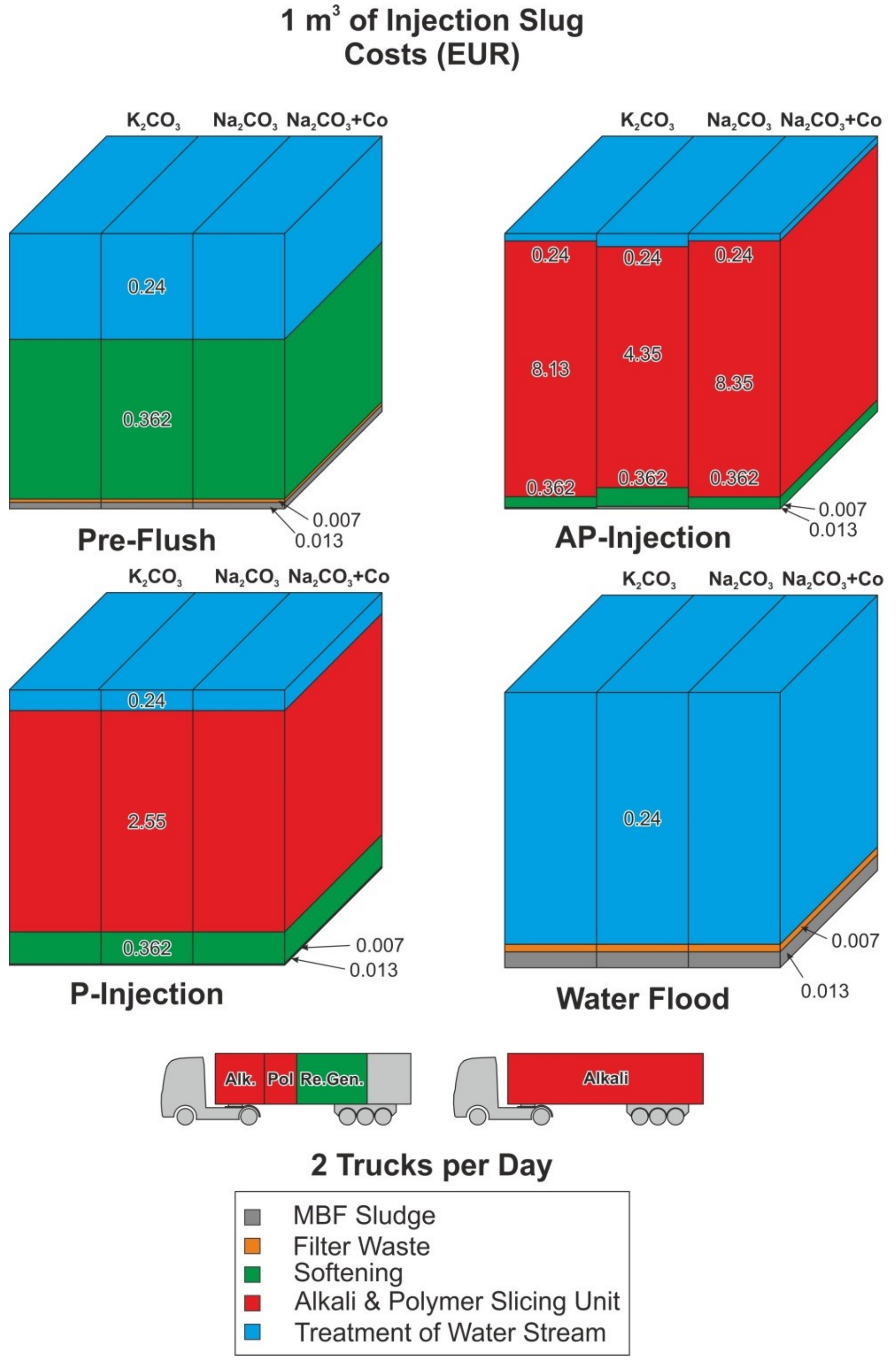


Figure 7-33: Summary of the occurring costs per m³ for each injection phase and the three formulations.

Table 7-13 compares the results of the three possible injection formulations (success case), of the failure case (polymer flood) and continue water flooding. The results of the volumetric P_{50} water flood case is shown, when no further field intervention is undertaken (**Appendix A4**). The total production of the equivalents of the base case will be 3.6 MM BOE. The total operational expenditures were 4.5 MM EUR per year, which means 1.2 EUR per BOE. No additional capital expenditures will arise in the base case. A point forward calculation was performed based on the water flood case. The planned field intervention of the three formulations was calculated based on the total production.

The cumulative production is controlled by the production forecast of Na_2CO_3 provided by OMV. Using K_2CO_3, the additional production of 13.1 MM BOE will be gained. The application of Na_2CO_3 will result in an additional 12.3 MM BOE, whereas the ACP application has a chance to recover 12.4 MM BOE. The total CAPEX spent for the planned AP flood was 142.2 MM EUR.

The total spent OPEX were 64.1 MM EUR for K_2CO_3, 53.7 MM EUR for the case with Na_2CO_3 (lowest required operational expenditures) and around 64.7 MM EUR for Na_2CO_3 with the co-solvent similar to K_2CO_3.

All key performance indicators are listed for the planned cEOR field intervention. The volumetric P_{50} case was calculated with two different price scenarios: once as base scenario at country hurdle rate and once as stress scenario at WACC. The IRR was 23% p.a. for K_2CO_3, 22% p.a. for Na_2CO_3 and for the ACP slug 21%. For the stress cases was the IRR lower and made up 17% for the ACP formulation, 18% for the Na_2CO_3 formulation and 19% p.a. for the K_2CO_3 option.

All investigated NPV´s of the volumetric P_{50} case were positive. The P_{50} base case simulated with K_2CO_3 had a NPV of 84 MM EUR, and with Na_2CO_3 75 MM EUR. The NPV was lower for the case simulated with the ACP slug (Na_2CO_3 + co-solvent 3) of 72.8 MM EUR.

The NPV calculated for the P_{50} stress case delivered 55.3 MM EUR for K_2CO_3, 48.3 MM EUR for Na_2CO_3 and for ACP 45.6 MM EUR.

The DPI of the P_{50} base price scenario was for the K_2CO_3 option 1.1 and for the other two formulations 1. At the stress case the DPI was for K_2CO_3 0.8 and for Na_2CO_3 as well as for the ACP case 0.7.

The maximum exposure of the P_{50} base case with K_2CO_3 was 87.2 MM EUR (97 MM EUR for the stress case), 87.9 MM EUR (94.6 MM EUR for the stress case) for the case with Na_2CO_3 and 90.5 MM EUR (99.9 MM EUR for the stress case) for the ACP case.

K_2CO_3 had the lowest discounted payback time at WACC with 7.2 years, followed by Na_2CO_3 with 7.3 years and ACP had 7.5 years (based on the P_{50} base price scenario).

In contrast, the polymer case (failure case of performing cEOR) had an NPV at country hurdle rate of 4.1 MM EUR and at WACC of 23.6 MM EUR, an IRR of 11% and a payback time at WACC of 12 years. The DPI for this case was 0.2 (**Appendix A4**).

The LCA KPIs indicate the environmental impacts of the AP project. No difference between the three formulations was recognized, because the environmental impacts were only related to the mass balances of the considered injection water stream. Uncertainties with regards to the ecological impacts from mining, processing and transporting of the alkalis, the materials used for polymer production and transportation as well as manufacturing of the co-solvent could not be sufficiently answered and were not incorporated. Furthermore the treatment of the generated sludge, filtration waste and waste water streams is unclear at this time. Hence, no significant decision criterion between the screened options is presented by the LCA KPIs.

As the final plant design was not available yet, the energy resource depletion, the metal resource depletion and the terrestrial biome disturbance could not be quantified. The water resource depletion was $5.32*10^8$ liters per year and the mineral resource depletion by mining the alkali was $1.36*10^7$ kg per year. In terms of global and artic climate change, as well as ocean warming, the impact will be $2.75*10^6$ kg CO_2 equivalents per year. The project will contribute $2.3*10^6$ kg of CO_2 per year to the acidification of the global oceans. Furthermore, $8.91*10^5$ kg of 1,4-dichlorbenzene equivalents will be emitted from the project per year (eco-toxicity). The generated toxic emissions (effects from inhalation) can be classified as carcinogenic and sum up to $3.98*10^{13}$ µg benzene equivalents per year. Overall $1.81*10^8$ kg of hazardous waste is generated by the project (considering the flotation sludge, filter waste and softening waste, **Figure 7-34**).

The highest NPV of all screened options was achieved by the formulation containing K_2CO_3, whereas the quickest payback time and the least exposure had been achieved by the formulation containing Na_2CO_3. The DPI was the same for all three options. K_2CO_3 reached a total score of 69.14 points, Na_2CO_3 achieved 67.44 points and Na_2CO_3 mixed with co-solvent had the lowest points (66.64 points out of 100 points).

		K_2CO_3		Na_2CO_3		Na_2CO_3 + Co-solvent 3	
Nomination	**Points**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**	**Degree of Fullfilment**	**Score (Points*Fullfilment)**
NPV (Hurdle Rate)	10	100	10	89.3	8.9	86.7	8.7
DPI (WACC)	10	100	10	90.9	9.1	90.9	9.1
DPP (WACC)	10	100	10	98.6	9.9	96	9.6
Maximum Exposure	10	100	10	99.2	9.9	96.4	9.6
Resource Depletion (RD)	10	25	2.5	25	2.5	25	2.5
Land Use Ecological Impacts (LU)	10	75	7.5	75	7.5	75	7.5
Impacts from Greenhouse Gase and Black Carbon (GG)	10	0	0	0	0	0	0
Emissions Linked to Regional Environmental Impacts (EI)	10	75	7.5	75	7.5	75	7.5
Emissions Linked to Human Health Impacts (HH)	10	71.4	7.14	71.4	7.14	71.4	7.14
Untreated Hazardous Waste Impacts (HW)	10	50	5	50	5	50	5
Score	100		69.14		67.44		66.64

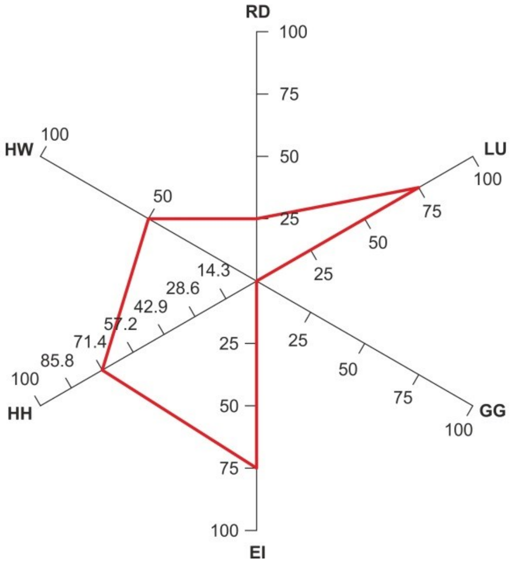


Figure 7-34: Scoring of economic KPIs and LCA KPIs of the three possible AP injection formulations [235].

Table 7-13: Comparison of the economic results of the possible 16.TH cases.

Chance of Maturation	**K_2CO_3 (cEOR "Success Case – Option 1")**	**Na_2CO_3 (cEOR "Success Case – Option 2")**	**Na_2CO_3 + Co-Solvent 3 (cEOR "Success Case – Option 3")**
Hydrocarbon Chance (%)	100	100	100
Recovery Chance (%)	75	65	70
Skills & Technology Chance (%)	55	60	55
Authorization & Market Chance (%)	80	75	70
Chance of Incremental Recovery (%)	75	65	70
Chance of Technical Success (%)	41.25	39	38.5
Chance of Realization (%)	44	45	38.5
Chance of Maturation (%)	**33**	**29.25**	**26.95**

Economic Indicators	**Unit**	**K_2CO_3 (cEOR – Option 1)**		**Na_2CO_3 (cEOR – Option 2)**		**Na_2CO_3 + Co-Solvent 3 (cEOR – Option 3)**		**Polymer Flood ("Failure Case")**	**Water Flood ("no further field intervention")**
		P_{50}	**P_{50} Stress**	**P_{50}**	**P_{50} Stress**	**P_{50}**	**P_{50} Stress**	**P_{50}**	**P_{50}**
NPV @ WACC	MM EUR	129.5	93.5	117.3	83.7	115.2	81.1	23.6	74.4
NPV @ Country Hurdle Rate)	MM EUR	84	55.3	75	48.3	72.8	45.6	4.1	63.8
Internal Rate of Return	% p.a.	23	19	22	18	21	17	11	n/a
DPI @ WACC		1.1	0.8	1	0.7	1	0.7	0.2	n/a
Maximum Exposure	MM EUR	87.2	97.0	87.9	94.6	90.5	99.9	88.2	0.0
CAPEX	EUR/BOE	10.8	10.8	11.6	11.6	11.4	11.4	20.1	0.0
OPEX	EUR/BOE	4.9	4.9	4.4	4.4	5.2	5.2	6.2	1.2
DPP @ WACC	Years	7.2	8	7.3	8.2	7.5	8.5	12	0.0
Total CAPEX	MM EUR	142.2	142.2	142.2	142.2	142.2	142.2	142.2	0.0
Total OPEX	MM EUR	64.1	64.1	53.7	53.7	64.7	64.7	44.3	4.5
Total Liquids	MM STB	12.1	12.1	11.3	11.3	11.5	11.5	6.5	3.3
Total Gas	BSCF	6.1	6.1	6.1	6.1	5.7	5.7	3.3	1.7
Total Equivalent	MM BOE	13.1	13.1	12.3	12.3	12.4	12.4	7.1	3.6

LCA Impact Categories and Score	**Unit**	**K_2CO_3**	**Na_2CO_3**	**Na_2CO_3+Co 3**
Energy Resource Depletion	J	no final plant design		
Water Resource Depletion	l/a	$5.32*10^8$		
Mineral & Metal Resource Depletion	kg/a	$1.36*10^7$		
Terrestrial Biome Disturbance	m²/a	no final plant design		
Global Climate Change	Eq. kg CO_2/a	$2.75*10^6$		
Arctic Climate Change	Eq. kg CO_2/a	$2.75*10^6$		
Ocean Acidification	kg CO_2/a	$2.3*10^6$		
Ocean Warming	Eq. kg CO_2/a	$2.75*10^6$		
Eco-toxicity	Eq. kg 1,4-Dichlorbenzene/a	$8.91*10^5$		
Toxic Emissions – Effects from Inhalation	Eq. µg benzene/a	$3.98*10^{13}$		
Toxic Emissions – Effects from Inhalation (carcinogenic)	Eq. µg benzene/a	$3.98*10^{13}$		
Risks from Hazardous Waste	kg waste/a	$1.81*10^8$		
Scoring of R&D KPIs				
NPV (Hurdle Rate)	Points	10/10	8.9/10	8.7/10
DPI (WACC)	Points	10/10	9.1/10	9.1/10
DPP (WACC)	Points	10/10	9.9/10	9.6/10
Maximum Exposure	Points	10/10	9.9/10	9.6/10
Resource Depletion	Points	2.5/10	2.5/10	2.5/10
Land Use Ecological Impacts	Points	7.5/10	7.5/10	7.5/10
Impacts from Greenhouse Gases and Black Carbon	Points	0/10	0/10	0/10
Emissions Linked to Regional Environmental Impacts	Points	7.5/10	7.5/10	7.5/10
Emissions Linked to Human Health Impacts	Points	7.14/10	7.14/10	7.14/10
Untreated Hazardous Waste Impacts	Points	5/10	5/10	5/10
Total Score	Points	**69.14**	**67.44**	**66.64**

7.5.1 Discussion

An economic model for R&D projects was established based on the E&P model and applied on the alkali-polymer case study. The developed model can be further used for other planned R&D prospects, because required R&D key performance indicators were worked out. Life cycle assessments represent an integrative part of the R&D evaluation model because it gives additional insights about the environmental impacts of the technology (non-monetarized tangible KPIs).

The economic feasibility of this case study is dependent on the amount of remaining oil to recover, but also strongly driven by the oil price to implement this R&D technology. The uncertainty regarding future oil prices and its profit is associated to the outcome of the project. The economic potential (success case) is represented by an R&D project, which achieves a more positive EMV than the alternative options. Basically, R&D projects can only be compared with each other because no comparison with normal ongoing E&P projects is possible (R&D portfolio). If the successfully tested R&D pilot will be implemented to the field, the NPV (risked with CoM) should be used as key performance indicator.

The considered CoM for future implementations should not contain specific R&D elements, because the de-risking of the technology shall have already happened throughout the pilot phase. The success case is represented through a positive NPV at hurdle rate. The ranking of the implementation should be according to OMV upstream project portfolio.

In the conducted case study, the three evaluated formulations had a positive NPV as well as EMV. From a technical point of view, AP flooding represents an opportunity in reservoirs where the remaining oil saturation is high. Every cEOR prospect is characterized by high capital and operational costs. High quantities of chemicals are required on a daily basis including alkali lye, polymer, process chemicals, regeneration chemicals, etc. Especially, major costs are generated by the water treatment process prior to the alkali-polymer slicing unit (MFB unit, water softening). The installation of optimal storage tanks and a logistic concept is mandatory.

The economic results indicate that the implementation of alkali-polymer flooding represents a better and more promising option than polymer flooding (failure case) alone for the 16.TH (EMV around 3 MM EUR). According to the EMV, the usage of K_2CO_3 for the chemical formulation is the best option for performing a cEOR prospect with 30.74 MM EUR (incl. success and failure case). The EMV for the usage of Na_2CO_3 for the cEOR flood makes up 24.8 MM EUR and is significantly lower than the one of K_2CO_3. The implementation of ACP is the economically least attractive option with an EMV of 22.6 MM EUR. According to the economic calculation and technical studies, it is recommended to verify the gathered results within a pilot study to decrease the uncertainty level.

However, for strategic reasons (larger portfolio, acceptance of a higher risk and costs) and a timely availability of results for further rollouts in other fields there may be the decision to include the pilot already in a full field implementation of the 16.TH.

According to the LCA results, the delivery of goods by train is a more environmental friendly option (20 g CO_2/ day) and reduces the truck transfers as well as associated CO_2 emissions. In addition, all goods can be delivered together at the same time and the risk of truck accidents will be reduced. The associated CO_2 emission of the delivery with trucks is strongly dependent on the injection phase, because different amounts are required. Furthermore, the environmental impact of the MBF unit could be reduced by using N_2 for the gas supply instead of fuel gas. Still it would lead to additional costs, a huge amount of gas bundles and an increased operational expenditure for the bundle replacement. Alternatively, liquid nitrogen could be used instead of nitrogen bundles and stored in a tank onsite.

The softening unit requires high chemical loads and generates a high waste stream. Therefore, the performance of a strong and weak cation exchanger was compared regarding the chemical loads and the generated amount of waste. The comparison of both resins showed, that WAC exchangers require less resin, but are operated with hazardous chemicals such as NaOH and HCl. In contrast, SAC exchangers require higher chemical loads (HCl, not dangerous) as well as higher resin amounts. Therefore, the implementation of a WAC exchanger for the field implementation represents a better alternative.

Overall, the AP project has a significant influence on the environment. However, the impact from greenhouse gases and black carbon in the current state of planning can be heavily decreased by the application of train transport and the relinquishment of fuel gas in the MBF unit. In order to provide a full cycle LCA, the environmental impacts from the mining, processing and production of the two alkalis as well as of the co-solvent must be additionally studied in detail.

8 Conclusion

The present PhD thesis yields new and important insights into the required design criteria for possible future application of cEOR in the Matzen oilfield. The results highlight the importance of a careful selection of the alkali-polymer slug (concentrations), the need of understanding alkali-rock interaction and the optimization of the water treatment handling process to ensure good filterability as well as to reach the desired injection water quality. Thereby, the impact of breakthrough polymer water was investigated on the treatment process. Furthermore, a suitable economic model for R&D projects was developed to allow R&D project comparison. This model was successfully tested on the AP-project, different AP slugs calculated and compared as well as a life cycle assessment carried out.

The phase screening experiments displayed the need of a meticulous selection of the compounds. As the modification of any parameter, like the alkali type, the water composition, the oil type, the concentration, the temperature etc. already lead already to slight changes of the phase behavior. The interaction between the alkali and the oil of Bo 112 oil (16.TH) was less strong compared to the S 85 oil the 8.TH (heavy degraded oil) because almost no non-polar compounds were left in the initial oil. The in-situ soap generation started at much higher alkali concentrations compared to the 16.TH oil as a result of non-soap forming acids which were formed through biodegradation. Adversely, the non-soap forming acids were stronger than the soap-forming naphthenic acids and consumed parts of the alkali lye before the soap generation started. Normally, acid number and TAN measurements are performed to get a feeling about the soap forming potential. In addition, information provided by acid number measurements could be linked with oil characterization to compare if equal results are gathered. Positively, the oil characterization provides additional information about the oil composition compared to acid number measurements.

In-situ soaps were formed because the moderately degraded oil interacted with the alkali lye, as the n-alkanes were missing (degradation). The first in-situ soaps with Bo 112 oil were formed with alkali concentrations of 5,000 ppm. Bo 112 oil is rich in non-polar isoprenoids and therefore significant emulsion amounts were formed at higher alkali concentrations. It could also be observed that the excess aqueous phase showed a brownish color with a high turbidity due to dissolved hydrocarbons and loss of in-situ soap components into the water phase. Hence, breakthrough alkali slug will be challenging to treat in surface facilities.

The optimal concentration range for the 16.TH was much narrower (5,000-10,000 ppm) than for the 8.TH, regarding the formulations prepared with real softened formation water and dead oil. The optimal concentration range for K_2CO_3 was between 5,000 ppm and 10,000 ppm. At higher alkali concentrations, the produced in-situ soap amount decreased stronger over time than those of the lower alkali concentrations. In contrast, Na_2CO_3 formed unfavorable type II (+) emulsions starting at a concentration of over 7,500 ppm. Type III emulsions were only formed at low alkali concentrations (<7,500 ppm), which declined strongly over time and no emulsion equilibrium could be observed. In general, the observed emulsions were not stable over the observation period and declined strongly (no micro emulsions).

Especially, the modified Bo 112 oil, with cyclohexane, showed a completely different phase behavior. Viscosity-matched oil is widely applied in the industry for core flood experiments. Formulations prepared with viscosity-matched Bo 112 oil showed a significantly reduced emulsion amount. Non-polar compounds, like cyclohexane, inhibit the alkali-crude oil interaction. The formed emulsion did not reach equilibrium over the observation time.

The addition of HPAM to the slug caused a significant reduction of the formed emulsion volume. Furthermore, the same trend could also be observed in the ACP-samples (co-solvent 1). The tested co-solvents 1 and 2 caused severe losses of generated in-situ soap to the aqueous phase. Co-solvent 3 showed more promising results than the other two co-solvents. Technically graded alkalis interact less strongly with the oil than pure alkalis.

Interestingly, formulations prepared with heavy degraded oil from the 8.TH (S 85 oil) formed larger emulsion amounts at higher concentration ranges compared to the moderately degraded oil from the 16.TH. Both alkalis performed satisfactorily and no significant loss of soap components into the aqueous phase could be observed in the formulations prepared with S 85 oil from the 8.TH (heavy degraded oil). This oil type contains no naphthalene’s because the depletion occurred already through biodegradation. Biodegradation itself resulted in an enrichment of acids in the crude oil. As in-situ soap was generated only at higher alkali concentrations (10,000 ppm for K_2CO_3 and at 12,500 ppm for Na_2CO_3) it can be concluded, that the acids generated during biodegradation can be classified as non-soap forming, (stronger than the acids originally presented in the crude oil).

The oil analysis showed that the excess oil phase of the phase experiment hardly displayed any alteration compared to the initial crude oil composition. In contrast, the emulsion phase was significantly altered. The oil which interacted with the alkali lye in the emulsion phase was enriched in polar organic compounds. No enrichment in the aliphatic and aromatic components could be observed in the oil phase leading to the fact that these compounds must be lost into the water phase. Besides, the relative and absolute naphthalene composition indicated a loss of methyl- and dimethyl variety. The shift in the sterane and hopane concentrations showed a loss of these compounds from the hydrocarbons contained in the emulsion phase to the excess water phase. Furthermore, the brownish color of the aqueous phase from the formulations prepared with moderately degraded oil surely points out a loss of additional NSO-compounds.

The performed oil characteristic could be seen as a fast screening method prior to the phase experiments. The crude oil composition has a major influence on the whole in-situ soap generation, whereby higher biodegraded oils represent a higher opportunity to form in-situ soaps. Basically, state-of-the-art oil analysis using GC systems might be an early indicator if A, AP, or ACP/ASP should be considered.

With respect to the tested WORs, the alkali concentrations as well as the used oils, potassium carbonate showed more promising results than sodium carbonate. The formed emulsions seemed to be more stable over time than those formed by Na_2CO_3 (higher emulsion amounts). In most of the samples more promising middle-phase (type III) emulsions were formed over time (diffusion process), whereas some formulations mixed with Na_2CO_3 declined massively and separated into their initial phases (WOR).

Various different co-solvents were screened in order to reduce the high emulsion viscosities and to promote Newtonian fluid behavior (removal of shear thinning behavior). Interestingly, the IFT values were the lowest when the co-solvent 3 was contained into the formulation containing K_2CO_3. A strong increase of the IFT occurred with both alkalis at high alkali concentrations (>15,000 ppm). Normally, ultra-low IFT regimes are preferable for alkali flooding. In this study, no ultra-low IFT regime could be achieved, neither by using dead oil nor by viscosity-matched Bo 112 oil.

Potassium carbonate is more favorable for the application of AP flooding in the Vienna Basin (related to the screened 8.TH and 16.TH) based on the phase experiments. The mixture of K_2CO_3 and Na_2CO_3 seems to be promising and should be further investigated in core flood experiments.

In the reservoir, the alkali slug will also interact with the reservoir rock. Therefore, an in-house static autoclave set-up was developed. The developed test set-up (batch reactors) allows analyzing the interaction of EOR fluids and reservoir rocks before conducting a field trial. All experiments were conducted with reservoir rocks and softened produced water at reservoir temperature. The outcome of this study demonstrated issues that might arise from dissolution and precipitations of minerals by the use of different alkali lyes.

No alterations of the alkalinity or pH changes to the initial values could be observed in any of the trials. Basically, the observed alkali-rock interactions include quartz and clay mineral dissolution as well as precipitations. The main controlling factors for the dissolution are the mineralogical composition and the reservoir temperature.

The use of NaOH will most likely cause formation damage and scaling during alkali flooding within a short period of time. This strong alkali lye showed the most severe alkali-rock interaction of all three examined solutions. Sodium hydroxide should therefore not be used as alkali lye for the planned EOR prospect. The carbonate-based alkalis (Na_2CO_3 and

K_2CO_3) showed minor alterations compared to NaOH and behaved almost similar. Na_2CO_3 showed a possible potential for scaling and formation damage. However, K_2CO_3 showed just minor interactions with the formation and was regarding alkali-rock interaction the best candidate to not cause any severe issues. The potential to generate formation damage can be argued as questionable especially when the exposure to the formation is long enough.

The 8.TH contains a higher amount of clays and is much more reactive than the 16.TH. The water-saturated plugs of the 8.TH exposed to NaOH and Na_2CO_3 were completely disintegrated after the trial. According to the mineralogical composition of the 8.TH, the reservoir is less favorable for any kind of alkali method compared to the 16.TH. Subsequently reservoirs with a similar or comparable composition of the 8.TH are most likely not suitable.

Based on the results K_2CO_3 might be probably the best candidate as alkali lye in the 8.TH. In the 16.TH both carbonate-based alkalis can be used and might cause just a minor severity of formation damage. However, to decide and give a recommendation in favor of one of these two alkalis, it is relevant to consider various other technical and economic studies and criteria.

Carbolite® beads showed just minor alterations by the use of Na_2CO_3 and K_2CO_3. Strong alterations as well as dissolution could be observed with NaOH. Dissolution of the uppermost layers could be observed (generation of hollows). The initial beads did not show a homogenous surface. K_2CO_3 just formed crusts and did not show any dissolution reaction, whereas Na_2CO_3 caused precipitations and dissolution.

Using Swarco® glass beads as gravel pack material may be unfavorable due to really strong alterations with all tested alkali lyes. NaOH caused severe alterations and Na_2CO_3 led to cracking and caused precipitations of calcium-silicates. K_2CO_3 did not create any cracks. Glass beads are a candidate for filter bed materials tested for the treatment of produced fluids. These findings are relevant to consider, when alkali lyes are contained in the produced fluids (pH changes), because it would lead to severe alterations of the glass beads (precipitations). As a consequence, the filter performance is decreased and might even lead to filter blockage.

The test set-up does not enable any fluid flow and the alkali-rock interactions were just evaluated at static conditions. Under reservoir conditions, the fluid flows through the porous rock and precipitations might appear especially by alterations of the temperature, the pressure or the flow regime. As a next step, the test set-up needs to be adapted and further extended in order to test the alkali-rock interaction under dynamic conditions. The plugs should thereby be flooded continuously with fresh alkali lye and the aqueous phase sampled in periodic time intervals. Additionally, the specific surface of the rocks needs to be measured in further studies.

When the fluids are produced from the reservoir rock and brought to the surface, the aqueous phase has to be treated in order to be re-injected into the reservoir. The produced oilfield water is not equal in its composition (e.g. hardness, salinity, and alkalinity) in the whole basin. The water which is transferred to the treatment facilities can change and be different than the defined inlet specifications. Therefore, it is relevant to choose the proper treatment system to handle breakthrough EOR water streams.

Precipitations will occur when alkalis and multivalent hardness ions, which are present in the injection water, interact with each other. In order to prohibit these precipitations at the injectors and in near-wellbore region, the injection water needs to be softened before further usage (prior to the alkali-polymer slicing unit). According to the fact, that high hydrocarbon loads are present in the produced water, the water needs to be de-oiled (chemically, mechanically) prior to the softening unit.

Produced water containing breakthrough polymer is more difficult to treat than conventional produced water. In this pilot study, the HPAM was removed through the chemical treatment step (contained and removed through the flotation sludge).

Especially, when back-produced EOR fluids are contained in the water, the oil-water properties are changed and treatment steps massively influenced. In this study, the results of the mechanical treatment steps (corrugated plate interceptor) showed no adverse effect when HPAM was contained in the inlet water stream. The water quality was strongly influenced by performed changes in the field (e.g. workover programs, pigging…) and lead to fluctuations of the hydrocarbon content.

The chemical treatment step (flotation) and the filtration step were relatively sensitive to polymer concentrations at the inlet stream (smaller than 2 ppm HPAM). The presence of polymer tremendously affected the filterability of the water. The efficiency of the chemical package in the flotation unit was relevant. The breakthrough polymer was removed chemically through the flotation step where HPAM was contained in the flotation sludge. Higher flotation sludge amounts could be realized when polymer was contained in the water stream compared to normal oilfield water handling.

The two tested chemical packages showed a great difference in the sludge composition. As a result, it is important to adjust the skimmer regarding the sludge properties in the pilot plant. Otherwise no proper sludge removal is possible, which results in a spill of the flotation cell. Further investigations about the sludge treatment are relevant and should be conducted.

At the end of the field study, one of tested chemical sets was found to have an efficiency of around 99% in presence of 30 ppm HPAM inlet concentration. Good removal efficiency and no plugging of the nutshell filter was observed. The currently used set in the water treatment plant Schoenkirchen led to plugging of the filtration system at relative low polymer concentrations and the removal efficiency of hydrocarbons as well as of the polymer was poor. Based on these results, it can be assumed that the evaluated treatment steps are not negatively affected in presence of up to 30 ppm HPAM load at the inlet water stream.

All conducted studies allowed the compilation of a possible workflow of studies which are relevant to ensure a successful cEOR field implementation (**Figure 8-1**).Thereby, necessary technical investigations in the laboratory and economic analysis are combined. This workflow can be further used as a guidline for further EOR projects.

The presented workflow is optimized and related to the developed R&D maturation funnel. The required tollgates are indicated in the scheme. The workflow starts with a portfolio screening and continues with the evaluation of suitable EOR options. If cEOR is chosen, further screening in the laboratory should include oil characterization, water characterization, tests if the back-produced water can be treated, phase experiments, (characterization of the formed in-situ soap with IFT and rheology measurements), alkali-rock interaction, micromodels as well as core flood experiments. In addition, a water treatment test in the field should be conducted. Thereby, possible uncertainties can be massively reduced. All data can be further used for reservoir simulation, economic and environment evaluation (LCA) as well as for the final pilot design. Also stakeholder management should be considered in the project evaluation as it can have an influence. After TG 2, the pilot is installed and operated. A lesson learned workshop closes this project phase and decides if the technology should be implemented into the field (either as full field or as sector roll out).

As an outcome of the economic study, the implementation of cEOR in the 16.TH West (Sector 1) seems to be promising and more attractive than continuing water flooding or the implementation of polymer flooding alone. The best economic results could be achieved by K_2CO_3 with an EMV of 30.74 MM EUR, whereas Na_2CO_3 showed an EMV of 24.8 MM EUR. The implementation of ACP is from an economic point of view the least suitable option with 22.6 MM EUR.

According to the developed R&D project maturation funnel, it is recommended to upscale the laboratory results into a pilot as a next step. However, the final pilot design decision also has to include strategic and other management considerations and will be made by OMV throughout the upcoming tollgates.

In summary, chemical flooding requires extremely high amounts of expensive chemicals. Especially, regeneration chemicals can have an adverse effect on the environment when the back-produced fluids cannot be handled properly in the surface facilities. Adversely, chemicals can be lost when well failures occur or through inappropriate injection profiles. The case study showed that extremely high up-front investments arise. The largest environmental influence is generated by the micro-bubble flotation through the chemical load and the fuel gas for the bubble generation but also through the softening unit.

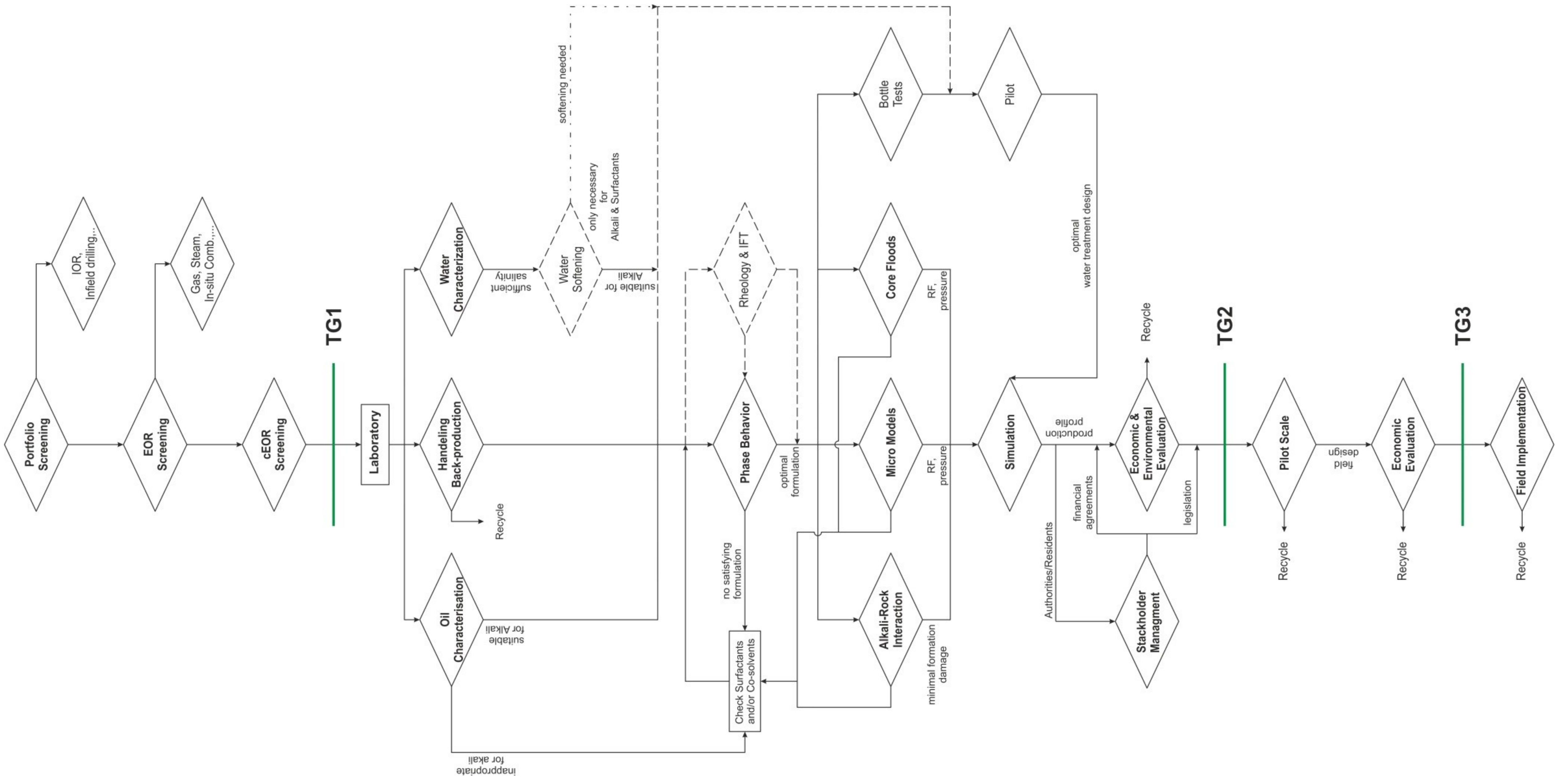


Figure 8-1: Overview of necessary and relevant investigations to perform cEOR flooding.

The following recommendations for future screenings and designs may be worth to consider:

- The use of real reservoir rocks, real water and technically graded alkalis in screening should be promoted to test closest to real field conditions. Within the present study it could be demonstrated that different results are achieved depending on the type of used rock, water and alkalis.
- Also the screening should include surfactants and co-solvents. They have shown their potential in increasing the performance of cEOR applications.
- Performing an oil characteristic at the start of a project gives valuable information about the applicability of alkali flooding
- As no ultra-low IFT environment had been encountered in any of the formulations probably no micro emulsion did form. This may be supported by the fact that no stable emulsions were formed.
- Although, the oil produced from the 8.TH showed very promising results (large volumes of formed emulsion). Still, the applicability of alkali flooding is limited due to the high reactivity of the reservoir formation.
- From an economic and technical point of view performed K_2CO_3 more promising than Na_2CO_3. The higher costs from the K_2CO_3 were recovered by the higher incremental production.
- A mix of both alkalis showed promising results, especially when one alkali was in the surplus. The cost-effect from Na_2CO_3 could be combined with the recovery effect from K_2CO_3 and provide an optimized stability of the formulation.
- As a next step, full-life cycle assessment (including the production of the alkali, polymer and the treatment of the sludge) should be conducted and the LCA KPIs monetarized.
- The large impact on Greenhouse Gas emissions and Black Carbon can be significantly reduced if nitrogen would be used as process gas in the MBF as well as through the delivery of goods by train.

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Appendices

Appendix A1 (Screening Study)

16.TH: Formulation 1a: Synthetic Make-up Water with Na_2CO_3 + Dead Bo 112 Oil @ 60°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
1	1:9	Dead	Na_2CO_3	2,500	0	9	0	1			
1	1:9	Dead	Na_2CO_3	2,500	3	8.9	0.3	0.8	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	6	8.9	0.15	0.95	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	9	8.9	0.15	0.95	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	13	8.95	0.05	1	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	16	8.95	0.05	1	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	20	8.95	0.05	1	clear	III	yes
1	1:9	Dead	Na_2CO_3	2,500	40	9	0	1	clear	x	x
1	1:9	Dead	Na_2CO_3	2,500	60	9	0	1	clear	x	x
1	1:9	Dead	Na_2CO_3	2,500	80	9	0	1	clear	x	x
1	1:9	Dead	Na_2CO_3	2,500	100	9	0	1	clear	x	x
2	1:9	Dead	Na_2CO_3	5,000	0	9	0	1			
2	1:9	Dead	Na_2CO_3	5,000	3	8.6	1.25	0.15	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	6	8.5	1.1	0.4	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	9	8.6	0.9	0.5	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	13	8.7	0.8	0.5	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	16	8.7	0.7	0.6	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	20	8.7	0.7	0.6	clear	III	no
2	1:9	Dead	Na_2CO_3	5,000	40	8.7	0.35	0.95	clear	III	yes
2	1:9	Dead	Na_2CO_3	5,000	60	8.9	0.1	1	clear	III	yes
2	1:9	Dead	Na_2CO_3	5,000	80	8.9	0.1	1	clear	III	yes
2	1:9	Dead	Na_2CO_3	5,000	100	8.9	0.1	1	clear	III	yes
3	1:9	Dead	Na_2CO_3	7,500	0	9	0	1			
3	1:9	Dead	Na_2CO_3	7,500	3	8.9	0.8	0.3	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	6	8.9	0.8	0.3	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	9	8.9	0.8	0.3	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	13	8.9	0.5	0.6	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	16	8.9	0.5	0.6	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	20	8.9	0.5	0.6	yellow, clear	III	no
3	1:9	Dead	Na_2CO_3	7,500	40	8.9	0.3	0.8	yellow, clear	III	yes
3	1:9	Dead	Na_2CO_3	7,500	60	8.9	0.3	0.8	yellow, clear	III	yes
3	1:9	Dead	Na_2CO_3	7,500	80	8.9	0.3	0.8	yellow, clear	III	yes
3	1:9	Dead	Na_2CO_3	7,500	100	8.9	0.3	0.8	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	0	9	0	1			
4	1:9	Dead	Na_2CO_3	10,000	3	8.15	0.85	1	yellow, clear	III	no
4	1:9	Dead	Na_2CO_3	10,000	6	8.5	0.55	0.95	yellow, clear	III	no
4	1:9	Dead	Na_2CO_3	10,000	9	8.65	0.35	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	13	8.65	0.35	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	16	8.7	0.3	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	20	8.7	0.3	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	40	8.8	0.2	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	60	8.95	0.05	1	yellow, clear	III	yes
4	1:9	Dead	Na_2CO_3	10,000	80	8.95	0.05	1	yellow, clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
4	1:9	Dead	Na_2CO_3	10,000	100	8.95	0.05	1	yellow, clear	III	yes
5	1:9	Dead	Na_2CO_3	12,500	0	9	0	1			
5	1:9	Dead	Na_2CO_3	12,500	3	7.45	2.5	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	6	8.5	1.45	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	9	8.6	1.35	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	13	8.45	1.5	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	16	8.5	1.45	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	20	8.5	1.45	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	40	8.5	1.45	0.05	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	60	8.6	0.8	0.6	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	80	8.6	0.6	0.8	clear	III	no
5	1:9	Dead	Na_2CO_3	12,500	100	8.6	0.6	0.8	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	0	9	0	1			
6	1:9	Dead	Na_2CO_3	15,000	3	7	2.9	0.1	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	6	8.6	1.3	0.1	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	9	8.5	1.45	0.05	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	13	8.6	1.35	0.05	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	16	8.5	1.45	0.05	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	20	8.6	1.35	0.05	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	40	8.5	1.45	0.05	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	60	8.7	0.7	0.6	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	80	8.7	0.7	0.6	clear	III	no
6	1:9	Dead	Na_2CO_3	15,000	100	8.7	0.7	0.6	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	0	9	0	1			
7	1:9	Dead	Na_2CO_3	17,500	3	7	2.9	0.1	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	6	8.7	1.25	0.05	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	9	8.7	1.25	0.05	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	13	8.6	1.35	0.05	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	16	8.6	1.35	0.05	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	20	8.6	1.35	0.05	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	40	8.5	1.3	0.2	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	60	8.8	0.5	0.7	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	80	8.8	0.5	0.7	clear	III	no
7	1:9	Dead	Na_2CO_3	17,500	100	8.8	0.5	0.7	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	0	9	0	1			
8	1:9	Dead	Na_2CO_3	20,000	3	7.5	2.4	0.1	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	6	8.5	1.45	0.05	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	9	8.7	0.9	0.4	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	13	8.6	0.95	0.45	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	16	8.6	0.85	0.55	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	20	8.6	0.85	0.55	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	40	8.6	0.85	0.55	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	60	8.6	0.8	0.6	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	80	8.6	0.8	0.6	clear	III	no
8	1:9	Dead	Na_2CO_3	20,000	100	8.6	0.8	0.6	clear	III	no
9	3:7	Dead	Na_2CO_3	2,500	0	7	0	3	precipitation		
9	3:7	Dead	Na_2CO_3	2,500	3	5.5	4.35	0.15	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	6	5.6	4.15	0.25	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	9	5.9	3.6	0.5	precipitation	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
9	3:7	Dead	Na_2CO_3	2,500	13	5.9	3.7	0.4	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	16	6	3.5	0.5	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	20	6.1	3.4	0.5	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	40	6.2	3.2	0.6	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	60	6.7	0.5	2.8	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	80	6.7	0.5	2.8	precipitation	III	no
9	3:7	Dead	Na_2CO_3	2,500	100	6.7	0.5	2.8	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	0	7	0	3			
10	3:7	Dead	Na_2CO_3	5,000	3	4.9	5.1	0	precipitation	II (-)	no
10	3:7	Dead	Na_2CO_3	5,000	6	5.25	4.75	0	precipitation	II (-)	no
10	3:7	Dead	Na_2CO_3	5,000	9	4.5	4.4	1.1	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	13	5.7	4.1	0.2	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	16	5.5	4.1	0.4	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	20	5.5	4.1	0.4	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	40	5.7	3.9	0.4	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	60	6.2	3.3	0.5	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	80	6.2	3.3	0.5	precipitation	III	no
10	3:7	Dead	Na_2CO_3	5,000	100	6.2	3.3	0.5	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	0	7	0	3			
11	3:7	Dead	Na_2CO_3	7,500	3	5.5	4.4	0.1	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	6	5.5	4.4	0.1	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	9	5.4	4.4	0.2	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	13	5.8	3.95	0.25	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	16	5.7	3.8	0.5	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	20	5.7	3.8	0.5	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	40	5.8	1.5	2.7	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	60	6.8	1.5	1.7	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	80	6.8	1.5	1.7	precipitation	III	no
11	3:7	Dead	Na_2CO_3	7,500	100	6.8	1.5	1.7	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	0	7	0	3			
12	3:7	Dead	Na_2CO_3	10,000	3	6.15	3.85	0	precipitation	II (-)	no
12	3:7	Dead	Na_2CO_3	10,000	6	6.3	3.7	0	precipitation	II (-)	no
12	3:7	Dead	Na_2CO_3	10,000	9	6	3.6	0.4	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	13	6.6	2.9	0.5	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	16	5.8	3.5	0.7	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	20	5.8	3.5	0.7	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	40	5.5	3.7	0.8	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	60	6.3	2.5	1.2	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	80	6.3	2.3	1.4	precipitation	III	no
12	3:7	Dead	Na_2CO_3	10,000	100	6.3	2.3	1.4	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	0	7	0	3			
13	3:7	Dead	Na_2CO_3	12,500	3	6.4	3.6	0	precipitation	II (-)	no
13	3:7	Dead	Na_2CO_3	12,500	6	6.6	3.4	0	precipitation	II (-)	no
13	3:7	Dead	Na_2CO_3	12,500	9	5.8	2.65	1.55	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	13	6.5	1.25	2.25	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	16	6.5	1.2	2.3	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	20	6.5	1.1	2.4	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	40	6.6	0.9	2.5	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	60	6.7	0.7	2.6	precipitation	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
13	3:7	Dead	Na_2CO_3	12,500	80	6.7	0.7	2.6	precipitation	III	no
13	3:7	Dead	Na_2CO_3	12,500	100	6.7	0.7	2.6	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	0	7	0	3			
14	3:7	Dead	Na_2CO_3	15,000	3	6.4	3.6	0	precipitation	II (-)	no
14	3:7	Dead	Na_2CO_3	15,000	6	6.5	3.5	0	precipitation	II (-)	no
14	3:7	Dead	Na_2CO_3	15,000	9	5.5	2.7	1.8	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	13	6.2	1.65	2.15	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	16	6	1.7	2.3	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	20	6.2	1.5	2.3	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	40	6.4	1.2	2.4	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	60	6.6	0.9	2.5	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	80	6.6	0.9	2.5	precipitation	III	no
14	3:7	Dead	Na_2CO_3	15,000	100	6.6	0.9	2.5	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	0	7	0	3			
15	3:7	Dead	Na_2CO_3	17,500	3	6.6	3.4	0	precipitation	II (-)	no
15	3:7	Dead	Na_2CO_3	17,500	6	6.8	3.2	0	precipitation	II (-)	no
15	3:7	Dead	Na_2CO_3	17,500	9	5.6	2.8	1.6	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	13	5.8	2.5	1.7	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	16	5.8	2.4	1.8	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	20	5.8	2.3	1.9	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	40	5.9	2	2.1	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	60	6.4	1.1	2.5	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	80	6.4	1.1	2.5	precipitation	III	no
15	3:7	Dead	Na_2CO_3	17,500	100	6.4	1.1	2.5	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	0	7	0	3			
16	3:7	Dead	Na_2CO_3	20,000	3	5.6	4.4	0	precipitation	II (-)	no
16	3:7	Dead	Na_2CO_3	20,000	6	5.5	3.7	0.8	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	9	6.2	1.98	1.82	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	13	6.5	1.5	2	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	16	6	1.8	2.2	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	20	6	1.7	2.3	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	40	6.2	1.3	2.5	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	60	6.5	0.8	2.7	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	80	6.5	0.8	2.7	precipitation	III	no
16	3:7	Dead	Na_2CO_3	20,000	100	6.6	0.8	2.6	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	0	5	0	5			
17	5:5	Dead	Na_2CO_3	2,500	3	0.1	9	0.9	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	6	1.5	8.15	0.35	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	9	2.4	7	0.6	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	13	2.9	6.7	0.4	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	16	3	6.5	0.5	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	20	3.1	6.4	0.5	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	40	3.3	6.1	0.6	precipitation	III	no
17	5:5	Dead	Na_2CO_3	2,500	60	5	0.1	4.9	precipitation	III	yes
17	5:5	Dead	Na_2CO_3	2,500	80	5	0.1	4.9	precipitation	III	yes
17	5:5	Dead	Na_2CO_3	2,500	100	5	0.1	4.9	precipitation	III	yes
18	5:5	Dead	Na_2CO_3	5,000	0	5	0	5			
18	5:5	Dead	Na_2CO_3	5,000	3	0.45	9.4	0.15	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	6	0.45	9.4	0.15	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
18	5:5	Dead	Na_2CO_3	5,000	9	1.1	8.6	0.3	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	13	1.65	7.7	0.65	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	16	2	7.15	0.85	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	20	2	7	1	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	40	2.4	6.2	1.4	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	60	3.3	5.9	0.8	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	80	3.3	5	1.7	clear	III	no
18	5:5	Dead	Na_2CO_3	5,000	100	2.9	5	2.1	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	0	5	0	5			
19	5:5	Dead	Na_2CO_3	7,500	3	0.4	9.5	0.1	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	6	2.5	7.35	0.15	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	9	3.05	6.65	0.3	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	13	3.5	6.35	0.15	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	16	3.6	6.2	0.2	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	20	3.6	6.2	0.2	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	40	3.9	5.9	0.2	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	60	4.5	4.6	0.9	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	80	4.5	4	1.5	clear	III	no
19	5:5	Dead	Na_2CO_3	7,500	100	4.5	4	1.5	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	0	5	0	5			
20	5:5	Dead	Na_2CO_3	10,000	3	0	8.7	1.3	clear	II (+)	no
20	5:5	Dead	Na_2CO_3	10,000	6	0	8.6	1.4	clear	II (+)	no
20	5:5	Dead	Na_2CO_3	10,000	9	1.2	7.3	1.5	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	13	1.9	6.3	1.8	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	16	2.1	5.9	2	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	20	2.3	5.6	2.1	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	40	2.8	4.4	2.8	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	60	4.4	1.5	4.1	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	80	4.4	1.5	4.1	clear	III	no
20	5:5	Dead	Na_2CO_3	10,000	100	4.4	1.5	4.1	clear	III	no
21	5:5	Dead	Na_2CO_3	12,500	0	5	0	5			
21	5:5	Dead	Na_2CO_3	12,500	3	0	9.1	0.9	precipitation	II (+)	no
21	5:5	Dead	Na_2CO_3	12,500	6	0	9	1	precipitation	II (+)	no
21	5:5	Dead	Na_2CO_3	12,500	9	1.4	7.5	1.1	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	13	2.1	6.45	1.45	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	16	2	6.4	1.6	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	20	2.3	6	1.7	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	40	2.5	5.7	1.8	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	60	4.5	1.5	4	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	80	4.5	1.5	4	precipitation	III	no
21	5:5	Dead	Na_2CO_3	12,500	100	4.5	1.5	4	precipitation	III	no
22	5:5	Dead	Na_2CO_3	15,000	0	5	0	5			
22	5:5	Dead	Na_2CO_3	15,000	3	0	9.2	0.8	clear	II (+)	no
22	5:5	Dead	Na_2CO_3	15,000	6	0	9.1	0.9	clear	II (+)	no
22	5:5	Dead	Na_2CO_3	15,000	9	0.6	8.4	1	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	13	1.4	7.25	1.35	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	16	1.6	6.8	1.6	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	20	1.8	6.5	1.7	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	40	2.1	6	1.9	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
22	5:5	Dead	Na_2CO_3	15,000	60	4	2.6	3.4	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	80	4	2.6	3.4	clear	III	no
22	5:5	Dead	Na_2CO_3	15,000	100	4	2.6	3.4	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	0	5	0	5			
23	5:5	Dead	Na_2CO_3	17,500	3	0	8.6	1.4	clear	II (+)	no
23	5:5	Dead	Na_2CO_3	17,500	6	0	8.45	1.55	clear	II (+)	no
23	5:5	Dead	Na_2CO_3	17,500	9	0.55	7.6	1.85	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	13	1.85	6	2.15	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	16	2	5.8	2.2	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	20	1.8	5.8	2.4	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	40	2.2	5.3	2.5	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	60	3.7	3	3.3	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	80	3.7	2.9	3.4	clear	III	no
23	5:5	Dead	Na_2CO_3	17,500	100	3.7	2.9	3.4	clear	III	no
24	5:5	Dead	Na_2CO_3	20,000	0	5	0	5			
24	5:5	Dead	Na_2CO_3	20,000	3	0	7.9	2.1	precipitation	II (+)	no
24	5:5	Dead	Na_2CO_3	20,000	6	0	7.65	2.35	precipitation	II (+)	no
24	5:5	Dead	Na_2CO_3	20,000	9	0.6	6.75	2.65	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	13	1.4	5.7	2.9	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	16	2.4	4.6	3	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	20	2.4	4.6	3	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	40	3	3.8	3.2	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	60	4.1	1.9	4	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	80	4.1	1.9	4	precipitation	III	no
24	5:5	Dead	Na_2CO_3	20,000	100	4.1	1.9	4	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	0	3	0	7			
25	7:3	Dead	Na_2CO_3	2,500	3	0.3	9.1	0.6	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	6	0.7	8.35	0.95	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	9	0.8	8.1	1.1	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	13	1.15	7	1.85	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	16	1.3	6.6	2.1	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	20	1.4	6	2.6	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	40	1.7	4.1	4.2	precipitation	III	no
25	7:3	Dead	Na_2CO_3	2,500	60	2.9	0.2	6.9	precipitation	III	yes
25	7:3	Dead	Na_2CO_3	2,500	80	2.9	0.2	6.9	precipitation	III	yes
25	7:3	Dead	Na_2CO_3	2,500	100	2.9	0.2	6.9	precipitation	III	yes
26	7:3	Dead	Na_2CO_3	5,000	0	3	0	7			
26	7:3	Dead	Na_2CO_3	5,000	3	0.3	8.2	1.5	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	6	1.6	6.2	2.2	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	9	1.6	6.3	2.1	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	13	1.6	2.45	5.95	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	16	2.5	0.95	6.55	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	20	2.6	0.6	6.8	precipitation	III	no
26	7:3	Dead	Na_2CO_3	5,000	40	2.85	0.15	7	precipitation	III	yes
26	7:3	Dead	Na_2CO_3	5,000	60	3	0.1	6.9	precipitation	III	yes
26	7:3	Dead	Na_2CO_3	5,000	80	3	0.1	6.9	precipitation	III	yes
26	7:3	Dead	Na_2CO_3	5,000	100	3	0.1	6.9	precipitation	III	yes
27	7:3	Dead	Na_2CO_3	7,500	0	3	0	7			
27	7:3	Dead	Na_2CO_3	7,500	3	0.6	8.9	0.5	precipitation	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
27	7:3	Dead	Na_2CO_3	7,500	6	0.6	8.9	0.5	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	9	0.6	8.9	0.5	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	13	1.43	8.27	0.3	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	16	1	8.5	0.5	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	20	1.2	8.2	0.6	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	40	1.3	7.7	1	precipitation	III	no
27	7:3	Dead	Na_2CO_3	7,500	60	3	0	7	precipitation	x	x
27	7:3	Dead	Na_2CO_3	7,500	80	3	0	7	precipitation	x	x
27	7:3	Dead	Na_2CO_3	7,500	100	3	0	7	precipitation	x	x
28	7:3	Dead	Na_2CO_3	10,000	0	3	0	7			
28	7:3	Dead	Na_2CO_3	10,000	3	0.2	8.2	1.6	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	6	0.2	8.2	1.6	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	9	0.2	7.6	2.2	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	13	0.8	4.4	4.8	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	16	1.5	4	4.5	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	20	2	3.1	4.9	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	40	2.3	2	5.7	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	60	2.9	3.3	3.8	clear	III	no
28	7:3	Dead	Na_2CO_3	10,000	80	3	0.4	6.6	clear	III	yes
28	7:3	Dead	Na_2CO_3	10,000	100	3.65	0.4	5.95	clear	III	yes
29	7:3	Dead	Na_2CO_3	12,500	0	3	0	7			
29	7:3	Dead	Na_2CO_3	12,500	3	0.1	9.45	0.45	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	6	0.1	9.45	0.45	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	9	0.2	8.9	0.9	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	13	0.5	7.4	2.1	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	16	0.6	7.2	2.2	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	20	0.6	6.9	2.5	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	40	0.8	6.2	3	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	60	2.8	0.5	6.7	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	80	3	0.5	6.5	clear	III	no
29	7:3	Dead	Na_2CO_3	12,500	100	3.05	0.5	6.45	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	0	3	0	7			
30	7:3	Dead	Na_2CO_3	15,000	3	0.1	9.2	0.7	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	6	0.3	9.2	0.5	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	9	0.3	8.7	1	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	13	0.6	6.85	2.55	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	16	0.6	6.4	3	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	20	0.6	5.9	3.5	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	40	1.2	4.4	4.4	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	60	2.8	0.5	6.7	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	80	2.85	0.5	6.65	clear	III	no
30	7:3	Dead	Na_2CO_3	15,000	100	2.85	0.5	6.65	clear	III	no
31	7:3	Dead	Na_2CO_3	17,500	0	broken				x	
32	7:3	Dead	Na_2CO_3	20,000	0	3	0	7			
32	7:3	Dead	Na_2CO_3	20,000	3	0.15	8.85	1	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	6	0.15	8.85	1	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	9	0.2	8.6	1.2	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	13	0.35	8.2	1.45	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	16	0.4	8	1.6	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
32	7:3	Dead	Na_2CO_3	20,000	20	0.4	8	1.6	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	40	0.45	7.6	1.95	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	60	2.8	0.5	6.7	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	80	2.8	0.5	6.7	clear	III	no
32	7:3	Dead	Na_2CO_3	20,000	100	2.85	0.5	6.65	clear	III	no
33	9:1	Dead	Na_2CO_3	2,500	0	1	0	9			
33	9:1	Dead	Na_2CO_3	2,500	3	0.2	2.7	7.1	precipitation	III	no
33	9:1	Dead	Na_2CO_3	2,500	6	0.4	2.7	6.9	precipitation	III	no
33	9:1	Dead	Na_2CO_3	2,500	9	0.38	1.82	7.8	precipitation	III	no
33	9:1	Dead	Na_2CO_3	2,500	13	0.6	0.8	8.6	precipitation	III	no
33	9:1	Dead	Na_2CO_3	2,500	16	0.8	0.4	8.8	precipitation	III	yes
33	9:1	Dead	Na_2CO_3	2,500	20	0.8	0.4	8.8	precipitation	III	yes
33	9:1	Dead	Na_2CO_3	2,500	40	0.8	0.3	8.9	precipitation	III	yes
33	9:1	Dead	Na_2CO_3	2,500	60	1	0.1	8.9	precipitation	III	yes
33	9:1	Dead	Na_2CO_3	2,500	80	1	0.1	8.9	precipitation	III	yes
33	9:1	Dead	Na_2CO_3	2,500	100	1	0.1	8.9	precipitation	III	yes
34	9:1	Dead	Na_2CO_3	5,000	0	1	0	9			
34	9:1	Dead	Na_2CO_3	5,000	3	0.4	1.85	7.75	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	6	0.6	1.85	7.55	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	9	0.7	1.3	8	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	13	0.9	0.9	8.2	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	16	0.3	1.15	8.55	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	20	0.4	0.8	8.8	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	40	0.4	0.8	8.8	precipitation	III	no
34	9:1	Dead	Na_2CO_3	5,000	60	1.05	0.2	8.75	precipitation	III	yes
34	9:1	Dead	Na_2CO_3	5,000	80	1	0.1	8.9	precipitation	III	yes
34	9:1	Dead	Na_2CO_3	5,000	100	1	0.1	8.9	precipitation	III	yes
35	9:1	Dead	Na_2CO_3	7,500	0	1	0	9			
35	9:1	Dead	Na_2CO_3	7,500	3	1	0	9	precipitation	x	x
35	9:1	Dead	Na_2CO_3	7,500	6	1	0	9	precipitation	x	x
35	9:1	Dead	Na_2CO_3	7,500	9	1	0	9	precipitation	x	x
35	9:1	Dead	Na_2CO_3	7,500	13	1	0	9	precipitation	x	x
35	9:1	Dead	Na_2CO_3	7,500	16	1	0	9	precipitation	x	x
35	9:1	Dead	Na_2CO_3	7,500	20	1	0.4	8.6	precipitation	III	yes
35	9:1	Dead	Na_2CO_3	7,500	40	1	0.4	8.6	precipitation	III	yes
35	9:1	Dead	Na_2CO_3	7,500	60	1	0.4	8.6	precipitation	III	yes
35	9:1	Dead	Na_2CO_3	7,500	80	1	0.4	8.6	precipitation	III	yes
35	9:1	Dead	Na_2CO_3	7,500	100	1	0.4	8.6	precipitation	III	yes
36	9:1	Dead	Na_2CO_3	10,000	0	1	0	9			
36	9:1	Dead	Na_2CO_3	10,000	3	0.35	1.75	7.9	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	6	0.6	1.75	7.65	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	9	0.6	1.6	7.8	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	13	0.75	1	8.25	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	16	0.9	0.8	8.3	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	20	0.9	0.6	8.5	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	40	0.9	0.6	8.5	precipitation	III	no
36	9:1	Dead	Na_2CO_3	10,000	60	0.95	0.1	8.95	precipitation	III	yes
36	9:1	Dead	Na_2CO_3	10,000	80	0.95	0.1	8.95	precipitation	III	yes
36	9:1	Dead	Na_2CO_3	10,000	100	1	0.1	8.9	precipitation	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
37	9:1	Dead	Na_2CO_3	12,500	0	1	0	9			
37	9:1	Dead	Na_2CO_3	12,500	3	1	0.95	8.05	precipitation	III	no
37	9:1	Dead	Na_2CO_3	12,500	6	1	0.95	8.05	precipitation	III	no
37	9:1	Dead	Na_2CO_3	12,500	9	1	0.5	8.5	precipitation	III	no
37	9:1	Dead	Na_2CO_3	12,500	13	1	0.5	8.5	precipitation	III	no
37	9:1	Dead	Na_2CO_3	12,500	16	1	0.4	8.6	precipitation	III	yes
37	9:1	Dead	Na_2CO_3	12,500	20	1	0.4	8.6	precipitation	III	yes
37	9:1	Dead	Na_2CO_3	12,500	40	1	0.3	8.7	precipitation	III	yes
37	9:1	Dead	Na_2CO_3	12,500	60	1	0.2	8.8	precipitation	III	yes
37	9:1	Dead	Na_2CO_3	12,500	80	1	0.2	8.8	precipitation	III	yes
37	9:1	Dead	Na_2CO_3	12,500	100	1	0.2	8.8	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	0	1	0	9			
38	9:1	Dead	Na_2CO_3	15,000	3	0.9	0.05	9.05	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	6	0.9	0.05	9.05	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	9	0.9	0.2	8.9	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	13	0.95	0.2	8.85	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	16	0.95	0.2	8.85	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	20	0.95	0.2	8.85	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	40	0.95	0.2	8.85	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	60	0.9	0.2	8.9	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	80	0.9	0.2	8.9	precipitation	III	yes
38	9:1	Dead	Na_2CO_3	15,000	100	0.9	0.2	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	0	1	0	9			
39	9:1	Dead	Na_2CO_3	17,500	3	1	0.15	8.85	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	6	1	0.15	8.85	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	9	1	0.15	8.85	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	13	1	0.15	8.85	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	16	1	0.1	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	20	1	0.1	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	40	1	0.1	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	60	1	0.1	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	80	1	0.1	8.9	precipitation	III	yes
39	9:1	Dead	Na_2CO_3	17,500	100	1	0.1	8.9	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	0	1	0	9			
40	9:1	Dead	Na_2CO_3	20,000	3	1	0	9	precipitation	x	x
40	9:1	Dead	Na_2CO_3	20,000	6	1	0	9	precipitation	x	x
40	9:1	Dead	Na_2CO_3	20,000	9	1	0	9	precipitation	x	x
40	9:1	Dead	Na_2CO_3	20,000	13	1	0.3	8.7	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	16	1	0.3	8.7	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	20	1	0.3	8.7	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	40	1	0.2	8.8	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	60	1	0.2	8.8	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	80	1	0.2	8.8	precipitation	III	yes
40	9:1	Dead	Na_2CO_3	20,000	100	1	0.2	8.8	precipitation	III	yes

16.TH: Formulation 1a: Synthetic Make-up Water with K_2CO_3 + Dead Bo 112 Oil @ 60°C (Alkali Slug)

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
41	1:9	Dead	K_2CO_3	2,500	0	9	0	1			
41	1:9	Dead	K_2CO_3	2,500	3	8.9	0.1	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	6	8.9	0.1	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	9	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	13	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	16	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	20	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	40	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	60	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	80	8.95	0.05	1	yellow, clear	III	yes
41	1:9	Dead	K_2CO_3	2,500	100	8.95	0.05	1	yellow, clear	III	yes
42	1:9	Dead	K_2CO_3	5,000	0	9	0	1			
42	1:9	Dead	K_2CO_3	5,000	3	8.6	1.4	0	yellow, clear	II (+)	no
42	1:9	Dead	K_2CO_3	5,000	6	8.5	1.4	0.1	yellow, clear	III	no
42	1:9	Dead	K_2CO_3	5,000	9	8.5	1.25	0.25	yellow, clear	III	no
42	1:9	Dead	K_2CO_3	5,000	13	8.6	0.9	0.5	yellow, clear	III	no
42	1:9	Dead	K_2CO_3	5,000	16	8.65	0.8	0.55	yellow, clear	III	no
42	1:9	Dead	K_2CO_3	5,000	20	8.7	0.7	0.6	yellow, clear	III	no
42	1:9	Dead	K_2CO_3	5,000	40	8.7	0.4	0.9	yellow, clear	III	yes
42	1:9	Dead	K_2CO_3	5,000	60	8.8	0.2	1	yellow, clear	III	yes
42	1:9	Dead	K_2CO_3	5,000	80	8.8	0.2	1	yellow, clear	III	yes
42	1:9	Dead	K_2CO_3	5,000	100	8.8	0.2	1	yellow, clear	III	yes
43	1:9	Dead	K_2CO_3	7,500	0	9	0	1			
43	1:9	Dead	K_2CO_3	7,500	3	8.4	1.55	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	6	8.4	1.55	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	9	8.4	1.55	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	13	8.5	1.45	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	16	8.5	1.45	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	20	8.5	1.45	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	40	8.6	1.35	0.05	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	60	8.8	0.5	0.7	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	80	8.8	0.5	0.7	yellow, clear	III	no
43	1:9	Dead	K_2CO_3	7,500	100	8.8	0.5	0.7	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	0	9	0	1			
44	1:9	Dead	K_2CO_3	10,000	3	8.4	1.55	0.05	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	6	8.4	1.55	0.05	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	9	8.4	1.55	0.05	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	13	8.5	1.45	0.05	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	16	8.5	1.45	0.05	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	20	8.5	1.3	0.2	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	40	8.5	1.3	0.2	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	60	8.5	0.9	0.6	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	80	8.5	0.9	0.6	yellow, clear	III	no
44	1:9	Dead	K_2CO_3	10,000	100	8.5	0.9	0.6	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	0	9	0	1			
45	1:9	Dead	K_2CO_3	12,500	3	8.1	1.9	0	yellow, clear	II (+)	no
45	1:9	Dead	K_2CO_3	12,500	6	8.1	1.9	0	yellow, clear	II (+)	no
45	1:9	Dead	K_2CO_3	12,500	9	8.1	1.9	0	yellow, clear	II (+)	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
45	1:9	Dead	K_2CO_3	12,500	13	8.1	1.9	0	yellow, clear	II (+)	no
45	1:9	Dead	K_2CO_3	12,500	16	8.2	1.6	0.2	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	20	8.4	1.4	0.2	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	40	8.4	0.9	0.7	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	60	8.55	0.9	0.55	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	80	8.55	0.9	0.55	yellow, clear	III	no
45	1:9	Dead	K_2CO_3	12,500	100	8.55	0.9	0.55	yellow, clear	III	no
46	1:9	Dead	K_2CO_3	15,000	0	9	0	1			
46	1:9	Dead	K_2CO_3	15,000	3	8	2	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	6	8	2	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	9	8	2	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	13	8.4	1.6	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	16	8.4	1.6	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	20	8.5	1.5	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	40	8.5	1.5	0	yellow, clear	II (+)	no
46	1:9	Dead	K_2CO_3	15,000	60	8.6	0.8	0.6	yellow, clear	III	no
46	1:9	Dead	K_2CO_3	15,000	80	8.7	0.8	0.5	yellow, clear	III	no
46	1:9	Dead	K_2CO_3	15,000	100	8.7	0.8	0.5	yellow, clear	III	no
47	1:9	Dead	K_2CO_3	17,500	0	9	0	1			
47	1:9	Dead	K_2CO_3	17,500	3	7.85	2.15	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	6	7.7	2.3	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	9	8	2	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	13	8.2	1.8	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	16	8.4	1.6	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	20	8.4	1.6	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	40	8.4	1.6	0	yellow, clear	II (+)	no
47	1:9	Dead	K_2CO_3	17,500	60	8.5	0.9	0.6	yellow, clear	III	no
47	1:9	Dead	K_2CO_3	17,500	80	8.5	0.9	0.6	yellow, clear	III	no
47	1:9	Dead	K_2CO_3	17,500	100	8.5	0.9	0.6	yellow, clear	III	no
48	1:9	Dead	K_2CO_3	20,000	0	9	0	1			
48	1:9	Dead	K_2CO_3	20,000	3	7.5	2.5	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	6	7.65	2.35	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	9	8	2	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	13	8.4	1.6	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	16	8.3	1.7	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	20	8.4	1.6	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	40	8.4	1.6	0	yellow, clear	II (+)	no
48	1:9	Dead	K_2CO_3	20,000	60	8.7	1.2	0.1	yellow, clear	III	no
48	1:9	Dead	K_2CO_3	20,000	80	8.8	0.8	0.4	yellow, clear	III	no
48	1:9	Dead	K_2CO_3	20,000	100	8.8	0.8	0.4	yellow, clear	III	no
49	3:7	Dead	K_2CO_3	2,500	0	7	0	3			
49	3:7	Dead	K_2CO_3	2,500	3	0.4	9.2	0.3	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	6	4.5	5.2	0.3	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	9	5.1	4.5	0.4	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	13	5.3	3.9	0.8	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	16	5.5	3.6	0.9	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	20	4.7	4.35	0.95	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	40	5.8	3	1.2	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	60	6.8	0.5	2.7	clear	III	no
49	3:7	Dead	K_2CO_3	2,500	80	6.8	0.4	2.8	clear	III	yes

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
49	3:7	Dead	K_2CO_3	2,500	100	6.8	0.4	2.8	clear	III	yes
50	3:7	Dead	K_2CO_3	5,000	0	7	0	3			
50	3:7	Dead	K_2CO_3	5,000	3	5.6	4.4	0	clear	II (+)	no
50	3:7	Dead	K_2CO_3	5,000	6	5.5	4.4	0.1	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	9	5.5	4.4	0.1	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	13	5.7	4.25	0.05	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	16	5.7	4.25	0.05	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	20	5.8	4.15	0.05	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	40	5.9	4.05	0.05	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	60	6.9	2.9	0.2	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	80	6.9	2.9	0.2	clear	III	no
50	3:7	Dead	K_2CO_3	5,000	100	6.9	2.9	0.2	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	0	7	0	3			
51	3:7	Dead	K_2CO_3	7,500	3	5.45	4.55	0	clear	II (+)	no
51	3:7	Dead	K_2CO_3	7,500	6	5	4.55	0.45	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	9	5.4	4.55	0.05	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	13	5.4	4.5	0.1	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	16	5.4	3.8	0.8	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	20	5.4	3.8	0.8	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	40	5.4	3.8	0.8	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	60	6	2.5	1.5	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	80	6	2.5	1.5	clear	III	no
51	3:7	Dead	K_2CO_3	7,500	100	6	2.5	1.5	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	0	7	0	3			
52	3:7	Dead	K_2CO_3	10,000	3	5.5	4.5	0	clear	II (+)	no
52	3:7	Dead	K_2CO_3	10,000	6	5	4.5	0.5	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	9	5.4	4.5	0.1	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	13	5.4	4.55	0.05	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	16	5.4	4	0.6	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	20	5.8	3.8	0.4	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	40	5.8	2.2	2	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	60	6.1	1.25	2.65	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	80	6.1	1.25	2.65	clear	III	no
52	3:7	Dead	K_2CO_3	10,000	100	6.1	1.25	2.65	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	0	7	0	3			
53	3:7	Dead	K_2CO_3	12,500	3	4.5	5.5	0	clear	II (+)	no
53	3:7	Dead	K_2CO_3	12,500	6	4.5	5.5	0	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	9	4.8	4.45	0.75	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	13	5.4	3.7	0.9	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	16	5.5	3	1.5	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	20	5.5	2.45	2.05	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	40	5.6	2	2.4	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	60	5.8	1.5	2.7	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	80	5.9	1.5	2.6	clear	III	no
53	3:7	Dead	K_2CO_3	12,500	100	5.9	1.5	2.6	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	0	7	0	3			
54	3:7	Dead	K_2CO_3	15,000	3	3.3	5.95	0.75	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	6	4	5.95	0.05	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	9	4.45	5.5	0.05	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	13	4.65	3.85	1.5	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
54	3:7	Dead	K_2CO_3	15,000	16	4.8	2.55	2.65	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	20	4.8	2.35	2.85	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	40	5.3	1.75	2.95	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	60	6	1	3	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	80	6.1	0.85	3.05	clear	III	no
54	3:7	Dead	K_2CO_3	15,000	100	6.1	0.85	3.05	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	0	7	0	3			
55	3:7	Dead	K_2CO_3	17,500	3	2.9	5	2.1	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	6	2.9	4.9	2.2	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	9	2.9	4	2.2	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	13	3.7	3.1	2.3	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	16	5.5	3.1	2.4	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	20	6	2.6	2.4	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	40	6.1	1.25	2.65	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	60	8.5	0.5	2.65	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	80	8.4	0.5	2.65	clear	III	no
55	3:7	Dead	K_2CO_3	17,500	100	8.4	0.5	2.7	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	0	7	0	3			
56	3:7	Dead	K_2CO_3	20,000	3	7.7	2.3	0	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	6	5.5	2.3	2.2	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	9	6.8	1	2.2	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	13	6.75	1	2.25	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	16	6.7	1	2.3	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	20	7.2	0.5	2.3	clear	III	no
56	3:7	Dead	K_2CO_3	20,000	40	7.5	0.2	2.3	clear	III	yes
56	3:7	Dead	K_2CO_3	20,000	60	7.6	0.2	2.2	clear	III	yes
56	3:7	Dead	K_2CO_3	20,000	80	7.6	0.2	2.2	clear	III	yes
56	3:7	Dead	K_2CO_3	20,000	100	7.6	0.2	2.2	clear	III	yes
57	5:5	Dead	K_2CO_3	2,500	0	5	0	5			
57	5:5	Dead	K_2CO_3	2,500	3	0	9.8	0.2	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	6	2.2	7.65	0.15	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	9	2.7	7.15	0.15	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	13	3.2	6.75	0.05	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	16	3.3	5.4	1.3	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	20	3.5	3	3.5	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	40	3.5	2	4.5	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	60	4.4	1.1	4.5	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	80	5	0.75	4.25	clear	III	no
57	5:5	Dead	K_2CO_3	2,500	100	5	0.1	4.9	clear	III	yes
58	5:5	Dead	K_2CO_3	5,000	0	5	0	5			
58	5:5	Dead	K_2CO_3	5,000	3	0.7	9.05	0.25	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	6	1.3	8.5	0.2	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	9	1.5	8.3	0.2	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	13	2.3	7.45	0.25	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	16	2.4	7.2	0.4	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	20	2.5	6.7	0.8	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	40	2.8	6	1.2	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	60	3.6	5.2	1.2	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	80	3.6	4.95	1.45	clear	III	no
58	5:5	Dead	K_2CO_3	5,000	100	3.6	4	2.4	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
59	5:5	Dead	K_2CO_3	7,500	0	5	0	5			
59	5:5	Dead	K_2CO_3	7,500	3	0.8	8.85	0.35	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	6	2	7.8	0.2	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	9	2.3	7.4	0.3	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	13	2.9	6.6	0.5	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	16	3	6.2	0.8	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	20	3.1	5.95	0.95	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	40	3.3	4.9	1.8	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	60	3.9	4.5	1.6	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	80	4	4	2	clear	III	no
59	5:5	Dead	K_2CO_3	7,500	100	4	4	2	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	0	5	0	5			
60	5:5	Dead	K_2CO_3	10,000	3	0.8	8.85	0.35	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	6	2	7.8	0.2	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	9	2.3	7.4	0.3	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	13	2.9	6.6	0.5	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	16	3	5.2	1.8	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	20	3.2	4.7	2.1	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	40	3.9	3.7	2.4	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	60	3.9	3.7	2.4	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	80	3.9	3.3	2.8	clear	III	no
60	5:5	Dead	K_2CO_3	10,000	100	3.9	3.3	2.8	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	0	5	0	5			
61	5:5	Dead	K_2CO_3	12,500	3	1.3	7.4	1.3	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	6	2.5	6.2	1.3	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	9	2.5	6	1.5	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	13	3	5.3	1.7	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	16	3.2	5	1.8	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	20	3.5	4.6	1.9	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	40	4.3	4.3	1.4	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	60	4.6	4	1.4	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	80	4.6	4	1.4	clear	III	no
61	5:5	Dead	K_2CO_3	12,500	100	4.6	4	1.4	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	0	5	0	5			
62	5:5	Dead	K_2CO_3	15,000	3	2	6.1	1.9	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	6	3.6	4.15	2.25	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	9	3.6	3.25	3.15	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	13	4.3	2.2	3.5	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	16	3.8	2.6	3.6	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	20	4.3	2	3.7	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	40	4.2	2	3.8	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	60	4.7	2	3.3	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	80	4.7	2	3.3	clear	III	no
62	5:5	Dead	K_2CO_3	15,000	100	4.7	2	3.3	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	0	5	0	5			
63	5:5	Dead	K_2CO_3	17,500	3	2	6.15	1.85	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	6	3.8	3.85	2.35	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	9	3.6	3	3.4	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	13	3.7	2.9	3.4	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	16	3.8	2.4	3.8	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
63	5:5	Dead	K_2CO_3	17,500	20	4.45	1.8	3.75	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	40	4.45	1.75	3.8	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	60	4.8	1.75	3.45	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	80	4.8	1.75	3.45	clear	III	no
63	5:5	Dead	K_2CO_3	17,500	100	4.85	1.75	3.4	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	0	5	0	5			
64	5:5	Dead	K_2CO_3	20,000	3	1.35	6.9	1.75	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	6	3.9	3.7	2.4	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	9	4.1	3.25	2.65	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	13	5.1	2.1	2.8	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	16	5	2.8	2.2	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	20	5	2	3	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	40	5	1.45	3.55	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	60	5.4	0.9	3.7	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	80	5.4	0.85	3.75	clear	III	no
64	5:5	Dead	K_2CO_3	20,000	100	5.4	0.85	3.75	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	0	3	0	7			
65	7:3	Dead	K_2CO_3	2,500	3	0	9.75	0.25	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	6	0.5	9.25	0.25	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	9	0.7	8.95	0.35	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	13	1.05	8.9	0.05	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	16	1.1	8.3	0.6	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	20	1.3	7.2	1.5	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	40	1.3	6.5	2.2	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	60	2.2	6	1.8	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	80	2.2	5.5	2.3	clear	III	no
65	7:3	Dead	K_2CO_3	2,500	100	2.2	5.5	2.3	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	0	3	0	7			
66	7:3	Dead	K_2CO_3	5,000	3	0.4	8.8	0.8	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	6	0.6	8.6	0.8	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	9	0.55	8.5	0.95	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	13	1	6.9	2.1	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	16	1.2	6.3	2.5	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	20	1.3	5.8	2.9	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	40	1.7	4.1	4.2	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	60	3	4.1	2.9	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	80	3	4.1	2.9	clear	III	no
66	7:3	Dead	K_2CO_3	5,000	100	3	4.1	2.9	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	0	3	0	7			
67	7:3	Dead	K_2CO_3	7,500	3	0.4	8.75	0.85	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	6	0.7	8.45	0.85	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	9	0.8	8.1	1.1	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	13	1.15	6.6	2.25	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	16	1.3	5.8	2.9	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	20	1.8	4.65	3.55	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	40	2.1	3.3	4.6	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	60	3	3.3	3.7	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	80	3	3.3	3.7	clear	III	no
67	7:3	Dead	K_2CO_3	7,500	100	3	3.3	3.7	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	0	3	0	7			

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
68	7:3	Dead	K_2CO_3	10,000	3	0.4	8.75	0.85	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	6	0.7	8.45	0.85	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	9	0.8	8.1	1.1	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	13	1.15	6.6	2.25	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	16	1.3	5.8	2.9	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	20	1.5	5	3.5	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	40	1.8	3.2	5	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	60	3	3.2	3.8	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	80	3	3.2	3.8	clear	III	no
68	7:3	Dead	K_2CO_3	10,000	100	3	3.2	3.8	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	0	3	0	7			
69	7:3	Dead	K_2CO_3	12,500	3	1	5.8	3.2	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	6	2	4.3	3.7	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	9	1.9	3.5	4.6	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	13	2.3	3.1	4.6	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	16	2.3	2.75	4.95	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	20	2.4	2.5	5.1	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	40	2.5	2.2	5.3	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	60	2.9	2.2	4.9	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	80	2.9	2.2	4.9	clear	III	no
69	7:3	Dead	K_2CO_3	12,500	100	2.9	2.2	4.9	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	0	3	0	7			
70	7:3	Dead	K_2CO_3	15,000	3	1.9	2.9	5.2	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	6	2.5	2.05	5.45	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	9	2.35	1.9	5.75	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	13	2.95	1.5	5.55	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	16	2.5	1.5	6	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	20	2.5	1.4	6.1	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	40	2.5	1.4	6.1	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	60	2.7	1.4	5.9	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	80	2.7	1.4	5.9	clear	III	no
70	7:3	Dead	K_2CO_3	15,000	100	2.7	1.4	5.9	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	0	3	0	7			
71	7:3	Dead	K_2CO_3	17,500	3	0	3.3	6.7	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	6	2.4	3.15	4.45	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	9	2.3	2.55	5.15	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	13	2.1	2.05	5.85	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	16	2.5	1.5	6	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	20	2.6	1.3	6.1	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	40	2.6	0.9	6.5	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	60	2.8	0.9	6.3	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	80	2.8	0.9	6.3	clear	III	no
71	7:3	Dead	K_2CO_3	17,500	100	2.8	0.9	6.3	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	0	3	0	7			
72	7:3	Dead	K_2CO_3	20,000	3	2.2	2	5.8	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	6	2.5	1.45	6.05	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	9	2.5	1	6.5	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	13	2.65	0.8	6.55	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	16	2.5	0.8	6.7	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	20	2.7	0.6	6.7	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
72	7:3	Dead	K_2CO_3	20,000	40	2.8	0.7	6.5	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	60	2.8	0.7	6.5	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	80	2.8	0.7	6.5	clear	III	no
72	7:3	Dead	K_2CO_3	20,000	100	2.8	0.7	6.5	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	0	1	0	9			
73	9:1	Dead	K_2CO_3	2,500	3	0.5	2.5	7	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	6	0.2	2.4	7.4	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	9	0.4	1.1	8.5	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	13	0.4	0.95	8.65	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	16	0.5	0.95	8.55	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	20	0.1	0.6	9.3	clear	III	no
73	9:1	Dead	K_2CO_3	2,500	40	0.9	0.1	9	clear	III	yes
73	9:1	Dead	K_2CO_3	2,500	60	1	0.1	8.9	clear	III	yes
73	9:1	Dead	K_2CO_3	2,500	80	1	0.1	8.9	clear	III	yes
73	9:1	Dead	K_2CO_3	2,500	100	1	0.1	8.9	clear	III	yes
74	9:1	Dead	K_2CO_3	5,000	0	1	0	9			
74	9:1	Dead	K_2CO_3	5,000	3	0.1	2.7	7.2	clear	III	no
74	9:1	Dead	K_2CO_3	5,000	6	0.2	1.9	7.9	clear	III	no
74	9:1	Dead	K_2CO_3	5,000	9	0.3	1.35	8.35	clear	III	no
74	9:1	Dead	K_2CO_3	5,000	13	0.4	1.05	8.55	clear	III	no
74	9:1	Dead	K_2CO_3	5,000	16	0.6	0.6	8.8	clear	III	no
74	9:1	Dead	K_2CO_3	5,000	20	0.8	0.3	8.9	clear	III	yes
74	9:1	Dead	K_2CO_3	5,000	40	1	0.2	8.8	clear	III	yes
74	9:1	Dead	K_2CO_3	5,000	60	1	0.2	8.8	clear	III	yes
74	9:1	Dead	K_2CO_3	5,000	80	1	0.2	8.8	clear	III	yes
74	9:1	Dead	K_2CO_3	5,000	100	1	0.2	8.8	clear	III	yes
75	9:1	Dead	K_2CO_3	7,500	0	1	0	9			
75	9:1	Dead	K_2CO_3	7,500	3	0.2	2.7	7.1	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	6	0.42	1.83	7.75	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	9	0.4	1.55	8.05	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	13	0.6	1.3	8.1	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	16	0.6	1.2	8.2	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	20	0.4	1.3	8.3	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	40	0.5	0.7	8.8	clear	III	no
75	9:1	Dead	K_2CO_3	7,500	60	0.8	0.2	9	clear	III	yes
75	9:1	Dead	K_2CO_3	7,500	80	0.8	0.2	9	clear	III	yes
75	9:1	Dead	K_2CO_3	7,500	100	0.8	0.2	9	clear	III	yes
76	9:1	Dead	K_2CO_3	10,000	0	1	0	9			
76	9:1	Dead	K_2CO_3	10,000	3	0.2	2.7	7.1	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	6	0.42	1.83	7.75	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	9	0.4	1.55	8.05	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	13	0.6	1.3	8.1	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	16	0.6	1.2	8.2	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	20	0.6	0.75	8.65	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	40	0.6	0.5	8.9	clear	III	no
76	9:1	Dead	K_2CO_3	10,000	60	1	0.1	8.9	clear	III	yes
76	9:1	Dead	K_2CO_3	10,000	80	1	0.1	8.9	clear	III	yes
76	9:1	Dead	K_2CO_3	10,000	100	1	0.1	8.9	clear	III	yes
77	9:1	Dead	K_2CO_3	12,500	0	1	0	9			
77	9:1	Dead	K_2CO_3	12,500	3	0.3	1.75	7.95	precipitation	III	no

Sampl. Name	**WOR**	**Oil Type**	**Alkali**	**Conc. (ppm)**	**Time**	**Oil Vol. (ml)**	**Emulsion Vol. (ml)**	**Water Vol. (ml)**	**Optical Visualisation of the Aqueous Phase**	**Emulsion Type**	**Emulsion Amount <0.5 ml**
77	9:1	Dead	K_2CO_3	12,500	6	0.3	1.75	7.95	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	9	0.3	1.5	8.2	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	13	0.4	1.4	8.2	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	16	0.4	1.4	8.2	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	20	0.5	1.2	8.3	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	40	0.5	1.1	8.4	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	60	0.5	0.7	8.8	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	80	0.5	0.7	8.8	precipitation	III	no
77	9:1	Dead	K_2CO_3	12,500	100	0.5	0.7	8.8	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	0	1	0	9			
78	9:1	Dead	K_2CO_3	15,000	3	0.35	2.05	7.6	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	6	0.35	2.05	7.6	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	9	0.4	1.95	7.65	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	13	0.4	1.7	7.9	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	16	0.4	1.7	7.9	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	20	0.5	1.6	7.9	precipitation	III	no
78	9:1	Dead	K_2CO_3	15,000	40	0.6	0.4	9	precipitation	III	yes
78	9:1	Dead	K_2CO_3	15,000	60	0.9	0.4	8.7	precipitation	III	yes
78	9:1	Dead	K_2CO_3	15,000	80	0.9	0.4	8.7	precipitation	III	yes
78	9:1	Dead	K_2CO_3	15,000	100	0.9	0.4	8.7	precipitation	III	yes
79	9:1	Dead	K_2CO_3	17,500	0	1	0	9	precipitation		
79	9:1	Dead	K_2CO_3	17,500	3	0.3	2.8	6.9	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	6	0.6	2.2	7.2	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	9	0.6	2	7.4	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	13	0.65	1.75	7.6	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	16	0.65	1.65	7.7	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	20	0.7	1.6	7.7	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	40	0.7	1.5	7.8	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	60	0.9	0.5	8.6	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	80	0.9	0.5	8.6	precipitation	III	no
79	9:1	Dead	K_2CO_3	17,500	100	0.9	0.5	8.6	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	0	1	0	9			
80	9:1	Dead	K_2CO_3	20,000	3	0.45	2.45	7.1	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	6	0.45	2.45	7.1	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	9	0.55	2.1	7.35	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	13	0.35	2.1	7.55	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	16	0.4	2	7.6	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	20	0.5	1.9	7.6	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	40	0.6	1.6	7.8	precipitation	III	no
80	9:1	Dead	K_2CO_3	20,000	60	1	0.4	8.6	precipitation	III	yes
80	9:1	Dead	K_2CO_3	20,000	80	1	0.4	8.6	precipitation	III	yes
80	9:1	Dead	K_2CO_3	20,000	100	1	0.4	8.6	precipitation	III	yes

16.TH: Formulation 2a: Softened Water with Na_2CO_3 + Dead Bo 112 Oil @ 60°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
81	1:9	Dead	Na_2CO_3	2,500	0	9		1			
81	1:9	Dead	Na_2CO_3	2,500	3	8.7	1.1	0.2	clear	III	no
81	1:9	Dead	Na_2CO_3	2,500	6	8.7	0.8	0.5	clear	III	no
81	1:9	Dead	Na_2CO_3	2,500	9	8.6	0.55	0.85	clear	III	no
81	1:9	Dead	Na_2CO_3	2,500	13	8.6	0.5	0.9	clear	III	no
81	1:9	Dead	Na_2CO_3	2,500	16	8.6	0.4	1	clear	III	yes
81	1:9	Dead	Na_2CO_3	2,500	20	8.7	0.3	1	clear	III	yes
81	1:9	Dead	Na_2CO_3	2,500	40	8.9	0.1	1	clear	III	yes
81	1:9	Dead	Na_2CO_3	2,500	60	8.9	0.1	1	clear	III	yes
81	1:9	Dead	Na_2CO_3	2,500	80	8.9	0.1	1	clear	III	yes
81	1:9	Dead	Na_2CO_3	2,500	100	8.9	0.1	1	clear	III	yes
82	1:9	Dead	Na_2CO_3	5,000	0	9		1			
82	1:9	Dead	Na_2CO_3	5,000	3	9.05	1.4	0	clear	II (-)	no
82	1:9	Dead	Na_2CO_3	5,000	6	8.9	1.4	0	clear	II (-)	no
82	1:9	Dead	Na_2CO_3	5,000	9	8.4	0.9	0.7	clear	III	no
82	1:9	Dead	Na_2CO_3	5,000	13	8.4	0.9	0.7	clear	III	no
82	1:9	Dead	Na_2CO_3	5,000	16	8.7	0.5	0.8	clear	III	no
82	1:9	Dead	Na_2CO_3	5,000	20	8.9	0.25	0.85	clear	III	yes
82	1:9	Dead	Na_2CO_3	5,000	40	8.9	0.25	0.85	clear	III	yes
82	1:9	Dead	Na_2CO_3	5,000	60	8.9	0.25	0.85	clear	III	yes
82	1:9	Dead	Na_2CO_3	5,000	80	8.9	0.25	0.85	clear	III	yes
82	1:9	Dead	Na_2CO_3	5,000	100	8.9	0.25	0.85	clear	III	yes
83	1:9	Dead	Na_2CO_3	7,500	0	9		1			
83	1:9	Dead	Na_2CO_3	7,500	3	9.5	1.1	0	clear	II (-)	no
83	1:9	Dead	Na_2CO_3	7,500	6	8.9	1.1	0	clear	II (-)	no
83	1:9	Dead	Na_2CO_3	7,500	9	8.7	1.1	0.2	clear	III	no
83	1:9	Dead	Na_2CO_3	7,500	13	8.6	0.9	0.5	clear	III	no
83	1:9	Dead	Na_2CO_3	7,500	16	8.6	0.9	0.5	clear	III	no
83	1:9	Dead	Na_2CO_3	7,500	20	8.6	0.9	0.5	clear	III	no
83	1:9	Dead	Na_2CO_3	7,500	40	8.7	0.3	1	clear	III	yes
83	1:9	Dead	Na_2CO_3	7,500	60	8.7	0.3	1	clear	III	yes
83	1:9	Dead	Na_2CO_3	7,500	80	8.7	0.3	1	clear	III	yes
83	1:9	Dead	Na_2CO_3	7,500	100	8.7	0.3	1	clear	III	yes
84	1:9	Dead	Na_2CO_3	10,000	0	9		1			
84	1:9	Dead	Na_2CO_3	10,000	3	8.45	1.55	0	yellow, high turbitity	II (-)	no
84	1:9	Dead	Na_2CO_3	10,000	6	8.45	1.55	0	yellow, high turbitity	II (-)	no
84	1:9	Dead	Na_2CO_3	10,000	9	8.45	1.55	0	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	13	8.5	1.4	0.1	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	16	8.6	1.3	0.1	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	20	8.5	1.4	0.1	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	40	8.7	0.8	0.5	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	60	8.7	0.8	0.5	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	80	8.7	0.8	0.5	yellow, high turbitity	III	no
84	1:9	Dead	Na_2CO_3	10,000	100	8.7	0.8	0.5	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	0	9		1			
85	1:9	Dead	Na_2CO_3	12,500	3	8.45	1.55	0	yellow, high turbitity	II (-)	no
85	1:9	Dead	Na_2CO_3	12,500	6	8.45	1.55	0	yellow, high turbitity	II (-)	no
85	1:9	Dead	Na_2CO_3	12,500	9	8.45	1.55	0	yellow, high turbitity	II (-)	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
85	1:9	Dead	Na_2CO_3	12,500	13	8.4	1.55	0.05	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	16	8.5	1.45	0.05	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	20	8.5	1.45	0.05	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	40	8.8	0.75	0.45	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	60	8.8	0.75	0.45	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	80	8.8	0.75	0.45	yellow, high turbitity	III	no
85	1:9	Dead	Na_2CO_3	12,500	100	8.8	0.75	0.45	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	0	9		1			
86	1:9	Dead	Na_2CO_3	15,000	3	8.35	1.65	0	yellow, high turbitity	II (-)	no
86	1:9	Dead	Na_2CO_3	15,000	6	8.3	1.65	0.05	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	9	8.6	1.3	0.1	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	13	8.6	1.3	0.1	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	16	8.55	1.35	0.1	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	20	8.55	1.35	0.1	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	40	8.7	0.6	0.7	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	60	8.7	0.6	0.7	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	80	8.7	0.6	0.7	yellow, high turbitity	III	no
86	1:9	Dead	Na_2CO_3	15,000	100	8.7	0.6	0.7	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	0	9		1			
87	1:9	Dead	Na_2CO_3	17,500	3	8.7	1.3	0	yellow, high turbitity	II (-)	no
87	1:9	Dead	Na_2CO_3	17,500	6	8.7	1.3	0	yellow, high turbitity	II (-)	no
87	1:9	Dead	Na_2CO_3	17,500	9	8.6	1.3	0.1	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	13	8.6	1.25	0.15	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	16	8.7	1.15	0.15	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	20	8.6	1.15	0.25	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	40	8.8	0.7	0.5	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	60	8.8	0.7	0.5	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	80	8.8	0.7	0.5	yellow, high turbitity	III	no
87	1:9	Dead	Na_2CO_3	17,500	100	8.8	0.7	0.5	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	0	9		1			
88	1:9	Dead	Na_2CO_3	20,000	3	8.95	1.05	0	yellow, high turbitity	II (-)	no
88	1:9	Dead	Na_2CO_3	20,000	6	8.6	1.05	0.35	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	9	8.6	0.9	0.5	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	13	8.9	0.9	0.2	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	16	8.9	0.8	0.3	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	20	8.9	0.8	0.3	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	40	8.9	0.5	0.6	yellow, high turbitity	III	no
88	1:9	Dead	Na_2CO_3	20,000	60	8.9	0.35	0.75	yellow, high turbitity	III	yes
88	1:9	Dead	Na_2CO_3	20,000	80	8.9	0.35	0.75	yellow, high turbitity	III	yes
88	1:9	Dead	Na_2CO_3	20,000	100	8.9	0.35	0.75	yellow, high turbitity	III	yes
89	3:7	Dead	Na_2CO_3	2,500	0	7	0	3			
89	3:7	Dead	Na_2CO_3	2,500	3	0	9.9	0.1	clear	II (+)	no
89	3:7	Dead	Na_2CO_3	2,500	6	5.8	3.6	0.6	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	9	5.4	3.8	0.8	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	13	5.6	3.4	1	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	16	5.8	2.7	1.5	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	20	5.9	2.22	1.88	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	40	6.3	1.3	2.4	clear	III	no
89	3:7	Dead	Na_2CO_3	2,500	60	6.3	0.85	2.85	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
89	3:7	Dead	Na_2CO_3	2,500	80	6.7	0.3	3	clear	III	yes
89	3:7	Dead	Na_2CO_3	2,500	100	6.7	0.3	3	clear	III	yes
90	3:7	Dead	Na_2CO_3	5,000	0	7	0	3			
90	3:7	Dead	Na_2CO_3	5,000	3	2.9	6.9	0.2	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	6	3.1	6.6	0.3	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	9	4.9	4.8	0.3	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	13	5.2	4.5	0.3	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	16	5.4	4.3	0.3	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	20	5.6	4.1	0.3	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	40	5.7	3.3	1	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	60	5.7	2.95	1.35	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	80	5.7	2.95	1.35	precipitation	III	no
90	3:7	Dead	Na_2CO_3	5,000	100	5.7	2.95	1.35	precipitation	III	no
91	3:7	Dead	Na_2CO_3	7,500	0	7	0	3			
91	3:7	Dead	Na_2CO_3	7,500	3	0	9.8	0.2	yellow, clear	II (+)	no
91	3:7	Dead	Na_2CO_3	7,500	6	3	6.6	0.4	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	9	4	5.6	0.4	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	13	4.5	5.1	0.4	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	16	5	4.5	0.5	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	20	5.3	4.2	0.5	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	40	5.3	3.9	0.8	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	60	5.3	3.3	1.4	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	80	5.3	3.3	1.4	yellow, clear	III	no
91	3:7	Dead	Na_2CO_3	7,500	100	5.3	3.3	1.4	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	0	7	0	3			
92	3:7	Dead	Na_2CO_3	10,000	3	0	9.8	0.2	yellow, clear	II (+)	no
92	3:7	Dead	Na_2CO_3	10,000	6	1.2	8.3	0.5	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	9	1.6	7.8	0.6	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	13	1.7	7.7	0.6	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	16	1.7	7.6	0.7	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	20	1.7	6.3	2	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	40	2.3	5	2.7	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	60	3.6	3.5	2.9	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	80	3.6	3.5	2.9	yellow, clear	III	no
92	3:7	Dead	Na_2CO_3	10,000	100	3.6	3.5	2.9	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	0	7	0	3			
93	3:7	Dead	Na_2CO_3	12,500	3	0	9.3	0.7	yellow, clear	II (+)	no
93	3:7	Dead	Na_2CO_3	12,500	6	0.2	8	1.8	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	9	0.5	8.45	1.05	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	13	0.5	8.4	1.1	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	16	0.5	8.4	1.1	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	20	0.5	8.4	1.1	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	40	1.5	7.4	1.1	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	60	1.5	7.4	1.1	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	80	1.5	6.9	1.6	yellow, clear	III	no
93	3:7	Dead	Na_2CO_3	12,500	100	1.5	5.5	3	yellow, clear	III	no
94	3:7	Dead	Na_2CO_3	15,000	0	7	0	3			
94	3:7	Dead	Na_2CO_3	15,000	3	0	9.5	0.5	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	6	0	9.3	0.7	yellow, clear	II (+)	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
94	3:7	Dead	Na_2CO_3	15,000	9	0	9.15	0.85	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	13	0	9.15	0.85	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	16	0	9.15	0.85	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	20	0	9.1	0.9	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	40	0	7.9	2.1	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	60	0	7.9	2.1	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	80	0	7.9	2.1	yellow, clear	II (+)	no
94	3:7	Dead	Na_2CO_3	15,000	100	0	7.9	2.1	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	0	7	0	3			
95	3:7	Dead	Na_2CO_3	17,500	3	0	9.8	0.2	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	6	0	9.7	0.3	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	9	0	6.32	2.2	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	13	0	6.32	2.3	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	16	0	5.1	2.4	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	20	0	4.2	2.4	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	40	0	3.6	6.4	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	60	0	3.2	2.65	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	80	0	3.2	2.65	yellow, clear	II (+)	no
95	3:7	Dead	Na_2CO_3	17,500	100	0	3.2	2.7	yellow, clear	II (+)	no
96	3:7	Dead	Na_2CO_3	20,000	0	7	0	3			
96	3:7	Dead	Na_2CO_3	20,000	3	5.1	3.1	1.8	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	6	5.7	2.4	1.9	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	9	5.7	2.4	1.9	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	13	5.7	2.4	1.9	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	16	5.7	2.4	1.9	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	20	5.7	2	2.3	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	40	5.7	2	2.3	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	60	5.7	2	2.3	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	80	5.7	2	2.3	yellow, clear	III	no
96	3:7	Dead	Na_2CO_3	20,000	100	5.7	2	2.3	yellow, clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	0	5	0	5			
97	5:5	Dead	Na_2CO_3	2,500	3	0	9.1	0.9	clear	II (+)	no
97	5:5	Dead	Na_2CO_3	2,500	6	2.5	7.1	0.4	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	9	3.8	4	2.2	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	13	3.6	3.65	2.75	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	16	3.9	2.4	3.7	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	20	4.1	1.4	4.5	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	40	4.6	0.6	4.8	clear	III	no
97	5:5	Dead	Na_2CO_3	2,500	60	4.9	0.2	4.9	clear	III	yes
97	5:5	Dead	Na_2CO_3	2,500	80	4.9	0.2	4.9	clear	III	yes
97	5:5	Dead	Na_2CO_3	2,500	100	4.9	0.2	4.9	clear	III	yes
98	5:5	Dead	Na_2CO_3	5,000	0	5	0	5			
98	5:5	Dead	Na_2CO_3	5,000	3	0.3	9.4	0.3	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	6	0.6	9.1	0.3	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	9	1.95	7.55	0.5	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	13	2.2	7.2	0.6	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	16	2.55	4.75	2.7	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	20	2.8	4	3.2	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	40	2.8	3.5	3.7	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
98	5:5	Dead	Na_2CO_3	5,000	60	2.8	0.75	6.45	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	80	2.8	0.75	6.45	yellow, clear	III	no
98	5:5	Dead	Na_2CO_3	5,000	100	2.8	0.75	6.45	yellow, clear	III	no
99	5:5	Dead	Na_2CO_3	7,500	0	5	0	5			
99	5:5	Dead	Na_2CO_3	7,500	3	0	8.7	1.3	yellow, high turbitity	II (+)	no
99	5:5	Dead	Na_2CO_3	7,500	6	1.3	8.4	0.3	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	9	1.3	7.3	1.4	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	13	1.4	4	4.6	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	16	1.6	3.2	5.2	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	20	1.8	2.3	5.9	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	40	2	2	6	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	60	2	1.4	6.6	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	80	2	0.8	7.2	yellow, high turbitity	III	no
99	5:5	Dead	Na_2CO_3	7,500	100	2	0.8	7.2	yellow, high turbitity	III	no
100	5:5	Dead	Na_2CO_3	10,000	0	5	0	5			
100	5:5	Dead	Na_2CO_3	10,000	3	0	9.6	0.4	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	6	0	8.45	1.55	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	9	0	8.45	1.55	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	13	0	7.9	2.1	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	16	0	7.9	2.1	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	20	0	5	5	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	40	0	4.8	5.2	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	60	0	3	7	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	80	0	3	7	yellow, high turbitity	II (+)	no
100	5:5	Dead	Na_2CO_3	10,000	100	0	3	7	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	0	5	0	5			
101	5:5	Dead	Na_2CO_3	12,500	3	0	8.15	1.85	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	6	0	8	2	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	9	0	8	2	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	13	0	7.25	2.75	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	16	0	7.5	2.5	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	20	0	7.45	2.55	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	40	0	6.9	3.1	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	60	0	6	4	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	80	0	6	4	yellow, high turbitity	II (+)	no
101	5:5	Dead	Na_2CO_3	12,500	100	0	5.8	4.2	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	0	5	0	5			
102	5:5	Dead	Na_2CO_3	15,000	3	0	9.15	0.85	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	6	0	7.95	2.05	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	9	0	7.75	2.25	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	13	0	7.7	2.3	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	16	0	6.7	3.3	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	20	0	6.35	3.65	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	40	0	5	5	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	60	0	4.9	5.1	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	80	0	4.9	5.1	yellow, high turbitity	II (+)	no
102	5:5	Dead	Na_2CO_3	15,000	100	0	4.9	5.1	yellow, high turbitity	II (+)	no
103	5:5	Dead	Na_2CO_3	17,500	0	broken					
104	5:5	Dead	Na_2CO_3	20,000	0	5	0	5			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
104	5:5	Dead	Na_2CO_3	20,000	3	0	8.4	1.6	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	6	0	8.3	1.7	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	9	0	7.65	2.35	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	13	0	7.4	2.6	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	16	0	6.8	3.2	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	20	0	5.6	4.4	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	40	0	5.2	4.8	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	60	0	4.9	5.1	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	80	0	4.2	5.8	yellow, high turbitity	II (+)	no
104	5:5	Dead	Na_2CO_3	20,000	100	0	4.2	5.8	yellow, high turbitity	II (+)	no
105	7:3	Dead	Na_2CO_3	2,500	0	3	0	7			
105	7:3	Dead	Na_2CO_3	2,500	3	0.1	7.1	2.8	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	6	0.5	6.5	3	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	9	2.2	1.6	6.2	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	13	2.5	1.1	6.4	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	16	2.5	0.8	6.7	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	20	2.5	0.7	6.8	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	40	2.8	0.5	6.7	clear	III	no
105	7:3	Dead	Na_2CO_3	2,500	60	2.9	0.25	6.85	clear	III	yes
105	7:3	Dead	Na_2CO_3	2,500	80	2.9	0.25	6.85	clear	III	yes
105	7:3	Dead	Na_2CO_3	2,500	100	2.9	0.25	6.85	clear	III	yes
106	7:3	Dead	Na_2CO_3	5,000	0	3	0	7			
106	7:3	Dead	Na_2CO_3	5,000	3	0.4	7.95	1.65	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	6	0.4	7.7	1.9	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	9	1.4	6.4	2.2	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	13	1.5	5.9	2.6	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	16	1.5	5	3.5	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	20	1.9	3.2	4.9	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	40	1.9	3.2	4.9	yellow, high turbitity	III	no
106	7:3	Dead	Na_2CO_3	5,000	60	1.9	0.1	8	yellow, high turbitity	III	yes
106	7:3	Dead	Na_2CO_3	5,000	80	1.9	0.1	8	yellow, high turbitity	III	yes
106	7:3	Dead	Na_2CO_3	5,000	100	1.9	0.1	8	yellow, high turbitity	III	yes
107	7:3	Dead	Na_2CO_3	7,500	0	3	0	7			
107	7:3	Dead	Na_2CO_3	7,500	3	0	8.4	1.6	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	6	0	8.1	1.9	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	9	0	7.5	2.5	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	13	0	7	3	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	16	0	5.9	4.1	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	20	0	3.35	6.65	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	40	0	3	7	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	60	0	1.1	8.9	yellow, high turbitity	III	no
107	7:3	Dead	Na_2CO_3	7,500	80	0	0.5	9.5	yellow, high turbitity	III	yes
107	7:3	Dead	Na_2CO_3	7,500	100	0	0.1	9.9	yellow, high turbitity	III	yes
108	7:3	Dead	Na_2CO_3	10,000	0	3	0	7			
108	7:3	Dead	Na_2CO_3	10,000	3	0	8.4	1.6	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	6	0	8.15	1.85	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	9	0	7.45	2.55	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	13	0	7.1	2.9	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	16	0	6.6	3.4	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
108	7:3	Dead	Na_2CO_3	10,000	20	0	5.7	4.3	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	40	0	5.5	4.5	yellow, high turbitity	III	no
108	7:3	Dead	Na_2CO_3	10,000	60	0	0.2	9.8	yellow, high turbitity	III	yes
108	7:3	Dead	Na_2CO_3	10,000	80	0	0.2	9.8	yellow, high turbitity	III	yes
108	7:3	Dead	Na_2CO_3	10,000	100	0	0.2	9.8	yellow, high turbitity	III	yes
109	7:3	Dead	Na_2CO_3	12,500	0	3	0	7			
109	7:3	Dead	Na_2CO_3	12,500	3	0	7.2	2.8	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	6	0	7	3	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	9	0	6.25	3.75	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	13	0	5.9	4.1	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	16	0	5.25	4.75	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	20	0	4.9	5.1	yellow, high turbitity	III	no
109	7:3	Dead	Na_2CO_3	12,500	40	0	0.25	9.75	yellow, high turbitity	III	yes
109	7:3	Dead	Na_2CO_3	12,500	60	0	0.25	9.75	yellow, high turbitity	III	yes
109	7:3	Dead	Na_2CO_3	12,500	80	0	0.25	9.75	yellow, high turbitity	III	yes
109	7:3	Dead	Na_2CO_3	12,500	100	0	0.25	9.75	yellow, high turbitity	III	yes
110	7:3	Dead	Na_2CO_3	15,000	0	3	0	7			
110	7:3	Dead	Na_2CO_3	15,000	3	0	7.2	2.8	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	6	0	7	3	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	9	0	5.7	4.3	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	13	0	6.2	3.8	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	16	0	4	6	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	20	0	3.5	6.5	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	40	0	0.5	9.5	yellow, high turbitity	III	no
110	7:3	Dead	Na_2CO_3	15,000	60	0	0.35	9.65	yellow, high turbitity	III	yes
110	7:3	Dead	Na_2CO_3	15,000	80	0	0.35	9.65	yellow, high turbitity	III	yes
110	7:3	Dead	Na_2CO_3	15,000	100	0	0.3	9.7	yellow, high turbitity	III	yes
111	7:3	Dead	Na_2CO_3	17,500	0	3	0	7			
111	7:3	Dead	Na_2CO_3	17,500	3	0	7.3	2.7	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	6	0	7	3	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	9	0	5.1	4.9	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	13	0	4.6	5.4	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	16	0	4	6	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	20	0	3.6	6.4	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	40	0	1.9	8.1	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	60	0	1	9	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	80	0	1	9	yellow, high turbitity	III	no
111	7:3	Dead	Na_2CO_3	17,500	100	0	1	9	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	0	3	0	7			
112	7:3	Dead	Na_2CO_3	20,000	3	0	8.3	1.7	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	6	0	8.4	1.6	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	9	0	5.2	4.8	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	13	0	4.6	5.4	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	16	0	4	6	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	20	0	3.6	6.4	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	40	0	2	8	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	60	0	1.75	8.25	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	80	0	1.1	8.9	yellow, high turbitity	III	no
112	7:3	Dead	Na_2CO_3	20,000	100	0	1.1	8.9	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
113	9:1	Dead	Na_2CO_3	2,500	0	1	0	9			
113	9:1	Dead	Na_2CO_3	2,500	3	0.8	0.1	9.1	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	6	0.2	0.1	9.7	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	9	0.85	0.1	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	13	0.9	0.1	9	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	16	0.9	0.05	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	20	0.9	0.05	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	40	0.9	0.05	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	60	0.9	0.05	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	80	0.9	0.05	9.05	clear	III	yes
113	9:1	Dead	Na_2CO_3	2,500	100	0.9	0.05	9.05	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	0	1	0	9			
114	9:1	Dead	Na_2CO_3	5,000	3	0.8	0.4	8.8	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	6	0.8	0.4	8.8	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	9	0.8	0.2	9	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	13	0.9	0.1	9	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	16	0.9	0.1	9	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	20	0.9	0.1	9	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	40	0.9	0.05	9.05	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	60	0.9	0.05	9.05	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	80	0.9	0.05	9.05	clear	III	yes
114	9:1	Dead	Na_2CO_3	5,000	100	0.9	0.05	9.05	clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	0	1	0	9			
115	9:1	Dead	Na_2CO_3	7,500	3	0.8	0.1	9.1	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	6	0.8	0.1	9.1	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	9	0.9	0.1	9	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	13	0.9	0.1	9	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	16	0.9	0.1	9	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	20	0.9	0.1	9	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	40	0.9	0.1	9	yellow, clear	III	yes
115	9:1	Dead	Na_2CO_3	7,500	60	0.9	0.1	9	yellow, clear	x	yes
115	9:1	Dead	Na_2CO_3	7,500	80	0.9	0.1	9	yellow, clear	x	yes
115	9:1	Dead	Na_2CO_3	7,500	100	0.9	0.1	9	yellow, clear	x	yes
116	9:1	Dead	Na_2CO_3	10,000	0	1	0	9			
116	9:1	Dead	Na_2CO_3	10,000	3	0.8	1.25	7.95	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	6	0.8	1.25	7.95	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	9	0.9	0.05	9.05	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	13	0.9	0.05	9.05	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	16	0.9	0.05	9.05	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	20	0.9	0.05	9.05	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	40	0.85	0.05	9.1	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	60	0.85	0.05	9.1	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	80	0.85	0.05	9.1	yellow, clear	III	yes
116	9:1	Dead	Na_2CO_3	10,000	100	0.85	0.05	9.1	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	0	1	0	9			
117	9:1	Dead	Na_2CO_3	12,000	3	0.9	0.1	9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	6	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	9	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	13	1	0.1	8.9	yellow, clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
117	9:1	Dead	Na_2CO_3	12,000	16	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	20	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	40	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	60	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	80	1	0.1	8.9	yellow, clear	III	yes
117	9:1	Dead	Na_2CO_3	12,000	100	1	0.1	8.9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	0	1	0	9			
118	9:1	Dead	Na_2CO_3	15,000	3	0.95	0.05	9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	6	0.95	0.05	9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	9	1	0.05	8.95	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	13	1	0.05	8.95	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	16	1	0.05	8.95	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	20	1	0.05	8.95	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	40	1	0.1	8.9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	60	1	0.1	8.9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	80	1	0.1	8.9	yellow, clear	III	yes
118	9:1	Dead	Na_2CO_3	15,000	100	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	0	1	0	9			
119	9:1	Dead	Na_2CO_3	17,500	3	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	6	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	9	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	13	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	16	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	20	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	40	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	60	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	80	1	0.1	8.9	yellow, clear	III	yes
119	9:1	Dead	Na_2CO_3	17,500	100	1	0.1	8.9	yellow, clear	III	yes
120	9:1	Dead	Na_2CO_3	20,000	0	broken					

16.TH: Formulation 2a: Softened Water with K_2CO_3 + Dead Bo 112 Oil @ 60°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
121	1:9	Dead	K_2CO_3	2,500	0	9	0	1			
121	1:9	Dead	K_2CO_3	2,500	3	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	6	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	9	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	13	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	16	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	20	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	40	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	60	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	80	8.95	0.05	1	clear	III	yes
121	1:9	Dead	K_2CO_3	2,500	100	8.95	0.05	1	clear	III	yes
122	1:9	Dead	K_2CO_3	5,000	0	9	0	1			
122	1:9	Dead	K_2CO_3	5,000	3	9.15	0.85	0	clear	II (-)	no
122	1:9	Dead	K_2CO_3	5,000	6	9.1	0.75	0.15	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	9	8.7	1	0.3	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	13	8.4	1.3	0.3	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	16	8.7	0.9	0.4	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	20	8.6	0.9	0.5	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	40	8.6	0.8	0.6	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	60	8.85	0.5	0.65	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	80	8.85	0.5	0.65	clear	III	no
122	1:9	Dead	K_2CO_3	5,000	100	8.85	0.5	0.65	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	0	9	0	1			
123	1:9	Dead	K_2CO_3	7,500	3	8.9	1.05	0.05	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	6	8.7	1.25	0.05	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	9	8.2	1.7	0.1	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	13	8.1	1.7	0.2	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	16	8.1	1.7	0.2	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	20	8.4	1.35	0.25	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	40	8.4	1.35	0.25	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	60	8.7	0.6	0.7	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	80	8.7	0.6	0.7	clear	III	no
123	1:9	Dead	K_2CO_3	7,500	100	8.7	0.6	0.7	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	0	9	0	1			
124	1:9	Dead	K_2CO_3	10,000	3	9	0	1	clear	x	x
124	1:9	Dead	K_2CO_3	10,000	6	9	0	1	clear	x	x
124	1:9	Dead	K_2CO_3	10,000	9	9	0	1	clear	x	x
124	1:9	Dead	K_2CO_3	10,000	13	8.5	1.45	0.05	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	16	8.6	1.35	0.05	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	20	8.5	1.47	0.03	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	40	8.5	1.47	0.03	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	60	8.7	1.1	0.2	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	80	8.7	1.1	0.2	clear	III	no
124	1:9	Dead	K_2CO_3	10,000	100	8.7	1.1	0.2	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	0	9	0	1			
125	1:9	Dead	K_2CO_3	12,500	3	9	0	1	clear	x	x
125	1:9	Dead	K_2CO_3	12,500	6	9	0	1	clear	x	x
125	1:9	Dead	K_2CO_3	12,500	9	9	0	1	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
125	1:9	Dead	K_2CO_3	12,500	13	8.3	1.65	0.05	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	16	8.3	1.56	0.14	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	20	8.3	1.56	0.14	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	40	8.4	1.4	0.2	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	60	8.6	1.4	0	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	80	8.6	1.4	0	clear	III	no
125	1:9	Dead	K_2CO_3	12,500	100	8.6	1.4	0	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	0	9	0	1			
126	1:9	Dead	K_2CO_3	15,000	3	9	0	1	clear	x	x
126	1:9	Dead	K_2CO_3	15,000	6	9	0	1	clear	x	x
126	1:9	Dead	K_2CO_3	15,000	9	9	0	1	clear	x	x
126	1:9	Dead	K_2CO_3	15,000	13	8	1.6	0.4	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	16	8	1.6	0.4	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	20	8.1	1.48	0.42	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	40	8.1	1.48	0.42	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	60	8.6	1.3	0.1	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	80	8.6	1.3	0.1	clear	III	no
126	1:9	Dead	K_2CO_3	15,000	100	8.6	1.3	0.1	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	0	9	0	1			
127	1:9	Dead	K_2CO_3	17,500	3	9	0	1	clear	x	x
127	1:9	Dead	K_2CO_3	17,500	6	9	0	1	clear	x	x
127	1:9	Dead	K_2CO_3	17,500	9	9	0	1	clear	x	x
127	1:9	Dead	K_2CO_3	17,500	13	7.5	2	0.5	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	16	8	1.5	0.5	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	20	8	1.5	0.5	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	40	8.2	1.5	0.3	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	60	9	0.9	0.1	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	80	9	0.9	0.1	clear	III	no
127	1:9	Dead	K_2CO_3	17,500	100	9	0.9	0.1	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	0	9	0	1			
128	1:9	Dead	K_2CO_3	20,000	3	9	0	1	clear	x	x
128	1:9	Dead	K_2CO_3	20,000	6	9	0	1	clear	x	x
128	1:9	Dead	K_2CO_3	20,000	9	9	0	1	clear	x	x
128	1:9	Dead	K_2CO_3	20,000	13	7.8	1.8	0.4	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	16	7.8	1.8	0.4	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	20	7.9	1.8	0.3	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	40	8.55	1.2	0.25	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	60	8.55	1.2	0.25	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	80	8.55	1.2	0.25	clear	III	no
128	1:9	Dead	K_2CO_3	20,000	100	8.55	1.2	0.25	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	0	7	0	3			
129	3:7	Dead	K_2CO_3	2,500	3	6.6	1.8	1.6	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	6	5.1	3.15	1.75	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	9	5.1	3	1.9	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	13	5.8	1.7	2.5	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	16	6.2	1.2	2.6	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	20	6.35	0.9	2.75	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	40	6.45	0.6	2.95	clear	III	no
129	3:7	Dead	K_2CO_3	2,500	60	6.7	0.3	3	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
129	3:7	Dead	K_2CO_3	2,500	80	6.7	0.3	3	clear	III	yes
129	3:7	Dead	K_2CO_3	2,500	100	6.7	0.3	3	clear	III	yes
130	3:7	Dead	K_2CO_3	5,000	0	7	0	3			
130	3:7	Dead	K_2CO_3	5,000	3	1.3	5.9	2.8	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	6	2.7	5	2.3	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	9	5.5	4.4	0.1	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	13	4.9	4.9	0.2	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	16	5.4	4.4	0.2	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	20	5.5	4.3	0.2	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	40	5.7	4.1	0.2	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	60	6.2	3.6	0.2	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	80	6.2	2.2	1.6	precipitation	III	no
130	3:7	Dead	K_2CO_3	5,000	100	6.2	2.2	1.6	precipitation	III	no
131	3:7	Dead	K_2CO_3	7,500	0	7	0	3			
131	3:7	Dead	K_2CO_3	7,500	3	0.7	6.4	2.9	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	6	0.7	6.35	2.95	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	9	1.8	5.25	2.95	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	13	2.3	5.65	2.05	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	16	2.9	5.1	2	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	20	3.3	4.9	1.8	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	40	4	4.8	1.2	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	60	4.95	4	1.05	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	80	4.95	4	1.05	yellow, clear	III	no
131	3:7	Dead	K_2CO_3	7,500	100	4.95	4	1.05	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	0	7	0	3			
132	3:7	Dead	K_2CO_3	10,000	3	1.5	5.85	2.65	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	6	2.1	5.35	2.55	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	9	3.3	4.65	2.05	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	13	3.7	5.05	1.25	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	16	4.1	4.75	1.15	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	20	4.2	4.65	1.15	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	40	4.2	3.5	2.3	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	60	4.9	3.5	1.6	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	80	4.9	3.5	1.6	yellow, clear	III	no
132	3:7	Dead	K_2CO_3	10,000	100	4.9	3.5	1.6	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	0	7	0	3			
133	3:7	Dead	K_2CO_3	12,500	3	2.15	6.8	1.05	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	6	4.35	5.2	0.45	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	9	4.75	4.85	0.4	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	13	5.3	4.4	0.3	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	16	5.3	4.4	0.3	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	20	5.5	4.3	0.2	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	40	5.5	4.3	0.2	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	60	6	3.7	0.3	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	80	6	3.7	0.3	yellow, clear	III	no
133	3:7	Dead	K_2CO_3	12,500	100	6	3.7	0.3	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	0	7	0	3			
134	3:7	Dead	K_2CO_3	15,000	3	2.2	7.65	0.15	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	6	2.6	7.3	0.1	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
134	3:7	Dead	K_2CO_3	15,000	9	3	6.9	0.1	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	13	5.2	4.65	0.15	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	16	5.3	4.5	0.2	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	20	5.4	3.8	0.8	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	40	5.5	3.8	0.7	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	60	6	3	1	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	80	6	3	1	yellow, clear	III	no
134	3:7	Dead	K_2CO_3	15,000	100	6	3	1	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	0	7	0	3			
135	3:7	Dead	K_2CO_3	17,500	3	2	7.95	0.05	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	6	2.4	7.5	0.1	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	9	2.8	7.1	2.2	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	13	5	4.85	2.3	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	16	5.1	4.7	2.4	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	20	5.4	4.4	2.4	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	40	5.4	3	1.6	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	60	5.9	2.55	2.65	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	80	5.9	2.55	2.65	yellow, clear	III	no
135	3:7	Dead	K_2CO_3	17,500	100	5.9	2.55	2.7	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	0	7	0	3			
136	3:7	Dead	K_2CO_3	20,000	3	3	7	0	yellow, clear	II (-)	no
136	3:7	Dead	K_2CO_3	20,000	6	2.9	7	0.1	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	9	3.2	6.7	0.1	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	13	4.5	5.4	0.1	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	16	5	4.8	0.2	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	20	5.3	4.5	0.2	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	40	4.8	4.5	0.7	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	60	5.3	3.86	0.84	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	80	5.2	3.86	0.94	yellow, clear	III	no
136	3:7	Dead	K_2CO_3	20,000	100	5.2	3.86	0.94	yellow, clear	III	no
137	5:5	Dead	K_2CO_3	2,500	0	5	0	5			
137	5:5	Dead	K_2CO_3	2,500	3	2	6.9	1.1	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	6	2.6	6.12	1.28	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	9	3	5.7	1.3	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	13	3.6	2.75	3.65	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	16	4.1	1.9	4	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	20	4.15	1.4	4.45	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	40	4.45	0.8	4.75	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	60	4.7	0.6	4.7	clear	III	no
137	5:5	Dead	K_2CO_3	2,500	80	4.9	0.1	5	clear	III	yes
137	5:5	Dead	K_2CO_3	2,500	100	4.9	0.1	5	clear	III	yes
138	5:5	Dead	K_2CO_3	5,000	0	5	0	5			
138	5:5	Dead	K_2CO_3	5,000	3	0.8	9.05	0.15	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	6	0.9	8.95	0.15	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	9	1.8	7.85	0.35	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	13	2.4	7.3	0.3	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	16	2.7	7	0.3	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	20	3	6.7	0.3	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	40	3.3	6.3	0.4	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
138	5:5	Dead	K_2CO_3	5,000	60	3.5	5.7	0.8	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	80	3.5	5.7	0.8	yellow, clear	III	no
138	5:5	Dead	K_2CO_3	5,000	100	3.5	5.7	0.8	yellow, clear	III	no
139	5:5	Dead	K_2CO_3	7,500	0	5	0	5			
139	5:5	Dead	K_2CO_3	7,500	3	0.6	8.9	0.5	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	6	0.7	8.75	0.55	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	9	2.2	7.3	0.5	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	13	1.9	7.4	0.7	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	16	2.2	6.8	1	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	20	2.5	6.2	1.3	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	40	2.8	4.3	2.9	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	60	2.8	4.3	2.9	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	80	4	2.9	3.1	yellow, high turbitity	III	no
139	5:5	Dead	K_2CO_3	7,500	100	4	2.9	3.1	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	0	5	0	5			
140	5:5	Dead	K_2CO_3	10,000	3	0.8	8.75	0.45	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	6	0.8	8.8	0.4	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	9	2	7.2	0.8	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	13	2.1	7.1	0.8	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	16	2.3	6.8	0.9	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	20	2.5	4.7	2.8	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	40	2.8	2.95	4.25	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	60	3.8	2.95	3.25	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	80	3.8	2.95	3.25	yellow, high turbitity	III	no
140	5:5	Dead	K_2CO_3	10,000	100	3.8	2.95	3.25	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	0	5	0	5			
141	5:5	Dead	K_2CO_3	12,500	3	0.6	8.95	0.45	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	6	0.65	8.85	0.5	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	9	1	7.95	1.05	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	13	2.5	6.75	0.75	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	16	2.7	6.55	0.75	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	20	2.9	5.8	1.3	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	40	3.1	5.8	1.1	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	60	3.9	1.2	4.9	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	80	3.9	1.2	4.9	yellow, high turbitity	III	no
141	5:5	Dead	K_2CO_3	12,500	100	3.9	1.2	4.9	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	0	5	0	5			
142	5:5	Dead	K_2CO_3	15,000	3	0.6	9.2	0.2	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	6	0.75	8.9	0.35	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	9	1.2	8.4	0.4	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	13	2.6	6.85	0.55	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	16	2.8	6.55	0.65	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	20	3	5.9	1.1	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	40	3.2	0.9	5.9	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	60	3.9	0.9	5.2	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	80	3.9	0.9	5.2	yellow, high turbitity	III	no
142	5:5	Dead	K_2CO_3	15,000	100	3.9	0.9	5.2	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	0	5	0	5			
143	5:5	Dead	K_2CO_3	17,500	3	0	9.55	0.45	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
143	5:5	Dead	K_2CO_3	17,500	6	0.4	8.3	1.3	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	9	0.9	8	1.1	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	13	1	6.3	2.7	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	16	1.1	6.1	2.8	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	20	1.4	5.7	2.9	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	40	4	3.7	2.3	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	60	4.5	0.95	4.55	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	80	4.7	0.95	4.35	yellow, high turbitity	III	no
143	5:5	Dead	K_2CO_3	17,500	100	4.7	0.95	4.35	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	0	5	0	5			
144	5:5	Dead	K_2CO_3	20,000	3	1.8	7.7	0.5	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	6	2	7.55	0.45	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	9	2.3	7.1	0.6	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	13	3.2	6	0.8	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	16	3.4	5.7	0.9	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	20	3.5	2.7	3.8	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	40	3.6	2.7	3.7	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	60	4.3	1.1	4.6	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	80	4.3	1.1	4.6	yellow, high turbitity	III	no
144	5:5	Dead	K_2CO_3	20,000	100	4.3	1.1	4.6	yellow, high turbitity	III	no
145	7:3	Dead	K_2CO_3	2,500	0	3	0	7			
145	7:3	Dead	K_2CO_3	2,500	3	0.3	8.4	1.3	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	6	0.35	7.9	1.75	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	9	0.55	4.2	5.25	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	13	0.8	3.8	5.4	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	16	1.2	3	5.8	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	20	1.6	2.05	6.35	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	40	2.2	1.2	6.6	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	60	2.2	0.8	7	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	80	2.2	0.8	7	clear	III	no
145	7:3	Dead	K_2CO_3	2,500	100	2.2	0.8	7	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	0	3	0	7			
146	7:3	Dead	K_2CO_3	5,000	3	0.6	9.25	0.15	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	6	0.6	9.2	0.2	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	9	0.6	8.2	1.2	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	13	1.3	7.7	1	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	16	1.5	6.9	1.6	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	20	1.7	5.35	2.95	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	40	2.05	3.05	4.9	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	60	2	1.1	6.9	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	80	2	1.1	6.9	clear	III	no
146	7:3	Dead	K_2CO_3	5,000	100	2	1.1	6.9	clear	III	no
147	7:3	Dead	K_2CO_3	7,500	0	3	0	7			
147	7:3	Dead	K_2CO_3	7,500	3	0.5	7.5	2	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	6	0.6	7.4	2	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	9	0.9	7.8	1.3	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	13	0.9	6.75	2.35	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	16	1.1	6.75	2.15	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	20	1.2	5	3.8	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
147	7:3	Dead	K_2CO_3	7,500	40	1.6	2.8	5.6	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	60	3	1	6	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	80	3	1	6	yellow, high turbitity	III	no
147	7:3	Dead	K_2CO_3	7,500	100	3	1	6	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	0	3	0	7			
148	7:3	Dead	K_2CO_3	10,000	3	0.5	8.1	1.4	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	6	0.5	8.15	1.35	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	9	0.6	7	2.4	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	13	0.7	6.35	2.95	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	16	0.8	5.5	3.7	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	20	1	2.3	6.7	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	40	1.4	1.25	7.35	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	60	2.9	1.25	5.85	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	80	2.9	1.25	5.85	yellow, high turbitity	III	no
148	7:3	Dead	K_2CO_3	10,000	100	2.9	1.25	5.85	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	0	3	0	7			
149	7:3	Dead	K_2CO_3	12,500	3	0.3	7.5	2.2	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	6	0.6	6.7	2.7	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	9	1.8	6.7	1.5	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	13	0.9	6.6	2.5	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	16	1	6.25	2.75	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	20	1.2	5.8	3	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	40	2.5	1.9	5.6	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	60	2.5	1.9	5.6	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	80	2.5	1.9	5.6	yellow, high turbitity	III	no
149	7:3	Dead	K_2CO_3	12,500	100	2.5	1.9	5.6	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	0	3	0	7			
150	7:3	Dead	K_2CO_3	15,000	3	0.3	8	1.7	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	6	0.3	8.2	1.5	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	9	0.3	8.1	1.6	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	13	1	6.8	2.2	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	16	1.2	6.3	2.5	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	20	1.25	5.45	3.3	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	40	1.5	4.5	4	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	60	2.6	2.4	5	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	80	2.6	2.4	5	yellow, high turbitity	III	no
150	7:3	Dead	K_2CO_3	15,000	100	2.6	2.4	5	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	0	3	0	7			
151	7:3	Dead	K_2CO_3	17,500	3	0.5	7.9	1.6	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	6	0.5	7.9	1.6	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	9	0.7	7.5	1.8	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	13	1.2	6.5	2.3	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	16	1.3	6.2	2.5	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	20	1.5	5.75	2.75	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	40	1.35	3.3	5.35	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	60	2.5	2	5.5	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	80	2.5	2	5.5	yellow, high turbitity	III	no
151	7:3	Dead	K_2CO_3	17,500	100	2.5	2	5.5	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	0	3	0	7			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
152	7:3	Dead	K_2CO_3	20,000	3	0.5	8.7	0.8	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	6	0.6	8.55	0.85	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	9	0.75	8.2	1.05	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	13	1.4	7	1.6	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	16	1.5	6.5	2	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	20	1.6	5.8	2.6	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	40	1.9	4.6	3.5	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	60	2.4	2.6	5	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	80	2.4	2.6	5	yellow, high turbitity	III	no
152	7:3	Dead	K_2CO_3	20,000	100	2.4	2.6	5	yellow, high turbitity	III	no
153	9:1	Dead	K_2CO_3	2,500	0	1	0	9			
153	9:1	Dead	K_2CO_3	2,500	3	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	6	0.1	0.1	9.8	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	9	0.3	0.1	9.6	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	13	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	16	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	20	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	40	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	60	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	80	0.95	0.1	8.95	clear	III	yes
153	9:1	Dead	K_2CO_3	2,500	100	0.95	0.1	8.95	clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	0	1	0	9			
154	9:1	Dead	K_2CO_3	5,000	3	0.8	0.2	9	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	6	0.7	0.2	9.1	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	9	0.2	0.2	9.6	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	13	0.1	0.2	9.7	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	16	0.1	0.2	9.7	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	20	0.1	0.2	9.7	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	40	0.1	0.2	9.7	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	60	0.2	0.2	9.6	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	80	0.2	0.2	9.6	yellow, clear	III	yes
154	9:1	Dead	K_2CO_3	5,000	100	0.2	0.2	9.6	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	0	1	0	9			
155	9:1	Dead	K_2CO_3	7,500	3	0.9	0.1	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	6	0.9	0.1	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	9	0.95	0.05	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	13	0.95	0.05	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	16	0.95	0.05	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	20	0.95	0.05	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	40	0.95	0.05	9	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	60	1	0.05	8.95	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	80	1	0.05	8.95	yellow, clear	III	yes
155	9:1	Dead	K_2CO_3	7,500	100	1	0.05	8.95	yellow, clear	III	yes
156	9:1	Dead	K_2CO_3	10,000	0	broken					
157	9:1	Dead	K_2CO_3	12,500	0	1	0	9			
157	9:1	Dead	K_2CO_3	12,500	3	0.9	0.35	8.75	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	6	0.85	0.3	8.85	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	9	0.85	0.3	8.85	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	13	0.9	0.25	8.85	yellow, clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
157	9:1	Dead	K_2CO_3	12,500	16	0.9	0.25	8.85	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	20	0.85	0.25	8.9	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	40	0.85	0.25	8.9	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	60	0.8	0.2	9	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	80	0.8	0.2	9	yellow, clear	III	yes
157	9:1	Dead	K_2CO_3	12,500	100	0.8	0.2	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	0	1	0	9			
158	9:1	Dead	K_2CO_3	15,000	3	0.8	0.2	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	6	0.75	0.15	9.1	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	9	0.2	0.05	9.75	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	13	0.95	0.05	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	16	0.95	0.05	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	20	0.95	0.05	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	40	0.95	0.05	9	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	60	1	0.05	8.95	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	80	1	0.05	8.95	yellow, clear	III	yes
158	9:1	Dead	K_2CO_3	15,000	100	1	0.05	8.95	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	0	1	0	9			
159	9:1	Dead	K_2CO_3	17,500	3	1	0.15	8.85	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	6	0.9	0.15	8.95	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	9	0.95	0.15	8.9	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	13	0.95	0.15	8.9	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	16	0.95	0.1	8.95	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	20	0.95	0.1	8.95	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	40	0.95	0.1	8.95	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	60	1	0.1	8.9	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	80	1	0.1	8.9	yellow, clear	III	yes
159	9:1	Dead	K_2CO_3	17,500	100	1	0.1	8.9	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	0	1	0	9			
160	9:1	Dead	K_2CO_3	20,000	3	0.9	0.15	8.95	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	6	0.95	0.15	8.9	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	9	0.95	0.15	8.9	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	13	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	16	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	20	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	40	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	60	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	80	1	0.15	8.85	yellow, clear	III	yes
160	9:1	Dead	K_2CO_3	20,000	100	1	0.15	8.85	yellow, clear	III	yes

16.TH: Formulation 3a: Softened Water with Na_2CO_3 + Modified Bo 112 Oil @ 60°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
161	1:9	Modified	Na_2CO_3	2,500	0	9	0	1			
161	1:9	Modified	Na_2CO_3	2,500	3	8.9	0.1	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	6	8.95	0.05	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	9	8.95	0.05	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	13	8.95	0.05	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	16	8.95	0.05	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	20	8.95	0.05	1	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	40	9	0.05	0.95	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	60	9	0.05	0.95	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	80	9	0.05	0.95	yellow, clear	III	no
161	1:9	Modified	Na_2CO_3	2,500	100	9	0.05	0.95	yellow, clear	III	no
162	1:9	Modified	Na_2CO_3	5,000	0	9	0	1			
162	1:9	Modified	Na_2CO_3	5,000	3	8.75	1.18	0	yellow, clear	II (-)	no
162	1:9	Modified	Na_2CO_3	5,000	6	8.8	1.13	0	yellow, clear	II (-)	no
162	1:9	Modified	Na_2CO_3	5,000	9	8.8	0.75	0.45	yellow, clear	III	no
162	1:9	Modified	Na_2CO_3	5,000	13	8.9	0.5	0.6	yellow, clear	III	no
162	1:9	Modified	Na_2CO_3	5,000	16	8.8	0.5	0.7	yellow, clear	III	no
162	1:9	Modified	Na_2CO_3	5,000	20	8.9	0.4	0.7	yellow, clear	III	yes
162	1:9	Modified	Na_2CO_3	5,000	40	8.9	0.2	0.9	yellow, clear	III	yes
162	1:9	Modified	Na_2CO_3	5,000	60	8.9	0.1	1	yellow, clear	III	yes
162	1:9	Modified	Na_2CO_3	5,000	80	8.9	0.1	1	yellow, clear	III	yes
162	1:9	Modified	Na_2CO_3	5,000	100	8.9	0.1	1	yellow, clear	III	yes
163	1:9	Modified	Na_2CO_3	7,500	0	9	0	1			
163	1:9	Modified	Na_2CO_3	7,500	3	8.5	1.48	0	yellow, clear	II (-)	no
163	1:9	Modified	Na_2CO_3	7,500	6	8.7	1.28	0.02	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	9	8.8	1.15	0.05	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	13	8.7	0.9	0.4	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	16	8.8	0.7	0.5	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	20	8.8	0.6	0.6	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	40	8.8	0.5	0.7	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	60	8.8	0.5	0.7	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	80	8.8	0.5	0.7	yellow, clear	III	no
163	1:9	Modified	Na_2CO_3	7,500	100	8.8	0.5	0.7	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	0	9	0	1			
164	1:9	Modified	Na_2CO_3	10,000	3	8.6	1.38	0	yellow, clear	II (-)	no
164	1:9	Modified	Na_2CO_3	10,000	6	8.7	1.2	0	yellow, clear	II (-)	no
164	1:9	Modified	Na_2CO_3	10,000	9	8.6	1.2	0	yellow, clear	II (-)	no
164	1:9	Modified	Na_2CO_3	10,000	13	8.7	0.95	0.35	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	16	8.75	0.75	0.5	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	20	8.8	0.6	0.6	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	40	8.8	0.6	0.6	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	60	8.9	0.6	0.5	yellow, clear	III	no
164	1:9	Modified	Na_2CO_3	10,000	80	8.9	0.4	0.7	yellow, clear	III	yes
164	1:9	Modified	Na_2CO_3	10,000	100	8.9	0.4	0.7	yellow, clear	III	yes
165	1:9	Modified	Na_2CO_3	12,500	0	9	0	1			
165	1:9	Modified	Na_2CO_3	12,500	3	8.5	1.48	0	yellow, clear	II (-)	no
165	1:9	Modified	Na_2CO_3	12,500	6	8.65	1.3	0	yellow, clear	II (-)	no
165	1:9	Modified	Na_2CO_3	12,500	9	8.7	1.1	0	yellow, clear	II (-)	no
165	1:9	Modified	Na_2CO_3	12,500	13	8.7	1.05	0.25	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
165	1:9	Modified	Na_2CO_3	12,500	16	8.7	0.9	0.4	yellow, clear	III	no
165	1:9	Modified	Na_2CO_3	12,500	20	8.8	0.6	0.6	yellow, clear	III	no
165	1:9	Modified	Na_2CO_3	12,500	40	8.8	0.5	0.7	yellow, clear	III	no
165	1:9	Modified	Na_2CO_3	12,500	60	8.8	0.3	0.9	yellow, clear	III	yes
165	1:9	Modified	Na_2CO_3	12,500	80	8.8	0.3	0.9	yellow, clear	III	yes
165	1:9	Modified	Na_2CO_3	12,500	100	8.8	0.3	0.9	yellow, clear	III	yes
166	1:9	Modified	Na_2CO_3	15,000	0	9	0	1			
166	1:9	Modified	Na_2CO_3	15,000	3	8.5	1.48	0	yellow, high turbitity	II (-)	no
166	1:9	Modified	Na_2CO_3	15,000	6	8.7	1.2	0.1	yellow, high turbitity	III	no
166	1:9	Modified	Na_2CO_3	15,000	9	8.7	1.1	0.2	yellow, high turbitity	III	no
166	1:9	Modified	Na_2CO_3	15,000	13	8.7	1	0.3	yellow, high turbitity	III	no
166	1:9	Modified	Na_2CO_3	15,000	16	8.7	0.7	0.6	yellow, high turbitity	III	no
166	1:9	Modified	Na_2CO_3	15,000	20	8.7	0.6	0.7	yellow, high turbitity	III	no
166	1:9	Modified	Na_2CO_3	15,000	40	8.9	0.4	0.7	yellow, high turbitity	III	yes
166	1:9	Modified	Na_2CO_3	15,000	60	8.9	0.4	0.7	yellow, high turbitity	III	yes
166	1:9	Modified	Na_2CO_3	15,000	80	8.9	0.4	0.7	yellow, high turbitity	III	yes
166	1:9	Modified	Na_2CO_3	15,000	100	8.9	0.4	0.7	yellow, high turbitity	III	yes
167	1:9	Modified	Na_2CO_3	17,500	0	9	0	1			
167	1:9	Modified	Na_2CO_3	17,500	3	8.5	1.48	0	yellow, high turbitity	II (-)	no
167	1:9	Modified	Na_2CO_3	17,500	6	8.6	1.35	0.05	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	9	8.7	1.1	0.2	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	13	8.6	1	0.4	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	16	8.7	0.8	0.5	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	20	8.8	0.6	0.6	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	40	8.8	0.5	0.7	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	60	8.8	0.5	0.7	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	80	8.8	0.5	0.7	yellow, high turbitity	III	no
167	1:9	Modified	Na_2CO_3	17,500	100	8.8	0.5	0.7	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	0	9	0	1			
168	1:9	Modified	Na_2CO_3	20,000	3	8.6	1.38	0	yellow, high turbitity	II (-)	no
168	1:9	Modified	Na_2CO_3	20,000	6	8.8	1.1	0.1	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	9	8.7	1.1	0.2	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	13	8.7	0.9	0.4	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	16	8.7	0.7	0.6	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	20	8.7	0.6	0.7	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	40	8.8	0.6	0.6	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	60	8.8	0.6	0.6	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	80	8.8	0.6	0.6	yellow, high turbitity	III	no
168	1:9	Modified	Na_2CO_3	20,000	100	8.8	0.6	0.6	yellow, high turbitity	III	no
169	3:7	Modified	Na_2CO_3	2,500	0	7	0	3			
169	3:7	Modified	Na_2CO_3	2,500	3	6.7	0.5	2.8	white, high turbidity	III	no
169	3:7	Modified	Na_2CO_3	2,500	6	6.9	0.3	2.8	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	9	6.9	0.2	2.9	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	13	6.95	0.1	2.95	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	16	6.95	0.1	2.95	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	20	6.95	0.1	2.95	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	40	7	0.1	2.9	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	60	7	0.1	2.9	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	80	7	0.1	2.9	white, high turbidity	III	yes
169	3:7	Modified	Na_2CO_3	2,500	100	7	0.1	2.9	white, high turbidity	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
170	3:7	Modified	Na_2CO_3	5,000	0	7	0	3			
170	3:7	Modified	Na_2CO_3	5,000	3	5.8	4.18	0.02	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	6	6	3.98	0.02	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	9	6.2	3.75	0.05	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	13	6.4	3.3	0.3	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	16	6.5	3.05	0.45	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	20	6.6	2.9	0.5	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	40	6.6	2.9	0.5	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	60	6.7	2.9	0.4	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	80	6.7	2.4	0.9	white, high turbidity	III	no
170	3:7	Modified	Na_2CO_3	5,000	100	6.7	2.4	0.9	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	0	7	0	3			
171	3:7	Modified	Na_2CO_3	7,500	3	5.4	4.58	0.02	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	6	5.8	4.18	0.02	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	9	5.9	4	0.1	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	13	6	3.85	0.15	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	16	6.1	3.75	0.15	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	20	6.1	3.7	0.2	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	40	6.4	3.2	0.4	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	60	6.4	3.2	0.4	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	80	6.4	3.2	0.4	white, high turbidity	III	no
171	3:7	Modified	Na_2CO_3	7,500	100	6.4	3.2	0.4	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	0	7	0	3			
172	3:7	Modified	Na_2CO_3	10,000	3	5	4.9	0.1	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	6	5.5	4.3	0.2	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	9	5.8	4	0.2	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	13	5.9	3.85	0.25	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	16	6	3.6	0.4	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	20	6.1	3.25	0.65	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	40	6.5	3.25	0.25	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	60	6.5	3	0.5	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	80	6.5	2	1.5	white, high turbidity	III	no
172	3:7	Modified	Na_2CO_3	10,000	100	6.5	2	1.5	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	0	7	0	3			
173	3:7	Modified	Na_2CO_3	12,500	3	5.1	4.7	0.2	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	6	5.4	4.3	0.3	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	9	5.8	3.7	0.5	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	13	5.9	3.35	0.75	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	16	6.1	2.95	0.95	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	20	6.3	2.5	1.2	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	40	6.3	2.5	1.2	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	60	6.7	2	1.3	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	80	6.7	1	2.3	white, high turbidity	III	no
173	3:7	Modified	Na_2CO_3	12,500	100	6.7	1	2.3	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	0	7	0	3			
174	3:7	Modified	Na_2CO_3	15,000	3	4	5.8	0.2	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	6	5.5	4.2	0.3	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	9	5.8	3.7	0.5	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	13	6	3.4	0.6	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	16	6	3.4	0.6	white, high turbidity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
174	3:7	Modified	Na_2CO_3	15,000	20	6	3.15	0.85	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	40	6.4	3.15	0.45	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	60	6.4	3	0.6	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	80	6.4	2.1	1.5	white, high turbidity	III	no
174	3:7	Modified	Na_2CO_3	15,000	100	6.4	2.1	1.5	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	0	7	0	3			
175	3:7	Modified	Na_2CO_3	17,500	3	6	3.8	0.2	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	6	5.8	3.8	0.4	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	9	6	3.6	2.2	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	13	6	3.4	2.3	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	16	6	3.4	2.4	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	20	6	3.4	2.4	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	40	6	3.4	0.6	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	60	6	2.7	2.65	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	80	6	2.7	2.65	white, high turbidity	III	no
175	3:7	Modified	Na_2CO_3	17,500	100	6	2.7	2.7	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	0	7	0	3			
176	3:7	Modified	Na_2CO_3	20,000	3	6	3.8	0.2	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	6	6	3.8	0.2	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	9	6	3.7	0.3	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	13	6	3.4	0.6	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	16	6	3.4	0.6	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	20	6	3.4	0.6	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	40	6	3.4	0.6	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	60	6	2.3	1.7	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	80	6	2.2	1.8	white, high turbidity	III	no
176	3:7	Modified	Na_2CO_3	20,000	100	6	2.2	1.8	white, high turbidity	III	no
177	5:5	Modified	Na_2CO_3	2,500	0	5	0	5			
177	5:5	Modified	Na_2CO_3	2,500	3	4.7	2.25	3.05	clear	III	no
177	5:5	Modified	Na_2CO_3	2,500	6	4.8	0.4	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	9	4.8	0.4	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	13	4.8	0.4	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	16	4.8	0.4	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	20	4.8	0.4	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	40	5	0.25	4.75	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	60	5	0.2	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	80	5	0.2	4.8	clear	III	yes
177	5:5	Modified	Na_2CO_3	2,500	100	5	0.2	4.8	clear	III	yes
178	5:5	Modified	Na_2CO_3	5,000	0	5	0	5			
178	5:5	Modified	Na_2CO_3	5,000	3	4.9	4.9	0.2	yellow, high turbidity	III	no
178	5:5	Modified	Na_2CO_3	5,000	6	4.2	5.15	0.65	yellow, high turbidity	III	no
178	5:5	Modified	Na_2CO_3	5,000	9	4.4	3.6	2	yellow, high turbidity	III	no
178	5:5	Modified	Na_2CO_3	5,000	13	4.6	1.8	3.6	yellow, high turbidity	III	no
178	5:5	Modified	Na_2CO_3	5,000	16	4.8	0.7	4.5	yellow, high turbidity	III	no
178	5:5	Modified	Na_2CO_3	5,000	20	5	0.1	4.9	yellow, high turbidity	III	yes
178	5:5	Modified	Na_2CO_3	5,000	40	5	0.1	4.9	yellow, high turbidity	III	yes
178	5:5	Modified	Na_2CO_3	5,000	60	5	0.1	4.9	yellow, high turbidity	III	yes
178	5:5	Modified	Na_2CO_3	5,000	80	5	0.1	4.9	yellow, high turbidity	III	yes
178	5:5	Modified	Na_2CO_3	5,000	100	5	0.1	4.9	yellow, high turbidity	III	yes
179	5:5	Modified	Na_2CO_3	7,500	0	5	0	5			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
179	5:5	Modified	Na_2CO_3	7,500	3	3.7	6.1	0.2	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	6	3.9	5.7	0.4	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	9	4.1	4.7	1.2	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	13	4.3	3.3	2.4	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	16	4.5	2.2	3.3	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	20	4.7	0.5	4.8	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	40	5	0.5	4.5	yellow, high turbitity	III	no
179	5:5	Modified	Na_2CO_3	7,500	60	5	0.2	4.8	yellow, high turbitity	III	yes
179	5:5	Modified	Na_2CO_3	7,500	80	5	0.1	4.9	yellow, high turbitity	III	yes
179	5:5	Modified	Na_2CO_3	7,500	100	5	0.1	4.9	yellow, high turbitity	III	yes
180	5:5	Modified	Na_2CO_3	10,000	0	5	0	5			
180	5:5	Modified	Na_2CO_3	10,000	3	3.7	6	0.3	yellow, high turbitity	III	no
180	5:5	Modified	Na_2CO_3	10,000	6	3.9	4.8	1.3	yellow, high turbitity	III	no
180	5:5	Modified	Na_2CO_3	10,000	9	4.2	2.9	2.9	yellow, high turbitity	III	no
180	5:5	Modified	Na_2CO_3	10,000	13	4.4	1.7	3.9	yellow, high turbitity	III	no
180	5:5	Modified	Na_2CO_3	10,000	16	4.4	1.7	3.9	yellow, high turbitity	III	no
180	5:5	Modified	Na_2CO_3	10,000	20	4.7	0.4	4.9	yellow, high turbitity	III	yes
180	5:5	Modified	Na_2CO_3	10,000	40	5	0.4	4.6	yellow, high turbitity	III	yes
180	5:5	Modified	Na_2CO_3	10,000	60	5	0.1	4.9	yellow, high turbitity	III	yes
180	5:5	Modified	Na_2CO_3	10,000	80	5	0.1	4.9	yellow, high turbitity	III	yes
180	5:5	Modified	Na_2CO_3	10,000	100	5	0.1	4.9	yellow, high turbitity	III	yes
181	5:5	Modified	Na_2CO_3	12,500	0	5	0	5			
181	5:5	Modified	Na_2CO_3	12,500	3	3	6.6	0.4	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	6	3.5	4.9	1.6	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	9	3.8	3.7	2.5	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	13	4.1	2.8	3.1	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	16	4.5	0.9	4.6	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	20	4.5	0.9	4.6	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	40	4.9	0.5	4.6	yellow, high turbitity	III	no
181	5:5	Modified	Na_2CO_3	12,500	60	4.9	0.4	4.7	yellow, high turbitity	III	yes
181	5:5	Modified	Na_2CO_3	12,500	80	4.9	0.3	4.8	yellow, high turbitity	III	yes
181	5:5	Modified	Na_2CO_3	12,500	100	4.9	0.3	4.8	yellow, high turbitity	III	yes
182	5:5	Modified	Na_2CO_3	15,000	0	5	0	5			
182	5:5	Modified	Na_2CO_3	15,000	3	2.2	7.2	0.6	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	6	2.9	5.7	1.4	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	9	3.4	4.35	2.25	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	13	3.8	3.5	2.7	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	16	4.2	2.7	3.1	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	20	4.3	2.25	3.45	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	40	4.8	2	3.2	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	60	4.8	1.9	3.3	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	80	4.8	0.9	4.3	yellow, high turbitity	III	no
182	5:5	Modified	Na_2CO_3	15,000	100	4.8	0.9	4.3	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	0	5	0	5			
183	5:5	Modified	Na_2CO_3	17,500	3	2	7.1	0.9	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	6	3.6	4.7	1.7	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	9	3.8	3.6	2.6	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	13	4.2	2.6	3.2	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	16	4.35	2.05	3.6	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	20	4.4	1.6	4	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
183	5:5	Modified	Na_2CO_3	17,500	40	4.8	1.3	3.9	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	60	4.8	1	4.2	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	80	4.8	0.7	4.5	yellow, high turbitity	III	no
183	5:5	Modified	Na_2CO_3	17,500	100	4.8	0.7	4.5	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	0	5	0	5			
184	5:5	Modified	Na_2CO_3	20,000	3	2.5	6.4	1.1	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	6	3.5	4.7	1.8	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	9	4.1	3.1	2.8	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	13	4.2	2.4	3.4	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	16	4.5	1.8	3.7	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	20	4.5	1.5	4	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	40	4.9	1	4.1	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	60	4.9	0.9	4.2	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	80	4.9	0.6	4.5	yellow, high turbitity	III	no
184	5:5	Modified	Na_2CO_3	20,000	100	4.9	0.6	4.5	yellow, high turbitity	III	no
185	7:3	Modified	Na_2CO_3	2,500	0	3	0	7			
185	7:3	Modified	Na_2CO_3	2,500	3	2.85	0.35	6.8	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	6	2.85	0.25	6.9	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	9	2.85	0.15	7	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	13	2.95	0.05	7	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	16	3	0.05	6.95	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	20	3	0.05	6.95	clear	III	no
185	7:3	Modified	Na_2CO_3	2,500	40	3	0	7	clear	x	no
185	7:3	Modified	Na_2CO_3	2,500	60	3	0	7	clear	x	no
185	7:3	Modified	Na_2CO_3	2,500	80	3	0	7	clear	x	no
185	7:3	Modified	Na_2CO_3	2,500	100	3	0	7	clear	x	no
186	7:3	Modified	Na_2CO_3	5,000	0	3	0	7			
186	7:3	Modified	Na_2CO_3	5,000	3	2.9	5	2.1	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	6	2.6	4.8	2.6	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	9	2.7	1	6.3	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	13	2.9	0.3	6.8	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	16	3.06	0.3	6.64	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	20	3.1	0.2	6.7	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	40	3.05	0.1	6.85	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	60	3.1	0.05	6.85	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	80	3.1	0.05	6.85	yellow, high turbitity	III	no
186	7:3	Modified	Na_2CO_3	5,000	100	3.1	0.05	6.85	yellow, high turbitity	III	no
187	7:3	Modified	Na_2CO_3	7,500	0	3	0	7			
187	7:3	Modified	Na_2CO_3	7,500	3	2.3	6.85	0.85	yellow, high turbitity	III	no
187	7:3	Modified	Na_2CO_3	7,500	6	2.1	3.9	4	yellow, high turbitity	III	no
187	7:3	Modified	Na_2CO_3	7,500	9	2.9	0.1	7	yellow, high turbitity	III	no
187	7:3	Modified	Na_2CO_3	7,500	13	2.9	0.1	7	yellow, high turbitity	III	no
187	7:3	Modified	Na_2CO_3	7,500	16	2.9	0	7.1	yellow, high turbitity	x	no
187	7:3	Modified	Na_2CO_3	7,500	20	2.9	0	7.1	yellow, high turbitity	x	no
187	7:3	Modified	Na_2CO_3	7,500	40	2.95	0	7.05	yellow, high turbitity	x	no
187	7:3	Modified	Na_2CO_3	7,500	60	2.95	0	7.05	yellow, high turbitity	x	no
187	7:3	Modified	Na_2CO_3	7,500	80	2.95	0	7.05	yellow, high turbitity	x	no
187	7:3	Modified	Na_2CO_3	7,500	100	2.95	0	7.05	yellow, high turbitity	x	no
188	7:3	Modified	Na_2CO_3	10,000	0	3	0	7			
188	7:3	Modified	Na_2CO_3	10,000	3	2.2	6.9	0.9	yellow, high turbitity	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
188	7:3	Modified	Na_2CO_3	10,000	6	2	4.3	3.7	yellow, high turbitity	III	no
188	7:3	Modified	Na_2CO_3	10,000	9	2.1	1.1	6.8	yellow, high turbitity	III	no
188	7:3	Modified	Na_2CO_3	10,000	13	2.1	1	6.9	yellow, high turbitity	III	no
188	7:3	Modified	Na_2CO_3	10,000	16	3.05	0.05	6.9	yellow, high turbitity	III	no
188	7:3	Modified	Na_2CO_3	10,000	20	3.1	0	6.9	yellow, high turbitity	x	no
188	7:3	Modified	Na_2CO_3	10,000	40	3.1	0	6.9	yellow, high turbitity	x	no
188	7:3	Modified	Na_2CO_3	10,000	60	3.1	0	6.9	yellow, high turbitity	x	no
188	7:3	Modified	Na_2CO_3	10,000	80	3.1	0	6.9	yellow, high turbitity	x	no
188	7:3	Modified	Na_2CO_3	10,000	100	3.1	0	6.9	yellow, high turbitity	x	no
189	7:3	Modified	Na_2CO_3	12,500	0	3	0	7			
189	7:3	Modified	Na_2CO_3	12,500	3	2.1	6	1.9	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	6	1.8	4	4.2	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	9	2	2.4	5.6	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	13	2.05	1.65	6.3	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	16	2.1	1	6.9	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	20	2.15	0.95	6.9	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	40	2.6	0.5	6.9	yellow, high turbitity	III	no
189	7:3	Modified	Na_2CO_3	12,500	60	2.6	0.1	7.3	yellow, high turbitity	III	yes
189	7:3	Modified	Na_2CO_3	12,500	80	2.6	0.1	7.3	yellow, high turbitity	III	yes
189	7:3	Modified	Na_2CO_3	12,500	100	2.6	0.1	7.3	yellow, high turbitity	III	yes
190	7:3	Modified	Na_2CO_3	15,000	0	3	0	7			
190	7:3	Modified	Na_2CO_3	15,000	3	2.3	5.6	2.1	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	6	2.8	2.2	5	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	9	2	2.4	5.6	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	13	2.2	0.8	7	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	16	2.2	1.1	6.7	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	20	2.25	0.85	6.9	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	40	3.6	0.5	5.9	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	60	3.6	0.5	5.9	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	80	3.6	0.5	5.9	yellow, high turbitity	III	no
190	7:3	Modified	Na_2CO_3	15,000	100	3.6	0.5	5.9	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	0	3	0	7			
191	7:3	Modified	Na_2CO_3	17,500	3	2.5	4.4	3.1	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	6	2.3	1.3	6.4	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	9	1.6	1.45	6.95	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	13	2.3	1.4	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	16	2.3	1.4	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	20	2.6	1.1	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	40	2.6	1.1	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	60	2.6	1.1	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	80	2.6	1.1	6.3	yellow, high turbitity	III	no
191	7:3	Modified	Na_2CO_3	17,500	100	2.6	1.1	6.3	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	0	3	0	7			
192	7:3	Modified	Na_2CO_3	20,000	3	2.5	4.5	3	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	6	2.5	0.8	6.7	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	9	1.3	1.7	7	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	13	2.5	0.5	7	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	16	2.4	0.6	7	yellow, high turbitity	III	no
192	7:3	Modified	Na_2CO_3	20,000	20	2.9	0.2	6.9	yellow, high turbitity	III	yes
192	7:3	Modified	Na_2CO_3	20,000	40	2.9	0.2	6.9	yellow, high turbitity	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
192	7:3	Modified	Na_2CO_3	20,000	60	2.9	0.2	6.9	yellow, high turbitity	III	yes
192	7:3	Modified	Na_2CO_3	20,000	80	2.9	0.2	6.9	yellow, high turbitity	III	yes
192	7:3	Modified	Na_2CO_3	20,000	100	2.9	0.2	6.9	yellow, high turbitity	III	yes
193	9:1	Modified	Na_2CO_3	2,500	0	1	0	9			
193	9:1	Modified	Na_2CO_3	2,500	3	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	6	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	9	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	13	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	16	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	20	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	40	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	60	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	80	1	0	9	clear, precipitation	x	x
193	9:1	Modified	Na_2CO_3	2,500	100	1	0	9	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	0	1	0	9			
194	9:1	Modified	Na_2CO_3	5,000	3	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	6	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	9	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	13	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	16	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	20	0.95	0	9.05	clear, precipitation	x	x
194	9:1	Modified	Na_2CO_3	5,000	40	0.95	0.15	8.9	clear, precipitation	III	yes
194	9:1	Modified	Na_2CO_3	5,000	60	0.95	0.15	8.9	clear, precipitation	III	yes
194	9:1	Modified	Na_2CO_3	5,000	80	0.95	0.15	8.9	clear, precipitation	III	yes
194	9:1	Modified	Na_2CO_3	5,000	100	0.95	0.15	8.9	clear, precipitation	III	yes
195	9:1	Modified	Na_2CO_3	7,500	0	1	0	9			
195	9:1	Modified	Na_2CO_3	7,500	3	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	6	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	9	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	13	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	16	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	20	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	40	0.95	0	9.05	clear, precipitation	x	x
195	9:1	Modified	Na_2CO_3	7,500	60	0.95	0.1	8.95	clear, precipitation	III	yes
195	9:1	Modified	Na_2CO_3	7,500	80	0.95	0.1	8.95	clear, precipitation	III	yes
195	9:1	Modified	Na_2CO_3	7,500	100	0.95	0.1	8.95	clear, precipitation	III	yes
196	9:1	Modified	Na_2CO_3	10,000	0	1	0	9			
196	9:1	Modified	Na_2CO_3	10,000	3	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	6	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	9	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	13	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	16	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	20	0.95	0	9.05	clear, precipitation	x	x
196	9:1	Modified	Na_2CO_3	10,000	40	0.95	0.2	8.85	clear, precipitation	III	yes
196	9:1	Modified	Na_2CO_3	10,000	60	0.95	0.2	8.85	clear, precipitation	III	yes
196	9:1	Modified	Na_2CO_3	10,000	80	0.95	0.2	8.85	clear, precipitation	III	yes
196	9:1	Modified	Na_2CO_3	10,000	100	0.95	0.2	8.85	clear, precipitation	III	yes
197	9:1	Modified	Na_2CO_3	12,500	0	broken					
198	9:1	Modified	Na_2CO_3	15,000	0	1	0	9			
198	9:1	Modified	Na_2CO_3	15,000	3	1	0	9	clear, precipitation	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
198	9:1	Modified	Na_2CO_3	15,000	6	1	0	9	clear, precipitation	x	x
198	9:1	Modified	Na_2CO_3	15,000	9	1	0	9	clear, precipitation	x	x
198	9:1	Modified	Na_2CO_3	15,000	13	1	0	9	clear, precipitation	x	x
198	9:1	Modified	Na_2CO_3	15,000	16	1	0	9	clear, precipitation	x	x
198	9:1	Modified	Na_2CO_3	15,000	20	1	0	9	clear, precipitation	x	x
198	9:1	Modified	Na_2CO_3	15,000	40	1	0.25	8.75	clear, precipitation	III	yes
198	9:1	Modified	Na_2CO_3	15,000	60	1	0.25	8.75	clear, precipitation	III	yes
198	9:1	Modified	Na_2CO_3	15,000	80	1	0.2	8.8	clear, precipitation	III	yes
198	9:1	Modified	Na_2CO_3	15,000	100	1	0.2	8.8	clear, precipitation	III	yes
199	9:1	Modified	Na_2CO_3	17,500	0	1	0	9			
199	9:1	Modified	Na_2CO_3	17,500	3	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	6	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	9	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	13	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	16	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	20	1	0	9	clear, precipitation	x	x
199	9:1	Modified	Na_2CO_3	17,500	40	1	0.15	8.85	clear, precipitation	III	no
199	9:1	Modified	Na_2CO_3	17,500	60	1	0.15	8.85	clear, precipitation	III	no
199	9:1	Modified	Na_2CO_3	17,500	80	1	0.15	8.85	clear, precipitation	III	no
199	9:1	Modified	Na_2CO_3	17,500	100	1	0.15	8.85	clear, precipitation	III	no
200	9:1	Modified	Na_2CO_3	20,000	0	1	0	9			
200	9:1	Modified	Na_2CO_3	20,000	3	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	6	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	9	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	13	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	16	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	20	0.9	0	9.1	clear, precipitation	x	x
200	9:1	Modified	Na_2CO_3	20,000	40	0.9	0.25	8.85	clear, precipitation	III	yes
200	9:1	Modified	Na_2CO_3	20,000	60	0.9	0.2	8.9	clear, precipitation	III	yes
200	9:1	Modified	Na_2CO_3	20,000	80	0.9	0.2	8.9	clear, precipitation	III	yes
200	9:1	Modified	Na_2CO_3	20,000	100	0.9	0.15	8.95	clear, precipitation	III	yes

16.TH: Formulation 3a: Softened Water with K_2CO_3 + Modified Bo 112 Oil @ 60°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
201	1:9	Modified	K_2CO_3	2,500	0	9	0	1			
201	1:9	Modified	K_2CO_3	2,500	3	9	0.03	0.97	clear	III	yes
201	1:9	Modified	K_2CO_3	2,500	6	9	0.03	0.97	clear	III	yes
201	1:9	Modified	K_2CO_3	2,500	9	9	0.03	0.97	clear	III	yes
201	1:9	Modified	K_2CO_3	2,500	13	9	0.03	0.97	clear	III	yes
201	1:9	Modified	K_2CO_3	2,500	16	9	0.03	0.97	clear	III	yes
201	1:9	Modified	K_2CO_3	2,500	20	9	0	1	clear	x	x
201	1:9	Modified	K_2CO_3	2,500	40	9	0	1	clear	x	x
201	1:9	Modified	K_2CO_3	2,500	60	9	0	1	clear	x	x
201	1:9	Modified	K_2CO_3	2,500	80	9	0	1	clear	x	x
201	1:9	Modified	K_2CO_3	2,500	100	9	0	1	clear	x	x
202	1:9	Modified	K_2CO_3	5,000	0	9	0	1			
202	1:9	Modified	K_2CO_3	5,000	3	8.74	0.9	0.36	clear	III	no
202	1:9	Modified	K_2CO_3	5,000	6	8.89	0.25	0.86	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	9	8.89	0.15	0.96	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	13	8.89	0.15	0.96	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	16	8.9	0.1	1	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	20	8.9	0.1	1	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	40	8.9	0.1	1	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	60	8.9	0.1	1	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	80	8.9	0.1	1	clear	III	yes
202	1:9	Modified	K_2CO_3	5,000	100	8.9	0.1	1	clear	III	yes
203	1:9	Modified	K_2CO_3	7,500	0	broken					
204	1:9	Modified	K_2CO_3	10,000	0	9	0	1			
204	1:9	Modified	K_2CO_3	10,000	3	7.92	1.38	0.7	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	6	8	1.3	0.7	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	9	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	13	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	16	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	20	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	40	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	60	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	80	8	1.05	0.95	clear	III	no
204	1:9	Modified	K_2CO_3	10,000	100	8	1.05	0.95	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	0	9	0	1			
205	1:9	Modified	K_2CO_3	12,500	3	8.5	1.5	0	clear	II (-)	no
205	1:9	Modified	K_2CO_3	12,500	6	8.6	1.4	0	clear	II (-)	no
205	1:9	Modified	K_2CO_3	12,500	9	8.7	1.28	0.02	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	13	8.8	1.18	0.02	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	16	8.8	1.18	0.02	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	20	8.8	1.18	0.02	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	40	8.7	1.1	0.2	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	60	8.7	1.1	0.2	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	80	8.7	1.1	0.2	clear	III	no
205	1:9	Modified	K_2CO_3	12,500	100	8.7	1.1	0.2	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	0	9	0	1			
206	1:9	Modified	K_2CO_3	15,000	3	8.5	1.5	0	clear	II (-)	no
206	1:9	Modified	K_2CO_3	15,000	6	8.6	1.4	0	clear	II (-)	no
206	1:9	Modified	K_2CO_3	15,000	9	8.6	1.4	0	clear	II (-)	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
206	1:9	Modified	K_2CO_3	15,000	13	8.7	1.3	0	clear	II (-)	no
206	1:9	Modified	K_2CO_3	15,000	16	8.6	1.35	0.05	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	20	8.6	1	0.4	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	40	8.6	0.95	0.45	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	60	8.6	0.95	0.45	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	80	8.6	0.95	0.45	clear	III	no
206	1:9	Modified	K_2CO_3	15,000	100	8.6	0.95	0.45	clear	III	no
207	1:9	Modified	K_2CO_3	17,500	0	9	0	1			
207	1:9	Modified	K_2CO_3	17,500	3	8.6	1.4	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	6	8.6	1.4	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	9	8.5	1.5	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	13	8.7	1.3	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	16	8.7	1.3	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	20	8.7	1.3	0	clear	II (-)	no
207	1:9	Modified	K_2CO_3	17,500	40	8.7	0.9	0.4	clear	III	no
207	1:9	Modified	K_2CO_3	17,500	60	8.7	0.9	0.4	clear	III	no
207	1:9	Modified	K_2CO_3	17,500	80	8.7	0.9	0.4	clear	III	no
207	1:9	Modified	K_2CO_3	17,500	100	8.7	0.9	0.4	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	0	9	0	1			
208	1:9	Modified	K_2CO_3	20,000	3	8.49	1.5	0.01	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	6	8.49	1.48	0.03	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	9	8.59	1.38	0.03	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	13	8.59	1.38	0.03	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	16	8.59	1.38	0.03	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	20	8.59	1.38	0.03	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	40	8.7	1.2	0.1	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	60	8.7	1.2	0.1	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	80	8.7	1.2	0.1	clear	III	no
208	1:9	Modified	K_2CO_3	20,000	100	8.7	1.2	0.1	clear	III	no
209	3:7	Modified	K_2CO_3	2,500	0	7	0	3			
209	3:7	Modified	K_2CO_3	2,500	3	6.8	0.21	2.99	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	6	6.9	0.1	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	9	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	13	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	16	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	20	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	40	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	60	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	80	6.95	0.05	3	clear	III	yes
209	3:7	Modified	K_2CO_3	2,500	100	6.95	0.05	3	clear	III	yes
210	3:7	Modified	K_2CO_3	5,000	0	7	0	3			
210	3:7	Modified	K_2CO_3	5,000	3	5.7	2.45	1.85	clear	III	no
210	3:7	Modified	K_2CO_3	5,000	6	6.2	1.05	2.75	clear	III	no
210	3:7	Modified	K_2CO_3	5,000	9	6.3	0.7	3	clear	III	no
210	3:7	Modified	K_2CO_3	5,000	13	6.5	0.5	3	clear	III	no
210	3:7	Modified	K_2CO_3	5,000	16	6.7	0.3	3	clear	III	yes
210	3:7	Modified	K_2CO_3	5,000	20	6.7	0.3	3	clear	III	yes
210	3:7	Modified	K_2CO_3	5,000	40	6.7	0.3	3	clear	III	yes
210	3:7	Modified	K_2CO_3	5,000	60	6.7	0.3	3	clear	III	yes
210	3:7	Modified	K_2CO_3	5,000	80	6.7	0.3	3	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
210	3:7	Modified	K_2CO_3	5,000	100	6.7	0.3	3	clear	III	yes
211	3:7	Modified	K_2CO_3	7,500	0	7	0	3			
211	3:7	Modified	K_2CO_3	7,500	3	5.3	4.7	0	high turbidity	II (-)	no
211	3:7	Modified	K_2CO_3	7,500	6	5.5	4.5	0	high turbidity	II (-)	no
211	3:7	Modified	K_2CO_3	7,500	9	6	4	0	high turbidity	II (-)	no
211	3:7	Modified	K_2CO_3	7,500	13	6.2	3.7	0.1	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	16	6.2	3.7	0.1	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	20	6.2	3	0.8	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	40	6.2	2.2	1.6	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	60	6.2	1.4	2.4	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	80	6.2	1.4	2.4	high turbidity	III	no
211	3:7	Modified	K_2CO_3	7,500	100	6.2	1.4	2.4	high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	0	7	0	3			
212	3:7	Modified	K_2CO_3	10,000	3	4.95	5	0.05	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	6	5.3	4.6	0.1	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	9	5.6	4.3	0.1	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	13	5.7	4.15	0.15	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	16	5.8	4.05	0.15	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	20	5.8	3.7	0.5	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	40	5.8	3.7	0.5	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	60	5.8	3.7	0.5	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	80	5.8	3.7	0.5	yellow, high turbidity	III	no
212	3:7	Modified	K_2CO_3	10,000	100	5.8	3.7	0.5	yellow, high turbidity	III	no
213	3:7	Modified	K_2CO_3	12,500	0	7	0	3			
213	3:7	Modified	K_2CO_3	12,500	3	4.7	5.25	0.05	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	6	5.1	4.85	0.05	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	9	5.3	4.6	0.1	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	13	5.45	4.45	0.1	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	16	5.5	4.4	0.1	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	20	5.5	4.4	0.1	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	40	5.5	2.5	2	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	60	5.9	2.4	1.7	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	80	5.9	2.2	1.9	yellow, clear	III	no
213	3:7	Modified	K_2CO_3	12,500	100	5.9	2.2	1.9	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	0	7	0	3			
214	3:7	Modified	K_2CO_3	15,000	3	4.5	5.45	0.05	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	6	5.1	4.8	0.1	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	9	5.4	4.45	0.15	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	13	5.5	4.3	0.2	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	16	5.5	4.3	0.2	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	20	5.5	3	1.5	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	40	5.5	3	1.5	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	60	5.5	3	1.5	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	80	5.5	3	1.5	yellow, clear	III	no
214	3:7	Modified	K_2CO_3	15,000	100	5.5	3	1.5	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	0	7	0	3			
215	3:7	Modified	K_2CO_3	17,500	3	3.5	6.5	0	yellow, clear	II (-)	no
215	3:7	Modified	K_2CO_3	17,500	6	4.9	5.08	0.02	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	9	5.2	4.78	2.2	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	13	5.34	4.64	2.3	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
215	3:7	Modified	K_2CO_3	17,500	16	5.4	4	2.4	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	20	5.4	3.5	2.4	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	40	5.9	2.3	1.8	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	60	5.9	2.3	2.65	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	80	5.9	2.3	2.65	yellow, clear	III	no
215	3:7	Modified	K_2CO_3	17,500	100	5.9	2.3	2.7	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	0	7	0	3			
216	3:7	Modified	K_2CO_3	20,000	3	4.5	5.45	0	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	6	5.1	4.85	2.2	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	9	5.3	4.6	2.2	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	13	5.45	4.45	2.25	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	16	5.5	3.2	2.3	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	20	5.5	3	2.3	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	40	6	2.5	2.3	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	60	6	2.5	2.2	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	80	6	2.5	2.2	yellow, clear	III	no
216	3:7	Modified	K_2CO_3	20,000	100	6	2.5	2.2	yellow, clear	III	no
217	5:5	Modified	K_2CO_3	2,500	0	5	0	5			
217	5:5	Modified	K_2CO_3	2,500	3	4.8	0.35	4.85	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	6	5	0.05	4.95	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	9	5	0.05	4.95	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	13	5	0.05	4.95	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	16	4.95	0.05	5	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	20	4.95	0.05	5	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	40	4.95	0.05	5	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	60	4.95	0.05	5	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	80	4.95	0.05	5	clear	III	yes
217	5:5	Modified	K_2CO_3	2,500	100	4.95	0.05	5	clear	III	yes
218	5:5	Modified	K_2CO_3	5,000	0	5	0	5			
218	5:5	Modified	K_2CO_3	5,000	3	3.8	6	0.2	clear	III	no
218	5:5	Modified	K_2CO_3	5,000	6	4.1	5.1	0.8	clear	III	no
218	5:5	Modified	K_2CO_3	5,000	9	4.4	3.5	2.1	clear	III	no
218	5:5	Modified	K_2CO_3	5,000	13	4.5	3.1	2.4	clear	III	no
218	5:5	Modified	K_2CO_3	5,000	16	4.7	0.8	4.5	clear	III	no
218	5:5	Modified	K_2CO_3	5,000	20	4.85	0.35	4.8	clear	III	yes
218	5:5	Modified	K_2CO_3	5,000	40	5	0.35	4.65	clear	III	yes
218	5:5	Modified	K_2CO_3	5,000	60	5	0.1	4.9	clear	III	yes
218	5:5	Modified	K_2CO_3	5,000	80	5	0.1	4.9	clear	III	yes
218	5:5	Modified	K_2CO_3	5,000	100	5	0.1	4.9	clear	III	yes
219	5:5	Modified	K_2CO_3	7,500	0	5	0	5			
219	5:5	Modified	K_2CO_3	7,500	3	3.4	6.4	0.2	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	6	3.9	5.4	0.7	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	9	4	4.1	1.9	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	13	4.2	2.2	3.6	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	16	4.3	1.2	4.5	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	20	4.5	0.5	5	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	40	4.5	0.5	5	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	60	4.5	0.5	5	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	80	4.5	0.5	5	yellow, clear	III	no
219	5:5	Modified	K_2CO_3	7,500	100	4.5	0.5	5	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
220	5:5	Modified	K_2CO_3	10,000	0	5	0	5			
220	5:5	Modified	K_2CO_3	10,000	3	2.2	7.65	0.15	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	6	2.65	7	0.35	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	9	3.3	6.2	0.5	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	13	3.5	5.5	1	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	16	3.5	5.5	1	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	20	3.6	3.2	3.2	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	40	3.6	3	3.4	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	60	3.6	1.5	4.9	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	80	4.6	0.5	4.9	yellow, clear	III	no
220	5:5	Modified	K_2CO_3	10,000	100	4.6	0.5	4.9	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	0	5	0	5			
221	5:5	Modified	K_2CO_3	12,500	3	1.35	8.6	0.05	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	6	2.2	7.7	0.1	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	9	2.6	7.25	0.15	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	13	2.8	6.8	0.4	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	16	3	6.8	0.2	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	20	3.1	4	2.9	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	40	3.1	4	2.9	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	60	3.1	2.3	4.6	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	80	3.2	1.8	5	yellow, clear	III	no
221	5:5	Modified	K_2CO_3	12,500	100	3.2	1.8	5	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	0	5	0	5			
222	5:5	Modified	K_2CO_3	15,000	3	1.5	8.05	0.45	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	6	1.6	7.7	0.7	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	9	2	7.1	0.9	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	13	2.3	6.8	0.9	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	16	2.5	4	3.5	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	20	2.5	3.5	4	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	40	2.5	3.5	4	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	60	2.5	2.7	4.8	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	80	3.1	2	4.9	yellow, clear	III	no
222	5:5	Modified	K_2CO_3	15,000	100	3.1	2	4.9	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	0	5	0	5			
223	5:5	Modified	K_2CO_3	17,500	3	0.95	8.9	0.15	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	6	1.7	8	0.3	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	9	2.2	7.4	0.4	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	13	2.35	7.15	0.5	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	16	2.6	6.9	0.5	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	20	2.6	3.9	3.5	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	40	3.3	3.9	2.8	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	60	3.3	3.2	3.5	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	80	3.3	3.2	3.5	yellow, clear	III	no
223	5:5	Modified	K_2CO_3	17,500	100	3.3	3.2	3.5	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	0	5	0	5			
224	5:5	Modified	K_2CO_3	20,000	3	1.85	8.1	0.05	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	6	1.85	8.07	0.08	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	9	1.8	8	0.2	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	13	2	7.8	0.2	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	16	2.2	7.5	0.3	yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
224	5:5	Modified	K_2CO_3	20,000	20	2.4	5	2.6	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	40	3.1	5	1.9	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	60	3.1	4	2.9	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	80	3.1	4	2.9	yellow, clear	III	no
224	5:5	Modified	K_2CO_3	20,000	100	3.1	4	2.9	yellow, clear	III	no
225	7:3	Modified	K_2CO_3	2,500	0	3	0	7			
225	7:3	Modified	K_2CO_3	2,500	3	2.9	0.2	6.9	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	6	3	0.05	6.95	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	9	3	0.03	6.97	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	13	3	0.03	6.97	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	16	3	0.03	6.97	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	20	3	0.03	6.97	clear	III	yes
225	7:3	Modified	K_2CO_3	2,500	40	3	0	7	clear	x	x
225	7:3	Modified	K_2CO_3	2,500	60	3	0	7	clear	x	x
225	7:3	Modified	K_2CO_3	2,500	80	3	0	7	clear	x	x
225	7:3	Modified	K_2CO_3	2,500	100	3	0	7	clear	x	x
226	7:3	Modified	K_2CO_3	5,000	0	3	0	7			
226	7:3	Modified	K_2CO_3	5,000	3	2.3	2.45	5.25	clear	III	no
226	7:3	Modified	K_2CO_3	5,000	6	2.3	1.05	6.65	clear	III	no
226	7:3	Modified	K_2CO_3	5,000	9	2.6	0.7	6.7	clear	III	no
226	7:3	Modified	K_2CO_3	5,000	13	2.7	0.5	6.8	clear	III	no
226	7:3	Modified	K_2CO_3	5,000	16	2.7	0.3	7	clear	III	yes
226	7:3	Modified	K_2CO_3	5,000	20	2.7	0.3	7	clear	III	yes
226	7:3	Modified	K_2CO_3	5,000	40	2.7	0.3	7	clear	III	yes
226	7:3	Modified	K_2CO_3	5,000	60	2.7	0.3	7	clear	III	yes
226	7:3	Modified	K_2CO_3	5,000	80	2.7	0.3	7	clear	III	yes
226	7:3	Modified	K_2CO_3	5,000	100	2.7	0.3	7	clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	0	3	0	7			
227	7:3	Modified	K_2CO_3	7,500	3	2.4	1.8	5.8	yellow, clear	III	no
227	7:3	Modified	K_2CO_3	7,500	6	2.5	1.5	6	yellow, clear	III	no
227	7:3	Modified	K_2CO_3	7,500	9	2.4	0.95	6.65	yellow, clear	III	no
227	7:3	Modified	K_2CO_3	7,500	13	2.9	0.25	6.85	yellow, clear	III	no
227	7:3	Modified	K_2CO_3	7,500	16	2.9	0.2	6.9	yellow, clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	20	2.9	0.2	6.9	yellow, clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	40	2.9	0.2	6.9	yellow, clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	60	2.9	0.2	6.9	yellow, clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	80	2.9	0.2	6.9	yellow, clear	III	yes
227	7:3	Modified	K_2CO_3	7,500	100	2.9	0.2	6.9	yellow, clear	III	yes
228	7:3	Modified	K_2CO_3	10,000	0	3	0	7			
228	7:3	Modified	K_2CO_3	10,000	3	2.1	3	4.9	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	6	2.2	2.7	5.1	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	9	2.4	2.4	5.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	13	2.5	2	5.5	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	16	2.9	1.9	5.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	20	3.05	0.75	6.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	40	3.05	0.75	6.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	60	3.05	0.75	6.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	80	3.05	0.75	6.2	yellow, clear	III	no
228	7:3	Modified	K_2CO_3	10,000	100	3.05	0.75	6.2	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	0	3	0	7			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
229	7:3	Modified	K_2CO_3	12,500	3	1.8	4	4.2	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	6	2.1	3.7	4.2	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	9	2.4	1.3	6.3	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	13	2.5	1.3	6.2	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	16	3	0.5	6.5	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	20	3	0.5	6.5	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	40	2.9	0.5	6.6	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	60	2.9	0.1	7	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	80	2.9	0.1	7	yellow, clear	III	no
229	7:3	Modified	K_2CO_3	12,500	100	2.9	0.1	7	yellow, clear	III	no
230	7:3	Modified	K_2CO_3	15,000	0	broken					
231	7:3	Modified	K_2CO_3	17,500	0	3	0	7			
231	7:3	Modified	K_2CO_3	17,500	3	1.95	2.9	5.15	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	6	2.1	2.75	5.15	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	9	2.3	2.6	5.1	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	13	2.4	2	5.6	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	16	2.7	1.8	5.5	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	20	2.7	0.9	6.4	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	40	2.8	0.9	6.3	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	60	2.8	0.9	6.3	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	80	2.8	0.9	6.3	yellow, clear	III	no
231	7:3	Modified	K_2CO_3	17,500	100	2.8	0.9	6.3	yellow, clear	III	no
232	7:3	Modified	K_2CO_3	20,000	0	broken					
233	9:1	Modified	K_2CO_3	2,500	0	1	0	9			
233	9:1	Modified	K_2CO_3	2,500	3	0.95	0.05	9	yellow, clear	III	no
233	9:1	Modified	K_2CO_3	2,500	6	0.95	0.05	9	yellow, clear	III	no
233	9:1	Modified	K_2CO_3	2,500	9	0.95	0.03	9.02	yellow, clear	III	no
233	9:1	Modified	K_2CO_3	2,500	13	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	16	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	20	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	40	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	60	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	80	0.95	0	9.05	yellow, clear	x	x
233	9:1	Modified	K_2CO_3	2,500	100	0.95	0	9.05	yellow, clear	x	x
234	9:1	Modified	K_2CO_3	5,000	0	1	0	9			
234	9:1	Modified	K_2CO_3	5,000	3	0.9	0.3	8.8	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	6	0.9	0.3	8.8	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	9	0.9	0.3	8.8	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	13	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	16	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	20	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	40	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	60	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	80	0.9	0.15	8.95	yellow, clear	III	yes
234	9:1	Modified	K_2CO_3	5,000	100	0.9	0.15	8.95	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	0	1	0	9			
235	9:1	Modified	K_2CO_3	7,500	3	0.9	0.1	9	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	6	0.9	0.1	9	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	9	0.9	0.1	9	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	13	0.9	0.1	9	yellow, clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
235	9:1	Modified	K_2CO_3	7,500	16	0.9	0.2	8.9	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	20	0.9	0.2	8.9	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	40	1	0.2	8.8	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	60	1	0.2	8.8	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	80	1	0.2	8.8	yellow, clear	III	yes
235	9:1	Modified	K_2CO_3	7,500	100	1	0.2	8.8	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	0	1	0	9			
236	9:1	Modified	K_2CO_3	10,000	3	1	0	9	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	6	0.95	0.15	8.9	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	9	0.95	0.15	8.9	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	13	0.95	0.15	8.9	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	16	0.95	0.1	8.95	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	20	0.95	0.1	8.95	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	40	0.95	0.1	8.95	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	60	0.95	0.1	8.95	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	80	0.95	0.1	8.95	yellow, clear	III	yes
236	9:1	Modified	K_2CO_3	10,000	100	0.95	0.1	8.95	yellow, clear	III	yes
237	9:1	Modified	K_2CO_3	12,500	0	1	0	9			
237	9:1	Modified	K_2CO_3	12,500	3	1	0.03	8.97	yellow, clear	III	yes
237	9:1	Modified	K_2CO_3	12,500	6	1	0.03	8.97	yellow, clear	III	yes
237	9:1	Modified	K_2CO_3	12,500	9	1	0.03	8.97	yellow, clear	III	yes
237	9:1	Modified	K_2CO_3	12,500	13	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	16	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	20	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	40	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	60	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	80	broken			yellow, clear	x	x
237	9:1	Modified	K_2CO_3	12,500	100	broken			yellow, clear	x	x
238	9:1	Modified	K_2CO_3	15,000	0	1	0	9			
238	9:1	Modified	K_2CO_3	15,000	3	0.95	0.45	8.6	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	6	0.95	0.45	8.6	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	9	0.95	0.45	8.6	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	13	0.95	0.45	8.6	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	16	0.95	0.45	8.6	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	20	0.95	0.15	8.9	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	40	0.95	0.15	8.9	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	60	0.95	0.15	8.9	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	80	0.95	0.15	8.9	yellow, clear	III	yes
238	9:1	Modified	K_2CO_3	15,000	100	0.95	0.15	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	0	1	0	9			
239	9:1	Modified	K_2CO_3	17,500	3	1	0.5	8.5	yellow, clear	III	no
239	9:1	Modified	K_2CO_3	17,500	6	1	0.5	8.5	yellow, clear	III	no
239	9:1	Modified	K_2CO_3	17,500	9	1	0.5	8.5	yellow, clear	III	no
239	9:1	Modified	K_2CO_3	17,500	13	1	0.5	8.5	yellow, clear	III	no
239	9:1	Modified	K_2CO_3	17,500	16	1	0.1	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	20	1	0.1	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	40	1	0.1	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	60	1	0.1	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	80	1	0.1	8.9	yellow, clear	III	yes
239	9:1	Modified	K_2CO_3	17,500	100	1	0.1	8.9	yellow, clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
240	9:1	Modified	K_2CO_3	20,000	0	1	0	9			
240	9:1	Modified	K_2CO_3	20,000	3	0.95	0.55	8.5	yellow, clear	III	no
240	9:1	Modified	K_2CO_3	20,000	6	0.95	0.55	8.5	yellow, clear	III	no
240	9:1	Modified	K_2CO_3	20,000	9	0.95	0.55	8.5	yellow, clear	III	no
240	9:1	Modified	K_2CO_3	20,000	13	0.95	0.3	8.75	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	16	0.95	0.25	8.8	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	20	0.95	0.25	8.8	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	40	0.95	0.25	8.8	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	60	0.95	0.25	8.8	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	80	0.95	0.25	8.8	yellow, clear	III	yes
240	9:1	Modified	K_2CO_3	20,000	100	0.95	0.25	8.8	yellow, clear	III	yes

16.TH: Formulation 4a: Alkalis + Co-Solvents @ 60°C (AC Slug)

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	0	5.0	0.0	5.0			
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	3	0.0	10.0	0.0	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	6	0.1	9.8	0.1	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	9	0.3	9.6	0.1	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	13	1.0	8.8	0.2	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	16	1.4	8.4	0.2	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	20	1.7	8.1	0.2	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	40	2.1	7.3	0.7	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	60	2.5	5.7	1.9	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	80	3.4	3.3	3.4	yellow, clear	III	no
241	5:5	Modified	Na_2CO_3	5,000	1	1,000	100	4.8	0.3	4.9	yellow, clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	0	5.0	0.0	5.0			
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	3	3.5	2.6	3.9	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	6	3.5	2.3	4.2	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	9	4.3	2.0	3.7	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	13	4.8	2.0	3.3	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	16	4.9	1.2	3.9	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	20	4.9	0.8	4.4	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	40	4.9	0.5	4.6	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	60	4.9	0.5	4.6	clear	III	no
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	80	5.0	0.4	4.6	clear	III	yes
242	5:5	Modified	Na_2CO_3	7,500	1	1,000	100	5.0	0.4	4.6	clear	III	yes
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	0	5.0	0.0	5.0			
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	3	0.0	10.0	0.0	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	6	4.7	1.1	4.2	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	9	4.7	0.7	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	13	4.7	0.7	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	16	4.7	0.7	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	20	4.8	0.6	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	40	4.8	0.6	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	60	4.8	0.6	4.6	clear	III	no
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	80	4.8	1.0	4.3	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
243	5:5	Modified	Na_2CO_3	10,000	1	1,000	100	4.8	1.3	3.9	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	0	5.0	0.0	5.0			
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	3	4.7	0.7	4.6	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	6	4.7	0.7	4.6	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	9	4.7	0.7	4.6	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	13	4.7	0.7	4.6	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	16	4.9	0.6	4.5	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	20	5.0	0.5	4.5	clear	III	no
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	40	5.0	0.4	4.7	clear	III	yes
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	60	5.0	0.3	4.7	clear	III	yes
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	80	5.0	0.1	4.9	clear	III	yes
244	5:5	Modified	Na_2CO_3	5,000	1	2,000	100	5.0	0.1	4.9	clear	III	yes
245	5:5	Modified	Na_2CO_3	7,500	1	2,000	0	broken					
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	0	5.0	0.0	5.0	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	3	0.0	6.0	4.0	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	6	3.6	2.0	4.4	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	9	3.4	2.3	4.4	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	13	4.1	1.6	4.4	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	16	4.2	1.5	4.4	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	20	4.7	1.0	4.3	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	40	4.8	1.0	4.2	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	60	4.8	1.0	4.2	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	80	4.8	1.0	4.2	clear	III	no
246	5:5	Modified	Na_2CO_3	10,000	1	2,000	100	4.8	1.0	4.2	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	0	5.0	0.0	5.0			
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	3	4.6	1.3	4.1	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	6	4.7	0.8	4.6	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	9	4.7	0.7	4.6	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	13	4.8	0.6	4.7	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	16	4.8	0.6	4.7	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	20	4.8	0.5	4.7	clear	III	no
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	40	5.0	0.5	4.6	clear	III	yes
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	60	5.0	0.5	4.6	clear	III	yes
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	80	5.0	0.5	4.6	clear	III	yes
247	5:5	Modified	Na_2CO_3	5,000	1	4,000	100	5.0	0.5	4.6	clear	III	yes
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	0	5.0	0.0	5.0			
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	3	4.4	1.0	4.6	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	6	4.5	0.9	4.7	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	9	4.5	0.9	4.7	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	13	4.5	0.7	4.8	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	16	4.7	0.6	4.8	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	20	4.7	0.6	4.8	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	40	4.8	0.6	4.7	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	60	4.9	0.6	4.6	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	80	5.0	0.6	4.5	clear	III	no
248	5:5	Modified	Na_2CO_3	7,500	1	4,000	100	5.0	0.6	4.5	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	0	5.0	0.0	5.0			
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	3	4.3	1.2	4.6	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	6	4.3	1.0	4.7	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	9	4.7	1.0	4.4	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	13	4.7	0.9	4.4	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	16	4.7	0.8	4.5	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	20	4.7	0.8	4.5	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	40	4.7	0.8	4.6	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	60	4.7	0.8	4.6	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	80	4.7	0.8	4.6	clear	III	no
249	5:5	Modified	Na_2CO_3	10,000	1	4,000	100	4.7	0.8	4.6	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	0	5.0	0.0	5.0			
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	3	4.2	1.6	4.2	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	6	4.8	0.6	4.7	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	9	4.8	0.6	4.7	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	13	4.8	0.6	4.7	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	16	4.8	0.6	4.7	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	20	4.9	0.5	4.7	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	40	4.9	0.6	4.6	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	60	4.9	0.3	4.9	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	80	4.9	0.3	4.8	clear	III	no
250	5:5	Modified	Na_2CO_3	5,000	1	5,000	100	4.9	0.3	4.8	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	0	5.0	0.0	5.0			
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	3	4.7	0.7	4.6	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	6	4.7	0.7	4.6	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	9	4.7	0.7	4.6	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	13	4.7	0.7	4.7	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	16	4.8	0.6	4.6	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	20	4.8	0.6	4.7	clear	III	no
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	40	4.8	0.7	4.5	clear	III	yes
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	60	4.8	0.8	4.4	clear	III	yes
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	80	4.8	0.9	4.3	clear	III	yes
251	5:5	Modified	Na_2CO_3	7,500	1	5,000	100	4.8	1.0	4.2	clear	III	yes
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	0	5.0	0.0	5.0			
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	3	4.8	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	6	4.7	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	9	4.7	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	13	4.7	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	16	4.8	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	20	4.8	0.7	4.6	clear	III	no
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	40	4.8	0.7	4.6	clear	III	yes
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	60	4.8	0.9	4.3	clear	III	yes
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	80	4.8	1.0	4.2	clear	III	yes
252	5:5	Modified	Na_2CO_3	10,000	1	5,000	100	4.9	1.1	4.0	clear	III	yes
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	0	5.0	0.0	5.0			
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	3	4.7	1.1	4.2	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	6	4.8	1.0	4.2	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	9	4.8	1.0	4.2	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	13	4.8	1.0	4.2	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	16	4.8	1.0	4.2	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	20	4.8	0.7	4.5	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	40	4.8	0.6	4.6	yellow, clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	60	4.8	0.6	4.6	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	80	4.8	0.4	4.9	yellow, clear	III	no
253	5:5	Dead	Na_2CO_3	5,000	1	1,000	100	4.8	0.3	5.0	yellow, clear	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	0	5.0	0.0	5.0			
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	3	3.9	5.7	0.4	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	6	4.1	5.7	0.2	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	9	4.5	5.3	0.2	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	13	4.7	4.8	0.6	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	16	4.7	0.8	4.6	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	20	4.5	0.8	4.7	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	40	4.5	0.8	4.7	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	60	4.5	0.8	4.8	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	80	4.5	0.6	5.0	light brown, high turbidity	III	no
254	5:5	Dead	Na_2CO_3	7,500	1	1,000	100	4.5	0.3	5.2	light brown, high turbidity	III	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	0	5.0	0.0	5.0			
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	3	4.8	5.2	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	6	4.9	5.1	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	9	5.0	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	13	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	16	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	20	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	40	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	60	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	80	5.1	5.0	0.0	x	II (-)	no
255	5:5	Dead	Na_2CO_3	10,000	1	1,000	100	5.1	5.0	0.0	x	II (-)	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	0	5.0	0.0	5.0			
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	3	4.8	0.9	4.3	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	6	4.7	1.1	4.2	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	9	4.7	1.1	4.2	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	13	4.7	1.2	4.1	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	16	4.7	1.1	4.2	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	20	4.7	1.0	4.3	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	40	4.7	0.8	4.5	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	60	4.8	0.8	4.4	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	80	4.9	0.6	4.6	yellow, clear	III	no
256	5:5	Dead	Na_2CO_3	5,000	1	2,000	100	4.9	0.3	4.9	yellow, clear	III	yes
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	0	5.0	0.0	5.0			
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	3	4.4	2.9	2.7	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	6	4.6	3.2	2.2	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	9	4.6	3.2	2.2	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	13	4.6	3.1	2.4	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	16	4.8	1.8	3.4	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	20	4.8	1.6	3.7	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	40	4.8	1.4	3.9	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	60	4.8	1.2	4.1	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	80	4.8	0.9	4.4	yellow, clear	III	no
257	5:5	Dead	Na_2CO_3	7,500	1	2,000	100	4.8	0.4	4.9	yellow, clear	III	yes
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	0	5.0	0.0	5.0			
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	3	4.6	5.4	0.0	x	II (-)	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	6	4.7	5.3	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	9	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	13	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	16	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	20	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	40	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	60	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	80	4.9	5.1	0.0	x	II (-)	no
258	5:5	Dead	Na_2CO_3	10,000	1	2,000	100	4.9	5.1	0.0	x	II (-)	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	0	5.0	0.0	5.0			
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	3	4.6	1.5	3.9	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	6	4.6	1.4	4.1	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	9	4.7	1.3	4.1	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	13	4.7	1.2	4.2	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	16	4.7	1.0	4.3	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	20	4.9	0.5	4.6	clear	III	no
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	40	4.9	0.5	4.6	clear	III	yes
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	60	4.9	0.5	4.6	clear	III	yes
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	80	4.9	0.5	4.6	clear	III	yes
259	5:5	Dead	Na_2CO_3	5,000	1	4,000	100	4.9	0.5	4.6	clear	III	yes
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	0	5.0	0.0	5.0			
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	3	4.5	1.0	4.5	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	6	4.6	0.9	4.6	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	9	4.6	0.9	4.5	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	13	4.7	0.9	4.5	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	16	4.8	0.8	4.4	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	20	4.9	0.6	4.6	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	40	4.9	0.5	4.7	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	60	4.9	0.5	4.6	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	80	4.9	0.5	4.6	clear	III	no
260	5:5	Dead	Na_2CO_3	7,500	1	4,000	100	4.9	0.5	4.6	clear	III	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	0	5.0	0.0	5.0			
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	3	4.8	5.3	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	6	4.8	5.3	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	9	4.8	5.3	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	13	4.8	5.3	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	16	4.9	5.1	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	20	4.9	5.1	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	40	4.9	5.1	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	60	4.9	5.1	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	80	4.9	5.1	0.0	x	II (-)	no
261	5:5	Dead	Na_2CO_3	10,000	1	4,000	100	4.9	5.1	0.0	x	II (-)	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	0	5.0	0.0	5.0			
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	3	4.7	2.0	3.3	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	6	4.8	1.7	3.5	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	9	4.8	1.9	3.3	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	13	4.8	1.9	3.3	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	16	4.8	1.7	3.6	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	20	4.8	1.3	3.9	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	40	4.8	1.3	3.9	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	60	4.8	0.6	4.7	clear	III	no
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	80	4.8	0.4	4.9	clear	III	yes
262	5:5	Dead	Na_2CO_3	5,000	1	5,000	100	4.8	0.2	5.0	clear	III	yes
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	0	5.0	0.0	5.0			
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	3	4.9	5.2	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	6	4.8	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	9	4.8	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	13	4.8	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	16	4.7	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	20	4.7	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	40	4.7	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	60	4.7	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	80	4.7	5.3	0.0	x	II (-)	no
263	5:5	Dead	Na_2CO_3	7,500	1	5,000	100	4.7	5.3	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	0	5.0	0.0	5.0			
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	3	4.8	5.3	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	6	4.8	5.3	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	9	4.8	5.3	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	13	4.8	5.3	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	16	4.9	5.1	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	20	4.9	5.1	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	40	4.9	5.1	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	60	4.9	5.1	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	80	4.9	5.1	0.0	x	II (-)	no
264	5:5	Dead	Na_2CO_3	10,000	1	5,000	100	4.9	5.1	0.0	x	II (-)	no
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	0	5.0	0.0	5.0			
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	3	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	6	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	9	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	13	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	16	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	20	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	40	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	60	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	80	5.0	0.0	5.0	x	x	x
265	5:5	Dead	Na_2CO_3	5,000	2	2,000	100	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	0	5.0	0.0	5.0			
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	3	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	6	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	9	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	13	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	16	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	20	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	40	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	60	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	80	5.0	0.0	5.0	x	x	x
266	5:5	Dead	Na_2CO_3	7,500	2	2,000	100	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	0	5.0	0.0	5.0			

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	3	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	6	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	9	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	13	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	16	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	20	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	40	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	60	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	80	5.0	0.0	5.0	x	x	x
267	5:5	Dead	Na_2CO_3	10,000	2	2,000	100	5.0	0.0	5.0	x	x	x
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	0	5.0	0.0	5.0			
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	3	3.5	2.3	4.2	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	6	3.7	2.0	4.4	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	9	3.8	1.8	4.5	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	13	3.9	1.0	5.2	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	16	4.3	1.0	4.8	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	20	4.3	0.9	4.8	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	40	4.3	0.9	4.9	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	60	4.3	0.9	4.9	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	80	4.3	0.9	4.9	brown, high turbidity	III	no
268	5:5	Dead	Na_2CO_3	5,000	2	4,000	100	4.3	0.9	4.9	brown, high turbidity	III	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	0	5.0	0.0	5.0			
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	3	4.0	6.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	6	4.2	5.8	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	9	4.5	5.5	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	13	4.8	5.3	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	16	5.0	5.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	20	5.0	5.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	40	5.0	5.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	60	5.0	5.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	80	5.0	5.0	0.0	x	II (-)	no
269	5:5	Dead	Na_2CO_3	7,500	2	4,000	100	5.0	5.0	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	0	5.0	0.0	5.0			
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	3	4.0	6.0	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	6	4.0	6.0	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	9	4.5	5.5	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	13	4.5	5.5	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	16	4.5	5.5	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	20	4.5	5.5	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	40	4.6	5.4	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	60	4.7	5.3	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	80	4.7	5.3	0.0	x	II (-)	no
270	5:5	Dead	Na_2CO_3	10,000	2	4,000	100	4.7	5.3	0.0	x	II (-)	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	0	5.0	0.0	5.0			
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	3	0.4	9.6	0.0	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	6	1.4	8.3	0.3	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	9	1.6	8.1	0.3	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	13	1.9	7.8	0.3	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	16	1.9	7.8	0.3	light yellow, high turbidity	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	20	2.8	6.7	0.5	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	40	2.9	6.4	0.8	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	60	3.0	6.3	0.8	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	80	3.2	5.3	1.6	light yellow, high turbidity	III	no
271	5:5	Dead	Na_2CO_3	5,000	2	5,000	100	3.3	4.7	2.1	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	0	5.0	0.0	5.0			
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	3	0.2	9.7	0.1	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	6	0.7	9.0	0.3	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	9	0.9	8.6	0.5	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	13	1.0	8.5	0.5	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	16	1.3	8.3	0.4	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	20	1.5	8.0	0.5	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	40	1.8	7.5	0.7	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	60	1.8	7.3	0.9	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	80	2.1	5.6	2.4	light yellow, high turbidity	III	no
272	5:5	Dead	Na_2CO_3	7,500	2	5,000	100	2.2	4.2	3.6	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	0	5.0	0.0	5.0			
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	3	0.1	9.9	0.1	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	6	0.3	9.5	0.2	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	9	0.3	9.4	0.3	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	13	0.4	9.2	0.4	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	16	0.6	9.0	0.4	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	20	0.8	8.8	0.4	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	40	0.8	8.1	1.2	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	60	1.0	7.7	1.3	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	80	1.1	5.9	3.1	light yellow, high turbidity	III	no
273	5:5	Dead	Na_2CO_3	10,000	2	5,000	100	1.4	4.9	3.8	light yellow, high turbidity	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	0	5.0	0.0	5.0			
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	3	4.5	1.3	4.2	clear	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	6	4.9	0.8	4.4	clear	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	9	5.0	0.5	4.5	clear	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	13	5.0	0.3	4.7	clear	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	16	5.0	0.1	4.9	clear	III	no
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	20	5.0	0.0	5.0	clear	x	x
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	40	5.0	0.0	5.0	clear	x	x
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	60	5.0	0.0	5.0	clear	x	x
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	80	5.0	0.0	5.0	clear	x	x
274	5:5	Modified	Na_2CO_3	5,000	2	4,000	100	5.0	0.0	5.0	clear	x	x
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	0	5.0	0.0	5.0			
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	3	0.1	8.5	1.4	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	6	0.1	8.5	1.4	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	9	0.2	8.0	1.8	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	13	0.2	7.3	2.5	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	16	0.5	7.0	2.5	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	20	0.8	6.8	2.5	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	40	0.8	6.5	2.7	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	60	0.9	6.5	2.7	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	80	0.9	6.5	2.7	clear	III	no
275	5:5	Modified	Na_2CO_3	7,500	2	4,000	100	0.9	6.5	2.6	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	0	5.0	0.0	5.0			
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	3	4.7	0.5	4.8	clear	III	no
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	6	4.7	0.5	4.8	clear	III	no
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	9	4.8	0.3	4.9	clear	III	yes
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	13	4.9	0.3	4.9	clear	III	yes
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	16	5.0	0.0	5.0	clear	x	x
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	20	5.0	0.0	5.0	clear	x	x
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	40	5.0	0.0	5.0	clear	x	x
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	60	5.0	0.0	5.0	clear	x	x
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	80	5.0	0.0	5.0	clear	x	x
276	5:5	Modified	Na_2CO_3	10,000	2	4,000	100	5.0	0.0	5.0	clear	x	x
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	0	5.0	0.0	5.0			
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	3	0.2	9.8	0.0	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	6	0.5	9.3	0.2	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	9	1.0	8.8	0.3	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	13	2.1	7.5	0.4	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	16	3.2	5.0	1.9	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	20	3.3	3.9	2.9	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	40	3.9	2.1	4.0	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	60	3.9	1.0	5.2	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	80	3.9	0.8	5.4	clear	III	no
277	5:5	Modified	Na_2CO_3	5,000	3	2,000	100	3.9	0.5	5.6	clear	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	0	5.0	0.0	5.0			
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	3	0.2	9.8	0.0	clear, precipitation	II (-)	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	6	0.4	9.5	0.2	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	9	0.7	9.1	0.2	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	13	2.0	7.8	0.3	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	16	3.0	6.9	0.1	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	20	3.5	5.9	0.7	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	40	4.0	4.1	2.0	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	60	4.0	2.6	3.5	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	80	4.0	1.4	4.7	clear, precipitation	III	no
278	5:5	Modified	Na_2CO_3	7,500	3	2,000	100	4.0	0.7	5.4	clear, precipitation	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	0	5.0	0.0	5.0			
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	3	0.3	9.8	0.0	clear	II (-)	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	6	0.5	9.4	0.2	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	9	0.8	9.0	0.2	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	13	2.5	7.3	0.2	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	16	3.0	6.8	0.2	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	20	3.5	5.7	0.8	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	40	3.9	5.1	1.0	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	60	3.9	3.3	2.8	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	80	3.9	1.8	4.4	clear	III	no
279	5:5	Modified	Na_2CO_3	8,000	3	2,000	100	3.9	0.9	5.2	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	0	5.0	0.0	5.0			
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	3	0.3	9.8	0.0	clear	II (-)	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	6	0.6	9.4	0.0	clear	II (-)	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	9	1.0	9.0	0.1	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	13	2.5	7.5	0.0	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	16	3.0	7.0	0.0	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	20	3.7	6.2	0.1	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	40	4.0	5.8	0.2	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	60	4.3	2.6	3.1	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	80	4.3	1.8	4.0	clear	III	no
280	5:5	Modified	Na_2CO_3	10,000	3	2,000	100	4.3	0.8	4.9	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	0	5.0	0.0	5.0			
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	3	0.2	9.8	0.0	clear	II (-)	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	6	0.7	9.3	0.0	clear	II (-)	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	9	1.0	9.0	0.0	clear	II (-)	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	13	2.8	7.2	0.1	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	16	3.1	6.8	0.1	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	20	3.7	6.2	0.1	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	40	4.0	5.9	0.1	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	60	4.2	4.3	1.5	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	80	4.2	3.8	2.1	clear	III	no
281	5:5	Modified	Na_2CO_3	12,500	3	2,000	100	4.2	3.3	2.5	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	0	5.0	0.0	5.0			
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	3	0.2	9.8	0.0	clear	II (-)	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	6	1.2	8.6	0.2	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	9	1.6	8.2	0.3	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	13	3.2	6.5	0.4	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	16	2.7	4.9	2.4	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	20	3.8	3.6	2.6	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	40	4.9	1.7	3.5	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	60	4.9	1.0	4.1	clear	III	no
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	80	4.9	0.2	4.9	clear	III	yes
282	5:5	Modified	Na_2CO_3	5,000	3	1,000	100	4.9	0.2	4.9	clear	III	yes
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	0	5.0	0.0	5.0			
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	3	0.0	10.0	0.1	clear, precipitation	II (+)	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	6	1.1	8.5	0.4	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	9	1.5	8.3	0.3	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	13	3.0	6.7	0.4	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	16	2.2	6.2	1.6	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	20	2.4	4.6	3.1	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	40	3.0	4.0	3.1	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	60	3.0	3.2	3.8	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	80	3.0	2.4	4.7	clear, precipitation	III	no
283	5:5	Modified	Na_2CO_3	7,500	3	1,000	100	3.0	1.0	6.0	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	0	5.0	0.0	5.0			
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	3	0.0	10.0	0.1	clear, precipitation	II (+)	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	6	1.1	8.7	0.2	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	9	1.7	8.1	0.2	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	13	3.7	6.0	0.3	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	16	3.9	5.7	0.4	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	20	4.0	5.2	0.8	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	40	4.3	4.7	1.1	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	60	4.3	3.8	1.9	clear, precipitation	III	no
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	80	4.3	3.2	2.5	clear, precipitation	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
284	5:5	Modified	Na_2CO_3	10,000	3	1,000	100	4.3	2.9	2.8	clear, precipitation	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	0	5.0	0.0	5.0			
285	5:5	Modified	K_2CO_3	5,000	3	2,000	3	0.3	9.7	0.1	clear	II (-)	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	6	0.5	9.3	0.3	clear	II (-)	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	9	0.4	9.6	0.0	clear	II (-)	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	13	2.3	7.5	0.3	clear	II (-)	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	16	broken			clear	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	20	broken			clear	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	40	broken			clear	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	60	broken			clear	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	80	broken			clear	III	no
285	5:5	Modified	K_2CO_3	5,000	3	2,000	100	broken			clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	0	5.0	0.0	5.0			
286	5:5	Modified	K_2CO_3	7,500	3	2,000	3	0.3	9.7	0.1	clear	II (-)	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	6	0.6	9.3	0.1	clear	II (-)	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	9	0.8	9.0	0.2	clear	II (-)	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	13	2.5	7.3	0.2	clear	II (-)	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	16	1.9	6.9	1.2	clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	20	2.2	6.0	1.9	clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	40	3.5	4.3	2.2	clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	60	3.5	2.2	4.4	clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	80	3.5	2.0	4.6	clear	III	no
286	5:5	Modified	K_2CO_3	7,500	3	2,000	100	3.5	1.7	4.8	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	0	5.0	0.0	5.0			
287	5:5	Modified	K_2CO_3	8,000	3	2,000	3	0.2	9.8	0.1	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	6	0.6	9.3	0.1	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	9	1.0	8.8	0.2	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	13	2.3	7.5	0.3	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	16	2.5	7.0	0.5	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	20	3.4	6.1	0.6	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	40	3.4	5.6	1.0	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	60	4.0	3.9	2.1	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	80	4.0	2.8	3.3	clear	III	no
287	5:5	Modified	K_2CO_3	8,000	3	2,000	100	4.0	2.0	4.1	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	0	5.0	0.0	5.0			
288	5:5	Modified	K_2CO_3	10,000	3	2,000	3	0.3	9.8	0.0	clear	II (-)	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	6	0.5	9.4	0.2	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	9	0.8	9.1	0.1	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	13	2.0	7.7	0.3	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	16	1.6	7.3	1.1	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	20	2.0	7.1	1.0	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	40	3.6	5.9	0.6	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	60	3.6	4.0	2.5	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	80	3.6	3.7	2.8	clear	III	no
288	5:5	Modified	K_2CO_3	10,000	3	2,000	100	3.6	3.4	3.0	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	0	5.0	0.0	5.0			
289	5:5	Modified	K_2CO_3	12,500	3	2,000	3	0.1	9.9	0.0	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	6	0.7	9.2	0.2	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	9	1.2	8.7	0.2	clear	III	no

Sampl. Name	WOR	Oil Type	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
289	5:5	Modified	K_2CO_3	12,500	3	2,000	13	1.5	8.5	0.0	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	16	1.4	8.3	0.3	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	20	1.6	8.0	0.4	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	40	2.0	7.3	0.7	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	60	3.8	2.0	4.2	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	80	3.8	1.7	4.6	clear	III	no
289	5:5	Modified	K_2CO_3	12,500	3	2,000	100	3.8	1.4	4.9	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	0	5.0	0.0	5.0			
290	5:5	Modified	K_2CO_3	5,000	3	1,000	3	0.0	9.9	0.2	clear	II (+)	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	6	1.0	8.8	0.2	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	9	2.0	7.8	0.3	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	13	3.5	6.1	0.4	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	16	4.0	2.8	3.2	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	20	4.4	1.7	3.9	clear	III	no
290	5:5	Modified	K_2CO_3	5,000	3	1,000	40	5.0	0.8	4.3	clear	III	yes
290	5:5	Modified	K_2CO_3	5,000	3	1,000	60	5.0	0.2	4.9	clear	III	yes
290	5:5	Modified	K_2CO_3	5,000	3	1,000	80	5.0	0.2	4.9	clear	III	yes
290	5:5	Modified	K_2CO_3	5,000	3	1,000	100	5.0	0.2	4.9	clear	III	yes
291	5:5	Modified	K_2CO_3	7,500	3	1,000	0	5.0	0.0	5.0			
291	5:5	Modified	K_2CO_3	7,500	3	1,000	3	0.7	9.3	0.1	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	6	1.8	8.1	0.1	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	9	1.9	7.9	0.2	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	13	3.0	6.8	0.2	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	16	4.0	4.0	2.0	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	20	4.3	2.9	2.9	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	40	4.3	2.2	3.6	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	60	4.3	2.2	3.6	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	80	4.3	2.2	3.6	clear	III	no
291	5:5	Modified	K_2CO_3	7,500	3	1,000	100	4.3	2.2	3.6	clear	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	0	5.0	0.0	5.0			
292	5:5	Modified	K_2CO_3	10,000	3	1,000	3	0.2	9.8	0.0	clear, precipitation	II (+)	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	6	0.4	9.5	0.1	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	9	0.7	9.2	0.2	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	13	2.5	7.4	0.2	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	16	2.1	7.2	0.7	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	20	2.5	7.0	0.6	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	40	3.0	5.1	1.9	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	60	3.0	3.7	3.3	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	80	3.0	3.4	3.7	clear, precipitation	III	no
292	5:5	Modified	K_2CO_3	10,000	3	1,000	100	3.0	3.0	4.1	clear, precipitation	III	no

16.TH: Formulation 5a: Alternative Water Source from WTP @ 60°C (AC Slug)

Sample Name	WOR	Oil Type	Water Source	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	0	5	0	5			
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	3	4	4.5	1.5	clear	III	no
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	6	4.15	3.45	2.4	clear	III	no
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	9	4.4	2.15	3.45	clear	III	no
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	13	4.45	1.7	3.85	clear	III	no
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	16	4.7	0.9	4.4	clear	III	no
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	20	4.75	0.45	4.8	clear	III	yes
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	40	4.85	0.45	4.7	clear	III	yes
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	60	5	0.3	4.7	clear	III	yes
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	80	5	0.2	4.8	clear	III	yes
293	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	x	x	100	5	0.2	4.8	clear	III	yes
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	0	5	0	5			
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	3	4.3	0.7	5	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	6	4.35	0.65	5	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	9	4.45	0.55	5	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	13	4.45	0.75	4.8	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	16	4.45	0.85	4.7	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	20	4.45	1.05	4.5	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	40	4.45	1.15	4.4	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	60	4.45	1.3	4.25	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	80	4.45	1.3	4.25	clear	III	no
294	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	1	2,000	100	4.45	1.3	4.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	0	5	0	5			
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	3	0.3	9.55	0.15	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	6	0.2	9.55	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	9	0.3	9.45	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	13	0.3	9.45	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	16	0.3	9.45	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	20	0.3	9.3	0.4	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	40	0.5	9.25	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	60	0.6	9.15	0.25	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	80	0.6	8.85	0.55	clear	III	no
295	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	2	2,000	100	0.6	8.85	0.55	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	0	5	0	5			
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	3	3.5	6.05	0.45	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	6	4	5.55	0.45	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	9	4.4	5.15	0.45	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	13	4	5	1	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	16	4.75	4.55	0.7	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	20	4.75	4.1	1.15	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	40	5	3.6	1.4	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	60	5	3.15	1.85	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	80	5	3.7	1.3	clear	III	no
296	5:5	Modified	Hydrocyclone	Na_2CO_3	7,500	3	2,000	100	5	3.7	1.3	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	0	5	0	5			
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	3	3.5	5.5	1	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	6	3.6	4.6	1.8	clear	III	no

Sample Name	WOR	Oil Type	Water Source	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	9	3.65	4.05	2.3	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	13	3.7	3.6	2.7	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	16	3.85	3.05	3.1	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	20	3.95	2.95	3.1	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	40	4.05	2.65	3.3	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	60	4.1	2.3	3.6	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	80	4.4	1.45	4.15	clear	III	no
297	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	x	x	100	4.4	0.9	4.7	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	0	5	0	5			
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	3	4.8	0.7	4.5	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	6	4.8	0.65	4.55	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	9	4.8	0.65	4.55	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	13	4.8	0.65	4.55	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	16	4.7	0.6	4.7	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	20	4.75	0.65	4.6	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	40	4.75	0.85	4.4	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	60	4.75	0.85	4.4	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	80	4.8	0.8	4.4	clear	III	no
298	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	1	2,000	100	4.8	0.8	4.4	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	0	5	0	5			
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	3	0.2	6.9	2.9	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	6	0.2	5.6	4.2	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	9	0.2	5.15	4.65	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	13	0.2	5.1	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	16	0.2	5.1	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	20	0.2	5.1	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	40	0.2	5.1	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	60	0.2	5.1	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	80	0.25	5.05	4.7	clear	III	no
299	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	2	2,000	100	0.25	5.05	4.7	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	0	5	0	5			
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	3	1	8.75	0.25	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	6	3.15	6.5	0.35	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	9	3.15	6.4	0.45	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	13	3.2	6.35	0.45	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	16	3.3	6.25	0.45	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	20	3.5	6.05	0.45	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	40	3.5	6.05	0.45	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	60	3.6	5.9	0.5	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	80	3.6	5.8	0.6	clear	III	no
300	5:5	Modified	Hydrocyclone	K_2CO_3	7,500	3	2,000	100	3.6	5.2	1.2	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	0	5	0	5			
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	3	2.5	6.85	0.65	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	6	3.1	4.95	1.95	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	9	3.7	3.8	2.5	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	13	3.8	3.3	2.9	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	16	3.8	3.2	3	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	20	3.8	3.2	3	clear	III	no

Sample Name	WOR	Oil Type	Water Source	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	40	4.55	2.35	3.1	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	60	4.7	1.9	3.4	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	80	4.9	1.4	3.7	clear	III	no
301	5:5	Modified	WTP	Na_2CO_3	7,500	x	x	100	4.9	0.75	4.35	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	0	5	0	5			
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	3	4.5	0.7	4.8	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	6	4.45	0.75	4.8	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	9	4.5	0.75	4.75	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	13	4.7	0.6	4.7	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	16	4.7	0.6	4.7	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	20	4.8	0.6	4.6	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	40	4.8	0.6	4.6	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	60	4.8	0.8	4.4	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	80	4.8	1	4.2	clear	III	no
302	5:5	Modified	WTP	Na_2CO_3	7,500	1	2,000	100	4.8	1.2	4	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	0	5	0	5			
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	3	0.2	9.55	0.25	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	6	0.3	9.3	0.4	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	9	0.35	9.15	0.5	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	13	0.5	8.5	1	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	16	0.5	8.45	1.05	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	20	0.6	8.1	1.3	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	40	0.65	8	1.35	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	60	0.7	7.8	1.5	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	80	0.9	7.25	1.85	clear	III	no
303	5:5	Modified	WTP	Na_2CO_3	7,500	2	2,000	100	0.9	6.3	2.8	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	0	5	0	5			
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	3	0.55	9.3	0.15	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	6	2.3	7.25	0.45	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	9	2.75	6.75	0.5	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	13	3.1	6	0.9	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	16	3.2	5.9	0.9	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	20	3.4	5.65	0.95	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	40	3.5	5.5	1	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	60	3.6	5.1	1.3	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	80	3.95	4.3	1.75	clear	III	no
304	5:5	Modified	WTP	Na_2CO_3	7,500	3	2,000	100	3.95	3.95	2.1	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	0	5	0	5			
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	3	3	6.6	0.4	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	6	4.1	4.9	1	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	9	4.25	3.85	1.9	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	13	4.4	2.6	3	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	16	4.5	2.15	3.35	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	20	4.6	1.55	3.85	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	40	4.7	1.3	4	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	60	4.8	0.7	4.5	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	80	4.9	0.5	4.6	clear	III	no
305	5:5	Modified	WTP	K_2CO_3	7,500	x	x	100	4.9	0.2	4.9	clear	III	yes

Sample Name	WOR	Oil Type	Water Source	Alkali	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	0	5	0	5			
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	3	4.25	0.7	5.05	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	6	4.25	0.65	5.1	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	9	4.25	0.65	5.1	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	13	4.3	0.7	5	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	16	4.3	0.8	4.9	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	20	4.4	0.8	4.8	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	40	4.4	0.8	4.8	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	60	4.4	0.9	4.7	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	80	4.4	0.9	4.7	clear	III	no
306	5:5	Modified	WTP	K_2CO_3	7,500	1	2,000	100	4.4	0.9	4.7	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	0	5	0	5			
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	3	0.2	9.3	0.5	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	6	0.25	8.05	1.7	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	9	0.2	7.2	2.6	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	13	0.35	6.4	3.25	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	16	0.35	6.15	3.5	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	20	0.35	5.85	3.8	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	40	0.35	5.7	3.95	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	60	0.4	5.35	4.25	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	80	0.4	5.1	4.5	clear	III	no
307	5:5	Modified	WTP	K_2CO_3	7,500	2	2,000	100	0.4	4.9	4.7	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	0	5	0	5			
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	3	1	8.65	0.35	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	6	2.4	7.25	0.35	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	9	2.6	6.95	0.45	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	13	3.1	6.45	0.45	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	16	3.15	6.4	0.45	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	20	3.3	6.2	0.5	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	40	3.4	6.05	0.55	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	60	3.5	6	0.5	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	80	3.6	5.5	0.9	clear	III	no
308	5:5	Modified	WTP	K_2CO_3	7,500	3	2,000	100	3.6	4.6	1.8	clear	III	no

16.TH: Formulation 6a: Technical graded Alkalis @ 60°C (Alkali/ AP Slug)

Sample Name	WOR	Oil Type	Alkali	Technical graded Alkali	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	0	5	0	5			
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	3	0.5	9.05	0.45	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	6	1	8.1	0.9	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	9	1	7.6	1.4	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	13	1.5	6.8	1.7	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	16	2.4	5.5	2.1	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	20	2.4	4.6	3	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	40	3.1	4.6	2.3	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	60	4	3.7	2.3	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	80	4.3	2.5	3.2	clear	III	no
309	5:5	Modified	Na_2CO_3	fine grained	5,000	x	x	100	4.5	1.85	3.65	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	0	5	0	5			
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	3	2.6	7.05	0.35	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	6	3.1	6.45	0.45	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	9	3.25	5.15	1.6	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	13	3.4	4.7	1.9	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	16	3.4	4.25	2.35	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	20	3.8	3.1	3.1	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	40	3.8	3.1	3.1	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	60	4.2	1.5	4.3	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	80	4.7	0.55	4.75	clear	III	no
310	5:5	Modified	Na_2CO_3	fine grained	7,500	x	x	100	4.9	0.2	4.9	clear	III	yes
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	0	5	0	5			
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	3	0	10	0	clear	x	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	6	3.3	6.3	0.4	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	9	3.7	4.5	1.8	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	13	3.8	4.1	2.1	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	16	3.9	4.4	1.7	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	20	4.2	1.8	4	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	40	4.2	1.8	4	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	60	4.5	1.3	4.2	clear	III	no
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	80	4.7	0.3	5	clear	III	yes
311	5:5	Modified	Na_2CO_3	fine grained	10,000	x	x	100	4.7	0.3	5	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Technical graded Alkali	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	0	5	0	5			
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	3	3.1	6.25	0.65	clear	III	no
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	6	3.85	4.95	1.2	clear	III	no
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	9	4	2.8	3.2	clear	III	no
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	13	4.15	2.25	3.6	clear	III	no
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	16	4.3	1.2	4.5	clear	III	no
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	20	4.5	0.4	5.1	clear	III	yes
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	40	4.7	0.4	4.9	clear	III	yes
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	60	5	0	5	clear	x	x
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	80	5	0	5	clear	x	x
312	5:5	Modified	Na_2CO_3	coarse grained	5,000	x	x	100	5	0	5	clear	x	x
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	0	5	0	5			
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	3	3.2	6.4	0.4	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	6	3.5	5.7	0.8	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	9	3.7	4.4	1.9	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	13	3.7	4.05	2.25	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	16	3.8	3.45	2.75	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	20	4.1	2.1	3.8	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	40	4.1	2.1	3.8	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	60	4.6	0.6	4.8	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	80	4.6	0.6	4.8	clear	III	no
313	5:5	Modified	Na_2CO_3	coarse grained	7,500	x	x	100	4.6	0.6	4.8	clear	III	no
314	5:5	Modified	Na_2CO_3	coarse grained	10,000	x	x	0	broken					
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	0	5	0	5			
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	3	3.3	6.65	0.05	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	6	3.4	6.2	0.4	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	9	3.9	5.6	0.5	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	13	3.9	5.1	1	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	16	4.1	4.5	1.4	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	20	4.1	3.4	2.5	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	40	4.2	2.1	3.7	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	60	4.6	1.75	3.65	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	80	4.6	1.2	4.2	clear	III	no
315	5:5	Modified	K_2CO_3	fine grained	5,000	x	x	100	4.9	0.2	4.9	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Technical graded Alkali	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	0	5	0	5			
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	3	2.65	7.3	0.05	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	6	2.7	6.95	0.35	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	9	3	6.65	0.35	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	13	3.3	6.35	0.35	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	16	3.3	6.3	0.4	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	20	3.5	6	0.5	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	40	3.5	5.95	0.55	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	60	3.55	5.5	0.95	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	80	3.7	5.2	1.1	clear	III	no
316	5:5	Modified	K_2CO_3	fine grained	7,500	x	x	100	3.85	4.6	1.55	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	0	5	0	5			
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	3	0.4	9.55	0.05	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	6	1	8.95	0.05	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	9	1.9	8	0.1	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	13	2	7.75	0.25	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	16	2.2	7.45	0.35	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	20	2.4	7.1	0.5	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	40	2.4	7	0.6	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	60	2.7	6.65	0.65	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	80	2.9	6.35	0.75	clear	III	no
317	5:5	Modified	K_2CO_3	fine grained	10,000	x	x	100	3	5.7	1.3	clear	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	0	5	0	5			
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	3	0.1	8.2	1.7	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	6	0.1	7.9	2	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	9	0.1	6.75	3.15	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	13	0.1	6	3.9	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	16	0.1	6	3.9	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	20	0.1	6	3.9	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	40	0.1	5.9	4	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine g.	7,500	3630S	1,000	60	0.1	5.9	4	light y.	III	no

Sample Name	WOR	Oil Type	Alkali	Technical graded Alkali	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	80	0.1	5.9	4	light yellow, turbidity	III	no
318	5:5	Modified	K_2CO_3	fine grained	7,500	FP 3630S	1,000	100	0.1	5.9	4	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	0	5	0	5			
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	3	4.55	3.45	2	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	6	4.65	2.95	2.4	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	9	4.65	2.05	3.3	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	13	4.7	1.6	3.7	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	16	4.7	1.2	4.1	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	20	4.7	0.5	4.8	light yellow, turbidity	III	no
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	40	4.7	0.35	4.95	light yellow, turbidity	III	yes
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	60	4.85	0.3	4.85	light yellow, turbidity	III	yes
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	80	4.9	0.2	4.9	light yellow, turbidity	III	yes
319	5:5	Dead	K_2CO_3	fine grained	7,500	FP 3630S	1,000	100	4.9	0.2	4.9	light yellow, turbidity	III	yes
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	0	5	0	5			
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	3	1.2	5.25	3.55	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	6	2.4	5	2.6	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	9	2.8	4.55	2.65	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	13	2.95	3	4.05	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	16	3.1	2.85	4.05	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	20	3.4	2.7	3.9	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	40	3.4	2.3	4.3	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	60	3.4	2.3	4.3	light yellow, turbidity	III	no
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	80	3.4	2.3	4.3	light yellow, turbidity	III	no

Sample Name	**WOR**	**Oil Type**	**Alkali**	**Technical graded Alkali**	**Conc. (ppm)**	**Polymer**	**Conc. (ppm)**	**Time**	**Oil Vol. (ml)**	**Emulsion Vol. (ml)**	**Water Vol. (ml)**	**Optical Visualisation of the Aqueous Phase**	**Emulsion Type**	**Emulsion Amount <0.5 ml**
320	5:5	Modified	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	100	3.4	2.3	4.3	light yellow, turbidity	III	no
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	0	5	0	5			
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	3	4.8	3.2	2	light yellow, turbidity	III	no
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	6	5	0.95	4.05	light yellow, turbidity	III	no
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	9	5	0.55	4.45	light yellow, turbidity	III	no
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	13	5	0.35	4.65	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	16	5	0.25	4.75	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	20	5	0.2	4.8	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	40	5	0.2	4.8	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	60	5	0.25	4.75	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	80	5	0.2	4.8	light yellow, turbidity	III	yes
321	5:5	Dead	Na_2CO_3	fine grained	7,500	FP 3630S	1,000	100	5	0	5	light yellow, turbidity	x	x

16.TH: Formulation 7a: Alkali + HPAM & Co-Solvents @ 60°C (AP & ACP Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Polymer	Conc. (ppm)	Co-Sol.	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	0	5	0	5			
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	3	4.6	3.1	2.3	clear	III	no
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	6	4.8	1.3	3.9	clear	III	no
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	9	4.9	1.4	3.7	clear	III	no
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	13	5	0.5	4.5	clear	III	no
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	16	5	0.5	4.5	clear	III	no
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	20	5	0.35	4.65	clear	III	yes
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	40	5	0.35	4.65	clear	III	yes
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	60	5	0.2	4.8	clear	III	yes
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	80	5	0.2	4.8	clear	III	yes
322	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	3	2,000	100	5	0.15	4.85	clear	III	yes
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	0	5	0	5			
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	3	4.7	3.4	1.9	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	6	4.9	2.8	2.3	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	9	4.8	2.5	2.7	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	13	4.9	1.3	3.8	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	16	4.95	1.1	3.95	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	20	4.95	0.9	4.15	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	40	5	0.8	4.2	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	60	5	0.7	4.3	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	80	5	0.55	4.45	clear	III	no
323	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	3	2,000	100	5	0.2	4.8	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	0	5	0	5			
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	3	5	0.8	4.2	clear	III	no
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	6	5	0.6	4.4	clear	III	no
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	9	5	0.55	4.45	clear	III	no
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	13	5	0.35	4.65	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	16	5	0.35	4.65	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	20	5	0.25	4.75	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	40	5	0.2	4.8	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	60	5	0.05	4.95	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	80	5	0.05	4.95	clear	III	yes
324	5:5	Modified	Na_2CO_3	7,500	FP 3630S	1,000	x	x	100	5	0.05	4.95	clear	III	yes
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	0	5	0	5			
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	3	4.9	3.3	1.8	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	6	4.95	2.65	2.4	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	9	4.9	2.2	2.9	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	13	4.95	1.25	3.8	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	16	4.95	0.85	4.2	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	20	4.95	0.8	4.25	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	40	5	0.7	4.3	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	60	5	0.5	4.5	clear	III	no
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	80	5	0.4	4.6	clear	III	yes
325	5:5	Modified	K_2CO_3	7,500	FP 3630S	1,000	x	x	100	5	0.3	4.7	clear	III	yes

16.TH: Formulation 8a: Mixture of K_2CO_3 & Na_2CO_3 @ 60°C (Alkali & AP Slug)

Sample Name	WOR	Oil Type	Alkali 1	Conc. (ppm)	Alkali 2	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Visualisation of the Aqueous	Emulsion Type	Emulsion Amount <0.5 ml
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	0	5	0	5			
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	3	1	8.5	0.5	clear	III	no
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	6	1.5	8.5	0	clear	III	no
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	9	2	7.3	0.7	clear	III	no
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	13	2.4	7.3	0.3	clear	III	no
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	16	2.7	7.1	0.2	clear	III	no
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	20	2.8	6.85	0.35	clear	III	yes
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	40	3.1	6.2	0.7	clear	III	yes
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	60	3.1	6	4	clear	III	yes
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	80	3.5	5.85	4.15	clear	III	yes
326	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	x	100	3.9	5.7	4.3	clear	III	yes
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	0	5	0	5			
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	3	1	8.5	0.5	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	6	1	8.4	0.6	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	9	1.5	7.9	0.6	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	13	1.5	7.9	0.6	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	16	1.65	7.65	0.7	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	20	1.75	7.2	1.05	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	40	2.3	6.6	1.1	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	60	2.5	6.3	1.2	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	80	2.8	5.5	1.7	clear	III	no
327	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	x	100	3	5.1	1.9	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	0	5	0	5			
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	3	3.75	6.3	-0.05	clear	III	no
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	6	3.75	6.1	0.15	clear	III	no
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	9	3.8	6	0.2	clear	III	no
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	13	3.85	5.75	0.4	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	16	4	5	1	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	20	4.5	4.65	0.85	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	40	4.65	3	2.35	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	60	4.7	2.6	2.7	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	80	4.8	2.3	2.9	clear	III	yes
328	5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	FP 3630S	1,000	100	4.8	2.3	2.9	clear	III	yes
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	0	5	0	5			
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	3	3.5	6	0.5	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	6	3.5	5.85	0.65	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	9	3.55	5.5	0.95	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	13	4.3	3.7	2	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	16	4.7	3.25	2.05	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	20	4.7	3	2.3	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	40	4.7	2.85	2.45	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	60	4.7	2.85	2.45	clear	III	no
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	80	4.7	2.85	2.45	clear	III	yes
329	5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	FP 3630S	1,000	100	4.7	2.85	2.45	clear	III	yes
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	0	5	0	5			
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	3	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	6	5	0	5	clear	x	x

Sample Name	WOR	Oil Type	Alkali 1	Conc. (ppm)	Alkali 2	Conc. (ppm)	Polymer	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Visualisation of the Aqueous	Emulsion Type	Emulsion Amount <0.5 ml
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	9	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	13	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	16	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	20	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	40	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	60	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	80	5	0	5	clear	x	x
330	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	x	x	100	5	0	5	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	0	5.05	0	4.95			
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	3	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	6	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	9	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	13	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	16	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	20	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	40	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	60	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	80	5.05	0	4.95	clear	x	x
331	5:5	Modified	Na_2CO_3	3,750	K_2CO_3	3,750	FP 3630S	1,000	100	5.05	0	4.95	clear	x	x

8.TH: Formulation 1b: Synthetic Make-up Water + Dead S 85 Oil @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
332	1:9	Dead	Na_2CO_3	2,500	0	9	0	1			
332	1:9	Dead	Na_2CO_3	2,500	3	9	0	0.8	clear	III	yes
332	1:9	Dead	Na_2CO_3	2,500	6	9	0	0.85	clear	III	yes
332	1:9	Dead	Na_2CO_3	2,500	9	9	0	0.95	clear	III	yes
332	1:9	Dead	Na_2CO_3	2,500	13	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	16	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	20	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	40	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	60	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	80	9	0	1	clear	x	x
332	1:9	Dead	Na_2CO_3	2,500	100	9	0	1	clear	x	x
333	1:9	Dead	Na_2CO_3	5,000	0	9	0	1			
333	1:9	Dead	Na_2CO_3	5,000	3	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	6	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	9	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	13	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	16	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	20	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	40	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	60	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	80	9	0	1	clear	III	yes
333	1:9	Dead	Na_2CO_3	5,000	100	9	0	1	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	0	9	0	1			
334	1:9	Dead	Na_2CO_3	7,500	3	9	0	1	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	6	9	0	1	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	9	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	13	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	16	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	20	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	40	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	60	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	80	9	0	0.9	clear	III	yes
334	1:9	Dead	Na_2CO_3	7,500	100	9	0	0.9	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	0	9	0	1			
335	1:9	Dead	Na_2CO_3	10,000	3	9	0	0.7	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	6	9	0	0.8	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	9	9	0	0.75	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	13	9	0	0.8	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	16	9	0	0.8	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	20	9	0	0.85	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	40	9	0	0.85	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	60	9	0	0.85	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	80	9	0	0.85	clear	III	yes
335	1:9	Dead	Na_2CO_3	10,000	100	9	0	0.85	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	0	9	0	1			
336	1:9	Dead	Na_2CO_3	12,500	3	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	6	9	0	1	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
336	1:9	Dead	Na_2CO_3	12,500	9	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	13	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	16	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	20	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	40	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	60	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	80	9	0	1	clear	III	yes
336	1:9	Dead	Na_2CO_3	12,500	100	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	0	9	0	1			
337	1:9	Dead	Na_2CO_3	15,000	3	9	0	0.95	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	6	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	9	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	13	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	16	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	20	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	40	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	60	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	80	9	0	1	clear	III	yes
337	1:9	Dead	Na_2CO_3	15,000	100	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	0	9	0	1			
338	1:9	Dead	Na_2CO_3	17,500	3	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	6	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	9	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	13	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	16	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	20	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	40	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	60	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	80	9	0	1	clear	III	yes
338	1:9	Dead	Na_2CO_3	17,500	100	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	0	9	0	1			
339	1:9	Dead	Na_2CO_3	20,000	3	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	6	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	9	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	13	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	16	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	20	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	40	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	60	9	0	1	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	80	9	0	0.95	clear	III	yes
339	1:9	Dead	Na_2CO_3	20,000	100	9	0	0.95	clear	III	yes
340	3:7	Dead	Na_2CO_3	2,500	0	7	0	3			
340	3:7	Dead	Na_2CO_3	2,500	3	1	5	4.7	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	6	6	3	0.8	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	9	6	3	1.05	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	13	6	2	1.35	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	16	6	2	1.6	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	20	6	2	1.8	clear	III	no
340	3:7	Dead	Na_2CO_3	2,500	40	7	1	2.35	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
340	3:7	Dead	Na_2CO_3	2,500	60	7	0	2.9	clear	III	yes
340	3:7	Dead	Na_2CO_3	2,500	80	7	0	2.9	clear	III	yes
340	3:7	Dead	Na_2CO_3	2,500	100	7	0	2.9	clear	III	yes
341	3:7	Dead	Na_2CO_3	5,000	0	7	0	3			
341	3:7	Dead	Na_2CO_3	5,000	3	3	6	0.5	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	6	0	4	5.6	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	9	6	3	0.55	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	13	6	4	0.6	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	16	5	4	0.7	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	20	6	3	0.7	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	40	6	3	0.75	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	60	6	2	1.3	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	80	6	2	1.3	clear	III	no
341	3:7	Dead	Na_2CO_3	5,000	100	6	2	1.3	clear	III	no
342	3:7	Dead	Na_2CO_3	7,500	0	7	0	3			
342	3:7	Dead	Na_2CO_3	7,500	3	7	0	3.05	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	6	7	0	3.05	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	9	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	13	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	16	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	20	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	40	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	60	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	80	7	0	3	clear	III	yes
342	3:7	Dead	Na_2CO_3	7,500	100	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	0	7	0	3			
343	3:7	Dead	Na_2CO_3	10,000	3	7	0	3	clear	x	x
343	3:7	Dead	Na_2CO_3	10,000	6	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	9	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	13	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	16	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	20	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	40	7	0	3	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	60	7	0	3.05	clear	III	yes
343	3:7	Dead	Na_2CO_3	10,000	80	7	0	3	clear	x	x
343	3:7	Dead	Na_2CO_3	10,000	100	7	0	3	clear	x	x
344	3:7	Dead	Na_2CO_3	12,500	0	broken					
345	3:7	Dead	Na_2CO_3	15,000	0	7	0	3			
345	3:7	Dead	Na_2CO_3	15,000	3	7	0	2.6	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	6	7	0	2.6	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	9	7	0	2.7	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	13	7	0	2.55	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	16	7	0	2.55	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	20	7	0	2.6	clear	III	yes
345	3:7	Dead	Na_2CO_3	15,000	40	7	1	2.65	clear	III	no
345	3:7	Dead	Na_2CO_3	15,000	60	7	1	2.65	clear	III	no
345	3:7	Dead	Na_2CO_3	15,000	80	7	1	2.65	clear	III	no
345	3:7	Dead	Na_2CO_3	15,000	100	7	1	2.65	clear	III	no
346	3:7	Dead	Na_2CO_3	17,500	0	7	0	3			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
346	3:7	Dead	Na_2CO_3	17,500	3	7	0	3	clear	x	x
346	3:7	Dead	Na_2CO_3	17,500	6	7	0	2.98	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	9	7	0	2.85	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	13	7	0	2.85	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	16	7	0	2.85	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	20	7	0	2.95	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	40	7	0	2.95	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	60	7	0	3	clear	III	yes
346	3:7	Dead	Na_2CO_3	17,500	80	7	0	3	clear	x	x
346	3:7	Dead	Na_2CO_3	17,500	100	7	0	3	clear	x	x
347	3:7	Dead	Na_2CO_3	20,000	0	7	0	3			
347	3:7	Dead	Na_2CO_3	20,000	3	7	0	2.9	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	6	7	0	2.9	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	9	7	0	2.9	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	13	7	0	3	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	16	7	0	2.9	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	20	7	0	2.95	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	40	7	0	2.95	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	60	7	0	2.95	clear	III	yes
347	3:7	Dead	Na_2CO_3	20,000	80	7	0	3	clear	x	x
347	3:7	Dead	Na_2CO_3	20,000	100	7	0	3	clear	x	x
348	5:5	Dead	Na_2CO_3	2,500	0	5	0	5			
348	5:5	Dead	Na_2CO_3	2,500	3	0	9	1.15	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	6	1	8	1.2	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	9	4	5	1.2	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	13	3	6	1.3	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	16	3	5	1.5	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	20	4	4	2.3	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	40	5	1	4.7	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	60	5	1	4.7	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	80	5	1	4.7	clear	III	no
348	5:5	Dead	Na_2CO_3	2,500	100	5	1	4.7	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	0	5	0	5			
349	5:5	Dead	Na_2CO_3	5,000	3	1	9	0.7	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	6	1	9	0.8	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	9	4	5	0.75	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	13	1	8	0.75	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	16	3	7	0.9	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	20	3	6	1	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	40	4	3	2.9	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	60	4	3	2.9	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	80	4	3	2.9	clear	III	no
349	5:5	Dead	Na_2CO_3	5,000	100	4	3	2.9	clear	III	no
350	5:5	Dead	Na_2CO_3	7,500	0	broken					
351	5:5	Dead	Na_2CO_3	10,000	0	5	0	5			
351	5:5	Dead	Na_2CO_3	10,000	3	0	8	1.6	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	6	1	8	1.6	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	9	5	2	2.65	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	13	1	8	1.65	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
351	5:5	Dead	Na_2CO_3	10,000	16	2	6	1.65	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	20	3	5	2	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	40	4	4	2.5	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	60	5	2	2.8	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	80	5	2	2.8	clear, oil traces on the glass	III	no
351	5:5	Dead	Na_2CO_3	10,000	100	5	2	2.8	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	0	5	0	5			
352	5:5	Dead	Na_2CO_3	12,500	3	1	6	3.2	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	6	1	6	3.4	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	9	5	1	4.1	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	13	1	5	3.5	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	16	4	3	3.5	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	20	5	2	3.7	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	40	5	1	3.9	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	60	5	1	3.95	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	80	5	1	3.95	clear, oil traces on the glass	III	no
352	5:5	Dead	Na_2CO_3	12,500	100	5	1	3.95	clear, oil traces on the glass	III	no
353	5:5	Dead	Na_2CO_3	15,000	0	5	0	5			
353	5:5	Dead	Na_2CO_3	15,000	3	5	0	4.6	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	6	5	0	4.65	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	9	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	13	5	0	4.65	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	16	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	20	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	40	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	60	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	80	5	0	4.7	clear, oil traces on the glass	III	yes
353	5:5	Dead	Na_2CO_3	15,000	100	5	0	4.7	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	0	5	0	5			
354	5:5	Dead	Na_2CO_3	17,500	3	5	1	4.5	clear, oil traces on the glass	III	no
354	5:5	Dead	Na_2CO_3	17,500	6	5	0	4.7	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	9	5	0	4.7	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	13	5	0	4.7	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	16	5	0	4.65	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	20	5	0	4.7	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	40	5	0	4.65	clear, oil traces on the glass	III	yes
354	5:5	Dead	Na_2CO_3	17,500	60	5	1	4.65	clear, oil traces on the glass	III	no
354	5:5	Dead	Na_2CO_3	17,500	80	5	1	4.65	clear, oil traces on the glass	III	no
354	5:5	Dead	Na_2CO_3	17,500	100	5	1	4.65	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	0	5	0	5			
355	5:5	Dead	Na_2CO_3	20,000	3	5	2	3.5	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	6	5	1	3.55	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	9	5	1	3.7	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	13	5	1	3.8	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	16	5	1	3.9	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	20	5	1	4	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	40	5	1	4.1	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	60	5	1	4.15	clear, oil traces on the glass	III	no
355	5:5	Dead	Na_2CO_3	20,000	80	5	1	4.15	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
355	5:5	Dead	Na_2CO_3	20,000	100	5	1	4.15	clear, oil traces on the glass	III	no
356	7:3	Dead	Na_2CO_3	2,500	0	3	0	7			
356	7:3	Dead	Na_2CO_3	2,500	3	0	8	1.45	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	6	2	7	1.5	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	9	1	8	1.45	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	13	1	7	1.5	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	16	1	7	1.5	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	20	2	7	1.6	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	40	2	6	2.3	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	60	3	1	6.3	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	80	3	1	6.3	clear	III	no
356	7:3	Dead	Na_2CO_3	2,500	100	3	1	6.3	clear	III	no
357	7:3	Dead	Na_2CO_3	5,000	0	3	0	7			
357	7:3	Dead	Na_2CO_3	5,000	3	0	9	1.2	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	6	1	8	1.2	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	9	1	8	1.25	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	13	1	8	1.3	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	16	1	7	1.3	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	20	2	7	1.4	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	40	2	7	1.9	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	60	2	3	4.5	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	80	2	3	4.5	clear, oil traces on the glass	III	no
357	7:3	Dead	Na_2CO_3	5,000	100	2	3	4.5	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	0	3	0	7			
358	7:3	Dead	Na_2CO_3	7,500	3	0	8	1.4	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	6	1	8	1.5	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	9	1	7	1.55	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	13	1	7	1.65	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	16	1	7	1.7	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	20	1	7	1.75	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	40	1	6	2.4	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	60	2	4	3.8	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	80	2	4	3.8	clear, oil traces on the glass	III	no
358	7:3	Dead	Na_2CO_3	7,500	100	2	4	3.8	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	0	3	0	7			
359	7:3	Dead	Na_2CO_3	10,000	3	0	7	3	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	6	1	7	2.9	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	9	0	7	2.9	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	13	1	6	3	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	16	1	6	3	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	20	2	5	3.1	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	40	2	5	3.2	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	60	2	4	3.9	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	80	3	3	4.15	clear, oil traces on the glass	III	no
359	7:3	Dead	Na_2CO_3	10,000	100	3	3	4.15	clear, oil traces on the glass	III	no
360	7:3	Dead	Na_2CO_3	12,500	0	broken					
361	7:3	Dead	Na_2CO_3	15,000	0	3	0	7			
361	7:3	Dead	Na_2CO_3	15,000	3	0	6	3.4	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	6	1	6	3.5	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
361	7:3	Dead	Na_2CO_3	15,000	9	1	6	3.5	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	13	1	5	3.5	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	16	1	5	3.6	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	20	1	5	3.6	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	40	2	5	3.8	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	60	2	4	4.1	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	80	2	3	4.25	clear, oil traces on the glass	III	no
361	7:3	Dead	Na_2CO_3	15,000	100	2	3	4.25	clear, oil traces on the glass	III	no
362	7:3	Dead	Na_2CO_3	17,500	0	3	0	7			
362	7:3	Dead	Na_2CO_3	17,500	3	1	7	2.4	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	6	1	7	2.5	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	9	1	6	2.6	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	13	1	6	2.6	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	16	1	6	2.65	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	20	2	6	2.7	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	40	2	6	2.7	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	60	2	5	2.9	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	80	2	5	3	yellow, high turbitity	III	no
362	7:3	Dead	Na_2CO_3	17,500	100	2	5	3	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	0	3	0	7			
363	7:3	Dead	Na_2CO_3	20,000	3	0	8	1.85	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	6	0	8	2	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	9	1	7	2.1	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	13	1	7	2.15	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	16	1	7	2.25	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	20	1	6	2.3	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	40	2	6	2.3	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	60	2	6	2.5	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	80	2	5	2.8	yellow, high turbitity	III	no
363	7:3	Dead	Na_2CO_3	20,000	100	2	5	2.8	yellow, high turbitity	III	no
364	9:1	Dead	Na_2CO_3	2,500	0	1	0	9			
364	9:1	Dead	Na_2CO_3	2,500	3	0	6	4.3	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	6	0	6	4.35	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	9	0	5	4.4	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	13	0	5	4.4	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	16	0	5	4.4	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	20	0	5	4.55	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	40	0	5	5	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	60	1	2	7.55	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	80	1	2	7.55	clear	III	no
364	9:1	Dead	Na_2CO_3	2,500	100	1	2	7.55	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	0	1	0	9			
365	9:1	Dead	Na_2CO_3	5,000	3	0	5	5.1	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	6	0	5	5.1	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	9	0	5	5.1	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	13	0	5	5.1	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	16	0	5	5.2	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	20	0	4	5.3	clear	III	no
365	9:1	Dead	Na_2CO_3	5,000	40	0	3	6.4	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
365	9:1	Dead	Na_2CO_3	5,000	60	1	0	8.9	clear	III	yes
365	9:1	Dead	Na_2CO_3	5,000	80	1	0	8.9	clear	III	yes
365	9:1	Dead	Na_2CO_3	5,000	100	1	0	8.9	clear	III	yes
366	9:1	Dead	Na_2CO_3	7,500	0	1	0	9			
366	9:1	Dead	Na_2CO_3	7,500	3	0	5	4.95	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	6	0	5	5.2	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	9	0	4	5.55	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	13	1	4	5.65	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	16	1	4	5.9	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	20	1	3	6	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	40	1	2	7.65	clear	III	no
366	9:1	Dead	Na_2CO_3	7,500	60	1	0	8.9	clear	III	yes
366	9:1	Dead	Na_2CO_3	7,500	80	1	0	8.9	clear	III	yes
366	9:1	Dead	Na_2CO_3	7,500	100	1	0	8.9	clear	III	yes
367	9:1	Dead	Na_2CO_3	10,000	0	1	0	9			
367	9:1	Dead	Na_2CO_3	10,000	3	0	4	5.8	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	6	0	4	5.9	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	9	0	4	6	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	13	0	3	6.1	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	16	1	3	6.2	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	20	1	3	6.2	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	40	1	3	6.6	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	60	1	1	8.1	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	80	1	1	8.5	clear	III	no
367	9:1	Dead	Na_2CO_3	10,000	100	1	1	8.5	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	0	1	0	9			
368	9:1	Dead	Na_2CO_3	12,500	3	0	4	5.7	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	6	0	4	6	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	9	0	3	6.4	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	13	0	3	6.5	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	16	1	3	6.65	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	20	1	3	6.7	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	40	1	3	6.6	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	60	1	1	8.4	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	80	1	1	8.6	clear	III	no
368	9:1	Dead	Na_2CO_3	12,500	100	1	1	8.6	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	0	1	0	9			
369	9:1	Dead	Na_2CO_3	15,000	3	0	5	5.2	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	6	0	5	5.2	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	9	0	4	5.3	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	13	0	4	5.4	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	16	0	4	5.5	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	20	1	4	5.6	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	40	1	4	5.85	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	60	1	1	8.1	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	80	1	1	8.45	clear	III	no
369	9:1	Dead	Na_2CO_3	15,000	100	1	1	8.45	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	0	1	0	9			
370	9:1	Dead	Na_2CO_3	17,500	3	0	4	5.5	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
370	9:1	Dead	Na_2CO_3	17,500	6	0	4	5.6	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	9	0	4	5.6	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	13	0	4	5.6	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	16	0	4	5.7	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	20	0	4	5.7	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	40	0	4	5.95	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	60	1	3	6.5	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	80	1	1	8	clear	III	no
370	9:1	Dead	Na_2CO_3	17,500	100	1	1	8	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	0	1	0	9			
371	9:1	Dead	Na_2CO_3	20,000	3	0	4	5.4	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	6	0	4	5.5	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	9	0	4	5.7	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	13	0	4	5.8	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	16	0	4	6	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	20	1	3	6.2	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	40	1	3	6.5	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	60	1	2	7.5	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	80	1	1	8.1	clear	III	no
371	9:1	Dead	Na_2CO_3	20,000	100	1	1	8.1	clear	III	no

8.TH: Formulation 1b: Synthetic Make-up Water + Dead S 85 Oil @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
372	1:9	Dead	K_2CO_3	2,500	0	9	0	1			
372	1:9	Dead	K_2CO_3	2,500	3	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	6	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	9	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	13	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	16	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	20	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	40	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	60	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	80	9	0	0.8	clear	III	yes
372	1:9	Dead	K_2CO_3	2,500	100	9	0	0.8	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	0	9	0	1			
373	1:9	Dead	K_2CO_3	5,000	3	9	0	0.85	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	6	9	0	0.9	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	9	9	0	0.95	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	13	9	0	1.05	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	16	9	0	0.85	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	20	9	0	1	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	40	9	0	1	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	60	9	0	1	clear	III	yes
373	1:9	Dead	K_2CO_3	5,000	80	9	0	1	clear	III	yes

373	1:9	Dead	K_2CO_3	5,000	100	9	0	1	clear	III	yes
Sample Name	**WOR**	**Oil Type**	**Alkali**	**Conc. (ppm)**	**Time**	**Oil Vol. (ml)**	**Emulsion Vol. (ml)**	**Water Vol. (ml)**	**Optical Visualisation of the Aqueous Phase**	**Emulsion Type**	**Emulsion Amount <0.5 ml**
374	1:9	Dead	K_2CO_3	7,500	0	9	0	1			
374	1:9	Dead	K_2CO_3	7,500	3	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	6	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	9	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	13	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	16	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	20	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	40	9	0	0.9	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	60	9	0	0.95	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	80	9	0	1	clear	III	yes
374	1:9	Dead	K_2CO_3	7,500	100	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	0	9	0	1			
375	1:9	Dead	K_2CO_3	10,000	3	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	6	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	9	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	13	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	16	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	20	9	0	1	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	40	9	0	0.95	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	60	9	0	1.05	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	80	9	0	1.05	clear	III	yes
375	1:9	Dead	K_2CO_3	10,000	100	9	0	1.05	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	0	9	0	1			
376	1:9	Dead	K_2CO_3	12,500	3	9	0	0.9	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	6	9	0	0.9	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	9	9	0	0.9	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	13	9	0	0.8	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	16	9	0	0.9	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	20	9	0	1.05	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	40	9	0	0.9	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	60	9	0	1	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	80	9	0	1.2	clear	III	yes
376	1:9	Dead	K_2CO_3	12,500	100	9	0	1.2	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	0	9	0	1			
377	1:9	Dead	K_2CO_3	15,000	3	9	0	0.8	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	6	9	0	0.8	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	9	9	0	0.8	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	13	9	0	0.8	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	16	9	0	0.8	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	20	9	0	0.75	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	40	9	0	0.9	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	60	9	0	0.9	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	80	9	0	0.9	clear	III	yes
377	1:9	Dead	K_2CO_3	15,000	100	9	0	0.9	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	0	9	0	1			
378	1:9	Dead	K_2CO_3	17,500	3	9	0	0.8	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	6	9	0	0.9	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	9	9	0	0.85	clear	III	yes

378	1:9	Dead	K_2CO_3	17,500	13	9	0	0.75	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
378	1:9	Dead	K_2CO_3	17,500	16	9	0	0.75	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	20	9	0	0.9	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	40	9	0	0.9	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	60	9	0	0.9	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	80	9	0	1	clear	III	yes
378	1:9	Dead	K_2CO_3	17,500	100	9	0	1	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	0	9	0	1			
379	1:9	Dead	K_2CO_3	20,000	3	9	0	0.9	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	6	9	0	0.9	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	9	9	0	0.95	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	13	9	0	0.9	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	16	9	0	0.95	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	20	9	0	0.95	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	40	9	0	0.85	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	60	9	0	0.85	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	80	9	0	0.9	clear	III	yes
379	1:9	Dead	K_2CO_3	20,000	100	9	0	0.9	clear	III	yes
380	3:7	Dead	K_2CO_3	2,500	0	7	0	3			
380	3:7	Dead	K_2CO_3	2,500	3	6	3	3	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	6	6	3	0.7	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	9	6	3	0.7	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	13	6	3	1	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	16	6	3	1.2	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	20	6	3	1.2	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	40	6	2	2	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	60	7	0	2.9	clear	III	no
380	3:7	Dead	K_2CO_3	2,500	80	7	0	2.9	clear	III	yes
380	3:7	Dead	K_2CO_3	2,500	100	7	0	2.9	clear	III	yes
381	3:7	Dead	K_2CO_3	5,000	0	7	0	3			
381	3:7	Dead	K_2CO_3	5,000	3	6	4	0.05	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	6	6	4	0.05	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	9	6	4	0.1	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	13	5	5	0.05	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	16	6	4	0.05	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	20	6	4	0.05	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	40	6	4	0.15	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	60	6	4	0.2	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	80	6	4	0.2	clear	III	no
381	3:7	Dead	K_2CO_3	5,000	100	6	4	0.2	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	0	7	0	3			
382	3:7	Dead	K_2CO_3	7,500	3	6	4	0.15	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	6	6	4	0.1	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	9	6	4	0.25	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	13	4	6	0.1	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	16	5	6	-0.9	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	20	4	6	0.1	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	40	5	5	0.1	clear	III	no
382	3:7	Dead	K_2CO_3	7,500	60	6	4	0.2	clear	III	no

382	3:7	Dead	K_2CO_3	7,500	80	6	4	0.2	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
382	3:7	Dead	K_2CO_3	7,500	100	6	4	0.2	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	0	7	0	3			
383	3:7	Dead	K_2CO_3	10,000	3	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	6	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	9	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	13	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	16	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	20	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	40	5	5	0.05	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	60	6	4	0.1	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	80	6	4	0.1	clear	III	no
383	3:7	Dead	K_2CO_3	10,000	100	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	0	7	0	3			
384	3:7	Dead	K_2CO_3	12,500	3	5	5	0.05	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	6	5	5	0.05	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	9	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	13	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	16	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	20	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	40	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	60	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	80	6	4	0.1	clear	III	no
384	3:7	Dead	K_2CO_3	12,500	100	6	4	0.1	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	0	7	0	3			
385	3:7	Dead	K_2CO_3	15,000	3	5	5	0.3	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	6	5	5	0.3	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	9	7	3	0.2	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	13	6	4	0.15	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	16	6	4	0.15	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	20	6	4	0.15	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	40	6	4	0.2	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	60	6	4	0.2	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	80	6	4	0.25	clear	III	no
385	3:7	Dead	K_2CO_3	15,000	100	6	4	0.25	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	0	7	0	3			
386	3:7	Dead	K_2CO_3	17,500	3	5	4	0.7	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	6	5	4	0.7	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	9	7	3	2.2	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	13	6	3	2.3	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	16	6	3	2.4	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	20	6	3	2.4	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	40	6	3	0.85	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	60	6	3	0.8	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	80	6	3	0.8	clear	III	no
386	3:7	Dead	K_2CO_3	17,500	100	6	3	0.8	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	0	7	0	3			
387	3:7	Dead	K_2CO_3	20,000	3	0	9	0	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	6	0	9	2.2	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
387	3:7	Dead	K_2CO_3	20,000	9	0	9	2.2	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	13	0	9	2.25	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	16	0	9	2.3	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	20	6	3	2.3	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	40	6	4	2.3	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	60	6	4	2.2	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	80	6	4	2.2	clear	III	no
387	3:7	Dead	K_2CO_3	20,000	100	6	4	2.2	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	0	5	0	5			
388	5:5	Dead	K_2CO_3	2,500	3	2	8	0.02	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	6	3	7	0.02	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	9	3	7	0.02	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	13	3	7	0.02	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	16	3	7	0.02	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	20	3	6	0.44	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	40	4	6	0.4	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	60	4	1	4.9	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	80	4	1	4.3	clear	III	no
388	5:5	Dead	K_2CO_3	2,500	100	5	1	3.9	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	0	5	0	5			
389	5:5	Dead	K_2CO_3	5,000	3	1	9	0.05	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	6	2	8	0.05	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	9	2	8	0.05	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	13	3	7	0.1	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	16	3	7	0.05	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	20	3	7	0.75	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	40	3	6	0.35	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	60	4	6	0.5	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	80	4	6	0.35	clear	III	no
389	5:5	Dead	K_2CO_3	5,000	100	4	6	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	0	5	0	5			
390	5:5	Dead	K_2CO_3	7,500	3	1	9	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	6	3	7	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	9	3	7	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	13	3	7	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	16	3	7	0.05	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	20	3	7	0.75	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	40	3	7	0.25	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	60	3	6	0.5	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	80	4	6	0.3	clear	III	no
390	5:5	Dead	K_2CO_3	7,500	100	4	6	0.1	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	0	5	0	5			
391	5:5	Dead	K_2CO_3	10,000	3	1	9	0.04	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	6	1	9	0.05	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	9	1	9	0.05	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	13	2	8	0.1	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	16	2	8	0.1	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	20	2	7	1.3	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	40	3	6	0.4	clear	III	no

391	5:5	Dead	K_2CO_3	10,000	60	4	6	0.4	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
391	5:5	Dead	K_2CO_3	10,000	80	4	6	0.3	clear	III	no
391	5:5	Dead	K_2CO_3	10,000	100	4	6	0.1	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	0	5	0	5			
392	5:5	Dead	K_2CO_3	12,500	3	4	6	0.05	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	6	4	6	0.05	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	9	4	6	0.3	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	13	4	6	0.3	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	16	4	6	0.1	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	20	4	6	0.2	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	40	4	6	0.1	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	60	4	6	0.3	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	80	4	6	0.5	clear	III	no
392	5:5	Dead	K_2CO_3	12,500	100	4	6	0.3	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	0	5	0	5			
393	5:5	Dead	K_2CO_3	15,000	3	3	7	0.2	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	6	3	7	0.2	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	9	4	6	0.25	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	13	4	6	0.3	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	16	4	6	0.4	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	20	4	6	0.6	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	40	4	6	0.4	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	60	4	6	0.4	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	80	4	6	0.5	clear	III	no
393	5:5	Dead	K_2CO_3	15,000	100	4	6	0.4	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	0	5	0	5			
394	5:5	Dead	K_2CO_3	17,500	3	3	7	0.2	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	6	3	7	0.2	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	9	4	6	0.2	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	13	4	6	0.25	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	16	4	6	0.25	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	20	4	6	0.3	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	40	4	6	0.2	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	60	4	6	0.4	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	80	4	6	0.5	clear	III	no
394	5:5	Dead	K_2CO_3	17,500	100	4	6	0.3	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	0	5	0	5			
395	5:5	Dead	K_2CO_3	20,000	3	3	7	0.3	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	6	4	6	0.3	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	9	4	6	0.3	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	13	4	6	0.35	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	16	4	6	0.35	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	20	4	5	0.5	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	40	4	5	0.4	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	60	4	5	0.5	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	80	4	5	0.5	clear	III	no
395	5:5	Dead	K_2CO_3	20,000	100	4	5	0.5	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	0	3		7			
396	7:3	Dead	K_2CO_3	2,500	3	1	9	0.8	clear	III	no

396	7:3	Dead	K_2CO_3	2,500	6	1	9	0.8	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
396	7:3	Dead	K_2CO_3	2,500	9	1	8	0.7	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	13	1	8	0.7	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	16	1	8	0.7	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	20	1	8	0.8	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	40	2	8	0.8	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	60	3	2	5.7	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	80	3	2	5.7	clear	III	no
396	7:3	Dead	K_2CO_3	2,500	100	3	2	5.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	0	3		7			
397	7:3	Dead	K_2CO_3	5,000	3	1	8	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	6	1	7	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	9	1	7	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	13	1	7	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	16	2	7	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	20	2	7	1.7	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	40	2	6	1.9	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	60	3	1	6.5	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	80	3	1	6.3	clear	III	no
397	7:3	Dead	K_2CO_3	5,000	100	3	1	6.3	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	0	3		7			
398	7:3	Dead	K_2CO_3	7,500	3	1	8	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	6	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	9	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	13	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	16	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	20	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	40	2	7	1	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	60	3	2	5.6	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	80	3	2	5.4	clear	III	no
398	7:3	Dead	K_2CO_3	7,500	100	3	2	5.4	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	0	3		7			
399	7:3	Dead	K_2CO_3	10,000	3	2	7	2	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	6	2	6	2.1	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	9	2	6	2.05	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	13	2	6	2.05	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	16	2	6	2.05	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	20	2	6	2.1	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	40	2	6	2.1	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	60	2	4	3.4	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	80	2	4	3.3	clear	III	no
399	7:3	Dead	K_2CO_3	10,000	100	2	4	3.3	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	0	3		7			
400	7:3	Dead	K_2CO_3	12,500	3	2	7	1.7	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	6	2	7	1.7	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	9	2	6	1.7	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	13	2	6	1.7	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	16	2	6	1.7	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	20	2	6	1.7	clear	III	no

400	7:3	Dead	K_2CO_3	12,500	40	2	6	1.7	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
400	7:3	Dead	K_2CO_3	12,500	60	2	6	2.1	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	80	2	6	2.1	clear	III	no
400	7:3	Dead	K_2CO_3	12,500	100	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	0	3		7			
401	7:3	Dead	K_2CO_3	15,000	3	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	6	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	9	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	13	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	16	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	20	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	40	2	6	2.1	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	60	3	5	2.3	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	80	2	5	2.4	clear	III	no
401	7:3	Dead	K_2CO_3	15,000	100	2	5	2.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	0	3		7			
402	7:3	Dead	K_2CO_3	17,500	3	2	7	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	6	2	7	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	9	2	7	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	13	2	6	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	16	2	6	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	20	2	6	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	40	2	6	1.4	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	60	2	6	1.8	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	80	2	6	1.7	clear	III	no
402	7:3	Dead	K_2CO_3	17,500	100	2	6	1.7	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	0	3		7			
403	7:3	Dead	K_2CO_3	20,000	3	2	8	1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	6	2	7	1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	9	2	7	1.1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	13	2	7	1.1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	16	2	7	1.1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	20	2	7	1.1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	40	2	7	1.1	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	60	2	4	3.4	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	80	3	4	3.3	clear	III	no
403	7:3	Dead	K_2CO_3	20,000	100	3	4	3.3	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	0	1		9			
404	9:1	Dead	K_2CO_3	2,500	3	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	6	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	9	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	13	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	16	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	20	0	4	5.7	clear	III	no
404	9:1	Dead	K_2CO_3	2,500	40	0	4	6	clear	III	yes
404	9:1	Dead	K_2CO_3	2,500	60	1	0	9.05	clear	III	yes
404	9:1	Dead	K_2CO_3	2,500	80	1	0	9.05	clear	III	yes
404	9:1	Dead	K_2CO_3	2,500	100	1	0	9.05	clear	III	yes
405	9:1	Dead	K_2CO_3	5,000	0	1		9			

405	9:1	Dead	K_2CO_3	5,000	3	0	4	5.7	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
405	9:1	Dead	K_2CO_3	5,000	6	0	4	5.7	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	9	0	4	5.7	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	13	0	4	5.7	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	16	0	4	5.7	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	20	0	4	5.75	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	40	0	4	5.8	clear	III	no
405	9:1	Dead	K_2CO_3	5,000	60	1	0	9	clear	III	yes
405	9:1	Dead	K_2CO_3	5,000	80	1	0	9	clear	III	yes
405	9:1	Dead	K_2CO_3	5,000	100	1	0	9	clear	III	yes
406	9:1	Dead	K_2CO_3	7,500	0	broken					
407	9:1	Dead	K_2CO_3	10,000	0	1		9			
407	9:1	Dead	K_2CO_3	10,000	3	0	4	6.1	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	6	0	4	6.1	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	9	0	4	6.1	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	13	0	4	6.15	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	16	0	4	6.15	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	20	0	4	6.2	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	40	0	3	6.2	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	60	0	3	6.9	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	80	1	3	7	clear	III	no
407	9:1	Dead	K_2CO_3	10,000	100	1	3	7	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	0	1		9			
408	9:1	Dead	K_2CO_3	12,500	3	0	4	5.5	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	6	0	4	5.55	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	9	0	4	5.55	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	13	0	4	5.6	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	16	0	4	5.7	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	20	0	4	5.7	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	40	0	4	5.75	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	60	1	4	6	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	80	1	3	6.3	clear	III	no
408	9:1	Dead	K_2CO_3	12,500	100	1	3	6.3	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	0	1		9			
409	9:1	Dead	K_2CO_3	15,000	3	0	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	6	0	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	9	0	4	5.5	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	13	0	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	16	0	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	20	0	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	40	1	4	5.55	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	60	1	3	5.9	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	80	1	3	6.2	clear	III	no
409	9:1	Dead	K_2CO_3	15,000	100	1	3	6.2	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	0	1		9			
410	9:1	Dead	K_2CO_3	17,500	3	0	4	5.5	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	6	0	4	5.5	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	9	0	4	5.65	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	13	0	4	5.7	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
410	9:1	Dead	K_2CO_3	17,500	16	0	4	5.7	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	20	0	4	5.8	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	40	0	4	5.9	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	60	1	4	6	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	80	1	3	6.35	clear	III	no
410	9:1	Dead	K_2CO_3	17,500	100	1	3	6.35	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	0	1		9			
411	9:1	Dead	K_2CO_3	20,000	3	0	4	5.95	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	6	0	4	5.95	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	9	0	4	5.95	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	13	0	4	6	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	16	0	4	5.95	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	20	0	4	6.1	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	40	0	4	6.1	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	60	1	3	6.4	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	80	1	3	6.6	clear	III	no
411	9:1	Dead	K_2CO_3	20,000	100	1	3	6.6	clear	III	no

8.TH: Formulation 2b: Softened Water + Dead S 85 Oil @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
412	1:9	Dead	Na_2CO_3	2,500	0	9	0	1			
412	1:9	Dead	Na_2CO_3	2,500	3	9	1	0.6	clear	III	no
412	1:9	Dead	Na_2CO_3	2,500	6	9	1	0.6	clear	III	no
412	1:9	Dead	Na_2CO_3	2,500	9	9	0	0.8	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	13	9	0	0.9	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	16	9	0	1.05	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	20	9	0	1.08	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	40	9	0	1.08	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	60	9	0	0.98	clear	III	yes
412	1:9	Dead	Na_2CO_3	2,500	80	9	0	1	clear	x	x
412	1:9	Dead	Na_2CO_3	2,500	100	9	0	1	clear	x	x
413	1:9	Dead	Na_2CO_3	5,000	0	9	0	1			
413	1:9	Dead	Na_2CO_3	5,000	3	9	1	0	clear	II (-)	no
413	1:9	Dead	Na_2CO_3	5,000	6	9	1	0	clear	II (-)	no
413	1:9	Dead	Na_2CO_3	5,000	9	9	1	0.75	clear	III	no
413	1:9	Dead	Na_2CO_3	5,000	13	9	1	0.6	clear	III	no
413	1:9	Dead	Na_2CO_3	5,000	16	9	0	0.7	clear	III	no
413	1:9	Dead	Na_2CO_3	5,000	20	9	1	0.6	clear	III	yes
413	1:9	Dead	Na_2CO_3	5,000	40	9	0	0.7	clear	III	yes
413	1:9	Dead	Na_2CO_3	5,000	60	9	0	0.8	clear	III	yes
413	1:9	Dead	Na_2CO_3	5,000	80	9	0	0.95	clear	III	yes
413	1:9	Dead	Na_2CO_3	5,000	100	9	0	1	clear	III	yes
414	1:9	Dead	Na_2CO_3	7,500	0	9	0	1			
414	1:9	Dead	Na_2CO_3	7,500	3	9	1	0	clear	II (-)	no
414	1:9	Dead	Na_2CO_3	7,500	6	9	1	0.6	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	9	9	0	0.95	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
414	1:9	Dead	Na_2CO_3	7,500	13	9	1	0.7	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	16	9	1	0.8	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	20	9	1	0.7	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	40	9	1	0.8	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	60	9	1	0.9	clear	III	no
414	1:9	Dead	Na_2CO_3	7,500	80	9	0	1.2	clear	III	yes
414	1:9	Dead	Na_2CO_3	7,500	100	9	0	1.2	clear	III	yes
415	1:9	Dead	Na_2CO_3	10,000	0	9	0	1			
415	1:9	Dead	Na_2CO_3	10,000	3	9	1	0	clear	II (-)	no
415	1:9	Dead	Na_2CO_3	10,000	6	9	0	0	clear	II (-)	yes
415	1:9	Dead	Na_2CO_3	10,000	9	9	0	0	clear	II (-)	yes
415	1:9	Dead	Na_2CO_3	10,000	13	9	1	0.75	clear	III	no
415	1:9	Dead	Na_2CO_3	10,000	16	9	1	0.85	clear	III	no
415	1:9	Dead	Na_2CO_3	10,000	20	9	1	0.75	clear	III	no
415	1:9	Dead	Na_2CO_3	10,000	40	9	0	0.9	clear	III	yes
415	1:9	Dead	Na_2CO_3	10,000	60	9	0	1	clear	III	yes
415	1:9	Dead	Na_2CO_3	10,000	80	9	0	1.45	clear	x	x
415	1:9	Dead	Na_2CO_3	10,000	100	9	0	1.45	clear	x	x
416	1:9	Dead	Na_2CO_3	12,500	0	9	0	1			
416	1:9	Dead	Na_2CO_3	12,500	3	9	0	0	clear	II (-)	yes
416	1:9	Dead	Na_2CO_3	12,500	6	9	0	0	clear	II (-)	yes
416	1:9	Dead	Na_2CO_3	12,500	9	9	0	0	clear	II (-)	yes
416	1:9	Dead	Na_2CO_3	12,500	13	9	0	0.9	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	16	9	0	0.8	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	20	9	0	0.8	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	40	9	0	0.8	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	60	9	0	0.8	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	80	9	0	1	clear	III	yes
416	1:9	Dead	Na_2CO_3	12,500	100	9	0	1	clear	III	yes
417	1:9	Dead	Na_2CO_3	15,000	0	9	0	1			
417	1:9	Dead	Na_2CO_3	15,000	3	9	0	0	clear	II (-)	yes
417	1:9	Dead	Na_2CO_3	15,000	6	9	0	0.7	clear	III	yes
417	1:9	Dead	Na_2CO_3	15,000	9	9	0	0.9	clear	III	yes
417	1:9	Dead	Na_2CO_3	15,000	13	9	1	0.7	clear	III	no
417	1:9	Dead	Na_2CO_3	15,000	16	9	1	0.8	clear	III	no
417	1:9	Dead	Na_2CO_3	15,000	20	9	1	0.6	clear	III	no
417	1:9	Dead	Na_2CO_3	15,000	40	9	1	0.75	clear	III	yes
417	1:9	Dead	Na_2CO_3	15,000	60	9	1	0.85	clear	III	yes
417	1:9	Dead	Na_2CO_3	15,000	80	9	0	1.5	clear	x	yes
417	1:9	Dead	Na_2CO_3	15,000	100	9	0	1.5	clear	x	yes
418	1:9	Dead	Na_2CO_3	17,500	0	9	0	1			
418	1:9	Dead	Na_2CO_3	17,500	3	9	1	0	clear	II (-)	no
418	1:9	Dead	Na_2CO_3	17,500	6	9	1	0.6	clear	III	no
418	1:9	Dead	Na_2CO_3	17,500	9	9	1	0.6	clear	III	no
418	1:9	Dead	Na_2CO_3	17,500	13	9	1	0.6	clear	III	no
418	1:9	Dead	Na_2CO_3	17,500	16	9	0	0.8	clear	III	yes
418	1:9	Dead	Na_2CO_3	17,500	20	9	0	0.95	clear	III	yes
418	1:9	Dead	Na_2CO_3	17,500	40	9	0	0.95	clear	III	yes
418	1:9	Dead	Na_2CO_3	17,500	60	9	0	0.85	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
418	1:9	Dead	Na_2CO_3	17,500	80	9	0	1	clear	III	yes
418	1:9	Dead	Na_2CO_3	17,500	100	9	0	1	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	0	9	0	1			
419	1:9	Dead	Na_2CO_3	20,000	3	9	1	0	clear	II (-)	no
419	1:9	Dead	Na_2CO_3	20,000	6	9	1	0.3	clear	III	no
419	1:9	Dead	Na_2CO_3	20,000	9	9	1	0.6	clear	III	no
419	1:9	Dead	Na_2CO_3	20,000	13	9	1	0.7	clear	III	no
419	1:9	Dead	Na_2CO_3	20,000	16	9	0	1.1	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	20	9	0	1.1	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	40	9	0	1.1	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	60	9	0	0.8	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	80	9	0	0.9	clear	III	yes
419	1:9	Dead	Na_2CO_3	20,000	100	9	0	0.9	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	0	7	0	3			
420	3:7	Dead	Na_2CO_3	2,500	3	0	8	2.3	clear	II (+)	no
420	3:7	Dead	Na_2CO_3	2,500	6	0	8	2.5	clear	II (+)	yes
420	3:7	Dead	Na_2CO_3	2,500	9	0	7	2.6	clear	II (+)	yes
420	3:7	Dead	Na_2CO_3	2,500	13	4	4	2.5	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	16	5	3	2	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	20	7	3	0.5	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	40	7	3	0.8	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	60	7	2	1	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	80	7	2	1.7	clear	III	yes
420	3:7	Dead	Na_2CO_3	2,500	100	7	1	2.9	clear	III	yes
421	3:7	Dead	Na_2CO_3	5,000	0	7	0	3			
421	3:7	Dead	Na_2CO_3	5,000	3	0	9	1.3	clear	II (+)	no
421	3:7	Dead	Na_2CO_3	5,000	6	0	8	1.8	clear	II (+)	no
421	3:7	Dead	Na_2CO_3	5,000	9	0	8	2.1	clear	II (+)	no
421	3:7	Dead	Na_2CO_3	5,000	13	0	8	2.3	clear	II (+)	no
421	3:7	Dead	Na_2CO_3	5,000	16	5	4	1	clear	III	no
421	3:7	Dead	Na_2CO_3	5,000	20	5	4	1.5	clear	III	no
421	3:7	Dead	Na_2CO_3	5,000	40	5	2	3	clear	III	no
421	3:7	Dead	Na_2CO_3	5,000	60	5	2	2.9	clear	III	no
421	3:7	Dead	Na_2CO_3	5,000	80	6	1	3	clear	III	no
421	3:7	Dead	Na_2CO_3	5,000	100	6	1	3	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	0	7	0	3			
422	3:7	Dead	Na_2CO_3	7,500	3	0	9	0.8	clear	II (+)	no
422	3:7	Dead	Na_2CO_3	7,500	6	0	9	1.1	clear	II (+)	no
422	3:7	Dead	Na_2CO_3	7,500	9	0	9	1.2	clear	II (+)	no
422	3:7	Dead	Na_2CO_3	7,500	13	0	9	1.2	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	16	3	4	2.9	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	20	4	3	2.95	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	40	5	2	3	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	60	5	2	3.05	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	80	6	1	3.05	clear	III	no
422	3:7	Dead	Na_2CO_3	7,500	100	6	1	3.05	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	0	7	0	3			
423	3:7	Dead	Na_2CO_3	10,000	3	0	10	0.3	clear	II (+)	no
423	3:7	Dead	Na_2CO_3	10,000	6	0	10	0.3	clear	II (+)	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
423	3:7	Dead	Na_2CO_3	10,000	9	2	8	0.3	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	13	2	7	0.8	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	16	4	5	1.2	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	20	4	5	1	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	40	7	2	1	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	60	7	2	1.5	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	80	7	1	2.15	clear	III	no
423	3:7	Dead	Na_2CO_3	10,000	100	7	1	2.6	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	0	7	0	3			
424	3:7	Dead	Na_2CO_3	12,500	3	0	10	0.2	clear	II (+)	no
424	3:7	Dead	Na_2CO_3	12,500	6	4	6	0.2	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	9	5	4	0.5	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	13	5	4	0.5	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	16	6	4	0.9	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	20	6	4	0.9	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	40	6	3	1	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	60	7	3	1	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	80	7	2	1.2	clear	III	no
424	3:7	Dead	Na_2CO_3	12,500	100	7	2	1.8	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	0	7	0	3			
425	3:7	Dead	Na_2CO_3	15,000	3	4	6	0.1	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	6	4	6	0.1	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	9	5	4	0.3	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	13	6	4	0.4	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	16	6	3	0.7	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	20	7	2	0.9	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	40	7	2	1.2	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	60	7	2	1.2	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	80	7	1	2.35	clear	III	no
425	3:7	Dead	Na_2CO_3	15,000	100	7	0	2.7	clear	III	yes
426	3:7	Dead	Na_2CO_3	17,500	0	7	0	3			
426	3:7	Dead	Na_2CO_3	17,500	3	3	7	0.2	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	6	5	5	0.3	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	9	5	4	2.2	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	13	5	4	2.3	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	16	6	4	2.4	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	20	6	3	2.4	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	40	6	3	1.5	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	60	6	2	2.65	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	80	6	2	2.65	clear	III	no
426	3:7	Dead	Na_2CO_3	17,500	100	6	3	2.7	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	0	7	0	3			
427	3:7	Dead	Na_2CO_3	20,000	3	6	4	0.15	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	6	6	4	0.25	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	9	5	4	0.55	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	13	5	4	1.05	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	16	5	3	1.75	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	20	5	3	2.1	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	40	5	2	2.4	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
427	3:7	Dead	Na_2CO_3	20,000	60	5	2	2.4	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	80	5	2	2.5	clear	III	no
427	3:7	Dead	Na_2CO_3	20,000	100	5	2	2.6	clear	III	no
428	5:5	Dead	Na_2CO_3	2,500	0	5	0	5			
428	5:5	Dead	Na_2CO_3	2,500	3	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	6	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	9	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	13	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	16	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	20	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	40	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	60	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	80	5	0	5	clear	x	x
428	5:5	Dead	Na_2CO_3	2,500	100	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	0	5	0	5			
429	5:5	Dead	Na_2CO_3	5,000	3	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	6	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	9	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	13	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	16	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	20	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	40	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	60	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	80	5	0	5	clear	x	x
429	5:5	Dead	Na_2CO_3	5,000	100	5	0	5	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	0	5	0	5			
430	5:5	Dead	Na_2CO_3	7,500	3	1	9	0.4	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	6	1	9	0.85	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	9	1	7	2.2	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	13	1	7	1.8	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	16	2	7	1.8	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	20	2	6	1.4	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	40	2	6	1.6	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	60	4	6	0.5	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	80	4	5	0.5	clear	x	x
430	5:5	Dead	Na_2CO_3	7,500	100	5	5	0.5	clear	x	x
431	5:5	Dead	Na_2CO_3	10,000	0	5	0	5			
431	5:5	Dead	Na_2CO_3	10,000	3	1	9	0.7	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	6	1	9	0.6	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	9	2	8	0.8	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	13	1	7	1.5	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	16	2	7	1.15	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	20	3	6	1.3	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	40	3	6	1.5	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	60	4	5	0.7	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	80	4	5	0.9	clear	III	no
431	5:5	Dead	Na_2CO_3	10,000	100	4	5	0.9	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	0	5	0	5			
432	5:5	Dead	Na_2CO_3	12,500	3	1	9	0.4	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
432	5:5	Dead	Na_2CO_3	12,500	6	1	9	0.4	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	9	2	8	0.6	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	13	1	7	1.6	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	16	3	6	1.35	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	20	3	6	1.5	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	40	3	5	1.8	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	60	3	5	1.7	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	80	3	5	2	clear	III	no
432	5:5	Dead	Na_2CO_3	12,500	100	4	4	2.1	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	0	5	0	5			
433	5:5	Dead	Na_2CO_3	15,000	3	1	8	0.7	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	6	1	8	0.45	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	9	2	8	0.7	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	13	2	7	1.5	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	16	2	7	1.5	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	20	2	6	1.7	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	40	3	5	1.6	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	60	5	5	0.35	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	80	5	4	0.75	clear	III	no
433	5:5	Dead	Na_2CO_3	15,000	100	5	4	0.75	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	0	1	0	9.3			
434	5:5	Dead	Na_2CO_3	17,500	3	1	9	0.7	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	6	1	9	0.7	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	9	1	9	0.4	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	13	2	7	0.5	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	16	3	7	0.7	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	20	3	5	1.7	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	40	4	5	0.9	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	60	4	5	1.1	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	80	4	4	1.6	clear	III	no
434	5:5	Dead	Na_2CO_3	17,500	100	4	3	2.5	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	0	1	0	8.9			
435	5:5	Dead	Na_2CO_3	20,000	3	1	8	0.7	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	6	1	8	0.6	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	9	1	8	0.9	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	13	2	7	1.45	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	16	2	7	1.45	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	20	3	5	1.9	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	40	4	4	1.85	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	60	4	4	2.1	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	80	4	4	2.2	clear	III	no
435	5:5	Dead	Na_2CO_3	20,000	100	4	3	2.7	clear	III	no
436	7:3	Dead	Na_2CO_3	2,500	0	3	0	7			
436	7:3	Dead	Na_2CO_3	2,500	3	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	6	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	9	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	13	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	16	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	20	3	0	6.9	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
436	7:3	Dead	Na_2CO_3	2,500	40	3	0	6.9	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	60	3	0	7	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	80	3	0	7	clear	x	x
436	7:3	Dead	Na_2CO_3	2,500	100	3	0	7	clear	x	x
437	7:3	Dead	Na_2CO_3	5,000	0	3		7			
437	7:3	Dead	Na_2CO_3	5,000	3	0	9	0.7	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	6	2	6	1.95	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	9	3	5	1.7	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	13	3	5	1.7	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	16	1	5	4.3	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	20	1	4	4.3	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	40	2	4	4.6	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	60	3	3	4.3	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	80	3	2	4.8	clear	III	no
437	7:3	Dead	Na_2CO_3	5,000	100	3	2	5.54	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	0	3		7			
438	7:3	Dead	Na_2CO_3	7,500	3	0	9	0.8	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	6	0	8	1.5	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	9	1	7	2.2	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	13	0	6	3.5	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	16	1	6	3.7	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	20	1	5	3.85	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	40	1	5	3.95	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	60	2	4	4.2	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	80	2	3	5	clear	III	no
438	7:3	Dead	Na_2CO_3	7,500	100	2	3	5.2	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	0	3		7			
439	7:3	Dead	Na_2CO_3	10,000	3	0	9	0.8	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	6	0	9	0.6	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	9	0	9	1	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	13	0	6	3.3	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	16	1	6	3.4	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	20	1	6	3.5	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	40	1	5	3.8	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	60	2	3	4.6	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	80	2	3	4.9	clear	III	no
439	7:3	Dead	Na_2CO_3	10,000	100	2	3	5.4	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	0	3		7			
440	7:3	Dead	Na_2CO_3	12,500	3	0	9	0.7	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	6	0	9	0.5	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	9	0	9	0.6	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	13	0	7	3.2	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	16	1	6	3.5	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	20	1	6	3.6	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	40	1	5	3.8	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	60	2	3	4.6	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	80	2	2	5.5	clear	III	no
440	7:3	Dead	Na_2CO_3	12,500	100	2	2	5.9	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	0	3		7			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
441	7:3	Dead	Na_2CO_3	15,000	3	0	9	0.7	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	6	0	9	0.7	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	9	0	9	0.7	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	13	0	7	2.9	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	16	1	6	3.1	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	20	1	6	3.3	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	40	1	5	3.5	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	60	2	4	4.2	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	80	2	4	4.7	clear	III	no
441	7:3	Dead	Na_2CO_3	15,000	100	2	3	5	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	0	3		7			
442	7:3	Dead	Na_2CO_3	17,500	3	0	9	0.6	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	6	0	9	0.4	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	9	1	9	0.8	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	13	1	6	3.8	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	16	1	5	3.95	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	20	1	5	4.2	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	40	1	5	4.3	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	60	2	3	4.6	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	80	2	3	5	clear	III	no
442	7:3	Dead	Na_2CO_3	17,500	100	2	2	5.6	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	0	3		7			
443	7:3	Dead	Na_2CO_3	20,000	3	0	9	0.6	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	6	0	9	0.4	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	9	1	9	0.7	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	13	1	9	0.7	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	16	1	5	3.7	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	20	1	5	3.8	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	40	2	4	3.85	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	60	2	4	4.3	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	80	2	3	4.7	clear	III	no
443	7:3	Dead	Na_2CO_3	20,000	100	2	3	4.9	clear	III	no
444	9:1	Dead	Na_2CO_3	2,500	0	1	0	9			
444	9:1	Dead	Na_2CO_3	2,500	3	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	6	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	9	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	13	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	16	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	20	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	40	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	60	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	80	1	0	9	clear	x	x
444	9:1	Dead	Na_2CO_3	2,500	100	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	0	1	0	9			
445	9:1	Dead	Na_2CO_3	5,000	3	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	6	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	9	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	13	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	16	1	0	9	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
445	9:1	Dead	Na_2CO_3	5,000	20	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	40	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	60	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	80	1	0	9	clear	x	x
445	9:1	Dead	Na_2CO_3	5,000	100	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	0	1	0	9			
446	9:1	Dead	Na_2CO_3	7,500	3	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	6	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	9	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	13	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	16	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	20	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	40	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	60	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	80	1	0	9	clear	x	x
446	9:1	Dead	Na_2CO_3	7,500	100	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	0	1	0	9			
447	9:1	Dead	Na_2CO_3	10,000	3	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	6	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	9	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	13	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	16	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	20	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	40	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	60	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	80	1	0	9	clear	x	x
447	9:1	Dead	Na_2CO_3	10,000	100	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	0	1	0	9			
448	9:1	Dead	Na_2CO_3	12,000	3	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	6	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	9	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	13	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	16	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	20	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	40	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	60	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	80	1	0	9	clear	x	x
448	9:1	Dead	Na_2CO_3	12,000	100	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	0	1	0	9			
449	9:1	Dead	Na_2CO_3	15,000	3	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	6	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	9	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	13	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	16	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	20	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	40	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	60	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	80	1	0	9	clear	x	x
449	9:1	Dead	Na_2CO_3	15,000	100	1	0	9	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
450	9:1	Dead	Na_2CO_3	17,500	0	1	0	9			
450	9:1	Dead	Na_2CO_3	17,500	3	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	6	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	9	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	13	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	16	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	20	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	40	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	60	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	80	1	0	9	clear	x	x
450	9:1	Dead	Na_2CO_3	17,500	100	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	0	1	0	9			
451	9:1	Dead	Na_2CO_3	20,000	3	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	6	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	9	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	13	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	16	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	20	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	40	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	60	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	80	1	0	9	clear	x	x
451	9:1	Dead	Na_2CO_3	20,000	100	1	0	9	clear	x	x

8.TH: Formulation 2b: Softened Water + Dead S 85 Oil @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
452	1:9	Dead	K_2CO_3	2,500	0	9	0	1			
452	1:9	Dead	K_2CO_3	2,500	3	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	6	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	9	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	13	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	16	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	20	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	40	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	60	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	80	9	0	0.8	clear	x	x
452	1:9	Dead	K_2CO_3	2,500	100	9	0	0.8	clear	x	x
453	1:9	Dead	K_2CO_3	5,000	0	9	0	1			
453	1:9	Dead	K_2CO_3	5,000	3	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	6	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	9	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	13	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	16	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	20	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	40	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	60	9	0	1	clear, oil traces on the glass	x	x

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
453	1:9	Dead	K_2CO_3	5,000	80	9	0	1	clear, oil traces on the glass	x	x
453	1:9	Dead	K_2CO_3	5,000	100	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	0	9	0	1			
454	1:9	Dead	K_2CO_3	7,500	3	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	6	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	9	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	13	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	16	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	20	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	40	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	60	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	80	9	0	1	clear, oil traces on the glass	x	x
454	1:9	Dead	K_2CO_3	7,500	100	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	0	9	0	1			
455	1:9	Dead	K_2CO_3	10,000	3	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	6	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	9	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	13	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	16	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	20	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	40	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	60	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	80	9	0	1	clear, oil traces on the glass	x	x
455	1:9	Dead	K_2CO_3	10,000	100	9	0	1	clear, oil traces on the glass	x	x
456	1:9	Dead	K_2CO_3	12,500	0	9	0	1			
456	1:9	Dead	K_2CO_3	12,500	3	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	6	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	9	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	13	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	16	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	20	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	40	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	60	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	80	9	0	1	clear	x	x
456	1:9	Dead	K_2CO_3	12,500	100	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	0	9	0	1			
457	1:9	Dead	K_2CO_3	15,000	3	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	6	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	9	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	13	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	16	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	20	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	40	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	60	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	80	9	0	1	clear	x	x
457	1:9	Dead	K_2CO_3	15,000	100	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	0	9	0	1			
458	1:9	Dead	K_2CO_3	17,500	3	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	6	9	0	1	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
458	1:9	Dead	K_2CO_3	17,500	9	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	13	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	16	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	20	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	40	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	60	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	80	9	0	1	clear	x	x
458	1:9	Dead	K_2CO_3	17,500	100	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	0	9	0	1			
459	1:9	Dead	K_2CO_3	20,000	3	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	6	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	9	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	13	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	16	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	20	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	40	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	60	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	80	9	0	1	clear	x	x
459	1:9	Dead	K_2CO_3	20,000	100	9	0	1	clear	x	x
460	3:7	Dead	K_2CO_3	2,500	0	7	0	3			
460	3:7	Dead	K_2CO_3	2,500	3	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	6	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	9	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	13	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	16	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	20	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	40	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	60	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	80	7	0	3	clear, oil traces on the glass	x	x
460	3:7	Dead	K_2CO_3	2,500	100	7	0	3	clear, oil traces on the glass	x	x
461	3:7	Dead	K_2CO_3	5,000	0	7	0	3			
461	3:7	Dead	K_2CO_3	5,000	3	1	8	1.3	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	6	1	8	1.4	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	9	1	8	1.5	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	13	1	8	1.65	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	16	1	7	2.3	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	20	1	7	2.3	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	40	2	5	3	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	60	3	4	2.9	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	80	5	2	3	clear, oil traces on the glass	III	no
461	3:7	Dead	K_2CO_3	5,000	100	5	2	3	clear, oil traces on the glass	III	no
462	3:7	Dead	K_2CO_3	7,500	0	7	0	3			
462	3:7	Dead	K_2CO_3	7,500	3	0	9	1.3	clear, oil traces on the glass	II (+)	no
462	3:7	Dead	K_2CO_3	7,500	6	0	8	1.55	clear, oil traces on the glass	II (+)	no
462	3:7	Dead	K_2CO_3	7,500	9	0	8	1.7	clear, oil traces on the glass	II (+)	no
462	3:7	Dead	K_2CO_3	7,500	13	0	8	1.85	clear, oil traces on the glass	II (+)	no
462	3:7	Dead	K_2CO_3	7,500	16	6	2	2.7	clear, oil traces on the glass	III	no
462	3:7	Dead	K_2CO_3	7,500	20	6	1	2.8	clear, oil traces on the glass	III	no
462	3:7	Dead	K_2CO_3	7,500	40	6	1	2.9	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
462	3:7	Dead	K_2CO_3	7,500	60	6	1	2.95	clear, oil traces on the glass	III	no
462	3:7	Dead	K_2CO_3	7,500	80	7	0	2.95	clear, oil traces on the glass	III	yes
462	3:7	Dead	K_2CO_3	7,500	100	7	0	2.95	clear, oil traces on the glass	III	yes
463	3:7	Dead	K_2CO_3	10,000	0	7	0	3			
463	3:7	Dead	K_2CO_3	10,000	3	0	9	0.8	clear, oil traces on the glass	II (+)	no
463	3:7	Dead	K_2CO_3	10,000	6	0	9	1	clear, oil traces on the glass	II (+)	no
463	3:7	Dead	K_2CO_3	10,000	9	0	9	1.1	clear, oil traces on the glass	II (+)	no
463	3:7	Dead	K_2CO_3	10,000	13	4	5	1.25	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	16	5	2	2.65	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	20	5	2	2.65	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	40	5	2	2.85	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	60	6	1	2.9	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	80	6	1	2.95	clear, oil traces on the glass	III	no
463	3:7	Dead	K_2CO_3	10,000	100	6	1	2.95	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	0	7	0	3			
464	3:7	Dead	K_2CO_3	12,500	3	0	10	0.4	clear, oil traces on the glass	II (+)	no
464	3:7	Dead	K_2CO_3	12,500	6	1	9	0.5	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	9	2	7	0.9	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	13	2	8	0.8	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	16	4	4	2.1	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	20	4	4	2.1	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	40	4	3	3	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	60	4	3	2.95	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	80	6	1	2.95	clear, oil traces on the glass	III	no
464	3:7	Dead	K_2CO_3	12,500	100	7	1	3	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	0	7	0	3			
465	3:7	Dead	K_2CO_3	15,000	3	0	9	0.2	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	6	1	9	0.5	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	9	2	8	0.3	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	13	1	8	0.45	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	16	4	5	0.45	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	20	4	5	0.45	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	40	4	5	0.95	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	60	5	4	1.05	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	80	6	1	2.75	clear, oil traces on the glass	III	no
465	3:7	Dead	K_2CO_3	15,000	100	7	0	2.8	clear, oil traces on the glass	III	yes
466	3:7	Dead	K_2CO_3	17,500	0	7	0	3			
466	3:7	Dead	K_2CO_3	17,500	3	0	10	0.1	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	6	1	9	0.2	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	9	1	9	2.2	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	13	2	8	2.3	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	16	5	5	2.4	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	20	5	5	2.4	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	40	5	5	0.05	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	60	5	4	1.25	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	80	5	3	2.2	clear, oil traces on the glass	III	no
466	3:7	Dead	K_2CO_3	17,500	100	5	2	3	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	0	7	0	3			
467	3:7	Dead	K_2CO_3	20,000	3	0	10	0	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
467	3:7	Dead	K_2CO_3	20,000	6	0	10	2.2	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	9	0	10	2.2	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	13	0	10	2.25	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	16	0	5	2.3	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	20	0	5	2.3	clear, oil traces on the glass	III	no
467	3:7	Dead	K_2CO_3	20,000	40	0	5	2.3	clear, oil traces on the glass	III	yes
467	3:7	Dead	K_2CO_3	20,000	60	0	4	2.2	clear, oil traces on the glass	III	yes
467	3:7	Dead	K_2CO_3	20,000	80	0	4	2.2	clear, oil traces on the glass	III	yes
467	3:7	Dead	K_2CO_3	20,000	100	0	3	2.2	clear, oil traces on the glass	III	yes
468	5:5	Dead	K_2CO_3	2,500	0	5	0	5			
468	5:5	Dead	K_2CO_3	2,500	3	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	6	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	9	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	13	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	16	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	20	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	40	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	60	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	80	5	0	5	clear, oil traces on the glass	x	x
468	5:5	Dead	K_2CO_3	2,500	100	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	0	5	0	5			
469	5:5	Dead	K_2CO_3	5,000	3	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	6	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	9	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	13	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	16	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	20	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	40	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	60	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	80	5	0	5	clear, oil traces on the glass	x	x
469	5:5	Dead	K_2CO_3	5,000	100	5	0	5	clear, oil traces on the glass	x	x
470	5:5	Dead	K_2CO_3	7,500	0	5	0	5			
470	5:5	Dead	K_2CO_3	7,500	3	0	7	2.6	clear, oil traces on the glass	II (+)	no
470	5:5	Dead	K_2CO_3	7,500	6	0	7	2.6	clear, oil traces on the glass	II (+)	no
470	5:5	Dead	K_2CO_3	7,500	9	0	7	3.2	clear, oil traces on the glass	II (+)	no
470	5:5	Dead	K_2CO_3	7,500	13	0	7	3.4	clear, oil traces on the glass	II (+)	no
470	5:5	Dead	K_2CO_3	7,500	16	5	1	4.25	clear, oil traces on the glass	III	no
470	5:5	Dead	K_2CO_3	7,500	20	5	1	4.5	clear, oil traces on the glass	III	no
470	5:5	Dead	K_2CO_3	7,500	40	5	1	4.3	clear, oil traces on the glass	III	no
470	5:5	Dead	K_2CO_3	7,500	60	5	1	4.6	clear, oil traces on the glass	III	no
470	5:5	Dead	K_2CO_3	7,500	80	5	0	4.8	clear, oil traces on the glass	III	yes
470	5:5	Dead	K_2CO_3	7,500	100	5	0	5	clear, oil traces on the glass	III	yes
471	5:5	Dead	K_2CO_3	10,000	0	5	0	5			
471	5:5	Dead	K_2CO_3	10,000	3	1	9	0.42	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	6	1	8	0.52	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	9	1	7	1.17	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	13	1	7	1.22	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	16	3	6	1.22	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	20	3	6	1.3	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
471	5:5	Dead	K_2CO_3	10,000	40	3	6	1.3	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	60	5	4	1.2	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	80	5	3	2.4	clear, oil traces on the glass	III	no
471	5:5	Dead	K_2CO_3	10,000	100	5	1	4.1	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	0	5	0	5			
472	5:5	Dead	K_2CO_3	12,500	3	1	9	0.1	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	6	1	9	0.2	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	9	1	9	0.35	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	13	1	9	0.35	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	16	2	7	0.8	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	20	2	7	0.85	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	40	2	7	0.85	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	60	4	5	0.4	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	80	4	4	1.5	clear, oil traces on the glass	III	no
472	5:5	Dead	K_2CO_3	12,500	100	4	4	2.2	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	0	5	0	5			
473	5:5	Dead	K_2CO_3	15,000	3	0	9	0.15	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	6	1	9	0.1	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	9	1	9	0.3	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	13	1	9	0.3	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	16	2	8	0.3	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	20	2	8	0.3	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	40	2	8	0.3	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	60	4	6	0.1	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	80	5	5	0.1	clear, oil traces on the glass	III	no
473	5:5	Dead	K_2CO_3	15,000	100	6	4	0.1	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	0	5	0	5			
474	5:5	Dead	K_2CO_3	17,500	3	1	9	0.4	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	6	1	9	0.2	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	9	1	9	0.5	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	13	1	9	0.5	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	16	2	8	0.8	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	20	2	7	0.8	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	40	2	7	0.8	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	60	2	7	0.8	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	80	2	7	0.8	clear, oil traces on the glass	III	no
474	5:5	Dead	K_2CO_3	17,500	100	2	7	0.8	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	0	5	0	5			
475	5:5	Dead	K_2CO_3	20,000	3	1	9	0.05	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	6	1	9	0.1	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	9	1	9	0.3	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	13	1	9	0.3	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	16	2	8	0.3	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	20	2	8	0.6	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	40	2	8	0.6	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	60	4	5	0.95	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	80	5	4	1.25	clear, oil traces on the glass	III	no
475	5:5	Dead	K_2CO_3	20,000	100	5	3	2.4	clear, oil traces on the glass	III	no
476	7:3	Dead	K_2CO_3	2,500	0	3	0	7			

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
476	7:3	Dead	K_2CO_3	2,500	3	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	6	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	9	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	13	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	16	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	20	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	40	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	60	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	80	3	0	7	light yellow, clear	x	x
476	7:3	Dead	K_2CO_3	2,500	100	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	0	3	0	7			
477	7:3	Dead	K_2CO_3	5,000	3	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	6	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	9	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	13	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	16	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	20	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	40	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	60	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	80	3	0	7	light yellow, clear	x	x
477	7:3	Dead	K_2CO_3	5,000	100	3	0	7	light yellow, clear	x	x
478	7:3	Dead	K_2CO_3	7,500	0	3	0	7			
478	7:3	Dead	K_2CO_3	7,500	3	1	7	2.3	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	6	1	4	4.2	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	9	2	2	5.6	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	13	3	2	5.1	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	16	3	2	5.1	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	20	3	2	5.1	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	40	3	2	5.35	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	60	3	1	5.75	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	80	3	1	6.1	light yellow, clear	III	no
478	7:3	Dead	K_2CO_3	7,500	100	3	1	6.1	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	0	3	0	7			
479	7:3	Dead	K_2CO_3	10,000	3	0	8	1.7	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	6	0	8	2	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	9	0	7	2.4	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	13	1	3	6.5	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	16	1	6	3	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	20	1	6	3	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	40	5	4	1.1	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	60	5	3	2.6	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	80	5	2	3.6	light yellow, clear	III	no
479	7:3	Dead	K_2CO_3	10,000	100	5	1	4	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	0	3	0	7			
480	7:3	Dead	K_2CO_3	12,500	3	0	8	1.8	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	6	0	8	1.9	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	9	0	8	2	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	13	0	7	3.1	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	16	1	7	2.35	light yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
480	7:3	Dead	K_2CO_3	12,500	20	1	7	2.45	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	40	3	6	1.3	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	60	3	6	2	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	80	3	4	3.9	light yellow, clear	III	no
480	7:3	Dead	K_2CO_3	12,500	100	3	3	4.9	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	0	3	0	7			
481	7:3	Dead	K_2CO_3	15,000	3	0	8	1.85	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	6	0	8	1.9	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	9	0	8	2	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	13	0	8	2.1	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	16	0	7	2.2	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	20	0	7	2.3	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	40	2	7	1	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	60	2	5	3.4	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	80	2	4	4.3	light yellow, clear	III	no
481	7:3	Dead	K_2CO_3	15,000	100	2	3	4.8	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	0	3	0	7			
482	7:3	Dead	K_2CO_3	17,500	3	0	8	1.5	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	6	0	8	1.6	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	9	0	8	1.6	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	13	0	8	1.7	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	16	0	8	1.8	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	20	0	8	1.85	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	40	2	7	0.9	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	60	2	7	1.2	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	80	2	5	2.9	light yellow, clear	III	no
482	7:3	Dead	K_2CO_3	17,500	100	2	5	3.5	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	0	3	0	7			
483	7:3	Dead	K_2CO_3	20,000	3	0	8	1.7	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	6	0	8	1.8	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	9	0	8	1.85	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	13	0	8	1.9	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	16	1	7	2.05	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	20	1	7	2.15	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	40	2	7	0.9	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	60	2	6	2.6	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	80	2	5	3.5	light yellow, clear	III	no
483	7:3	Dead	K_2CO_3	20,000	100	2	4	3.8	light yellow, clear	III	no
484	9:1	Dead	K_2CO_3	2,500	0	1	0	9			
484	9:1	Dead	K_2CO_3	2,500	3	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	6	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	9	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	13	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	16	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	20	1	0	9	clear	III	no
484	9:1	Dead	K_2CO_3	2,500	40	1	0	9	clear	III	yes
484	9:1	Dead	K_2CO_3	2,500	60	1	0	9	clear	III	yes
484	9:1	Dead	K_2CO_3	2,500	80	1	0	9	clear	III	yes
484	9:1	Dead	K_2CO_3	2,500	100	1	0	9	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
485	9:1	Dead	K_2CO_3	5,000	0	1	0	9			
485	9:1	Dead	K_2CO_3	5,000	3	1	0	9	clear	III	no
485	9:1	Dead	K_2CO_3	5,000	6	1	0	9	clear	III	no
485	9:1	Dead	K_2CO_3	5,000	9	1	0	9	clear	III	no
485	9:1	Dead	K_2CO_3	5,000	13	1	0	9	clear	III	no
485	9:1	Dead	K_2CO_3	5,000	16	1	0	9	clear	III	no
485	9:1	Dead	K_2CO_3	5,000	20	1	0	9	clear	III	yes
485	9:1	Dead	K_2CO_3	5,000	40	1	0	9	clear	III	yes
485	9:1	Dead	K_2CO_3	5,000	60	1	0	9	clear	III	yes
485	9:1	Dead	K_2CO_3	5,000	80	1	0	9	clear	III	yes
485	9:1	Dead	K_2CO_3	5,000	100	1	0	9	clear	III	yes
486	9:1	Dead	K_2CO_3	7,500	0	1	0	9			
486	9:1	Dead	K_2CO_3	7,500	3	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	6	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	9	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	13	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	16	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	20	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	40	1	0	9	clear	III	no
486	9:1	Dead	K_2CO_3	7,500	60	1	0	9	clear	III	yes
486	9:1	Dead	K_2CO_3	7,500	80	1	0	9	clear	III	yes
486	9:1	Dead	K_2CO_3	7,500	100	1	0	9	clear	III	yes
487	9:1	Dead	K_2CO_3	10,000	0	1	0	9			
487	9:1	Dead	K_2CO_3	10,000	3	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	6	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	9	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	13	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	16	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	20	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	40	1	0	9	clear	III	no
487	9:1	Dead	K_2CO_3	10,000	60	1	0	9	clear	III	yes
487	9:1	Dead	K_2CO_3	10,000	80	1	0	9	clear	III	yes
487	9:1	Dead	K_2CO_3	10,000	100	1	0	9	clear	III	yes
488	9:1	Dead	K_2CO_3	12,500	0	1	0	9			
488	9:1	Dead	K_2CO_3	12,500	3	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	6	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	9	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	13	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	16	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	20	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	40	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	60	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	80	1	0	9	clear	III	no
488	9:1	Dead	K_2CO_3	12,500	100	1	0	9	clear	III	no
489	9:1	Dead	K_2CO_3	15,000	0	1	0	9			
489	9:1	Dead	K_2CO_3	15,000	3	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	6	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	9	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	13	1	0	8.95	clear	III	yes

Sample Name	WOR	Oil Type	Alkali	Concentration (ppm)	Time	Oil Volume (ml)	Emulsion Volume (ml)	Water Volume (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
489	9:1	Dead	K_2CO_3	15,000	16	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	20	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	40	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	60	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	80	1	0	8.95	clear	III	yes
489	9:1	Dead	K_2CO_3	15,000	100	1	0	8.9	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	0	1	0	9			
490	9:1	Dead	K_2CO_3	17,500	3	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	6	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	9	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	13	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	16	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	20	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	40	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	60	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	80	1	0	8.95	clear	III	yes
490	9:1	Dead	K_2CO_3	17,500	100	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	0	1	0	9			
491	9:1	Dead	K_2CO_3	20,000	3	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	6	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	9	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	13	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	16	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	20	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	40	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	60	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	80	1	0	8.9	clear	III	yes
491	9:1	Dead	K_2CO_3	20,000	100	1	0	8.85	clear	III	yes

8.TH: Formulation 3b: Softened Water + Modified S 85 Oil with C_6H_{12} @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
492	1:9	Modified	Na_2CO_3	2,500	0	9	0	1			
492	1:9	Modified	Na_2CO_3	2,500	3	9	1	0.6	clear	III	no
492	1:9	Modified	Na_2CO_3	2,500	6	9	1	0.6	clear	III	no
492	1:9	Modified	Na_2CO_3	2,500	9	9	0	0.8	clear	III	yes
492	1:9	Modified	Na_2CO_3	2,500	13	9	0	0.9	clear	III	yes
492	1:9	Modified	Na_2CO_3	2,500	16	9	0	0.9	clear	III	yes
492	1:9	Modified	Na_2CO_3	2,500	20	9	0	0.95	clear	III	yes
492	1:9	Modified	Na_2CO_3	2,500	40	9	0	0.95	clear	III	yes
492	1:9	Modified	Na_2CO_3	2,500	60	9	0	1	clear	x	x
492	1:9	Modified	Na_2CO_3	2,500	80	9	0	1	clear	x	x
492	1:9	Modified	Na_2CO_3	2,500	100	9	0	1	clear	x	x
493	1:9	Modified	Na_2CO_3	5000	0	9	0	1			
493	1:9	Modified	Na_2CO_3	5,000	3	9	1	0.4	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
493	1:9	Modified	Na_2CO_3	5,000	6	9	1	0.4	clear	III	no
493	1:9	Modified	Na_2CO_3	5,000	9	9	1	0.75	clear	III	no
493	1:9	Modified	Na_2CO_3	5,000	13	9	1	0.6	clear	III	no
493	1:9	Modified	Na_2CO_3	5,000	16	9	0	0.85	clear	III	yes
493	1:9	Modified	Na_2CO_3	5,000	20	9	0	0.95	clear	III	yes
493	1:9	Modified	Na_2CO_3	5,000	40	9	0	0.95	clear	III	yes
493	1:9	Modified	Na_2CO_3	5,000	60	9	0	1	clear	x	x
493	1:9	Modified	Na_2CO_3	5,000	80	9	0	1	clear	x	x
493	1:9	Modified	Na_2CO_3	5,000	100	9	0	1	clear	x	x
494	1:9	Modified	Na_2CO_3	7,500	0	9	0	1			
494	1:9	Modified	Na_2CO_3	7500	3	8.9	0.5	0.6	clear	III	no
494	1:9	Modified	Na_2CO_3	7,500	6	9	1	0.9	clear	III	no
494	1:9	Modified	Na_2CO_3	7,500	9	9	0	0.95	clear	III	yes
494	1:9	Modified	Na_2CO_3	7,500	13	9	0	0.95	clear	III	yes
494	1:9	Modified	Na_2CO_3	7,500	16	9	0	1.05	clear	III	yes
494	1:9	Modified	Na_2CO_3	7,500	20	9	0	1.15	clear	III	yes
494	1:9	Modified	Na_2CO_3	7,500	40	9	0	1.15	clear	III	yes
494	1:9	Modified	Na_2CO_3	7,500	60	9	0	1	clear	x	x
494	1:9	Modified	Na_2CO_3	7,500	80	9	0	1	clear	x	x
494	1:9	Modified	Na_2CO_3	7,500	100	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	0	9	0	1			
495	1:9	Modified	Na_2CO_3	10,000	3	9	1	0.85	clear	III	no
495	1:9	Modified	Na_2CO_3	10000	6	8.6	0.45	0.95	clear	III	yes
495	1:9	Modified	Na_2CO_3	10,000	9	9	0	1	clear	III	yes
495	1:9	Modified	Na_2CO_3	10,000	13	9	0	1	clear	III	yes
495	1:9	Modified	Na_2CO_3	10,000	16	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	20	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	40	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	60	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	80	9	0	1	clear	x	x
495	1:9	Modified	Na_2CO_3	10,000	100	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	0	9	0	1			
496	1:9	Modified	Na_2CO_3	12,500	3	9	0	0.7	clear	III	yes
496	1:9	Modified	Na_2CO_3	12,500	6	9	0	0.7	clear	III	yes
496	1:9	Modified	Na_2CO_3	12500	9	8.9	0.2	0.9	clear	III	yes
496	1:9	Modified	Na_2CO_3	12,500	13	9	0	0.9	clear	III	yes
496	1:9	Modified	Na_2CO_3	12,500	16	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	20	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	40	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	60	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	80	9	0	1	clear	x	x
496	1:9	Modified	Na_2CO_3	12,500	100	9	0	1	clear	x	x
497	1:9	Modified	Na_2CO_3	15,000	0	9	0	1			
497	1:9	Modified	Na_2CO_3	15,000	3	9	0	0.7	clear	III	yes
497	1:9	Modified	Na_2CO_3	15,000	6	9	0	0.7	clear	III	yes
497	1:9	Modified	Na_2CO_3	15,000	9	9	0	0.7	clear	III	yes
497	1:9	Modified	Na_2CO_3	15000	13	8.8	0.4	0.8	clear	III	yes
497	1:9	Modified	Na_2CO_3	15,000	16	9	0	1	clear	x	x
497	1:9	Modified	Na_2CO_3	15,000	20	9	0	1	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
497	1:9	Modified	Na_2CO_3	15,000	40	9	0	1	clear	x	x
497	1:9	Modified	Na_2CO_3	15,000	60	9	0	1	clear	x	x
497	1:9	Modified	Na_2CO_3	15,000	80	9	0	1	clear	x	x
497	1:9	Modified	Na_2CO_3	15,000	100	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	0	9	0	1			
498	1:9	Modified	Na_2CO_3	17,500	3	9	1	0.6	clear	III	no
498	1:9	Modified	Na_2CO_3	17,500	6	9	1	0.6	clear	III	no
498	1:9	Modified	Na_2CO_3	17,500	9	9	1	0.6	clear	III	no
498	1:9	Modified	Na_2CO_3	17,500	13	9	1	0.6	clear	III	no
498	1:9	Modified	Na_2CO_3	17500	16	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	20	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	40	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	60	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	80	9	0	1	clear	x	x
498	1:9	Modified	Na_2CO_3	17,500	100	9	0	1	clear	x	x
499	1:9	Modified	Na_2CO_3	20,000	0	9	0	1			
499	1:9	Modified	Na_2CO_3	20,000	3	9	1	0.3	clear	III	no
499	1:9	Modified	Na_2CO_3	20,000	6	9	1	0.3	clear	III	no
499	1:9	Modified	Na_2CO_3	20,000	9	9	1	0.6	clear	III	no
499	1:9	Modified	Na_2CO_3	20,000	13	9	1	0.7	clear	III	no
499	1:9	Modified	Na_2CO_3	20,000	16	9	0	0.9	clear	III	yes
499	1:9	Modified	Na_2CO_3	20000	20	9	0.02	0.98	clear	III	yes
499	1:9	Modified	Na_2CO_3	20,000	40	9	0	0.98	clear	III	yes
499	1:9	Modified	Na_2CO_3	20,000	60	9	0	1	clear	x	x
499	1:9	Modified	Na_2CO_3	20,000	80	9	0	1	clear	x	x
499	1:9	Modified	Na_2CO_3	20,000	100	9	0	1	clear	x	x
500	3:7	Modified	Na_2CO_3	2,500	0	7	0	3			
500	3:7	Modified	Na_2CO_3	2,500	3	0	8	2.3	clear	II (+)	no
500	3:7	Modified	Na_2CO_3	2,500	6	0	8	2.5	clear	II (+)	no
500	3:7	Modified	Na_2CO_3	2,500	9	7	0	2.6	clear	II (+)	yes
500	3:7	Modified	Na_2CO_3	2,500	13	7	0	2.6	clear	III	yes
500	3:7	Modified	Na_2CO_3	2,500	16	7	0	3	clear	x	x
500	3:7	Modified	Na_2CO_3	2,500	20	7	0	3	clear	x	x
500	3:7	Modified	Na_2CO_3	2500	40	7	0	3	clear	x	x
500	3:7	Modified	Na_2CO_3	2,500	60	7	0	3	clear	x	x
500	3:7	Modified	Na_2CO_3	2,500	80	7	0	3	clear	x	x
500	3:7	Modified	Na_2CO_3	2,500	100	7	0	3	clear	x	x
501	3:7	Modified	Na_2CO_3	5,000	0	7	0	3			
501	3:7	Modified	Na_2CO_3	5,000	3	0	9	1.3	clear	II (+)	no
501	3:7	Modified	Na_2CO_3	5,000	6	0	8	1.8	clear	II (+)	no
501	3:7	Modified	Na_2CO_3	5,000	9	5	3	2.5	clear	III	no
501	3:7	Modified	Na_2CO_3	5,000	13	5	0	5.1	clear	III	yes
501	3:7	Modified	Na_2CO_3	5,000	16	7	0	2.95	clear	III	yes
501	3:7	Modified	Na_2CO_3	5,000	20	7	0	2.95	clear	III	yes
501	3:7	Modified	Na_2CO_3	5,000	40	7	0	2.95	clear	III	yes
501	3:7	Modified	Na_2CO_3	5000	60	7	0	3	clear	x	x
501	3:7	Modified	Na_2CO_3	5,000	80	7	0	3	clear	x	x
501	3:7	Modified	Na_2CO_3	5,000	100	7	0	3	clear	x	x
502	3:7	Modified	Na_2CO_3	7,500	0	7	0	3			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
502	3:7	Modified	Na_2CO_3	7,500	3	0	9	0.8	clear	II (+)	no
502	3:7	Modified	Na_2CO_3	7,500	6	0	9	1.1	clear	II (+)	no
502	3:7	Modified	Na_2CO_3	7,500	9	4	5	1.4	clear	III	no
502	3:7	Modified	Na_2CO_3	7,500	13	4	2	4.4	clear	III	no
502	3:7	Modified	Na_2CO_3	7,500	16	6	1	3.15	clear	III	no
502	3:7	Modified	Na_2CO_3	7,500	20	7	1	2.7	clear	III	no
502	3:7	Modified	Na_2CO_3	7,500	40	7	0	2.8	clear	III	yes
502	3:7	Modified	Na_2CO_3	7,500	60	7	0	3	clear	x	x
502	3:7	Modified	Na_2CO_3	7500	80	7	0	3	clear	x	x
502	3:7	Modified	Na_2CO_3	7,500	100	7	0	3	clear	x	x
503	3:7	Modified	Na_2CO_3	10,000	0	7	0	3			
503	3:7	Modified	Na_2CO_3	10,000	3	0	10	0.3	clear	II (+)	no
503	3:7	Modified	Na_2CO_3	10,000	6	0	10	0.3	clear	II (+)	no
503	3:7	Modified	Na_2CO_3	10,000	9	5	4	0.7	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	13	5	3	2	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	16	6	2	2.9	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	20	6	1	2.5	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	40	6	1	2.6	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	60	7	0	3.35	clear	III	no
503	3:7	Modified	Na_2CO_3	10,000	80	7	0	2.95	clear	III	no
503	3:7	Modified	Na_2CO_3	10000	100	7	0.05	2.95	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	0	7	0	3			
504	3:7	Modified	Na_2CO_3	12,500	3	0	10	0.2	clear	II (+)	no
504	3:7	Modified	Na_2CO_3	12,500	6	4	6	0.2	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	9	5	4	0.5	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	13	5	3	1.3	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	16	6	3	1.7	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	20	6	2	1.65	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	40	6	2	1.65	clear	III	no
504	3:7	Modified	Na_2CO_3	12,500	60	6	0	3.15	clear	III	yes
504	3:7	Modified	Na_2CO_3	12,500	80	7	0	2.55	clear	III	yes
504	3:7	Modified	Na_2CO_3	12,500	100	7	0	2.55	clear	III	yes
505	3:7	Modified	Na_2CO_3	15000	0	7	0	3			
505	3:7	Modified	Na_2CO_3	15,000	3	4	6	0.1	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	6	4	6	0.1	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	9	5	4	0.3	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	13	5	4	1.1	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	16	6	3	1.4	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	20	6	3	1.2	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	40	6	3	1.3	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	60	6	1	2.8	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	80	7	1	2.2	clear	III	no
505	3:7	Modified	Na_2CO_3	15,000	100	7	1	2.2	clear	III	no
506	3:7	Modified	Na_2CO_3	17,500	0	7	0	3			
506	3:7	Modified	Na_2CO_3	17500	3	2.9	6.9	0.2	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	6	5	5	0.3	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	9	5	4	2.2	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	13	5	4	2.3	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
506	3:7	Modified	Na_2CO_3	17,500	16	6	3	2.4	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	20	6	3	2.4	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	40	6	3	1.35	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	60	6	1	2.65	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	80	7	1	2.65	clear, oil traces on the glass	III	no
506	3:7	Modified	Na_2CO_3	17,500	100	7	1	2.7	clear, oil traces on the glass	III	no
507	3:7	Modified	Na_2CO_3	20,000	0	7	0	3			
507	3:7	Modified	Na_2CO_3	20,000	3	6	4	0.15	clear	III	no
507	3:7	Modified	Na_2CO_3	20000	6	5.95	3.8	0.25	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	9	5	4	0.35	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	13	5	3	1.25	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	16	6	3	1.15	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	20	6	3	1.25	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	40	6	3	1.25	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	60	6	1	2.6	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	80	7	1	1.95	clear	III	no
507	3:7	Modified	Na_2CO_3	20,000	100	7	1	1.95	clear	III	no
508	5:5	Modified	Na_2CO_3	2,500	0	5	0	5			
508	5:5	Modified	Na_2CO_3	2,500	3	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	6	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2500	9	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	13	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	16	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	20	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	40	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	60	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	80	5	0	5	clear	x	x
508	5:5	Modified	Na_2CO_3	2,500	100	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	0	5	0	5			
509	5:5	Modified	Na_2CO_3	5,000	3	0	0	10	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	6	0	0	10	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	9	5	0	5.1	clear	x	x
509	5:5	Modified	Na_2CO_3	5000	13	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	16	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	20	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	40	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	60	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	80	5	0	5	clear	x	x
509	5:5	Modified	Na_2CO_3	5,000	100	5	0	5	clear	x	x
510	5:5	Modified	Na_2CO_3	7,500	0	5	0	5			
510	5:5	Modified	Na_2CO_3	7,500	3	1	1	8.39	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	6	1	1	8	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	9	2	1	7.4	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	13	1	1	7.8	clear	III	no
510	5:5	Modified	Na_2CO_3	7500	16	2.9	1	6.1	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	20	4	1	5	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	40	4	1	4.8	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	60	5	1	4.6	clear	III	no
510	5:5	Modified	Na_2CO_3	7,500	80	5	1	4.1	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
510	5:5	Modified	Na_2CO_3	7,500	100	5	0	5	clear	x	x
511	5:5	Modified	Na_2CO_3	10,000	0	5	0	5			
511	5:5	Modified	Na_2CO_3	10,000	3	1	9	0.7	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	6	1	9	0.6	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	9	2	8	0.8	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	13	1	7	1.5	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	16	3	6	1.1	clear	III	no
511	5:5	Modified	Na_2CO_3	10000	20	3.1	6.4	0.5	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	40	3	2	4.5	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	60	4	5	1.7	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	80	5	4	1	clear	III	no
511	5:5	Modified	Na_2CO_3	10,000	100	5	1	4.5	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	0	5	0	5			
512	5:5	Modified	Na_2CO_3	12,500	3	1	9	0.4	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	6	1	9	0.4	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	9	2	8	0.6	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	13	1	7	1.6	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	16	3	6	0.9	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	20	3	6	0.5	clear	III	no
512	5:5	Modified	Na_2CO_3	12500	40	3.3	5.05	1.65	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	60	4	5	1.3	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	80	4	5	0.8	clear	III	no
512	5:5	Modified	Na_2CO_3	12,500	100	4	3	2.75	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	0	5	0	5			
513	5:5	Modified	Na_2CO_3	15,000	3	1	8	0.7	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	6	1	8	0.45	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	9	2	8	0.7	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	13	2	7	1.5	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	16	3	6	1.1	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	20	4	6	0.7	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	40	4	5	0.9	clear	III	no
513	5:5	Modified	Na_2CO_3	15000	60	3.7	4.6	1.7	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	80	5	5	0.9	clear	III	no
513	5:5	Modified	Na_2CO_3	15,000	100	5	2	3	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	0	5	0	5			
514	5:5	Modified	Na_2CO_3	17,500	3	1	9	0.7	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	6	1	9	0.7	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	9	1	9	0.7	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	13	1	8	1.1	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	16	1	8	1.1	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	20	1	8	1.1	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	40	1	8	1.1	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	60	1	8	1	clear	III	no
514	5:5	Modified	Na_2CO_3	17500	80	3	6	1	clear	III	no
514	5:5	Modified	Na_2CO_3	17,500	100	5	3	2.7	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	0	5	0	5			
515	5:5	Modified	Na_2CO_3	20,000	3	1	8	0.7	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	6	1	8	0.6	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	9	1	8	0.9	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
515	5:5	Modified	Na_2CO_3	20,000	13	1	7	1.9	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	16	3	6	1	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	20	4	6	0.7	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	40	4	5	1.2	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	60	4	5	1.4	clear	III	no
515	5:5	Modified	Na_2CO_3	20,000	80	4	5	1.15	clear	III	no
515	5:5	Modified	Na_2CO_3	20000	100	4.3	3.3	2.4	clear	III	no
516	7:3	Modified	Na_2CO_3	2,500	0	3	0	7			
516	7:3	Modified	Na_2CO_3	2,500	3	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	6	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	9	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	13	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	16	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	20	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	40	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	60	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	80	3	0	7	clear	x	x
516	7:3	Modified	Na_2CO_3	2,500	100	3	0	7	clear	x	x
517	7:3	Modified	Na_2CO_3	5000	0	3	0	7			
517	7:3	Modified	Na_2CO_3	5,000	3	0	9	0.7	clear	III	no
517	7:3	Modified	Na_2CO_3	5,000	6	2	2	5.85	clear	III	no
517	7:3	Modified	Na_2CO_3	5,000	9	3	0	6.7	clear	III	yes
517	7:3	Modified	Na_2CO_3	5,000	13	3	0	6.7	clear	III	yes
517	7:3	Modified	Na_2CO_3	5,000	16	3	0	6.95	clear	III	yes
517	7:3	Modified	Na_2CO_3	5,000	20	3	0	7	clear	III	yes
517	7:3	Modified	Na_2CO_3	5,000	40	3	0	7	clear	x	x
517	7:3	Modified	Na_2CO_3	5,000	60	3	0	7	clear	x	x
517	7:3	Modified	Na_2CO_3	5,000	80	3	0	7	clear	x	x
517	7:3	Modified	Na_2CO_3	5,000	100	3	0	7	clear	x	x
518	7:3	Modified	Na_2CO_3	7,500	0	3	0	7			
518	7:3	Modified	Na_2CO_3	7500	3	0.3	8.9	0.8	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	6	0	8	1.5	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	9	1	7	2.2	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	13	0	6	3.5	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	16	2	5	3.7	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	20	2	3	4.75	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	40	3	2	5.1	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	60	2	2	5.8	clear	III	no
518	7:3	Modified	Na_2CO_3	7,500	80	2	0	7.8	clear	x	x
518	7:3	Modified	Na_2CO_3	7,500	100	2	0	7.8	clear	x	x
519	7:3	Modified	Na_2CO_3	10,000	0	3	0	7			
519	7:3	Modified	Na_2CO_3	10,000	3	0	9	0.8	clear	III	no
519	7:3	Modified	Na_2CO_3	10000	6	0.2	9.2	0.6	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	9	0	9	1	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	13	0	6	3.3	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	16	1	8	1.5	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	20	1	7	2.4	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	40	1	6	2.6	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	60	1	6	2.8	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
519	7:3	Modified	Na_2CO_3	10,000	80	1	3	5.25	clear	III	no
519	7:3	Modified	Na_2CO_3	10,000	100	1	3	5.25	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	0	3	0	7			
520	7:3	Modified	Na_2CO_3	12,500	3	0	9	0.7	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	6	0	9	0.5	clear	III	no
520	7:3	Modified	Na_2CO_3	12500	9	0.4	9	0.6	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	13	0	7	3.2	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	16	1	8	1.1	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	20	1	7	1.9	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	40	2	6	2.1	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	60	2	6	2.1	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	80	2	4	4.8	clear	III	no
520	7:3	Modified	Na_2CO_3	12,500	100	2	4	4.8	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	0	3	0	7			
521	7:3	Modified	Na_2CO_3	15,000	3	0	9	0.7	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	6	0	9	0.7	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	9	0	9	0.7	clear	III	no
521	7:3	Modified	Na_2CO_3	15000	13	0.35	6.75	2.9	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	16	1	8	1.1	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	20	1	7	1.9	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	40	1	7	2.1	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	60	2	6	2.2	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	80	2	5	4	clear	III	no
521	7:3	Modified	Na_2CO_3	15,000	100	2	5	4	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	0	3	0	7			
522	7:3	Modified	Na_2CO_3	17,500	3	0	9	0.6	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	6	0	9	0.4	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	9	1	9	0.8	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	13	1	6	3.8	clear	III	no
522	7:3	Modified	Na_2CO_3	17500	16	1.3	7.6	1.1	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	20	2	7	1.7	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	40	2	7	1.9	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	60	2	6	2	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	80	2	4	4.2	clear	III	no
522	7:3	Modified	Na_2CO_3	17,500	100	2	4	4.2	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	0	3	0	7			
523	7:3	Modified	Na_2CO_3	20,000	3	0	9	0.6	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	6	0	9	0.4	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	9	1	9	0.7	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	13	1	9	0.7	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	16	1	8	1	clear	III	no
523	7:3	Modified	Na_2CO_3	20000	20	1.4	7.2	1.4	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	40	2	7	1.5	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	60	2	7	1.5	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	80	2	6	2.7	clear	III	no
523	7:3	Modified	Na_2CO_3	20,000	100	2	6	2.7	clear	III	no
524	9:1	Modified	Na_2CO_3	2,500	0	1	0	9			
524	9:1	Modified	Na_2CO_3	2,500	3	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	6	1	0	9	clear	x	x

Sample Name	**WOR**	**Oil Type**	**Alkali**	**Conc. (ppm)**	**Time**	**Oil Vol. (ml)**	**Emulsion Vol. (ml)**	**Water Vol. (ml)**	**Optical Visualisation of the Aqueous Phase**	**Emulsion Type**	**Emulsion Amount <0.5 ml**
524	9:1	Modified	Na_2CO_3	2,500	9	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	13	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	16	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	20	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2500	40	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	60	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	80	1	0	9	clear	x	x
524	9:1	Modified	Na_2CO_3	2,500	100	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	0	1	0	9			
525	9:1	Modified	Na_2CO_3	5,000	3	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	6	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	9	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	13	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	16	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	20	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	40	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5000	60	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	80	1	0	9	clear	x	x
525	9:1	Modified	Na_2CO_3	5,000	100	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	0	1	0	9			
526	9:1	Modified	Na_2CO_3	7,500	3	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	6	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	9	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	13	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	16	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	20	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	40	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	60	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7500	80	1	0	9	clear	x	x
526	9:1	Modified	Na_2CO_3	7,500	100	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	0	1	0	9			
527	9:1	Modified	Na_2CO_3	10,000	3	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	6	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	9	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	13	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	16	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	20	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	40	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	60	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10,000	80	1	0	9	clear	x	x
527	9:1	Modified	Na_2CO_3	10000	100	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	0	1	0	9			
528	9:1	Modified	Na_2CO_3	12,000	3	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	6	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	9	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	13	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	16	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	20	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	40	1	0	9	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
528	9:1	Modified	Na_2CO_3	12,000	60	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	80	1	0	9	clear	x	x
528	9:1	Modified	Na_2CO_3	12,000	100	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15000	0	1	0	9			
529	9:1	Modified	Na_2CO_3	15,000	3	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	6	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	9	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	13	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	16	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	20	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	40	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	60	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	80	1	0	9	clear	x	x
529	9:1	Modified	Na_2CO_3	15,000	100	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	0	1	0	9			
530	9:1	Modified	Na_2CO_3	17500	3	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	6	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	9	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	13	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	16	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	20	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	40	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	60	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	80	1	0	9	clear	x	x
530	9:1	Modified	Na_2CO_3	17,500	100	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	0	1	0	9			
531	9:1	Modified	Na_2CO_3	20,000	3	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20000	6	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	9	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	13	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	16	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	20	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	40	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	60	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	80	1	0	9	clear	x	x
531	9:1	Modified	Na_2CO_3	20,000	100	1	0	9	clear	x	x

8.TH: Formulation 3b: Softened Water + Modified S 85 Oil with C_6H_{12} @ 49°C (Alkali Slug)

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
532	1:9	Modified	K_2CO_3	2,500	0	9	0	1			
532	1:9	Modified	K_2CO_3	2,500	3	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	6	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	9	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	13	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	16	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	20	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	40	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	60	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	80	9	0	1	clear	x	x
532	1:9	Modified	K_2CO_3	2,500	100	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	0	9	0	1			
533	1:9	Modified	K_2CO_3	5,000	3	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	6	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	9	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	13	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	16	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	20	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	40	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	60	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	80	9	0	1	clear	x	x
533	1:9	Modified	K_2CO_3	5,000	100	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	0	9	0	1			
534	1:9	Modified	K_2CO_3	7,500	3	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	6	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	9	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	13	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	16	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	20	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	40	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	60	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	80	9	0	1	clear	x	x
534	1:9	Modified	K_2CO_3	7,500	100	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	0	9	0	1			
535	1:9	Modified	K_2CO_3	10,000	3	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	6	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	9	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	13	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	16	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	20	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	40	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	60	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	80	9	0	1	clear	x	x
535	1:9	Modified	K_2CO_3	10,000	100	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	0	9	0	1			
536	1:9	Modified	K_2CO_3	12,500	3	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	6	9	0	1	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
536	1:9	Modified	K_2CO_3	12,500	9	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	13	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	16	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	20	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	40	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	60	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	80	9	0	1	clear	x	x
536	1:9	Modified	K_2CO_3	12,500	100	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	0	9	0	1			
537	1:9	Modified	K_2CO_3	15,000	3	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	6	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	9	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	13	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	16	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	20	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	40	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	60	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	80	9	0	1	clear	x	x
537	1:9	Modified	K_2CO_3	15,000	100	9	0	1	clear	x	x
538	1:9	Modified	K_2CO_3	17,500	0	9	0	1			
538	1:9	Modified	K_2CO_3	17,500	3	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	6	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	9	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	13	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	16	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	20	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	40	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	60	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	80	9	0	1	clear, oil traces on the glass	x	x
538	1:9	Modified	K_2CO_3	17,500	100	9	0	1	clear, oil traces on the glass	x	x
539	1:9	Modified	K_2CO_3	20,000	0	broken					
540	3:7	Modified	K_2CO_3	2,500	0	7	0	3			
540	3:7	Modified	K_2CO_3	2,500	3	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	6	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	9	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	13	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	16	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	20	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	40	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	60	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	80	7	0	3	clear	x	x
540	3:7	Modified	K_2CO_3	2,500	100	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	0	7	0	3			
541	3:7	Modified	K_2CO_3	5,000	3	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	6	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	9	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	13	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	16	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	20	7	0	3	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
541	3:7	Modified	K_2CO_3	5,000	40	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	60	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	80	7	0	3	clear	x	x
541	3:7	Modified	K_2CO_3	5,000	100	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	0	7	0	3			
542	3:7	Modified	K_2CO_3	7,500	3	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	6	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	9	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	13	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	16	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	20	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	40	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	60	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	80	7	0	3	clear	x	x
542	3:7	Modified	K_2CO_3	7,500	100	7	0	3	clear	x	x
543	3:7	Modified	K_2CO_3	10,000	0	7	0	3			
543	3:7	Modified	K_2CO_3	10,000	3	0	9	0.95	clear	II (+)	no
543	3:7	Modified	K_2CO_3	10,000	6	0	9	1.2	clear	II (+)	no
543	3:7	Modified	K_2CO_3	10,000	9	0	9	1.4	clear	II (+)	no
543	3:7	Modified	K_2CO_3	10,000	13	0	8	1.85	clear	II (+)	no
543	3:7	Modified	K_2CO_3	10,000	16	6	2	2.2	clear	III	no
543	3:7	Modified	K_2CO_3	10,000	20	6	1	2.3	clear	III	no
543	3:7	Modified	K_2CO_3	10,000	40	6	1	2.3	clear	III	no
543	3:7	Modified	K_2CO_3	10,000	60	7	0	2.8	clear	III	yes
543	3:7	Modified	K_2CO_3	10,000	80	7	0	2.8	clear	III	yes
543	3:7	Modified	K_2CO_3	10,000	100	7	0	2.8	clear	III	yes
544	3:7	Modified	K_2CO_3	12,500	0	7	0	3			
544	3:7	Modified	K_2CO_3	12,500	3	0	10	0.1	clear	II (+)	no
544	3:7	Modified	K_2CO_3	12,500	6	0	10	0.1	clear	II (+)	no
544	3:7	Modified	K_2CO_3	12,500	9	3	7	0.2	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	13	1	8	0.75	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	16	6	3	1.1	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	20	6	3	1.1	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	40	6	3	1.1	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	60	7	1	1.9	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	80	7	1	1.9	clear	III	no
544	3:7	Modified	K_2CO_3	12,500	100	7	1	1.9	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	0	7	0	3			
545	3:7	Modified	K_2CO_3	15,000	3	0	9	0.25	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	6	0	9	0.25	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	9	2	8	0.25	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	13	2	7	0.35	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	16	5	4	0.85	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	20	5	4	0.85	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	40	5	4	0.9	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	60	6	3	1	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	80	6	3	1	clear	III	no
545	3:7	Modified	K_2CO_3	15,000	100	6	3	1	clear	III	yes
546	3:7	Modified	K_2CO_3	17,500	0	7	0	3			

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
546	3:7	Modified	K_2CO_3	17,500	3	1	9	0.1	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	6	1	9	0.1	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	9	2	8	0.1	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	13	1	9	0.2	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	16	5	4	0.6	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	20	5	4	0.6	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	40	5	4	0.6	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	60	6	3	0.7	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	80	6	3	0.7	clear	III	no
546	3:7	Modified	K_2CO_3	17,500	100	6	3	0.7	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	0	7	0	3			
547	3:7	Modified	K_2CO_3	20,000	3	1	9	0.05	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	6	1	9	0.05	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	9	2	8	0.05	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	13	1	9	0.1	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	16	5	4	0.4	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	20	5	4	0.4	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	40	5	4	0.4	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	60	6	4	0.4	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	80	6	4	0.4	clear	III	no
547	3:7	Modified	K_2CO_3	20,000	100	6	4	0.4	clear	III	no
548	5:5	Modified	K_2CO_3	2,500	0	5	0	5			
548	5:5	Modified	K_2CO_3	2,500	3	0	6	4.5	clear, oil traces on the glass	II (+)	no
548	5:5	Modified	K_2CO_3	2,500	6	0	5	4.7	clear, oil traces on the glass	II (+)	no
548	5:5	Modified	K_2CO_3	2,500	9	5	0	4.8	clear, oil traces on the glass	III	yes
548	5:5	Modified	K_2CO_3	2,500	13	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	16	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	20	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	40	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	60	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	80	5	0	5	clear, oil traces on the glass	x	x
548	5:5	Modified	K_2CO_3	2,500	100	5	0	5	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	0	5	0	5			
549	5:5	Modified	K_2CO_3	5,000	3	0	5	4.9	clear, oil traces on the glass	II (+)	no
549	5:5	Modified	K_2CO_3	5,000	6	0	5	4.9	clear, oil traces on the glass	II (+)	no
549	5:5	Modified	K_2CO_3	5,000	9	0	5	4.9	clear, oil traces on the glass	II (+)	no
549	5:5	Modified	K_2CO_3	5,000	13	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	16	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	20	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	40	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	60	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	80	5	0	5.05	clear, oil traces on the glass	x	x
549	5:5	Modified	K_2CO_3	5,000	100	5	0	5.05	clear, oil traces on the glass	x	x
550	5:5	Modified	K_2CO_3	7,500	0	5	0	5			
550	5:5	Modified	K_2CO_3	7,500	3	0	9	0.85	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	6	1	8	1.15	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	9	1	8	1.45	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	13	1	7	1.95	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	16	3	5	2.25	clear, oil traces on the glass	III	no

Sample Name	**WOR**	**Oil Type**	**Alkali**	**Conc. (ppm)**	**Time**	**Oil Vol. (ml)**	**Emulsion Vol. (ml)**	**Water Vol. (ml)**	**Optical Visualisation of the Aqueous Phase**	**Emulsion Type**	**Emulsion Amount <0.5 ml**
550	5:5	Modified	K_2CO_3	7,500	20	3	5	1.95	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	40	3	5	1.75	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	60	5	4	1.25	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	80	5	4	1.25	clear, oil traces on the glass	III	no
550	5:5	Modified	K_2CO_3	7,500	100	5	4	1.25	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	0	5	0	5			
551	5:5	Modified	K_2CO_3	10,000	3	0	9	0.3	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	6	1	9	0.3	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	9	1	9	0.7	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	13	1	8	0.7	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	16	2	7	1.1	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	20	2	7	1	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	40	3	7	0.6	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	60	3	6	0.85	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	80	3	6	0.85	clear, oil traces on the glass	III	no
551	5:5	Modified	K_2CO_3	10,000	100	3	6	0.85	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	0	5	0	5			
552	5:5	Modified	K_2CO_3	12,500	3	0	9	0.25	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	6	1	9	0.25	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	9	1	9	0.35	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	13	1	9	0.35	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	16	1	8	0.75	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	20	1	8	1.05	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	40	1	8	1.05	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	60	1	7	1.22	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	80	1	7	1.22	clear, oil traces on the glass	III	no
552	5:5	Modified	K_2CO_3	12,500	100	1	7	1.22	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	0	5	0	5			
553	5:5	Modified	K_2CO_3	15,000	3	0	10	0.2	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	6	1	9	0.2	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	9	1	9	0.3	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	13	1	9	0.2	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	16	1	8	0.7	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	20	2	8	0.8	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	40	2	8	0.8	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	60	2	7	0.9	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	80	2	7	0.9	clear, oil traces on the glass	III	no
553	5:5	Modified	K_2CO_3	15,000	100	2	7	0.9	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	0	5	0	5			
554	5:5	Modified	K_2CO_3	17,500	3	0	9	0.2	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	6	0	9	0.2	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	9	1	9	0.3	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	13	1	9	0.3	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	16	1	8	0.7	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	20	2	8	0.6	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	40	2	8	0.6	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	60	2	8	0.75	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	80	2	8	0.75	clear, oil traces on the glass	III	no
554	5:5	Modified	K_2CO_3	17,500	100	2	8	0.75	clear, oil traces on the glass	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
555	5:5	Modified	K_2CO_3	20,000	0	5	0	5			
555	5:5	Modified	K_2CO_3	20,000	3	0	9	0.21	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	6	0	9	0.21	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	9	0	9	0.31	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	13	1	9	0.31	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	16	1	8	0.46	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	20	1	8	0.61	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	40	1	8	0.61	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	60	1	8	0.91	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	80	1	8	0.91	clear, oil traces on the glass	III	no
555	5:5	Modified	K_2CO_3	20,000	100	1	8	0.91	clear, oil traces on the glass	III	no
556	7:3	Modified	K_2CO_3	2,500	0	3	0	7			
556	7:3	Modified	K_2CO_3	2,500	3	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	6	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	9	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	13	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	16	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	20	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	40	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	60	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	80	3	0	7	clear	x	x
556	7:3	Modified	K_2CO_3	2,500	100	3	0	7	clear	x	x
557	7:3	Modified	K_2CO_3	5,000	0	3	0	7			
557	7:3	Modified	K_2CO_3	5,000	3	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	6	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	9	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	13	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	16	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	20	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	40	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	60	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	80	3	0	7	light yellow, clear	x	x
557	7:3	Modified	K_2CO_3	5,000	100	3	0	7	light yellow, clear	x	x
558	7:3	Modified	K_2CO_3	7,500	0	3	0	7			
558	7:3	Modified	K_2CO_3	7,500	3	0	9	0.45	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	6	0	9	0.45	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	9	1	8	1.55	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	13	2	6	2.75	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	16	3	2	5.25	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	20	3	1	5.85	light yellow, clear	III	no
558	7:3	Modified	K_2CO_3	7,500	40	3	0	6.85	light yellow, clear	III	yes
558	7:3	Modified	K_2CO_3	7,500	60	3	0	7.05	light yellow, clear	x	x
558	7:3	Modified	K_2CO_3	7,500	80	3	0	7.05	light yellow, clear	x	x
558	7:3	Modified	K_2CO_3	7,500	100	3	0	7.05	light yellow, clear	x	x
559	7:3	Modified	K_2CO_3	10,000	0	3	0	7			
559	7:3	Modified	K_2CO_3	10,000	3	0	9	0.42	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	6	0	9	0.42	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	9	0	9	1.02	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	13	1	7	1.9	clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
559	7:3	Modified	K_2CO_3	10,000	16	2	5	3.3	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	20	2	5	3.4	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	40	2	5	3.4	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	60	2	2	6.1	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	80	2	2	6.1	clear	III	no
559	7:3	Modified	K_2CO_3	10,000	100	2	2	6.1	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	0	3	0	7			
560	7:3	Modified	K_2CO_3	12,500	3	0	9	0.65	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	6	0	9	0.85	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	9	0	9	0.95	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	13	1	8	1.05	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	16	1	8	1.3	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	20	1	8	1.3	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	40	1	8	1.4	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	60	1	7	2.6	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	80	1	7	2.6	clear	III	no
560	7:3	Modified	K_2CO_3	12,500	100	1	7	2.6	clear	III	no
561	7:3	Modified	K_2CO_3	15,000	0	3	0	7			
561	7:3	Modified	K_2CO_3	15,000	3	0	9	0.9	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	6	0	9	1	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	9	0	9	1	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	13	0	9	1.1	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	16	0	8	1.2	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	20	0	8	1.2	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	40	1	8	1.3	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	60	1	7	2.2	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	80	1	7	2.2	light yellow, clear	III	no
561	7:3	Modified	K_2CO_3	15,000	100	1	7	2.2	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	0	3	0	7			
562	7:3	Modified	K_2CO_3	17,500	3	0	9	0.35	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	6	0	9	0.35	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	9	0	9	0.6	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	13	0	9	0.3	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	16	1	9	0.7	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	20	1	9	0.75	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	40	1	9	0.8	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	60	1	8	1.5	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	80	1	8	1.5	light yellow, clear	III	no
562	7:3	Modified	K_2CO_3	17,500	100	1	8	1.5	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	0	3	0	7			
563	7:3	Modified	K_2CO_3	20,000	3	0	10	0.3	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	6	0	10	0.3	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	9	0	9	0.5	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	13	0	9	0.35	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	16	1	9	0.75	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	20	1	9	0.75	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	40	1	9	0.75	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	60	1	8	1.7	light yellow, clear	III	no
563	7:3	Modified	K_2CO_3	20,000	80	1	8	1.7	light yellow, clear	III	no

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
563	7:3	Modified	K_2CO_3	20,000	100	1	8	1.7	light yellow, clear	III	no
564	9:1	Modified	K_2CO_3	2,500	0	1	0	9			
564	9:1	Modified	K_2CO_3	2,500	3	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	6	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	9	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	13	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	16	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	20	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	40	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	60	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	80	1	0	9	clear	x	x
564	9:1	Modified	K_2CO_3	2,500	100	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	0	1	0	9			
565	9:1	Modified	K_2CO_3	5,000	3	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	6	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	9	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	13	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	16	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	20	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	40	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	60	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	80	1	0	9	clear	x	x
565	9:1	Modified	K_2CO_3	5,000	100	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	0	1	0	9			
566	9:1	Modified	K_2CO_3	7,500	3	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	6	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	9	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	13	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	16	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	20	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	40	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	60	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	80	1	0	9	clear	x	x
566	9:1	Modified	K_2CO_3	7,500	100	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	0	1	0	9			
567	9:1	Modified	K_2CO_3	10,000	3	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	6	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	9	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	13	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	16	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	20	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	40	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	60	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	80	1	0	9	clear	x	x
567	9:1	Modified	K_2CO_3	10,000	100	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	0	1	0	9			
568	9:1	Modified	K_2CO_3	12,500	3	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	6	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	9	1	0	9	clear	x	x

Sample Name	WOR	Oil Type	Alkali	Conc. (ppm)	Time	Oil Vol. (ml)	Emulsion Vol. (ml)	Water Vol. (ml)	Optical Visualisation of the Aqueous Phase	Emulsion Type	Emulsion Amount <0.5 ml
568	9:1	Modified	K_2CO_3	12,500	13	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	16	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	20	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	40	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	60	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	80	1	0	9	clear	x	x
568	9:1	Modified	K_2CO_3	12,500	100	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	0	1	0	9			
569	9:1	Modified	K_2CO_3	15,000	3	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	6	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	9	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	13	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	16	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	20	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	40	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	60	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	80	1	0	9	clear	x	x
569	9:1	Modified	K_2CO_3	15,000	100	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	0	1	0	9			
570	9:1	Modified	K_2CO_3	17,500	3	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	6	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	9	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	13	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	16	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	20	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	40	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	60	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	80	1	0	9	clear	x	x
570	9:1	Modified	K_2CO_3	17,500	100	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	0	1	0	9			
571	9:1	Modified	K_2CO_3	20,000	3	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	6	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	9	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	13	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	16	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	20	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	40	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	60	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	80	1	0	9	clear	x	x
571	9:1	Modified	K_2CO_3	20,000	100	1	0	9	clear	x	x

16.TH: IFT Results @ 60°C

WOR	IFT Phase	Oil Type	Alkali Type	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Solvent 3 Conc. (ppm)	Ø Measur. 1 (mN/m)	Ø Measur. 2 (mN/m)	Ø Measur. 3 (mN/m)	Ø Measur. 4 (mN/m)	Ø Measur. 5 (mN/m)	Mean (mN/m)	Stand. Dev. (mN/m)
5:5	Aqueous	Dead	K_2CO_3	5,000	x	x	0.444	0.442	0.511	0.535	0.509	0.488	0.038
5:5	Aqueous	Dead	K_2CO_3	7,500	x	x	0.335	0.365	0.341	0.366	0.385	0.358	0.018
5:5	Aqueous	Dead	K_2CO_3	10,000	x	x	0.409	0.374	0.365	0.377	0.399	0.385	0.016
5:5	Aqueous	Dead	K_2CO_3	12,500	x	x	0.142	0.144	0.134	0.142	0.142	0.141	0.004
5:5	Aqueous	Dead	K_2CO_3	15,000	x	x	0.081	0.083	0.088	0.069	0.047	0.073	0.015
5:5	Aqueous	Dead	K_2CO_3	17,500	x	x	1.918	1.916	1.937	1.919	1.911	1.920	0.009
5:5	Aqueous	Dead	K_2CO_3	7,500	1,000	x	0.592	0.621	0.673	0.707	0.732	0.665	0.052
5:5	Aqueous	Dead	K_2CO_3	7,500	1,000	2,000	0.076	0.065	0.100	0.019	0.091	0.070	0.028
5:5	Aqueous	Dead	Na2CO3	5,000	x	x	0.718	0.733	0.635	0.699	0.732	0.704	0.036
5:5	Aqueous	Dead	Na_2CO_3	7,500	x	x	0.464	0.483	0.474	0.463	0.463	0.469	0.008
5:5	Aqueous	Dead	Na_2CO_3	10,000	x	x	0.195	0.192	0.182	0.172	0.162	0.181	0.012
5:5	Aqueous	Dead	Na_2CO_3	12,500	x	x	0.104	0.087	0.090	0.079	0.078	0.088	0.010
5:5	Aqueous	Dead	Na_2CO_3	15,000	x	x	0.160	0.183	0.199	0.209	0.220	0.194	0.021
5:5	Aqueous	Dead	Na_2CO_3	17,500	x	x	2.134	2.140	2.141	2.159	2.148	2.144	0.009
5:5	Aqueous	Dead	Na_2CO_3	7,500	1,000	x	0.611	0.617	0.622	0.631	0.627	0.621	0.007
5:5	Aqueous	Dead	Na_2CO_3	7,500	1,000	2,000	1.036	1.029	1.026	1.023	1.022	1.027	0.005
5:5	Cloud	Modified	K_2CO_3	5,000	x	x	0.638	0.809	0.896	0.946	x	0.777	0.138
5:5	Cloud	Modified	K_2CO_3	7,500	x	x	0.049	0.063	0.067	0.073	x	0.060	0.010
5:5	Cloud	Modified	K_2CO_3	10,000	x	x	x	x	x	x	x	x	x
5:5	Cloud	Modified	K_2CO_3	12,500	x	x	0.276	0.302	0.343	0.336	x	0.314	0.024
5:5	Cloud	Modified	K_2CO_3	15,000	x	x	0.087	0.100	0.103	0.103	x	0.106	0.017
5:5	Cloud	Modified	K_2CO_3	17,500	x	x	x	x	x	x	x	x	x
5:5	Cloud	Modified	K_2CO_3	7,500	1,000	x	0.890	0.935	0.913	0.022	x	0.719	0.350
5:5	Aqueous	Modified	K_2CO_3	7,500	1,000	2,000	x	x	x	x	x	x	x
5:5	Aqueous	Modified	K_2CO_3	5,000	x	x	0.858	0.845	0.842	0.831	0.818	0.839	0.014
5:5	Aqueous	Modified	K_2CO_3	7,500	x	x	0.397	0.397	0.389	0.395	0.396	0.395	0.003
5:5	Aqueous	Modified	K_2CO_3	10,000	x	x	0.157	0.207	0.273	0.349	0.511	0.299	0.124
5:5	Aqueous	Modified	K_2CO_3	12,500	x	x	0.765	0.747	0.727	0.712	0.698	0.730	0.024
5:5	Aqueous	Modified	K_2CO_3	15,000	x	x	0.496	0.394	0.306	0.284	0.531	0.402	0.099
5:5	Aqueous	Modified	K_2CO_3	17,500	x	x	2.850	2.974	3.085	3.116	3.135	3.032	0.107
5:5	Aqueous	Modified	K_2CO_3	7,500	1,000	x	1.248	1.274	1.304	1.344	1.378	1.309	0.047
5:5	Aqueous	Modified	K_2CO_3	7,500	1,000	2,000	0.081	0.087	0.084	0.080	x	0.083	0.003
5:5	Aqueous	Modified	Na_2CO_3	5,000	x	x	1.289	1.214	1.264	1.293	1.291	1.270	0.030
5:5	Aqueous	Modified	Na_2CO_3	7,500	x	x	1.105	1.306	1.408	1.357	1.283	1.292	0.103
5:5	Aqueous	Modified	Na_2CO_3	10,000	x	x	0.821	0.899	0.902	0.736	0.726	0.817	0.076
5:5	Aqueous	Modified	Na_2CO_3	12,500	x	x	1.335	1.382	1.209	1.133		1.265	0.099
5:5	Aqueous	Modified	Na_2CO_3	15,000	x	x	1.434	1.392	1.545	1.539	1.586	1.500	0.073
5:5	Aqueous	Modified	Na_2CO_3	17,500	x	x	2.517	2.637	2.307	2.474	2.608	2.509	0.117
5:5	Aqueous	Modified	Na_2CO_3	7,500	1,000	x	1.398	1.413	x	x	x	1.398	0.012
5:5	Aqueous	Modified	Na_2CO_3	7,500	1,000	2,000	0.053	0.056	0.057	0.054	x	0.054	0.002

16.TH: Viscosity Results - Real Water mixed with Alkalis + Flopaam 3630S @ 60°C

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
Blank	5:5	x	x	x	1,000	x	0.01	-35.7	-51.9	x	-43.80	8.10
Blank	5:5	x	x	x	1,000	x	0.01	-33.2	63.6	x	15.20	48.40
Blank	5:5	x	x	x	1,000	x	0.02	-16.3	91.8	x	37.75	54.05
Blank	5:5	x	x	x	1,000	x	0.03	-3.67	250	x	123.17	126.84
Blank	5:5	x	x	x	1,000	x	0.05	8.51	32.6	x	20.56	12.05
Blank	5:5	x	x	x	1,000	x	0.07	21.7	16.1	x	18.90	2.80
Blank	5:5	x	x	x	1,000	x	0.10	20.8	21.6	x	21.20	0.40
Blank	5:5	x	x	x	1,000	x	0.15	19.7	17.8	x	18.75	0.95
Blank	5:5	x	x	x	1,000	x	0.22	14.6	17.2	x	15.90	1.30
Blank	5:5	x	x	x	1,000	x	0.32	12.1	15.9	x	14.00	1.90
Blank	5:5	x	x	x	1,000	x	0.46	11.1	15.4	x	13.25	2.15
Blank	5:5	x	x	x	1,000	x	0.68	10.6	13.8	x	12.20	1.60
Blank	5:5	x	x	x	1,000	x	1.00	11.5	12.4	x	11.95	0.45
Blank	5:5	x	x	x	1,000	x	1.47	11	12	x	11.50	0.50
Blank	5:5	x	x	x	1,000	x	2.15	10.3	11.5	x	10.90	0.60
Blank	5:5	x	x	x	1,000	x	3.16	8.68	8.6	x	8.64	0.04
Blank	5:5	x	x	x	1,000	x	4.64	7.42	6.59	x	7.01	0.42
Blank	5:5	x	x	x	1,000	x	6.81	6.74	5.73	x	6.24	0.51
Blank	5:5	x	x	x	1,000	x	10.00	5.45	5.27	x	5.36	0.09
Blank	5:5	x	x	x	1,000	x	14.70	4.71	4.78	x	4.75	0.04
Blank	5:5	x	x	x	1,000	x	21.50	4.27	4.04	x	4.16	0.12
Blank	5:5	x	x	x	1,000	x	31.60	3.91	3.68	x	3.80	0.12
Blank	5:5	x	x	x	1,000	x	46.40	3.49	3.45	x	3.47	0.02
Blank	5:5	x	x	x	1,000	x	68.10	3.16	3.15	x	3.16	0.01
Blank	5:5	x	x	x	1,000	x	100.00	2.87	2.9	x	2.89	0.01
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	24.2	24.6	x	12.11	3.61
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	15.5	17.3	x	7.76	2.24
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.02	22.2	15.9	x	11.11	1.02
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.03	5.76	10.1	x	2.90	0.43
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.05	6.42	10.5	x	3.23	0.37
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.07	3.9	11	x	1.98	0.12
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.10	3.28	10.5	x	1.69	0.20
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.15	3.7	8.17	x	1.92	0.17
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.22	4.03	6.07	x	2.12	0.15
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.32	4.7	5.55	x	2.51	0.13
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.46	4.7	5.43	x	2.58	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.68	5	5.24	x	2.84	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.00	4.86	5.26	x	2.93	0.05
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.47	4.92	5.26	x	3.20	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	2.15	4.84	5.13	x	3.50	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	3.16	4.71	4.96	x	3.94	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	4.64	4.59	4.75	x	4.62	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	6.81	4.46	4.6	x	5.64	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	10.00	4.27	4.37	x	7.14	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	14.70	4.03	4.17	x	9.37	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	21.50	3.78	3.93	x	12.64	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	31.60	3.52	3.69	x	17.56	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	46.40	3.27	3.44	x	24.84	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	68.10	3.01	3.18	x	35.56	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	100.00	2.76	2.93	x	51.38	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	61.90	59.90	-0.62	40.39	29.01
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	56.40	35.10	20.70	37.40	14.66

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.02	43.10	30.90	39.50	37.83	5.12
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.03	32.20	21.50	58.70	37.47	15.64
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.05	16.90	18.70	8.65	14.75	4.38
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.07	11.30	12.00	11.90	11.73	0.31
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.10	9.03	10.30	9.95	9.76	0.54
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.15	8.36	8.25	8.30	8.30	0.04
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.22	6.49	7.01	6.87	6.79	0.22
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.32	7.19	6.73	6.64	6.85	0.24
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.46	7.27	6.48	7.19	6.98	0.36
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.68	7.84	6.37	6.65	6.95	0.64
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.00	8.78	6.35	5.47	6.87	1.40
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.47	8.64	6.30	5.18	6.71	1.44
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	2.15	7.33	6.34	5.10	6.26	0.91
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	3.16	6.69	6.13	5.12	5.98	0.65
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	4.64	6.15	5.67	5.06	5.63	0.45
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	6.81	5.47	5.12	4.86	5.15	0.25
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	10.00	4.93	4.68	4.52	4.71	0.17
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	14.70	4.54	4.27	4.20	4.34	0.15
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	21.50	4.11	3.91	3.93	3.98	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	31.60	3.83	3.62	3.66	3.70	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	46.40	3.48	3.36	3.41	3.42	0.05
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	68.10	3.20	3.12	3.15	3.16	0.03
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	100.00	2.93	2.87	2.91	2.90	0.02
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.01	0.04	117.00	20.10	45.71	10.03
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.01	34.60	107.00	44.40	62.00	4.90
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.02	55.80	92.20	54.70	67.57	0.55
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.03	10.90	67.60	39.90	39.47	14.50
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.05	20.30	45.70	29.40	31.80	4.55
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.07	12.50	33.10	27.70	24.43	7.60
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.10	16.70	20.70	18.00	18.47	0.65
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.15	13.10	24.50	12.76	16.79	0.17
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.22	12.40	24.50	10.60	15.83	0.90
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.32	11.50	22.10	9.30	14.30	1.10
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.46	10.80	19.60	9.09	13.16	0.86
3	5:5	K_2CO_3	HQ	7,500	1,000	x	0.68	10.10	19.00	8.92	12.67	0.59
3	5:5	K_2CO_3	HQ	7,500	1,000	x	1.00	9.50	18.60	8.75	12.28	0.38
3	5:5	K_2CO_3	HQ	7,500	1,000	x	1.47	9.00	15.00	7.56	10.52	0.72
3	5:5	K_2CO_3	HQ	7,500	1,000	x	2.15	8.84	11.90	7.93	9.56	0.46
3	5:5	K_2CO_3	HQ	7,500	1,000	x	3.16	7.76	9.92	6.86	8.18	0.45
3	5:5	K_2CO_3	HQ	7,500	1,000	x	4.64	6.90	8.06	5.72	6.89	0.59
3	5:5	K_2CO_3	HQ	7,500	1,000	x	6.81	6.01	6.95	4.57	5.84	0.72
3	5:5	K_2CO_3	HQ	7,500	1,000	x	10.00	5.40	6.00	4.40	5.27	0.50
3	5:5	K_2CO_3	HQ	7,500	1,000	x	14.70	4.98	5.38	4.11	4.82	0.44
3	5:5	K_2CO_3	HQ	7,500	1,000	x	21.50	4.47	4.89	3.90	4.42	0.29
3	5:5	K_2CO_3	HQ	7,500	1,000	x	31.60	4.03	4.29	3.64	3.99	0.20
3	5:5	K_2CO_3	HQ	7,500	1,000	x	46.40	3.61	3.87	3.38	3.62	0.12
3	5:5	K_2CO_3	HQ	7,500	1,000	x	68.10	3.27	3.41	3.11	3.26	0.08
3	5:5	K_2CO_3	HQ	7,500	1,000	x	100.00	2.96	2.98	2.88	2.94	0.04
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.01	260.00	71.50	35.10	122.20	98.57
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.01	175.00	57.90	64.70	99.20	53.67

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.02	97.40	36.40	62.00	65.27	25.01
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.03	56.60	26.10	46.60	43.10	12.70
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.05	30.50	21.10	463.00	171.53	206.13
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.07	20.10	21.80	19.70	20.53	0.91
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.10	15.00	15.60	15.20	15.27	0.25
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.15	14.90	14.70	15.10	14.90	0.16
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.22	13.30	14.20	13.50	13.67	0.39
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.32	12.62	12.54	12.80	12.65	0.11
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.46	11.19	11.09	11.32	11.20	0.09
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	0.68	9.78	9.42	9.58	9.59	0.15
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	1.00	8.74	8.66	8.61	8.67	0.05
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	1.47	8.68	8.57	8.97	8.74	0.17
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	2.15	7.68	7.20	7.63	7.50	0.22
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	3.16	5.75	6.12	6.10	5.99	0.17
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	4.64	5.03	5.19	5.36	5.19	0.13
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	6.81	4.54	4.34	4.68	4.52	0.14
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	10.00	4.15	3.92	4.35	4.14	0.18
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	14.70	3.93	3.65	3.25	3.61	0.28
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	21.50	3.64	3.30	3.00	3.31	0.26
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	31.60	3.36	3.05	2.87	3.09	0.20
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	46.40	3.12	2.88	2.71	2.90	0.17
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	68.10	2.89	2.70	2.59	2.73	0.12
4	5:5	K_2CO_3	HQ	7,500	1,000	2,000	100.00	2.67	2.53	2.43	2.54	0.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.01	538.00	235.00	x	386.50	151.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.01	345.00	210.00	x	277.50	67.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.02	246.00	157.00	x	201.50	44.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.03	180.00	72.30	x	126.15	53.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.05	119.00	74.80	x	96.90	22.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.07	87.40	61.00	x	74.20	13.20
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.10	52.60	49.10	x	50.85	1.75
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.15	34.30	32.60	x	33.45	0.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.22	21.00	20.40	x	20.70	0.30
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.32	18.00	16.10	x	17.05	0.95
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.46	13.20	14.00	x	13.60	0.40
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.68	12.90	11.20	x	12.05	0.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	1.00	10.40	10.30	x	10.35	0.05
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	1.47	9.72	9.54	x	9.63	0.09
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	2.15	9.05	9.39	x	9.22	0.17
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	3.16	7.99	8.84	x	8.42	0.43
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	4.64	7.39	7.56	x	7.48	0.09
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	6.81	6.78	6.94	x	6.86	0.08
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	10.00	6.22	6.18	x	6.20	0.02
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	14.70	5.75	5.56	x	5.66	0.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	21.50	5.19	4.77	x	4.98	0.21
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	31.60	4.64	4.36	x	4.50	0.14
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	46.40	4.15	3.87	x	4.01	0.14
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	68.10	3.74	3.50	x	3.62	0.12
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	100.00	3.40	3.20	x	3.30	0.10
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.01	225.00	411.00	x	245.67	127.40
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.01	194.00	214.00	x	165.30	55.34

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.02	143.00	263.00	x	156.87	81.59
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.03	71.70	112.00	x	82.17	21.41
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.05	55.20	60.00	x	58.70	2.50
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.07	35.70	38.30	x	40.27	4.74
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.10	23.70	25.80	x	26.25	0.45
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.15	19.70	26.50	x	26.95	0.45
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.22	19.50	19.70	x	19.60	0.10
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.32	17.10	16.40	x	16.75	0.35
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.46	14.30	13.70	x	14.00	0.30
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.68	11.90	12.60	x	12.25	0.35
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	1.00	9.62	10.60	x	10.11	0.49
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	1.47	9.13	10.20	x	9.84	0.50
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	2.15	8.54	8.66	x	8.58	0.05
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	3.16	8.27	7.40	x	7.36	0.76
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	4.64	7.47	6.54	x	6.81	0.47
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	6.81	6.79	6.00	x	6.29	0.36
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	10.00	6.19	5.56	x	5.79	0.28
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	14.70	5.17	5.15	x	5.13	0.04
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	21.50	4.70	4.68	x	4.67	0.03
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	31.60	4.33	4.19	x	4.26	0.06
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	46.40	3.92	3.82	x	3.86	0.04
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	68.10	3.58	3.47	x	3.52	0.05
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	100.00	3.23	3.16	x	3.20	0.03
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.01	206.00	522.00	x	169.50	158.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.01	210.00	342.00	x	276.00	66.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.02	230.00	214.00	x	222.00	8.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.03	108.00	171.00	x	139.50	31.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.05	92.30	119.00	x	105.65	13.35
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.07	76.90	82.10	x	79.50	2.60
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.10	26.20	51.40	x	51.75	0.35
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.15	34.70	41.20	x	34.20	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.22	30.80	32.70	x	31.75	0.95
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.32	30.10	29.80	x	29.95	0.15
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.46	27.60	31.00	x	27.10	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.68	25.90	26.90	x	26.40	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	1.00	18.90	17.70	x	18.30	0.60
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	1.47	15.40	14.00	x	14.70	0.70
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	2.15	12.70	12.80	x	12.75	0.05
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	3.16	10.70	12.20	x	11.45	0.75
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	4.64	8.93	10.30	x	9.62	0.69
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	6.81	7.45	8.38	x	7.92	0.47
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	10.00	6.62	7.22	x	6.92	0.30
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	14.70	5.88	6.87	x	6.38	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	21.50	5.39	6.01	x	5.70	0.31
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	31.60	4.66	5.17	x	4.92	0.26
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	46.40	4.04	4.51	x	4.28	0.24
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	68.10	3.59	3.92	x	3.76	0.17
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	100.00	3.27	3.51	x	3.39	0.12
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.01	317.00	1500.00	x	908.50	591.50
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.01	188.00	12600.00	x	6394.00	6206.00

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.02	64.00	18200.00	x	9132.00	9068.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.03	57.00	2590.00	x	1323.50	1266.50
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.05	39.70	115.00	x	77.35	37.65
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.07	17.90	83.90	x	50.90	33.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.10	21.20	20.90	x	21.05	0.15
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.15	19.80	20.30	x	20.05	0.25
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.22	14.00	15.10	x	14.55	0.55
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.32	10.60	11.50	x	11.05	0.45
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.46	9.55	10.70	x	10.13	0.57
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.68	8.49	9.30	x	8.90	0.41
8	5:5	K_2CO_3	TQ	5,000	x	2,000	1.00	8.19	7.76	x	7.98	0.22
8	5:5	K_2CO_3	TQ	5,000	x	2,000	1.47	6.74	6.96	x	6.85	0.11
8	5:5	K_2CO_3	TQ	5,000	x	2,000	2.15	6.84	8.38	x	7.61	0.77
8	5:5	K_2CO_3	TQ	5,000	x	2,000	3.16	6.74	7.10	x	6.92	0.18
8	5:5	K_2CO_3	TQ	5,000	x	2,000	4.64	6.48	6.62	x	6.55	0.07
8	5:5	K_2CO_3	TQ	5,000	x	2,000	6.81	6.04	6.37	x	6.21	0.17
8	5:5	K_2CO_3	TQ	5,000	x	2,000	10.00	5.55	5.81	x	5.68	0.13
8	5:5	K_2CO_3	TQ	5,000	x	2,000	14.70	5.09	5.35	x	5.22	0.13
8	5:5	K_2CO_3	TQ	5,000	x	2,000	21.50	4.66	4.81	x	4.74	0.07
8	5:5	K_2CO_3	TQ	5,000	x	2,000	31.60	4.29	4.30	x	4.30	0.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	46.40	3.90	3.77	x	3.84	0.06
8	5:5	K_2CO_3	TQ	5,000	x	2,000	68.10	3.55	3.49	x	3.52	0.03
8	5:5	K_2CO_3	TQ	5,000	x	2,000	100.00	3.25	3.15	x	3.20	0.05
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.01	66.10	440.00	x	253.05	186.95
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.01	187.00	958.00	x	572.50	385.50
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.02	75.70	418.00	x	246.85	171.15
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.03	68.10	365.00	x	216.55	148.45
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.05	71.60	77.80	x	74.70	3.10
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.07	41.10	54.50	x	47.80	6.70
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.10	28.40	27.00	x	27.70	0.70
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.15	18.20	18.60	x	18.40	0.20
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.22	13.30	14.90	x	14.10	0.80
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.32	12.70	11.80	x	12.25	0.45
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.46	10.90	9.16	x	10.03	0.87
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.68	9.25	9.12	x	9.19	0.07
9	5:5	K_2CO_3	TQ	7,500	x	2,000	1.00	8.88	8.90	x	8.89	0.01
9	5:5	K_2CO_3	TQ	7,500	x	2,000	1.47	7.59	6.74	x	7.17	0.43
9	5:5	K_2CO_3	TQ	7,500	x	2,000	2.15	7.15	6.95	x	7.05	0.10
9	5:5	K_2CO_3	TQ	7,500	x	2,000	3.16	6.67	6.62	x	6.65	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	4.64	5.86	6.14	x	6.00	0.14
9	5:5	K_2CO_3	TQ	7,500	x	2,000	6.81	5.62	5.83	x	5.73	0.11
9	5:5	K_2CO_3	TQ	7,500	x	2,000	10.00	5.16	5.39	x	5.28	0.12
9	5:5	K_2CO_3	TQ	7,500	x	2,000	14.70	4.85	4.94	x	4.90	0.05
9	5:5	K_2CO_3	TQ	7,500	x	2,000	21.50	4.48	4.44	x	4.46	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	31.60	4.10	4.04	x	4.07	0.03
9	5:5	K_2CO_3	TQ	7,500	x	2,000	46.40	3.77	3.73	x	3.75	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	68.10	3.46	3.40	x	3.43	0.03
9	5:5	K_2CO_3	TQ	7,500	x	2,000	100.00	3.15	3.09	x	3.12	0.03
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.01	101.00	347.00	x	224.00	123.00
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.01	108.00	274.00	x	191.00	83.00

Sampl. Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Measur. 1 (cP)	Measur. 2 (cP)	Measur. 3 (cP)	Mean (cP)	Standard Deviation (cP)
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.02	81.90	196.00	x	138.95	57.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.03	59.20	132.00	x	95.60	36.40
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.05	50.90	97.20	x	74.05	23.15
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.07	42.40	64.00	x	53.20	10.80
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.10	36.20	40.30	x	38.25	2.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.15	29.00	24.90	x	26.95	2.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.22	20.00	20.00	x	20.00	0.00
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.32	15.10	16.80	x	15.95	0.85
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.46	12.80	14.50	x	13.65	0.85
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.68	11.30	10.90	x	11.10	0.20
10	5:5	K_2CO_3	TQ	10,000	x	2,000	1.00	9.65	10.10	x	9.88	0.23
10	5:5	K_2CO_3	TQ	10,000	x	2,000	1.47	9.34	8.83	x	9.09	0.26
10	5:5	K_2CO_3	TQ	10,000	x	2,000	2.15	8.88	8.33	x	8.61	0.28
10	5:5	K_2CO_3	TQ	10,000	x	2,000	3.16	8.00	7.52	x	7.76	0.24
10	5:5	K_2CO_3	TQ	10,000	x	2,000	4.64	7.11	6.80	x	6.96	0.16
10	5:5	K_2CO_3	TQ	10,000	x	2,000	6.81	6.65	6.17	x	6.41	0.24
10	5:5	K_2CO_3	TQ	10,000	x	2,000	10.00	6.12	5.82	x	5.97	0.15
10	5:5	K_2CO_3	TQ	10,000	x	2,000	14.70	5.53	5.27	x	5.40	0.13
10	5:5	K_2CO_3	TQ	10,000	x	2,000	21.50	4.89	4.85	x	4.87	0.02
10	5:5	K_2CO_3	TQ	10,000	x	2,000	31.60	4.39	4.43	x	4.41	0.02
10	5:5	K_2CO_3	TQ	10,000	x	2,000	46.40	3.93	4.00	x	3.97	0.03
10	5:5	K_2CO_3	TQ	10,000	x	2,000	68.10	3.53	3.63	x	3.58	0.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	100.00	3.20	3.31	x	3.26	0.05

16.TH: SEC Results - Molecular Weight Distribution with Flopaam 3630S + High Quality Alkalis @ 60°C

Date	Days	FP 3630S Blank (MDa)	Co-Solvent 3 Blank (MDa)	Na_2CO_3 (MDa)	K_2CO_3 (MDa)	Na_2CO_3+Co 3 (MDa)	K_2CO_3+Co 3 (MDa)
18.01.2018	0	20.0	x	20.0	20.0	19.6	18.7
23.01.2018	5	20.0	x	20.0	20.0	12.0	14.0
29.01.2018	11	12.0	x	11.6	11.4	5.4	5.8
21.02.2018	34	8.8	x	11.2	10.9	3.5	4.1
07.03.2018	48	6.0	x	10.0	9.0	3.0	4.0

16.TH: SEC Results - Molecular Weight Distribution with Flopaam 3630S + Technical graded Alkalis @ 60°C

Date	Days	FP 3630S Blank (MDa)	Co-Solvent 3 Blank (MDa)	Na_2CO_3 (MDa)	K_2CO_3 (MDa)	Na_2CO_3+Co 3 (Mda)	K_2CO_3+Co 3 (MDa)
13.06.2018	0	20.0	18.1	20.0	18.4	18.5	20.0
20.06.2018	7	19.2	7.8	20.0	19.8	7.9	7.9
27.06.2018	14	19.4	7.1	19.9	18.8	7.2	6.9
04.07.2018	21	17.6	5.6	16.7	15.7	5.0	4.5
11.07.2018	28	14.6	4.7	19.5	16.9	3.8	3.8
18.07.2018	35	11.6	3.8	17.8	16.8	sample broken	3.2
25.07.2018	42	9.6	3.5	16.1	13.8	sample broken	3.5
01.08.2018	49	8.3	2.3	15.3	14.0	sample broken	2.8
08.08.2018	56	7.2	3.1	15.3	13.7	sample broken	2.5
14.08.2018	63	6.5	2.9	16.7	11.8	sample broken	2.4
22.08.2018	70	6.1	2.8	13.1	11.8	sample broken	2.5

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.01	4,630	1,840	x	3,235	1,395
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.01	3,160	1,490	x	2,325	835
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.02	2,160	1,160	x	1,660	500
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.03	1,640	932	x	1,286	354
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.05	1,180	768	x	974	206
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.07	928	631	x	780	149
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.10	758	519	x	639	120
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.15	610	434	x	522	88
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.22	497	365	x	431	66
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.32	407	308	x	358	50
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.47	333	263	x	298	35
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	0.69	277	225	x	251	26
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	1.01	231	192	x	212	20
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	1.49	194	165	x	180	15
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	2.19	165	144	x	155	11
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	3.22	142	126	x	134	8
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	4.73	123	111	x	117	6
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	6.95	107	99	x	103	4
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	10.20	94	88	x	91	3
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	15.00	83	78	x	81	3
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	22.10	74	70	x	72	2
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	32.40	65	63	x	64	1
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	47.60	58	57	x	58	0
5:5	Modified	Na_2CO_3	fine (TQ)	5,000	x	70.00	53	52	x	52	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.01	163	231	x	197	34
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.01	97	247	x	172	75
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.02	92	219	x	155	64
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.03	85	119	x	102	17
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.05	66	103	x	84	19
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.07	43	85	x	64	21
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.10	35	65	x	50	15
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.15	32	47	x	39	8
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.22	24	37	x	30	7
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.32	18	31	x	24	6
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.47	16	26	x	21	5
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	0.69	13	20	x	16	4
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	1.01	12	17	x	14	3
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	1.49	10	14	x	12	2
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	2.19	7	11	x	9	2
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	3.22	7	10	x	8	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	4.73	6	9	x	7	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	6.95	5	8	x	6	1

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	10.20	5	6	x	5	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	15.00	4	5	x	5	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	22.10	4	5	x	4	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	32.40	3	4	x	4	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	47.60	3	4	x	4	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	x	70.00	3	4	x	4	1
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.01	5,450	357	x	2,904	2,547
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.01	2,170	218	x	1,194	976
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.02	1,010	159	x	585	426
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.03	583	136	x	360	224
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.05	350	106	x	228	122
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.07	261	84	x	172	89
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.10	198	71	x	134	64
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.15	150	56	x	103	47
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.22	113	47	x	80	33
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.32	87	38	x	62	24
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.47	76	29	x	52	23
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	0.69	56	21	x	38	17
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	1.01	46	18	x	32	14
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	1.49	39	16	x	28	11
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	2.19	35	14	x	25	11
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	3.22	31	13	x	22	9
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	4.73	28	10	x	19	9
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	6.95	25	8	x	17	8
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	10.20	23	6	x	14	8
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	15.00	21	5	x	13	8
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	22.10	19	5	x	12	7
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	32.40	18	4	x	11	7
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	47.60	17	3	x	10	7
5:5	Modified	Na_2CO_3	fine (TQ)	10,000	x	70.00	15	3	x	9	6
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.01	9,400	6,610	x	8,005	1,395
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.01	7,550	4,930	x	6,240	1,310
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.02	5,720	3,880	x	4,800	920
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.03	4,320	2,970	x	3,645	675
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.05	3,250	2,290	x	2,770	480
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.07	2,410	1,730	x	2,070	340
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.10	1,810	1,390	x	1,600	210
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.15	1,380	1,060	x	1,220	160
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.22	1,050	842	x	946	104
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.32	819	639	x	729	90
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.47	641	504	x	573	69
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	0.69	510	406	x	458	52
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	1.01	408	330	x	369	39

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	1.49	331	270	x	301	31
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	2.19	271	224	x	248	24
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	3.22	224	187	x	206	19
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	4.73	186	159	x	173	14
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	6.95	156	135	x	146	11
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	10.20	132	117	x	125	8
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	15.00	114	102	x	108	6
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	22.10	98	90	x	94	4
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	32.40	85	79	x	82	3
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	47.60	74	70	x	72	2
5:5	Modified	Na_2CO_3	coarse (TQ)	5,000	x	70.00	65	62	x	64	1
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.01	108	698	x	403	295
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.01	163	568	x	366	203
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.02	155	472	x	314	159
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.03	131	413	x	272	141
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.05	116	341	x	229	113
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.07	100	181	x	141	41
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.10	78	137	x	107	30
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.15	58	117	x	87	30
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.22	45	96	x	71	26
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.32	39	77	x	58	19
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.47	32	62	x	47	15
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	0.69	27	53	x	40	13
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	1.01	24	47	x	36	11
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	1.49	22	41	x	31	10
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	2.19	20	37	x	28	9
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	3.22	17	33	x	25	8
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	4.73	15	30	x	23	7
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	6.95	14	27	x	20	7
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	10.20	13	25	x	19	6
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	15.00	12	24	x	18	6
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	22.10	11	22	x	17	6
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	32.40	10	21	x	16	5
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	47.60	10	19	x	15	5
5:5	Modified	Na_2CO_3	coarse (TQ)	7,500	x	70.00	9	18	x	14	4
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.01	371	1,430	x	901	530
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.01	360	877	x	619	259
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.02	355	633	x	494	139
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.03	347	487	x	417	70
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.05	320	374	x	347	27
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.07	288	302	x	295	7
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.10	239	246	x	243	4
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.15	208	199	x	204	5

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.22	186	158	x	172	14
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.32	158	129	x	144	15
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.47	141	108	x	125	17
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	0.69	126	91	x	108	18
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	1.01	111	76	x	94	17
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	1.49	98	65	x	81	17
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	2.19	88	55	x	71	16
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	3.22	78	47	x	63	16
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	4.73	71	40	x	55	16
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	6.95	65	34	x	49	15
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	10.20	60	30	x	45	15
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	15.00	55	25	x	40	15
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	22.10	50	22	x	36	14
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	32.40	46	19	x	32	14
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	47.60	42	17	x	29	13
5:5	Modified	Na_2CO_3	coarse (TQ)	10,000	x	70.00	39	15	x	27	12
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.01	442	423	x	433	10
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.01	294	269	x	282	13
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.02	245	193	x	219	26
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.03	184	164	x	174	10
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.05	140	127	x	134	7
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.07	98	93	x	95	3
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.10	76	79	x	77	1
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.15	54	62	x	58	4
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.22	41	46	x	44	3
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.32	30	36	x	33	3
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.47	22	31	x	27	4
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	0.69	18	24	x	21	3
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	1.01	16	21	x	19	2
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	1.49	14	16	x	15	1
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	2.19	11	13	x	12	1
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	3.22	10	11	x	10	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	4.73	9	9	x	9	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	6.95	8	7	x	8	1
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	10.20	7	6	x	7	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	15.00	6	6	x	6	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	22.10	5	5	x	5	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	32.40	5	4	x	4	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	47.60	4	4	x	4	0
5:5	Modified	K_2CO_3	fine (TQ)	5,000	x	70.00	3	4	x	4	0
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.01	827	1,080	x	954	127
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.01	1,020	1,050	x	1,035	15
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.02	942	916	x	929	13

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.03	779	720	x	750	30
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.05	630	594	x	612	18
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.07	487	472	x	480	8
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.10	408	387	x	398	11
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.15	336	325	x	331	6
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.22	283	275	x	279	4
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.32	236	236	x	236	0
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.47	193	203	x	198	5
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	0.69	159	176	x	168	9
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	1.01	133	153	x	143	10
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	1.49	114	136	x	125	11
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	2.19	99	121	x	110	11
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	3.22	87	108	x	97	11
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	4.73	78	98	x	88	10
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	6.95	71	88	x	79	9
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	10.20	64	81	x	72	8
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	15.00	58	74	x	66	8
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	22.10	53	68	x	60	8
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	32.40	49	62	x	56	7
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	47.60	46	57	x	51	6
5:5	Modified	K_2CO_3	fine (TQ)	7,500	x	70.00	42	53	x	48	5
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.01	218	131	x	175	44
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.01	157	115	x	136	21
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.02	141	81	x	111	30
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.03	110	43	x	77	33
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.05	77	31	x	54	23
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.07	60	20	x	40	20
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.10	49	17	x	33	16
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.15	41	12	x	27	15
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.22	31	7	x	19	12
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.32	25	6	x	15	9
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.47	20	6	x	13	7
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	0.69	15	5	x	10	5
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	1.01	12	4	x	8	4
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	1.49	12	4	x	8	4
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	2.19	10	3	x	7	3
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	3.22	9	3	x	6	3
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	4.73	8	3	x	5	2
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	6.95	7	3	x	5	2
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	10.20	6	2	x	4	2
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	15.00	6	2	x	4	2
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	22.10	5	2	x	3	2
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	32.40	5	2	x	3	2

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	47.60	4	2	x	3	1
5:5	Modified	K_2CO_3	fine (TQ)	10,000	x	70.00	4	1	x	3	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.01	250	214	x	232	18
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.01	281	183	x	232	49
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.02	232	268	x	250	18
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.03	173	233	x	203	30
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.05	144	150	x	147	3
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.07	119	133	x	126	7
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.10	88	110	x	99	11
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.15	67	74	x	71	3
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.22	51	69	x	60	9
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.32	42	50	x	46	4
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.47	34	45	x	40	6
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	0.69	29	47	x	38	9
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	1.01	28	30	x	29	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	1.49	24	28	x	26	2
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	2.19	21	25	x	23	2
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	3.22	19	22	x	20	2
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	4.73	16	19	x	17	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	6.95	14	17	x	15	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	10.20	13	16	x	14	2
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	15.00	12	14	x	13	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	22.10	10	13	x	11	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	32.40	9	11	x	10	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	47.60	8	10	x	9	1
5:5	Modified	K_2CO_3	fine (TQ)	7,500	1,000	70.00	7	9	x	8	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.01	104	229	x	167	63
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.01	129	162	x	146	17
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.02	115	168	x	142	27
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.03	75	117	x	96	21
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.05	50	65	x	57	7
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.07	47	63	x	55	8
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.10	28	40	x	34	6
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.15	27	37	x	32	5
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.22	20	24	x	22	2
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.32	16	21	x	18	3
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.47	14	17	x	16	2
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	0.69	14	17	x	15	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	1.01	11	13	x	12	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	1.49	10	12	x	11	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	2.19	9	10	x	10	1
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	3.22	8	9	x	8	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	4.73	8	8	x	8	0

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	6.95	7	7	x	7	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	10.20	6	7	x	7	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	15.00	6	6	x	6	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	22.10	5	6	x	6	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	32.40	5	5	x	5	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	47.60	4	5	x	5	0
5:5	Modified	Na_2CO_3	fine (TQ)	7,500	1,000	70.00	4	4	x	4	0

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.01	716	577	646.50	69.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.01	484	410	447.00	37.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.02	281	301	291.00	10.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.03	217	224	220.50	3.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.05	159	171	165.00	6.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.07	119	135	127.00	8.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.10	95.9	109	102.45	6.55
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.15	81	88.5	84.75	3.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.22	67.8	74.3	71.05	3.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.32	58.1	63.3	60.70	2.60
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.46	50.7	54.9	52.80	2.10
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.68	45.7	49	47.35	1.65
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	1.00	41.5	44.9	43.20	1.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	1.47	38.9	41.8	40.35	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	2.15	36.7	39.7	38.20	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	3.16	35	38	36.50	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	4.64	33.7	36.6	35.15	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	6.81	32.8	35.4	34.10	1.30
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	10.00	31.9	34.2	33.05	1.15
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	14.70	31	33.1	32.05	1.05
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	21.50	30.2	32	31.10	0.90
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	31.60	29.3	30.9	30.10	0.80
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	46.40	28.4	29.8	29.10	0.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	68.10	27.5	28.7	28.10	0.60
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.01	-32.7	213	90.15	122.85
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.01	8.58	149	78.79	70.21
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.02	26.9	118	72.45	45.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.03	37.3	89.5	63.40	26.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.05	44.3	73.8	59.05	14.75
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.07	48.9	65.2	57.05	8.15
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.10	49.2	58	53.60	4.40

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.15	50	50.8	50.40	0.40
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.22	50.1	45.9	48.00	2.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.32	48.6	42.4	45.50	3.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.46	46.1	39.6	42.85	3.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.68	44.3	37.8	41.05	3.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	1.00	42.5	36.6	39.55	2.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	1.47	40.4	35.5	37.95	2.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	2.15	39	34.7	36.85	2.15
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	3.16	37.9	34	35.95	1.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	4.64	37.2	33.1	35.15	2.05
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	6.81	36.6	32.2	34.40	2.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	10.00	35.9	31.3	33.60	2.30
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	14.70	35	30.6	32.80	2.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	21.50	34.2	29.7	31.95	2.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	31.60	33.4	28.7	31.05	2.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	46.40	32.4	27.9	30.15	2.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	68.10	31.6	27	29.30	2.30
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.01	90.8	-12.1	39.35	51.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.01	89.7	25.3	57.50	32.20
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.02	76.3	47.7	62.00	14.30
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.03	73.6	53.4	63.50	10.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.05	72.1	55.8	63.95	8.15
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.07	71.8	56.5	64.15	7.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.10	62.5	55.6	59.05	3.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.15	60.2	55.5	57.85	2.35
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.22	54.6	52.6	53.60	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.32	53.2	49.9	51.55	1.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.46	50.7	47.3	49.00	1.70
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.68	48.4	44.9	46.65	1.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	1.00	46.6	43	44.80	1.80
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	1.47	45.1	41	43.05	2.05
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	2.15	43.8	39.5	41.65	2.15
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	3.16	42.2	38.6	40.40	1.80
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	4.64	40.6	37.6	39.10	1.50
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	6.81	39	36.8	37.90	1.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	10.00	37.8	35.9	36.85	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	14.70	36.6	34.8	35.70	0.90
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	21.50	35.3	33.8	34.55	0.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	31.60	34.1	32.8	33.45	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	46.40	32.9	31.6	32.25	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	68.10	31.7	30.6	31.15	0.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.01	187	113	150.00	37.00
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.01	141	135	138.00	3.00

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.02	164	123	143.50	20.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.03	164	111	137.50	26.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.05	189	119	154.00	35.00
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.07	117	93.9	105.45	11.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.10	107	99.7	103.35	3.65
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.15	101	91.4	96.20	4.80
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.22	92.2	81.9	87.05	5.15
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.32	86.2	80.1	83.15	3.05
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.46	79.7	75.5	77.60	2.10
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.68	75.8	73.4	74.60	1.20
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	1.00	72.5	71	71.75	0.75
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	1.47	67.6	68.6	68.10	0.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	2.15	64	65.7	64.85	0.85
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	3.16	60.6	63.1	61.85	1.25
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	4.64	57.4	60.4	58.90	1.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	6.81	54.8	57.6	56.20	1.40
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	10.00	52.6	55.3	53.95	1.35
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	14.70	50.3	53.4	51.85	1.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	21.50	48.2	51.2	49.70	1.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	31.60	46.1	48.9	47.50	1.40
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	46.40	43.8	46.7	45.25	1.45
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	68.10	41.5	44.4	42.95	1.45
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.01	574	576	575.00	1.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.01	422	417	419.50	2.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.02	311	314	312.50	1.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.03	232	233	232.50	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.05	181	185	183.00	2.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.07	143	147	145.00	2.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.10	117	118	117.50	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.15	99.9	96.7	98.30	1.60
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.22	84.2	82.6	83.40	0.80
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.32	71.9	71.8	71.85	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.46	63.5	63.5	63.50	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.68	58	58	58.00	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	1.00	53.8	53.8	53.80	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	1.47	50.6	50.6	50.60	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	2.15	48.3	48	48.15	0.15
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	3.16	46.4	45.9	46.15	0.25
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	4.64	44.8	44.7	44.75	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	6.81	43.3	43.4	43.35	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	10.00	42.1	42	42.05	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	14.70	40.8	40.6	40.70	0.10
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	21.50	39.6	39.3	39.45	0.15

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	31.60	38.4	37.8	38.10	0.30
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	46.40	37	36.4	36.70	0.30
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	68.10	35.7	34.9	35.30	0.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.01	132	76.7	104.35	27.65
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.01	99.8	80	89.90	9.90
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.02	89.2	88.9	89.05	0.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.03	87.6	81.2	84.40	3.20
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.05	84	76.5	80.25	3.75
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.07	65.8	71.9	68.85	3.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.10	67.8	68.1	67.95	0.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.15	62.5	61.9	62.20	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.22	58.1	56.4	57.25	0.85
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.32	53.6	53.5	53.55	0.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.46	50.5	50.4	50.45	0.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.68	48.5	48.3	48.40	0.10
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	1.00	46.2	46.8	46.50	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	1.47	44.4	45.2	44.80	0.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	2.15	42.5	44.2	43.35	0.85
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	3.16	40.8	42.7	41.75	0.95
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	4.64	39.1	41.4	40.25	1.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	6.81	37.6	40.1	38.85	1.25
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	10.00	36.2	38.9	37.55	1.35
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	14.70	35	37.8	36.40	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	21.50	33.6	36.8	35.20	1.60
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	31.60	32.3	35.6	33.95	1.65
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	46.40	31.2	34.7	32.95	1.75
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	68.10	30	33.6	31.80	1.80
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.01	202	74.7	138.35	63.65
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.01	169	65.8	117.40	51.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.02	138	70	104.00	34.00
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.03	117	74.4	95.70	21.30
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.05	100	65.2	82.60	17.40
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.07	87.1	66.2	76.65	10.45
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.10	78.7	60.9	69.80	8.90
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.15	71.8	56.6	64.20	7.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.22	66.2	55.8	61.00	5.20
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.32	60.7	53	56.85	3.85
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.46	56.6	51.2	53.90	2.70
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.68	53.3	49.4	51.35	1.95
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	1.00	50.8	47.8	49.30	1.50
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	1.47	48.2	46.1	47.15	1.05
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	2.15	45.9	44.7	45.30	0.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	3.16	43.9	43.1	43.50	0.40

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	4.64	41.7	41.3	41.50	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	6.81	39.6	39.8	39.70	0.10
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	10.00	37.7	38.5	38.10	0.40
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	14.70	36.2	37.3	36.75	0.55
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	21.50	34.7	36.1	35.40	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	31.60	33.2	34.9	34.05	0.85
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	46.40	31.8	33.7	32.75	0.95
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	68.10	30.4	32.5	31.45	1.05
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.01	203	194	198.50	4.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.01	148	156	152.00	4.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.02	125	114	119.50	5.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.03	111	98.8	104.90	6.10
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.05	120	98	109.00	11.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.07	109	93.7	101.35	7.65
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.10	102	90.8	96.40	5.60
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.15	91.8	85.8	88.80	3.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.22	84.4	82.8	83.60	0.80
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.32	77.2	77.4	77.30	0.10
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.46	69.4	72.7	71.05	1.65
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.68	66.1	70	68.05	1.95
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	1.00	62.2	68	65.10	2.90
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	1.47	59.4	64.1	61.75	2.35
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	2.15	56.3	60.8	58.55	2.25
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	3.16	53.4	57.5	55.45	2.05
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	4.64	50.6	54.6	52.60	2.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	6.81	47.7	51.6	49.65	1.95
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	10.00	45.3	48.8	47.05	1.75
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	14.70	43.2	46.3	44.75	1.55
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	21.50	41.2	44.2	42.70	1.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	31.60	39.3	42.1	40.70	1.40
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	46.40	37.9	40.5	39.20	1.30
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	68.10	36.4	38.7	37.55	1.15

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.01	601	682	641.50	40.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.01	417	502	459.50	42.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.02	297	370	333.50	36.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.03	219	267	243.00	24.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.05	157	194	175.50	18.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.07	123	148	135.50	12.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.10	113	116	114.50	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.15	87.7	90.3	89.00	1.30
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.22	73.4	75.2	74.30	0.90
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.32	62.8	65.1	63.95	1.15
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.46	54	58	56.00	2.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.68	49.8	52.7	51.25	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	1.00	46.9	49.5	48.20	1.30
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	1.47	45	47.4	46.20	1.20
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	2.15	42.8	45.3	44.05	1.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	3.16	41.8	43.8	42.80	1.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	4.64	41	42.6	41.80	0.80
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	6.81	39	41.5	40.25	1.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	10.00	39	40.5	39.75	0.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	14.70	38	39.5	38.75	0.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	21.50	37	38.4	37.70	0.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	31.60	36.7	37.1	36.90	0.20
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	46.40	34.8	35.7	35.25	0.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	68.10	33	34.2	33.60	0.60
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	55.6	-39.5	8.05	47.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	65.7	-19	23.35	42.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.02	50	7.9	28.95	21.05
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.03	45.7	41.8	43.75	1.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.05	39.4	57.8	48.60	9.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.07	41.1	43.6	42.35	1.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.10	38.3	39.2	38.75	0.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.15	36	37.4	36.70	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.22	35	36.4	35.70	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.32	34.6	36	35.30	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.46	34.3	35.4	34.85	0.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.68	33.5	34.2	33.85	0.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	1.00	32.5	33.7	33.10	0.60
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	1.47	31.9	32.3	32.10	0.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	2.15	30.5	31	30.75	0.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	3.16	29.7	30.4	30.05	0.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	4.64	28	29.9	28.95	0.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	6.81	29	29.7	29.35	0.35

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	10.00	27.9	29.4	28.65	0.75
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	14.70	28.2	29	28.60	0.40
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	21.50	27.8	28.4	28.10	0.30
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	31.60	27	27.9	27.45	0.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	46.40	26.8	27	26.90	0.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	68.10	25.2	26.2	25.70	0.50
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.01	29.9	156	92.95	63.05
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.01	17.5	86.6	52.05	34.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.02	40.8	55.8	48.30	7.50
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.03	54.5	66.2	60.35	5.85
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.05	42.6	63.7	53.15	10.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.07	38.7	55.6	47.15	8.45
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.10	49	50.1	49.55	0.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.15	45	47.4	46.20	1.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.22	42.9	44.1	43.50	0.60
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.32	40.1	42.1	41.10	1.00
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.46	38	38.4	38.20	0.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.68	35.5	36.8	36.15	0.65
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	1.00	33.6	35.3	34.45	0.85
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	1.47	32	34.1	33.05	1.05
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	2.15	31.9	33.4	32.65	0.75
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	3.16	32.6	33	32.80	0.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	4.64	31	32.8	31.90	0.90
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	6.81	31	32.6	31.80	0.80
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	10.00	31.4	32.3	31.85	0.45
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	14.70	31.5	31.8	31.65	0.15
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	21.50	31	31.2	31.10	0.10
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	31.60	29	30.5	29.75	0.75
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	46.40	28.5	29.6	29.05	0.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	68.10	27.8	28.7	28.25	0.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.01	-74.4	38.4	-18.00	56.40
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.01	-73.1	44.8	-14.15	58.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.02	-88.3	37.6	-25.35	62.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.03	-44.3	45.9	0.80	45.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.05	-12.8	69.1	28.15	40.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.07	30.5	58	44.25	13.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.10	55	58	56.50	1.50
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.15	50	51.2	50.60	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.22	42.9	44.1	43.50	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.32	38.8	40	39.40	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.46	37.1	38	37.55	0.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.68	37	39	38.00	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	1.00	37.5	38.6	38.05	0.55

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	1.47	35.6	37.7	36.65	1.05
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	2.15	35	36.4	35.70	0.70
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	3.16	34	35.9	34.95	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	4.64	33.5	35.4	34.45	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	6.81	34	35.3	34.65	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	10.00	33	34.8	33.90	0.90
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	14.70	32.9	34	33.45	0.55
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	21.50	32	33.2	32.60	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	31.60	30.3	32.2	31.25	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	46.40	29.4	30.9	30.15	0.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	68.10	28.5	29.5	29.00	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.01	2600	994	#####	803.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.01	2240	980	#####	630.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.02	1820	894	#####	463.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.03	1480	835	#####	322.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.05	1180	735	957.50	222.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.07	930	636	783.00	147.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.10	742	530	636.00	106.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.15	592	455	523.50	68.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.22	476	387	431.50	44.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.32	387	323	355.00	32.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.46	317	273	295.00	22.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.68	264	232	248.00	16.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	1.00	221	197	209.00	12.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	1.47	186	169	177.50	8.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	2.15	159	147	153.00	6.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	3.16	136	128	132.00	4.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	4.64	117	111	114.00	3.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	6.81	102	97.8	99.90	2.10
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	10.00	89	85.6	87.30	1.70
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	14.70	77.8	75.1	76.45	1.35
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	21.50	68.5	66.2	67.35	1.15
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	31.60	60.6	58.3	59.45	1.15
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	46.40	54	51.3	52.65	1.35
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	68.10	49	45.7	47.35	1.65
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.01	117	-16.7	50.15	66.85
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.01	129	4.84	66.92	62.08
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.02	79.4	16.3	47.85	31.55
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.03	42	21.6	31.80	10.20
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.05	52.5	19.6	36.05	16.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.07	44.8	22.2	33.50	11.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.10	44.1	43.2	43.65	0.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.15	36.2	33.6	34.90	1.30

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.22	31.5	32.4	31.95	0.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.32	30.9	29.6	30.25	0.65
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.46	32	31.4	31.70	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.68	31.9	31.3	31.60	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	1.00	31.4	30.7	31.05	0.35
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	1.47	32.1	30	31.05	1.05
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	2.15	31.9	29.2	30.55	1.35
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	3.16	31.6	28.4	30.00	1.60
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	4.64	31.3	27.9	29.60	1.70
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	6.81	31.2	27.7	29.45	1.75
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	10.00	30.7	27.6	29.15	1.55
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	14.70	30.3	27.3	28.80	1.50
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	21.50	30.1	27	28.55	1.55
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	31.60	29.5	26.7	28.10	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	46.40	29	26.2	27.60	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	68.10	28.3	25.7	27.00	1.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.01	-12.2	-50.3	-31.25	19.05
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.01	-18.2	11.8	-3.20	15.00
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.02	40.4	33	36.70	3.70
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.03	48.6	54.8	51.70	3.10
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.05	36.1	65	50.55	14.45
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.07	41.5	42.7	42.10	0.60
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.10	41.2	44.5	42.85	1.65
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.15	40.5	43.2	41.85	1.35
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.22	38.4	37.8	38.10	0.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.32	36.4	36.2	36.30	0.10
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.46	35.6	34.8	35.20	0.40
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.68	34.6	33.8	34.20	0.40
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	1.00	34.2	32.7	33.45	0.75
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	1.47	33.5	31.6	32.55	0.95
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	2.15	32	31.6	31.80	0.20
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	3.16	31.7	29.2	30.45	1.25
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	4.64	31.2	30.1	30.65	0.55
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	6.81	31.1	30	30.55	0.55
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	10.00	30.8	28.8	29.80	1.00
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	14.70	30.3	29.4	29.85	0.45
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	21.50	29.7	28	28.85	0.85
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	31.60	29.2	28.5	28.85	0.35
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	46.40	28.5	27.9	28.20	0.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	68.10	27.7	26.3	27.00	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.01	701	575	638.00	63.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.01	525	423	474.00	51.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.02	400	320	360.00	40.00

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.03	295	249	272.00	23.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.05	225	203	214.00	11.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.07	186	164	175.00	11.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.10	150	137	143.50	6.50
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.15	130	120	125.00	5.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.22	113	105	109.00	4.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.32	100	95.7	97.85	2.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.46	90.6	88.3	89.45	1.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.68	83.4	82.3	82.85	0.55
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	1.00	76.8	77.1	76.95	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	1.47	71.1	72.3	71.70	0.60
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	2.15	65.8	67.3	66.55	0.75
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	3.16	60.8	62.2	61.50	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	4.64	56.3	57.6	56.95	0.65
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	6.81	52.2	53.1	52.65	0.45
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	10.00	48.3	48.8	48.55	0.25
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	14.70	44.7	45.1	44.90	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	21.50	41.4	41.8	41.60	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	31.60	38.5	38.8	38.65	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	46.40	35.9	36.2	36.05	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	68.10	33.6	34	33.80	0.20

16.TH: Viscosity Results - Real Water from WTP mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.01	623	685	654.00	31.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.01	480	464	472.00	8.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.02	356	337	346.50	9.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.03	260	264	262.00	2.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.05	194	217	205.50	11.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.07	153	165	159.00	6.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.10	124	126	125.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.15	103	105.5	104.25	1.25
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.22	87.6	90	88.80	1.20
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.32	76.3	78.3	77.30	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.46	67.2	69.4	68.30	1.10
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.68	60.6	62	61.30	0.70
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	1.00	55.8	56.8	56.30	0.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	1.47	52.1	54	53.05	0.95
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	2.15	48.7	49.5	49.10	0.40
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	3.16	46.2	47.5	46.85	0.65
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	4.64	44	45.5	44.75	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	6.81	42.2	43.5	42.85	0.65
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	10.00	40.6	42.1	41.35	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	14.70	39.1	40.9	40.00	0.90
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	21.50	37.5	39	38.25	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	31.60	35.9	37	36.45	0.55
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	46.40	34.4	35.9	35.15	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	68.10	32.9	34	33.45	0.55
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.01	622	662	642.00	20.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.01	492	529	510.50	18.50
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.02	417	392	404.50	12.50
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.03	295	292	293.50	1.50
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.05	216	228	222.00	6.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.07	168	176	172.00	4.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.10	135	137.5	136.25	1.25
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.15	114	116	115.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.22	92.7	95.3	94.00	1.30
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.32	80.1	82.7	81.40	1.30
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.46	70.9	72.9	71.90	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	0.68	62.5	64.3	63.40	0.90
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	1.00	56.3	58.3	57.30	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	1.47	51.4	54.2	52.80	1.40
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	2.15	46.6	48.8	47.70	1.10
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	3.16	42.3	44.9	43.60	1.30
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	4.64	38.6	40.5	39.55	0.95
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	6.81	35.3	37.3	36.30	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	10.00	32.5	37.3	34.90	2.40
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	14.70	30	32.2	31.10	1.10

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	21.50	27.6	29.4	28.50	0.90
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	31.60	25.4	27	26.20	0.80
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	46.40	23.5	25	24.25	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	2	2,000	68.10	21.9	23	22.45	0.55
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.01	596	565	580.50	15.50
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.01	408	406	407.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.02	287	297	292.00	5.00
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.03	213	216	214.50	1.50
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.05	159	151	155.00	4.00
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.07	120	123	121.50	1.50
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.10	95.4	96.9	96.15	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.15	77.5	77.5	77.50	0.00
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.22	64	66.5	65.25	1.25
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.32	54.8	58.1	56.45	1.65
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.46	50.7	52.1	51.40	0.70
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	0.68	46.3	47.5	46.90	0.60
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	1.00	42.3	43.9	43.10	0.80
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	1.47	40.9	41.6	41.25	0.35
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	2.15	38.3	40	39.15	0.85
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	3.16	37	38.5	37.75	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	4.64	35.5	37.4	36.45	0.95
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	6.81	35.1	36.4	35.75	0.65
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	10.00	33.6	35.5	34.55	0.95
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	14.70	33	34.6	33.80	0.80
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	21.50	32.3	33.6	32.95	0.65
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	31.60	31.5	32.5	32.00	0.50
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	46.40	30.6	31.3	30.95	0.35
5:5	Dead	K_2CO_3	HQ	7,500	x	3	2,000	68.10	29.5	30	29.75	0.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.01	731	762	746.50	15.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.01	546	556	551.00	5.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.02	417	420	418.50	1.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.03	329	328	328.50	0.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.05	250	255	252.50	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.07	199	206	202.50	3.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.10	158	164	161.00	3.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.15	131	134	132.50	1.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.22	112	116	114.00	2.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.32	95.9	88.5	92.20	3.70
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.46	83.3	85.3	84.30	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	0.68	73.8	75.6	74.70	0.90
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	1.00	66.6	69	67.80	1.20
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	1.47	60.5	62.5	61.50	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	2.15	54.9	57.8	56.35	1.45
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	3.16	50.1	54.6	52.35	2.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	4.64	45.9	48	46.95	1.05

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	6.81	42	44	43.00	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	10.00	38.6	40.7	39.65	1.05
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	14.70	35.5	37.1	36.30	0.80
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	21.50	32.7	33.8	33.25	0.55
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	31.60	30.3	31.7	31.00	0.70
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	46.40	28.2	29.2	28.70	0.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	2	2,000	68.10	26.5	27.1	26.80	0.30
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	515	570	542.50	27.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	383	391	387.00	4.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.02	289	266	277.50	11.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.03	210	193	201.50	8.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.05	163	140	151.50	11.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.07	127	108	117.50	9.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.10	98.5	93.4	95.95	2.55
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.15	79.1	75.6	77.35	1.75
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.22	66.9	63	64.95	1.95
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.32	56.2	53.5	54.85	1.35
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.46	49.5	46.7	48.10	1.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	0.68	44.9	42.2	43.55	1.35
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	1.00	41.1	39.6	40.35	0.75
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	1.47	38.2	36.8	37.50	0.70
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	2.15	36	34.2	35.10	0.90
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	3.16	34.3	33	33.65	0.65
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	4.64	33.1	32	32.55	0.55
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	6.81	32	31.1	31.55	0.45
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	10.00	31.2	30.4	30.80	0.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	14.70	30.4	29.7	30.05	0.35
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	21.50	29.6	28.9	29.25	0.35
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	31.60	28.7	28.1	28.40	0.30
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	46.40	27.7	27.2	27.45	0.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	3	2,000	68.10	26.7	26.2	26.45	0.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.01	582	708	645.00	63.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.01	452	532	492.00	40.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.02	362	410	386.00	24.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.03	278	319	298.50	20.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.05	216	246	231.00	15.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.07	175	188	181.50	6.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.10	150	153	151.50	1.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.15	125	127	126.00	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.22	105.5	107	106.25	0.75
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.32	91	93.1	92.05	1.05
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.46	80.2	82.7	81.45	1.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.68	72.4	75	73.70	1.30
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	1.00	66.5	69.4	67.95	1.45
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	1.47	61.8	65	63.40	1.60

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	2.15	57.7	60.9	59.30	1.60
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	3.16	54.1	57.5	55.80	1.70
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	4.64	51.3	54.4	52.85	1.55
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	6.81	49.9	51.4	50.65	0.75
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	10.00	46.7	48.6	47.65	0.95
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	14.70	44.8	46.1	45.45	0.65
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	21.50	42.9	43.7	43.30	0.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	31.60	41	41.4	41.20	0.20
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	46.40	39.1	39.5	39.30	0.20
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	68.10	37.3	37.6	37.45	0.15

16.TH: Viscosity Results - Real Water mixed with Alkalis + Flopaam 3630S @ 60°C

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
FP 3630S Blank	5:5	x	x	x	1,000	x	0.01	-35.7	-51.9	x	-43.80	8.10
FP 3630S Blank	5:5	x	x	x	1,000	x	0.01	-33.2	63.6	x	15.20	48.40
FP 3630S Blank	5:5	x	x	x	1,000	x	0.02	-16.3	91.8	x	37.75	54.05
FP 3630S Blank	5:5	x	x	x	1,000	x	0.03	-3.67	250	x	123.17	126.84
FP 3630S Blank	5:5	x	x	x	1,000	x	0.05	8.51	32.6	x	20.56	12.05
FP 3630S Blank	5:5	x	x	x	1,000	x	0.07	21.7	16.1	x	18.90	2.80
FP 3630S Blank	5:5	x	x	x	1,000	x	0.10	20.8	21.6	x	21.20	0.40
FP 3630S Blank	5:5	x	x	x	1,000	x	0.15	19.7	17.8	x	18.75	0.95
FP 3630S Blank	5:5	x	x	x	1,000	x	0.22	14.6	17.2	x	15.90	1.30
FP 3630S Blank	5:5	x	x	x	1,000	x	0.32	12.1	15.9	x	14.00	1.90
FP 3630S Blank	5:5	x	x	x	1,000	x	0.46	11.1	15.4	x	13.25	2.15
FP 3630S Blank	5:5	x	x	x	1,000	x	0.68	10.6	13.8	x	12.20	1.60
FP 3630S Blank	5:5	x	x	x	1,000	x	1.00	11.5	12.4	x	11.95	0.45
FP 3630S Blank	5:5	x	x	x	1,000	x	1.47	11	12	x	11.50	0.50
FP 3630S Blank	5:5	x	x	x	1,000	x	2.15	10.3	11.5	x	10.90	0.60
FP 3630S Blank	5:5	x	x	x	1,000	x	3.16	8.68	8.6	x	8.64	0.04
FP 3630S Blank	5:5	x	x	x	1,000	x	4.64	7.42	6.59	x	7.01	0.42
FP 3630S Blank	5:5	x	x	x	1,000	x	6.81	6.74	5.73	x	6.24	0.51
FP 3630S Blank	5:5	x	x	x	1,000	x	10.00	5.45	5.27	x	5.36	0.09
FP 3630S Blank	5:5	x	x	x	1,000	x	14.70	4.71	4.78	x	4.75	0.04
FP 3630S Blank	5:5	x	x	x	1,000	x	21.50	4.27	4.04	x	4.16	0.12
FP 3630S Blank	5:5	x	x	x	1,000	x	31.60	3.91	3.68	x	3.80	0.12
FP 3630S Blank	5:5	x	x	x	1,000	x	46.40	3.49	3.45	x	3.47	0.02
FP 3630S Blank	5:5	x	x	x	1,000	x	68.10	3.16	3.15	x	3.16	0.01
FP 3630S Blank	5:5	x	x	x	1,000	x	100.00	2.87	2.9	x	2.89	0.01
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	24.2	24.6	x	12.11	3.61
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	15.5	17.3	x	7.76	2.24
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.02	22.2	15.9	x	11.11	1.02
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.03	5.76	10.1	x	2.90	0.43
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.05	6.42	10.5	x	3.23	0.37

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.07	3.9	11	x	1.98	0.12
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.10	3.28	10.5	x	1.69	0.20
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.15	3.7	8.17	x	1.92	0.17
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.22	4.03	6.07	x	2.12	0.15
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.32	4.7	5.55	x	2.51	0.13
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.46	4.7	5.43	x	2.58	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.68	5	5.24	x	2.84	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.00	4.86	5.26	x	2.93	0.05
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.47	4.92	5.26	x	3.20	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	2.15	4.84	5.13	x	3.50	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	3.16	4.71	4.96	x	3.94	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	4.64	4.59	4.75	x	4.62	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	6.81	4.46	4.6	x	5.64	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	10.00	4.27	4.37	x	7.14	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	14.70	4.03	4.17	x	9.37	0.07
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	21.50	3.78	3.93	x	12.64	0.08
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	31.60	3.52	3.69	x	17.56	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	46.40	3.27	3.44	x	24.84	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	68.10	3.01	3.18	x	35.56	0.09
1	5:5	Na_2CO_3	HQ	7,500	1,000	x	100.00	2.76	2.93	x	51.38	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	61.90	59.90	-0.62	40.39	29.01
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	56.40	35.10	20.70	37.40	14.66
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.02	43.10	30.90	39.50	37.83	5.12
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.03	32.20	21.50	58.70	37.47	15.64
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.05	16.90	18.70	8.65	14.75	4.38
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.07	11.30	12.00	11.90	11.73	0.31
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.10	9.03	10.30	9.95	9.76	0.54
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.15	8.36	8.25	8.30	8.30	0.04
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.22	6.49	7.01	6.87	6.79	0.22
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.32	7.19	6.73	6.64	6.85	0.24
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.46	7.27	6.48	7.19	6.98	0.36
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.68	7.84	6.37	6.65	6.95	0.64
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.00	8.78	6.35	5.47	6.87	1.40
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.47	8.64	6.30	5.18	6.71	1.44
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	2.15	7.33	6.34	5.10	6.26	0.91
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	3.16	6.69	6.13	5.12	5.98	0.65
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	4.64	6.15	5.67	5.06	5.63	0.45
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	6.81	5.47	5.12	4.86	5.15	0.25
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	10.00	4.93	4.68	4.52	4.71	0.17
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	14.70	4.54	4.27	4.20	4.34	0.15
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	21.50	4.11	3.91	3.93	3.98	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	31.60	3.83	3.62	3.66	3.70	0.09
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	46.40	3.48	3.36	3.41	3.42	0.05
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	68.10	3.20	3.12	3.15	3.16	0.03
2	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	100.00	2.93	2.87	2.91	2.90	0.02

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	0.04	117.00	20.10	45.71	10.03
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.01	34.60	107.00	44.40	62.00	4.90
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.02	55.80	92.20	54.70	67.57	0.55
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.03	10.90	67.60	39.90	39.47	14.50
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.05	20.30	45.70	29.40	31.80	4.55
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.07	12.50	33.10	27.70	24.43	7.60
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.10	16.70	20.70	18.00	18.47	0.65
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.15	13.10	24.50	12.76	16.79	0.17
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.22	12.40	24.50	10.60	15.83	0.90
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.32	11.50	22.10	9.30	14.30	1.10
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.46	10.80	19.60	9.09	13.16	0.86
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	0.68	10.10	19.00	8.92	12.67	0.59
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.00	9.50	18.60	8.75	12.28	0.38
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	1.47	9.00	15.00	7.56	10.52	0.72
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	2.15	8.84	11.90	7.93	9.56	0.46
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	3.16	7.76	9.92	6.86	8.18	0.45
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	4.64	6.90	8.06	5.72	6.89	0.59
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	6.81	6.01	6.95	4.57	5.84	0.72
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	10.00	5.40	6.00	4.40	5.27	0.50
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	14.70	4.98	5.38	4.11	4.82	0.44
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	21.50	4.47	4.89	3.90	4.42	0.29
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	31.60	4.03	4.29	3.64	3.99	0.20
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	46.40	3.61	3.87	3.38	3.62	0.12
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	68.10	3.27	3.41	3.11	3.26	0.08
3	5:5	Na_2CO_3	HQ	7,500	1,000	x	100.00	2.96	2.98	2.88	2.94	0.04
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	260.00	71.50	35.10	122.20	98.57
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.01	175.00	57.90	64.70	99.20	53.67
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.02	97.40	36.40	62.00	65.27	25.01
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.03	56.60	26.10	46.60	43.10	12.70
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.05	30.50	21.10	463.00	171.53	206.13
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.07	20.10	21.80	19.70	20.53	0.91
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.10	15.00	15.60	15.20	15.27	0.25
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.15	14.90	14.70	15.10	14.90	0.16
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.22	13.30	14.20	13.50	13.67	0.39
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.32	12.62	12.54	12.80	12.65	0.11
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.46	11.19	11.09	11.32	11.20	0.09
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	0.68	9.78	9.42	9.58	9.59	0.15
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.00	8.74	8.66	8.61	8.67	0.05
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	1.47	8.68	8.57	8.97	8.74	0.17
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	2.15	7.68	7.20	7.63	7.50	0.22
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	3.16	5.75	6.12	6.10	5.99	0.17
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	4.64	5.03	5.19	5.36	5.19	0.13
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	6.81	4.54	4.34	4.68	4.52	0.14
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	10.00	4.15	3.92	4.35	4.14	0.18
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	14.70	3.93	3.65	3.25	3.61	0.28

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	21.50	3.64	3.30	3.00	3.31	0.26
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	31.60	3.36	3.05	2.87	3.09	0.20
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	46.40	3.12	2.88	2.71	2.90	0.17
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	68.10	2.89	2.70	2.59	2.73	0.12
4	5:5	Na_2CO_3	HQ	7,500	1,000	2,000	100.00	2.67	2.53	2.43	2.54	0.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.01	538.00	235.00	x	386.50	151.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.01	345.00	210.00	x	277.50	67.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.02	246.00	157.00	x	201.50	44.50
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.03	180.00	72.30	x	126.15	53.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.05	119.00	74.80	x	96.90	22.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.07	87.40	61.00	x	74.20	13.20
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.10	52.60	49.10	x	50.85	1.75
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.15	34.30	32.60	x	33.45	0.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.22	21.00	20.40	x	20.70	0.30
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.32	18.00	16.10	x	17.05	0.95
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.46	13.20	14.00	x	13.60	0.40
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	0.68	12.90	11.20	x	12.05	0.85
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	1.00	10.40	10.30	x	10.35	0.05
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	1.47	9.72	9.54	x	9.63	0.09
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	2.15	9.05	9.39	x	9.22	0.17
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	3.16	7.99	8.84	x	8.42	0.43
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	4.64	7.39	7.56	x	7.48	0.09
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	6.81	6.78	6.94	x	6.86	0.08
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	10.00	6.22	6.18	x	6.20	0.02
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	14.70	5.75	5.56	x	5.66	0.10
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	21.50	5.19	4.77	x	4.98	0.21
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	31.60	4.64	4.36	x	4.50	0.14
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	46.40	4.15	3.87	x	4.01	0.14
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	68.10	3.74	3.50	x	3.62	0.12
5	5:5	Na_2CO_3	TQ	5,000	x	2,000	100.00	3.40	3.20	x	3.30	0.10
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.01	225.00	411.00	x	245.67	127.40
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.01	194.00	214.00	x	165.30	55.34
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.02	143.00	263.00	x	156.87	81.59
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.03	71.70	112.00	x	82.17	21.41
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.05	55.20	60.00	x	58.70	2.50
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.07	35.70	38.30	x	40.27	4.74
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.10	23.70	25.80	x	26.25	0.45
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.15	19.70	26.50	x	26.95	0.45
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.22	19.50	19.70	x	19.60	0.10
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.32	17.10	16.40	x	16.75	0.35
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.46	14.30	13.70	x	14.00	0.30
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	0.68	11.90	12.60	x	12.25	0.35
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	1.00	9.62	10.60	x	10.11	0.49
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	1.47	9.13	10.20	x	9.84	0.50
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	2.15	8.54	8.66	x	8.58	0.05

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	3.16	8.27	7.40	x	7.36	0.76
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	4.64	7.47	6.54	x	6.81	0.47
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	6.81	6.79	6.00	x	6.29	0.36
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	10.00	6.19	5.56	x	5.79	0.28
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	14.70	5.17	5.15	x	5.13	0.04
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	21.50	4.70	4.68	x	4.67	0.03
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	31.60	4.33	4.19	x	4.26	0.06
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	46.40	3.92	3.82	x	3.86	0.04
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	68.10	3.58	3.47	x	3.52	0.05
6	5:5	Na_2CO_3	TQ	7,500	x	2,000	100.00	3.23	3.16	x	3.20	0.03
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.01	206.00	522.00	x	169.50	158.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.01	210.00	342.00	x	276.00	66.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.02	230.00	214.00	x	222.00	8.00
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.03	108.00	171.00	x	139.50	31.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.05	92.30	119.00	x	105.65	13.35
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.07	76.90	82.10	x	79.50	2.60
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.10	26.20	51.40	x	51.75	0.35
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.15	34.70	41.20	x	34.20	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.22	30.80	32.70	x	31.75	0.95
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.32	30.10	29.80	x	29.95	0.15
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.46	27.60	31.00	x	27.10	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	0.68	25.90	26.90	x	26.40	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	1.00	18.90	17.70	x	18.30	0.60
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	1.47	15.40	14.00	x	14.70	0.70
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	2.15	12.70	12.80	x	12.75	0.05
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	3.16	10.70	12.20	x	11.45	0.75
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	4.64	8.93	10.30	x	9.62	0.69
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	6.81	7.45	8.38	x	7.92	0.47
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	10.00	6.62	7.22	x	6.92	0.30
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	14.70	5.88	6.87	x	6.38	0.50
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	21.50	5.39	6.01	x	5.70	0.31
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	31.60	4.66	5.17	x	4.92	0.26
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	46.40	4.04	4.51	x	4.28	0.24
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	68.10	3.59	3.92	x	3.76	0.17
7	5:5	Na_2CO_3	TQ	10,000	x	2,000	100.00	3.27	3.51	x	3.39	0.12
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.01	317.00	1500.00	x	908.50	591.50
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.01	188.00	######	x	#####	6206.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.02	64.00	######	x	#####	9068.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.03	57.00	2590.00	x	#####	1266.50
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.05	39.70	115.00	x	77.35	37.65
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.07	17.90	83.90	x	50.90	33.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.10	21.20	20.90	x	21.05	0.15
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.15	19.80	20.30	x	20.05	0.25
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.22	14.00	15.10	x	14.55	0.55
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.32	10.60	11.50	x	11.05	0.45

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.46	9.55	10.70	x	10.13	0.57
8	5:5	K_2CO_3	TQ	5,000	x	2,000	0.68	8.49	9.30	x	8.90	0.41
8	5:5	K_2CO_3	TQ	5,000	x	2,000	1.00	8.19	7.76	x	7.98	0.22
8	5:5	K_2CO_3	TQ	5,000	x	2,000	1.47	6.74	6.96	x	6.85	0.11
8	5:5	K_2CO_3	TQ	5,000	x	2,000	2.15	6.84	8.38	x	7.61	0.77
8	5:5	K_2CO_3	TQ	5,000	x	2,000	3.16	6.74	7.10	x	6.92	0.18
8	5:5	K_2CO_3	TQ	5,000	x	2,000	4.64	6.48	6.62	x	6.55	0.07
8	5:5	K_2CO_3	TQ	5,000	x	2,000	6.81	6.04	6.37	x	6.21	0.17
8	5:5	K_2CO_3	TQ	5,000	x	2,000	10.00	5.55	5.81	x	5.68	0.13
8	5:5	K_2CO_3	TQ	5,000	x	2,000	14.70	5.09	5.35	x	5.22	0.13
8	5:5	K_2CO_3	TQ	5,000	x	2,000	21.50	4.66	4.81	x	4.74	0.07
8	5:5	K_2CO_3	TQ	5,000	x	2,000	31.60	4.29	4.30	x	4.30	0.00
8	5:5	K_2CO_3	TQ	5,000	x	2,000	46.40	3.90	3.77	x	3.84	0.06
8	5:5	K_2CO_3	TQ	5,000	x	2,000	68.10	3.55	3.49	x	3.52	0.03
8	5:5	K_2CO_3	TQ	5,000	x	2,000	100.00	3.25	3.15	x	3.20	0.05
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.01	66.10	440.00	x	253.05	186.95
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.01	187.00	958.00	x	572.50	385.50
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.02	75.70	418.00	x	246.85	171.15
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.03	68.10	365.00	x	216.55	148.45
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.05	71.60	77.80	x	74.70	3.10
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.07	41.10	54.50	x	47.80	6.70
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.10	28.40	27.00	x	27.70	0.70
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.15	18.20	18.60	x	18.40	0.20
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.22	13.30	14.90	x	14.10	0.80
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.32	12.70	11.80	x	12.25	0.45
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.46	10.90	9.16	x	10.03	0.87
9	5:5	K_2CO_3	TQ	7,500	x	2,000	0.68	9.25	9.12	x	9.19	0.07
9	5:5	K_2CO_3	TQ	7,500	x	2,000	1.00	8.88	8.90	x	8.89	0.01
9	5:5	K_2CO_3	TQ	7,500	x	2,000	1.47	7.59	6.74	x	7.17	0.43
9	5:5	K_2CO_3	TQ	7,500	x	2,000	2.15	7.15	6.95	x	7.05	0.10
9	5:5	K_2CO_3	TQ	7,500	x	2,000	3.16	6.67	6.62	x	6.65	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	4.64	5.86	6.14	x	6.00	0.14
9	5:5	K_2CO_3	TQ	7,500	x	2,000	6.81	5.62	5.83	x	5.73	0.11
9	5:5	K_2CO_3	TQ	7,500	x	2,000	10.00	5.16	5.39	x	5.28	0.12
9	5:5	K_2CO_3	TQ	7,500	x	2,000	14.70	4.85	4.94	x	4.90	0.05
9	5:5	K_2CO_3	TQ	7,500	x	2,000	21.50	4.48	4.44	x	4.46	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	31.60	4.10	4.04	x	4.07	0.03
9	5:5	K_2CO_3	TQ	7,500	x	2,000	46.40	3.77	3.73	x	3.75	0.02
9	5:5	K_2CO_3	TQ	7,500	x	2,000	68.10	3.46	3.40	x	3.43	0.03
9	5:5	K_2CO_3	TQ	7,500	x	2,000	100.00	3.15	3.09	x	3.12	0.03
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.01	101.00	347.00	x	224.00	123.00
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.01	108.00	274.00	x	191.00	83.00
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.02	81.90	196.00	x	138.95	57.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.03	59.20	132.00	x	95.60	36.40
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.05	50.90	97.20	x	74.05	23.15

Sample Name	WOR	Alkali	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. 3 Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.07	42.40	64.00	x	53.20	10.80
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.10	36.20	40.30	x	38.25	2.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.15	29.00	24.90	x	26.95	2.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.22	20.00	20.00	x	20.00	0.00
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.32	15.10	16.80	x	15.95	0.85
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.46	12.80	14.50	x	13.65	0.85
10	5:5	K_2CO_3	TQ	10,000	x	2,000	0.68	11.30	10.90	x	11.10	0.20
10	5:5	K_2CO_3	TQ	10,000	x	2,000	1.00	9.65	10.10	x	9.88	0.23
10	5:5	K_2CO_3	TQ	10,000	x	2,000	1.47	9.34	8.83	x	9.09	0.26
10	5:5	K_2CO_3	TQ	10,000	x	2,000	2.15	8.88	8.33	x	8.61	0.28
10	5:5	K_2CO_3	TQ	10,000	x	2,000	3.16	8.00	7.52	x	7.76	0.24
10	5:5	K_2CO_3	TQ	10,000	x	2,000	4.64	7.11	6.80	x	6.96	0.16
10	5:5	K_2CO_3	TQ	10,000	x	2,000	6.81	6.65	6.17	x	6.41	0.24
10	5:5	K_2CO_3	TQ	10,000	x	2,000	10.00	6.12	5.82	x	5.97	0.15
10	5:5	K_2CO_3	TQ	10,000	x	2,000	14.70	5.53	5.27	x	5.40	0.13
10	5:5	K_2CO_3	TQ	10,000	x	2,000	21.50	4.89	4.85	x	4.87	0.02
10	5:5	K_2CO_3	TQ	10,000	x	2,000	31.60	4.39	4.43	x	4.41	0.02
10	5:5	K_2CO_3	TQ	10,000	x	2,000	46.40	3.93	4.00	x	3.97	0.03
10	5:5	K_2CO_3	TQ	10,000	x	2,000	68.10	3.53	3.63	x	3.58	0.05
10	5:5	K_2CO_3	TQ	10,000	x	2,000	100.00	3.20	3.31	x	3.26	0.05

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.01	716	577	646.50	69.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.01	484	410	447.00	37.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.02	281	301	291.00	10.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.03	217	224	220.50	3.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.05	159	171	165.00	6.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.07	119	135	127.00	8.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.10	95.9	109	102.45	6.55
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.15	81	88.5	84.75	3.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.22	67.8	74.3	71.05	3.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.32	58.1	63.3	60.70	2.60
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.46	50.7	54.9	52.80	2.10
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	0.68	45.7	49	47.35	1.65
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	1.00	41.5	44.9	43.20	1.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	1.47	38.9	41.8	40.35	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	2.15	36.7	39.7	38.20	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	3.16	35	38	36.50	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	4.64	33.7	36.6	35.15	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	6.81	32.8	35.4	34.10	1.30

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	10.00	31.9	34.2	33.05	1.15
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	14.70	31	33.1	32.05	1.05
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	21.50	30.2	32	31.10	0.90
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	31.60	29.3	30.9	30.10	0.80
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	46.40	28.4	29.8	29.10	0.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	x	x	68.10	27.5	28.7	28.10	0.60
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.01	-32.7	213	90.15	122.85
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.01	8.58	149	78.79	70.21
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.02	26.9	118	72.45	45.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.03	37.3	89.5	63.40	26.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.05	44.3	73.8	59.05	14.75
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.07	48.9	65.2	57.05	8.15
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.10	49.2	58	53.60	4.40
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.15	50	50.8	50.40	0.40
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.22	50.1	45.9	48.00	2.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.32	48.6	42.4	45.50	3.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.46	46.1	39.6	42.85	3.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	0.68	44.3	37.8	41.05	3.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	1.00	42.5	36.6	39.55	2.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	1.47	40.4	35.5	37.95	2.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	2.15	39	34.7	36.85	2.15
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	3.16	37.9	34	35.95	1.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	4.64	37.2	33.1	35.15	2.05
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	6.81	36.6	32.2	34.40	2.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	10.00	35.9	31.3	33.60	2.30
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	14.70	35	30.6	32.80	2.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	21.50	34.2	29.7	31.95	2.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	31.60	33.4	28.7	31.05	2.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	46.40	32.4	27.9	30.15	2.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	x	x	68.10	31.6	27	29.30	2.30
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.01	90.8	-12.1	39.35	51.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.01	89.7	25.3	57.50	32.20
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.02	76.3	47.7	62.00	14.30
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.03	73.6	53.4	63.50	10.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.05	72.1	55.8	63.95	8.15
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.07	71.8	56.5	64.15	7.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.10	62.5	55.6	59.05	3.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.15	60.2	55.5	57.85	2.35
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.22	54.6	52.6	53.60	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.32	53.2	49.9	51.55	1.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.46	50.7	47.3	49.00	1.70
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	0.68	48.4	44.9	46.65	1.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	1.00	46.6	43	44.80	1.80

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	1.47	45.1	41	43.05	2.05
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	2.15	43.8	39.5	41.65	2.15
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	3.16	42.2	38.6	40.40	1.80
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	4.64	40.6	37.6	39.10	1.50
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	6.81	39	36.8	37.90	1.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	10.00	37.8	35.9	36.85	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	14.70	36.6	34.8	35.70	0.90
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	21.50	35.3	33.8	34.55	0.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	31.60	34.1	32.8	33.45	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	46.40	32.9	31.6	32.25	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	x	x	68.10	31.7	30.6	31.15	0.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.01	187	113	150.00	37.00
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.01	141	135	138.00	3.00
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.02	164	123	143.50	20.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.03	164	111	137.50	26.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.05	189	119	154.00	35.00
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.07	117	93.9	105.45	11.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.10	107	99.7	103.35	3.65
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.15	101	91.4	96.20	4.80
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.22	92.2	81.9	87.05	5.15
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.32	86.2	80.1	83.15	3.05
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.46	79.7	75.5	77.60	2.10
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	0.68	75.8	73.4	74.60	1.20
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	1.00	72.5	71	71.75	0.75
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	1.47	67.6	68.6	68.10	0.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	2.15	64	65.7	64.85	0.85
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	3.16	60.6	63.1	61.85	1.25
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	4.64	57.4	60.4	58.90	1.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	6.81	54.8	57.6	56.20	1.40
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	10.00	52.6	55.3	53.95	1.35
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	14.70	50.3	53.4	51.85	1.55
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	21.50	48.2	51.2	49.70	1.50
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	31.60	46.1	48.9	47.50	1.40
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	46.40	43.8	46.7	45.25	1.45
5:5	Modified	Na_2CO_3	HQ	12,500	x	x	x	68.10	41.5	44.4	42.95	1.45
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.01	574	576	575.00	1.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.01	422	417	419.50	2.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.02	311	314	312.50	1.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.03	232	233	232.50	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.05	181	185	183.00	2.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.07	143	147	145.00	2.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.10	117	118	117.50	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.15	99.9	96.7	98.30	1.60

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.22	84.2	82.6	83.40	0.80
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.32	71.9	71.8	71.85	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.46	63.5	63.5	63.50	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	0.68	58	58	58.00	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	1.00	53.8	53.8	53.80	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	1.47	50.6	50.6	50.60	0.00
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	2.15	48.3	48	48.15	0.15
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	3.16	46.4	45.9	46.15	0.25
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	4.64	44.8	44.7	44.75	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	6.81	43.3	43.4	43.35	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	10.00	42.1	42	42.05	0.05
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	14.70	40.8	40.6	40.70	0.10
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	21.50	39.6	39.3	39.45	0.15
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	31.60	38.4	37.8	38.10	0.30
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	46.40	37	36.4	36.70	0.30
5:5	Modified	K_2CO_3	HQ	5,000	x	x	x	68.10	35.7	34.9	35.30	0.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.01	132	76.7	104.35	27.65
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.01	99.8	80	89.90	9.90
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.02	89.2	88.9	89.05	0.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.03	87.6	81.2	84.40	3.20
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.05	84	76.5	80.25	3.75
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.07	65.8	71.9	68.85	3.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.10	67.8	68.1	67.95	0.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.15	62.5	61.9	62.20	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.22	58.1	56.4	57.25	0.85
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.32	53.6	53.5	53.55	0.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.46	50.5	50.4	50.45	0.05
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	0.68	48.5	48.3	48.40	0.10
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	1.00	46.2	46.8	46.50	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	1.47	44.4	45.2	44.80	0.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	2.15	42.5	44.2	43.35	0.85
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	3.16	40.8	42.7	41.75	0.95
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	4.64	39.1	41.4	40.25	1.15
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	6.81	37.6	40.1	38.85	1.25
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	10.00	36.2	38.9	37.55	1.35
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	14.70	35	37.8	36.40	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	21.50	33.6	36.8	35.20	1.60
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	31.60	32.3	35.6	33.95	1.65
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	46.40	31.2	34.7	32.95	1.75
5:5	Modified	K_2CO_3	HQ	7,500	x	x	x	68.10	30	33.6	31.80	1.80
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.01	202	74.7	138.35	63.65
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.01	169	65.8	117.40	51.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.02	138	70	104.00	34.00

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.03	117	74.4	95.70	21.30
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.05	100	65.2	82.60	17.40
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.07	87.1	66.2	76.65	10.45
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.10	78.7	60.9	69.80	8.90
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.15	71.8	56.6	64.20	7.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.22	66.2	55.8	61.00	5.20
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.32	60.7	53	56.85	3.85
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.46	56.6	51.2	53.90	2.70
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	0.68	53.3	49.4	51.35	1.95
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	1.00	50.8	47.8	49.30	1.50
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	1.47	48.2	46.1	47.15	1.05
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	2.15	45.9	44.7	45.30	0.60
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	3.16	43.9	43.1	43.50	0.40
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	4.64	41.7	41.3	41.50	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	6.81	39.6	39.8	39.70	0.10
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	10.00	37.7	38.5	38.10	0.40
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	14.70	36.2	37.3	36.75	0.55
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	21.50	34.7	36.1	35.40	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	31.60	33.2	34.9	34.05	0.85
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	46.40	31.8	33.7	32.75	0.95
5:5	Modified	K_2CO_3	HQ	10,000	x	x	x	68.10	30.4	32.5	31.45	1.05
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.01	203	194	198.50	4.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.01	148	156	152.00	4.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.02	125	114	119.50	5.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.03	111	98.8	104.90	6.10
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.05	120	98	109.00	11.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.07	109	93.7	101.35	7.65
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.10	102	90.8	96.40	5.60
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.15	91.8	85.8	88.80	3.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.22	84.4	82.8	83.60	0.80
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.32	77.2	77.4	77.30	0.10
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.46	69.4	72.7	71.05	1.65
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	0.68	66.1	70	68.05	1.95
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	1.00	62.2	68	65.10	2.90
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	1.47	59.4	64.1	61.75	2.35
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	2.15	56.3	60.8	58.55	2.25
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	3.16	53.4	57.5	55.45	2.05
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	4.64	50.6	54.6	52.60	2.00
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	6.81	47.7	51.6	49.65	1.95
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	10.00	45.3	48.8	47.05	1.75
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	14.70	43.2	46.3	44.75	1.55
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	21.50	41.2	44.2	42.70	1.50
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	31.60	39.3	42.1	40.70	1.40

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	46.40	37.9	40.5	39.20	1.30
5:5	Modified	K_2CO_3	HQ	12,500	x	x	x	68.10	36.4	38.7	37.55	1.15

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.01	601	682	641.50	40.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.01	417	502	459.50	42.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.02	297	370	333.50	36.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.03	219	267	243.00	24.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.05	157	194	175.50	18.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.07	123	148	135.50	12.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.10	113	116	114.50	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.15	87.7	90.3	89.00	1.30
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.22	73.4	75.2	74.30	0.90
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.32	62.8	65.1	63.95	1.15
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.46	54	58	56.00	2.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	0.68	49.8	52.7	51.25	1.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	1.00	46.9	49.5	48.20	1.30
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	1.47	45	47.4	46.20	1.20
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	2.15	42.8	45.3	44.05	1.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	3.16	41.8	43.8	42.80	1.00
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	4.64	41	42.6	41.80	0.80
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	6.81	39	41.5	40.25	1.25
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	10.00	39	40.5	39.75	0.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	14.70	38	39.5	38.75	0.75
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	21.50	37	38.4	37.70	0.70
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	31.60	36.7	37.1	36.90	0.20
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	46.40	34.8	35.7	35.25	0.45
5:5	Modified	Na_2CO_3	HQ	5,000	x	3	2,000	68.10	33	34.2	33.60	0.60
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	55.6	-39.5	8.05	47.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.01	65.7	-19	23.35	42.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.02	50	7.9	28.95	21.05
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.03	45.7	41.8	43.75	1.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.05	39.4	57.8	48.60	9.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.07	41.1	43.6	42.35	1.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.10	38.3	39.2	38.75	0.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.15	36	37.4	36.70	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.22	35	36.4	35.70	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.32	34.6	36	35.30	0.70
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.46	34.3	35.4	34.85	0.55
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	0.68	33.5	34.2	33.85	0.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	1.00	32.5	33.7	33.10	0.60

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	1.47	31.9	32.3	32.10	0.20
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	2.15	30.5	31	30.75	0.25
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	3.16	29.7	30.4	30.05	0.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	4.64	28	29.9	28.95	0.95
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	6.81	29	29.7	29.35	0.35
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	10.00	27.9	29.4	28.65	0.75
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	14.70	28.2	29	28.60	0.40
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	21.50	27.8	28.4	28.10	0.30
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	31.60	27	27.9	27.45	0.45
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	46.40	26.8	27	26.90	0.10
5:5	Modified	Na_2CO_3	HQ	7,500	x	3	2,000	68.10	25.2	26.2	25.70	0.50
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.01	29.9	156	92.95	63.05
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.01	17.5	86.6	52.05	34.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.02	40.8	55.8	48.30	7.50
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.03	54.5	66.2	60.35	5.85
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.05	42.6	63.7	53.15	10.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.07	38.7	55.6	47.15	8.45
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.10	49	50.1	49.55	0.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.15	45	47.4	46.20	1.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.22	42.9	44.1	43.50	0.60
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.32	40.1	42.1	41.10	1.00
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.46	38	38.4	38.20	0.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	0.68	35.5	36.8	36.15	0.65
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	1.00	33.6	35.3	34.45	0.85
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	1.47	32	34.1	33.05	1.05
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	2.15	31.9	33.4	32.65	0.75
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	3.16	32.6	33	32.80	0.20
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	4.64	31	32.8	31.90	0.90
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	6.81	31	32.6	31.80	0.80
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	10.00	31.4	32.3	31.85	0.45
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	14.70	31.5	31.8	31.65	0.15
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	21.50	31	31.2	31.10	0.10
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	31.60	29	30.5	29.75	0.75
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	46.40	28.5	29.6	29.05	0.55
5:5	Modified	Na_2CO_3	HQ	8,000	x	3	2,000	68.10	27.8	28.7	28.25	0.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.01	-74.4	38.4	-18.00	56.40
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.01	-73.1	44.8	-14.15	58.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.02	-88.3	37.6	-25.35	62.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.03	-44.3	45.9	0.80	45.10
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.05	-12.8	69.1	28.15	40.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.07	30.5	58	44.25	13.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.10	55	58	56.50	1.50
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.15	50	51.2	50.60	0.60

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.22	42.9	44.1	43.50	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.32	38.8	40	39.40	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.46	37.1	38	37.55	0.45
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	0.68	37	39	38.00	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	1.00	37.5	38.6	38.05	0.55
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	1.47	35.6	37.7	36.65	1.05
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	2.15	35	36.4	35.70	0.70
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	3.16	34	35.9	34.95	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	4.64	33.5	35.4	34.45	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	6.81	34	35.3	34.65	0.65
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	10.00	33	34.8	33.90	0.90
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	14.70	32.9	34	33.45	0.55
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	21.50	32	33.2	32.60	0.60
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	31.60	30.3	32.2	31.25	0.95
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	46.40	29.4	30.9	30.15	0.75
5:5	Modified	Na_2CO_3	HQ	10,000	x	3	2,000	68.10	28.5	29.5	29.00	0.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.01	2600	994	#####	803.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.01	2240	980	#####	630.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.02	1820	894	#####	463.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.03	1480	835	#####	322.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.05	1180	735	957.50	222.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.07	930	636	783.00	147.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.10	742	530	636.00	106.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.15	592	455	523.50	68.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.22	476	387	431.50	44.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.32	387	323	355.00	32.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.46	317	273	295.00	22.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	0.68	264	232	248.00	16.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	1.00	221	197	209.00	12.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	1.47	186	169	177.50	8.50
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	2.15	159	147	153.00	6.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	3.16	136	128	132.00	4.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	4.64	117	111	114.00	3.00
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	6.81	102	97.8	99.90	2.10
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	10.00	89	85.6	87.30	1.70
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	14.70	77.8	75.1	76.45	1.35
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	21.50	68.5	66.2	67.35	1.15
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	31.60	60.6	58.3	59.45	1.15
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	46.40	54	51.3	52.65	1.35
5:5	Modified	K_2CO_3	HQ	5,000	x	3	2,000	68.10	49	45.7	47.35	1.65
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.01	117	-16.7	50.15	66.85
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.01	129	4.84	66.92	62.08
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.02	79.4	16.3	47.85	31.55

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.03	42	21.6	31.80	10.20
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.05	52.5	19.6	36.05	16.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.07	44.8	22.2	33.50	11.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.10	44.1	43.2	43.65	0.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.15	36.2	33.6	34.90	1.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.22	31.5	32.4	31.95	0.45
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.32	30.9	29.6	30.25	0.65
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.46	32	31.4	31.70	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	0.68	31.9	31.3	31.60	0.30
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	1.00	31.4	30.7	31.05	0.35
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	1.47	32.1	30	31.05	1.05
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	2.15	31.9	29.2	30.55	1.35
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	3.16	31.6	28.4	30.00	1.60
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	4.64	31.3	27.9	29.60	1.70
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	6.81	31.2	27.7	29.45	1.75
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	10.00	30.7	27.6	29.15	1.55
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	14.70	30.3	27.3	28.80	1.50
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	21.50	30.1	27	28.55	1.55
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	31.60	29.5	26.7	28.10	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	46.40	29	26.2	27.60	1.40
5:5	Modified	K_2CO_3	HQ	7,500	x	3	2,000	68.10	28.3	25.7	27.00	1.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.01	-12.2	-50.3	-31.25	19.05
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.01	-18.2	11.8	-3.20	15.00
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.02	40.4	33	36.70	3.70
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.03	48.6	54.8	51.70	3.10
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.05	36.1	65	50.55	14.45
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.07	41.5	42.7	42.10	0.60
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.10	41.2	44.5	42.85	1.65
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.15	40.5	43.2	41.85	1.35
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.22	38.4	37.8	38.10	0.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.32	36.4	36.2	36.30	0.10
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.46	35.6	34.8	35.20	0.40
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	0.68	34.6	33.8	34.20	0.40
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	1.00	34.2	32.7	33.45	0.75
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	1.47	33.5	31.6	32.55	0.95
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	2.15	32	31.6	31.80	0.20
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	3.16	31.7	29.2	30.45	1.25
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	4.64	31.2	30.1	30.65	0.55
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	6.81	31.1	30	30.55	0.55
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	10.00	30.8	28.8	29.80	1.00
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	14.70	30.3	29.4	29.85	0.45
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	21.50	29.7	28	28.85	0.85
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	31.60	29.2	28.5	28.85	0.35

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Sol. Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	46.40	28.5	27.9	28.20	0.30
5:5	Modified	K_2CO_3	HQ	8,000	x	3	2,000	68.10	27.7	26.3	27.00	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.01	701	575	638.00	63.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.01	525	423	474.00	51.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.02	400	320	360.00	40.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.03	295	249	272.00	23.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.05	225	203	214.00	11.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.07	186	164	175.00	11.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.10	150	137	143.50	6.50
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.15	130	120	125.00	5.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.22	113	105	109.00	4.00
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.32	100	95.7	97.85	2.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.46	90.6	88.3	89.45	1.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	0.68	83.4	82.3	82.85	0.55
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	1.00	76.8	77.1	76.95	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	1.47	71.1	72.3	71.70	0.60
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	2.15	65.8	67.3	66.55	0.75
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	3.16	60.8	62.2	61.50	0.70
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	4.64	56.3	57.6	56.95	0.65
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	6.81	52.2	53.1	52.65	0.45
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	10.00	48.3	48.8	48.55	0.25
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	14.70	44.7	45.1	44.90	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	21.50	41.4	41.8	41.60	0.20
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	31.60	38.5	38.8	38.65	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	46.40	35.9	36.2	36.05	0.15
5:5	Modified	K_2CO_3	HQ	10,000	x	3	2,000	68.10	33.6	34	33.80	0.20

16.TH: Viscosity Results - Alkali Mix @ 60°C

WOR	Oil Type	Alkali 1	Alkali 1 Conc. (ppm)	Alkali 2	Alkali 2 Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Meas. 4 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.01	696	224	315	x	306.67	290.09
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.01	561	202	287	x	254.34	231.99
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.02	391	132	179	x	174.34	162.40
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.03	259	88.7	122	x	115.91	107.46
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.05	190	61.4	82.2	x	83.82	79.15
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.07	128	44.9	60.2	x	57.66	53.00
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.10	93.4	33.3	44.1	x	42.27	38.61
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.15	67	26.9	33.4	x	31.35	27.47
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.22	48.5	21.8	23.3	x	23.51	19.75
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.32	34.7	16.9	17.3	x	17.31	14.04
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.46	26	14.1	14	x	13.52	10.43
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.68	20.6	12.2	11.6	x	11.16	8.17
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	1.00	16.3	11	9.84	x	9.43	6.34

WOR	Oil Type	Alkali 1	Alkali 1 Conc. (ppm)	Alkali 2	Alkali 2 Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Meas. 4 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	1.47	13.1	9.91	8.54	x	8.16	4.91
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	2.15	11	8.99	7.77	x	7.38	3.79
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	3.16	9.54	8.18	7.2	x	6.96	2.74
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	4.64	8.33	7.66	6.64	x	6.88	1.61
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	6.81	7.46	7.13	6.11	x	7.13	0.27
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	10.00	6.86	6.65	5.82	x	7.84	1.53
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	14.70	6.34	6.26	5.5	x	9.10	3.96
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	21.50	5.94	5.93	5.16	x	11.12	7.34
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	31.60	5.37	5.64	4.88	x	14.20	12.30
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	46.40	4.9	5.34	4.62	x	18.88	19.46
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	68.10	4.57	5.01	4.34	x	25.89	29.85
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.01	120	87.8	41.9	x	69.27	50.71
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.01	127	111	78	x	79.34	56.47
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.02	130	119	102	x	83.01	58.85
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.03	139	121	114	x	86.68	61.71
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.05	136	123	118	x	86.35	61.26
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.07	132	123	117	x	85.02	60.18
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.10	127	123	116	x	83.37	58.90
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.15	122	120	112	x	80.72	56.98
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.22	117	115	109	x	77.41	54.59
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.32	112	110	104	x	74.11	52.18
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.46	107	106	99.6	x	71.15	49.99
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	0.68	103	102	95.4	x	68.56	48.00
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	1.00	97.5	97.6	91	x	65.37	45.51
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	1.47	92.7	93.5	86.8	x	62.56	43.20
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	2.15	88.5	89.6	82.8	x	60.08	40.97
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	3.16	84.2	85.6	79.1	x	57.65	38.54
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	4.64	79.9	81.7	75.7	x	55.41	35.91
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	6.81	75.8	78.1	72.4	x	53.57	33.08
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	10.00	72	74.5	69.1	x	52.17	29.83
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	14.70	68.6	71.3	66	x	51.53	26.07
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	21.50	65.2	67.7	62.9	x	51.47	21.21
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	31.60	62.2	64.1	59.7	x	52.63	14.89
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	46.40	59.6	60.6	56.1	x	55.53	6.47
5:5	Modified	Na_2CO_3	2,500	K_2CO_3	5,000	x	68.10	56.6	56.9	52.8	x	60.53	5.35
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.01	1290	3980	503	x	#####	1488.66
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.01	900	1830	543	x	#####	542.50
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.02	515	927	429	x	623.67	217.34
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.03	320	533	382	x	411.67	89.45
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.05	213	349	281	x	281.00	55.52
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.07	153	243	218	x	204.67	37.93
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.10	109	175	148	x	144.00	27.09
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.15	84.1	130	103	x	105.70	18.84

WOR	Oil Type	Alkali 1	Alkali 1 Conc. (ppm)	Alkali 2	Alkali 2 Conc. (ppm)	FP 3630S Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Meas. 4 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.22	66.2	97.9	87.6	x	83.90	13.20
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.32	51	77.1	58.4	x	62.17	10.98
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.46	41.2	61.8	45.1	x	49.37	8.93
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	0.68	33.4	50.9	35.2	x	39.83	7.86
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	1.00	27.4	42.6	30.7	x	33.57	6.53
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	1.47	23.1	36.4	24.1	x	27.87	6.05
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	2.15	19.3	31.5	19.6	x	23.47	5.68
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	3.16	16.4	27.5	16.9	x	20.27	5.12
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	4.64	13.9	24.2	15	x	17.70	4.62
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	6.81	12.4	21.3	12.8	x	15.50	4.10
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	10.00	11	18.7	11.3	x	13.67	3.56
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	14.70	9.59	16.3	10	x	11.96	3.07
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	21.50	8.4	13.9	8.83	x	10.38	2.50
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	31.60	7.43	12	7.91	x	9.11	2.05
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	46.40	6.74	10.2	7.12	x	8.02	1.55
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	1,000	68.10	6.03	8.39	6.4	x	6.94	1.04
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.01	60	16	34.1	x	84.78	84.72
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.01	71	46.7	55.3	x	95.00	65.25
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.02	77.8	64.9	82	x	94.43	34.40
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.03	82.7	75.4	85.1	x	93.30	21.49
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.05	85.2	83.3	84.6	x	90.78	11.12
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.07	84.8	86.1	84.3	x	87.75	4.69
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.10	84.6	87.4	85.4	x	85.53	1.13
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.15	85.3	86.3	85.8	x	84.03	3.09
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.22	83.9	85.7	83.7	x	82.15	4.03
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.32	81.7	85	83.5	x	80.55	5.07
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.46	80.2	83.5	81.2	x	78.55	5.47
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	0.68	78	81.6	79.3	x	76.50	5.58
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	1.00	75.6	79.9	77.8	x	74.73	5.48
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	1.47	73.3	78	75.7	x	72.80	5.24
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	2.15	70.9	75.5	73.6	x	70.73	4.80
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	3.16	68.3	72.9	71.5	x	68.58	4.36
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	4.64	65.8	70	69.5	x	66.38	3.92
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	6.81	63.5	66.8	67.2	x	64.05	3.41
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	10.00	61.5	63.6	64.7	x	61.75	2.87
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	14.70	59.6	60.6	62.2	x	59.58	2.32
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	21.50	57.7	57.8	59.7	x	57.45	1.83
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	31.60	56	54.9	57.3	x	55.33	1.54
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	46.40	54.3	51.8	54.6	x	53.05	1.41
5:5	Modified	Na_2CO_3	5,000	K_2CO_3	2,500	x	68.10	52.4	48.5	51.7	x	50.60	1.54

16.TH: Viscosity Results - Real Water mixed with Alkalis @ 60°C

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Solvent Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.01	279	155	217.00	62.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.01	250	140	195.00	55.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.02	226	136	181.00	45.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.03	194	135	164.50	29.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.05	176	125	150.50	25.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.07	163	118	140.50	22.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.10	147	132	139.50	7.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.15	135	133	134.00	1.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.22	124	118	121.00	3.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.32	115	108	111.50	3.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.46	107	110	108.50	1.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	0.68	101	99	100.00	1.00
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	1.00	94.8	92.5	93.65	1.15
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	1.47	90.3	88	89.15	1.15
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	2.15	86.4	83	84.70	1.70
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	3.16	82.8	80	81.40	1.40
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	4.64	79.3	77	78.15	1.15
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	6.81	76.1	73	74.55	1.55
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	10.00	73	70	71.50	1.50
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	14.70	69.4	66.5	67.95	1.45
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	21.50	65.9	61.3	63.60	2.30
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	31.60	62.7	59.5	61.10	1.60
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	46.40	59.9	55	57.45	2.45
5:5	Dead	Na_2CO_3	HQ	5,000	x	x	x	68.10	57.4	53.5	55.45	1.95
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.01	113	310	211.50	98.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.01	142	291	216.50	74.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.02	158	272	215.00	57.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.03	159	251	205.00	46.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.05	158	227	192.50	34.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.07	153	212	182.50	29.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.10	191	196	193.50	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.15	186	181	183.50	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.22	162	168	165.00	3.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.32	155	157	156.00	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.46	143	148	145.50	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	0.68	133	139	136.00	3.00
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	1.00	131	132	131.50	0.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	1.47	119	126	122.50	3.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	2.15	116	121	118.50	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	3.16	109	116	112.50	3.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	4.64	101	110	105.50	4.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	6.81	98.5	105	101.75	3.25
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	10.00	95.1	98.6	96.85	1.75

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Solvent Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	14.70	89.2	92	90.60	1.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	21.50	80.5	85.5	83.00	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	31.60	74.3	79.1	76.70	2.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	46.40	71	73.8	72.40	1.40
5:5	Dead	Na_2CO_3	HQ	7,500	x	x	x	68.10	66	69.6	67.80	1.80
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.01	339	307	323.00	16.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.01	333	311	322.00	11.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.02	326	306	316.00	10.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.03	310	294	302.00	8.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.05	292	279	285.50	6.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.07	274	253	263.50	10.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.10	253	235	244.00	9.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.15	235	220	227.50	7.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.22	218	206	212.00	6.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.32	204	192	198.00	6.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.46	192	182	187.00	5.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	0.68	181	173	177.00	4.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	1.00	171	165	168.00	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	1.47	162	157	159.50	2.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	2.15	154	150	152.00	2.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	3.16	145	142	143.50	1.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	4.64	136	134	135.00	1.00
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	6.81	127	126	126.50	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	10.00	118	117	117.50	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	14.70	109	108	108.50	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	21.50	99.4	99.5	99.45	0.05
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	31.60	90.6	90.9	90.75	0.15
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	46.40	83.2	83.6	83.40	0.20
5:5	Dead	Na_2CO_3	HQ	10,000	x	x	x	68.10	77.7	78	77.85	0.15
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.01	42.7	119	80.85	38.15
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.01	42.9	114	78.45	35.55
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.02	44.4	96	70.20	25.80
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.03	51.6	89.9	70.75	19.15
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.05	56.5	85.7	71.10	14.60
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.07	60.7	78.6	69.65	8.95
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.10	58.4	78.9	68.65	10.25
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.15	59.5	70.8	65.15	5.65
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.22	57.6	67	62.30	4.70
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.32	56.8	62.9	59.85	3.05
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.46	55.4	60.2	57.80	2.40
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	0.68	54.4	57.2	55.80	1.40
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	1.00	53	55.4	54.20	1.20
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	1.47	52	53.9	52.95	0.95
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	2.15	50.8	52.9	51.85	1.05

WOR	Oil Type	Alkali Type	Alkali Quality	Alkali Conc. (ppm)	FP 3630S Conc. (ppm)	Co-Solvent Type	Co-Sol. Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	3.16	49.6	52.2	50.90	1.30
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	4.64	48.2	51.4	49.80	1.60
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	6.81	46.7	50.5	48.60	1.90
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	10.00	45.5	49.4	47.45	1.95
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	14.70	44.4	47.9	46.15	1.75
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	21.50	43	46.4	44.70	1.70
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	31.60	41.4	44.7	43.05	1.65
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	46.40	39.8	42.9	41.35	1.55
5:5	Dead	K_2CO_3	HQ	5,000	x	x	x	68.10	38.1	41.1	39.60	1.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.01	245	290	267.50	22.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.01	231	245	238.00	7.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.02	211	217	214.00	3.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.03	192	189	190.50	1.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.05	171	175	173.00	2.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.07	155	160	157.50	2.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.10	140	146	143.00	3.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.15	131	133	132.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.22	121	123	122.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.32	113	117	115.00	2.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.46	107	109	108.00	1.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	0.68	103	103	103.00	0.00
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	1.00	99.1	98.6	98.85	0.25
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	1.47	96.4	95.6	96.00	0.40
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	2.15	94.1	93.1	93.60	0.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	3.16	91.9	90.5	91.20	0.70
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	4.64	89.2	87.6	88.40	0.80
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	6.81	85.8	84.3	85.05	0.75
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	10.00	81.7	80.5	81.10	0.60
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	14.70	77.4	76.4	76.90	0.50
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	21.50	72.8	72	72.40	0.40
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	31.60	67.9	67.2	67.55	0.35
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	46.40	63	62.4	62.70	0.30
5:5	Dead	K_2CO_3	HQ	7,500	x	x	x	68.10	58.7	58	58.35	0.35
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.01	218	89.1	153.55	64.45
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.01	208	107	157.50	50.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.02	186	115	150.50	35.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.03	169	121	145.00	24.00
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.05	160	123	141.50	18.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.07	149	122	135.50	13.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.10	136	121	128.50	7.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.15	127	117	122.00	5.00
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.22	121	114	117.50	3.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.32	114	110	112.00	2.00
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.46	108	107	107.50	0.50

WOR	**Oil Type**	**Alkali Type**	**Alkali Quality**	**Alkali Conc. (ppm)**	**FP 3630S Conc. (ppm)**	**Co-Solvent Type**	**Co-Sol. Conc. (ppm)**	**Shear Rate (s^{-1})**	**Meas. 1 (cP)**	**Meas. 2 (cP)**	**Mean (cP)**	**Standard Deviation (cP)**
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	0.68	105	104	104.50	0.50
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	1.00	101	101	101.00	0.00
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	1.47	98.7	98.5	98.60	0.10
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	2.15	96.5	96.1	96.30	0.20
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	3.16	94.3	93.5	93.90	0.40
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	4.64	92	91.1	91.55	0.45
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	6.81	89.2	88.8	89.00	0.20
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	10.00	85.8	86.1	85.95	0.15
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	14.70	81.9	83	82.45	0.55
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	21.50	77.4	79.1	78.25	0.85
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	31.60	72.3	74.9	73.60	1.30
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	46.40	66.8	70	68.40	1.60
5:5	Dead	K_2CO_3	HQ	10,000	x	x	x	68.10	61.5	64.8	63.15	1.65

8.TH: Viscosity Results - Real Water mixed with Alkalis @ 49°C

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	5,000	0.01	680	675	x	677.5	2.50
5:5	Dead	Na_2CO_3	HQ	5,000	0.01	652	636	x	644	8.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.02	630	610	x	620	10.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.03	608	598	x	603	5.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.05	601	593	x	597	4.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.07	590	573	x	581.5	8.50
5:5	Dead	Na_2CO_3	HQ	5,000	0.10	355	350	x	352.5	2.50
5:5	Dead	Na_2CO_3	HQ	5,000	0.15	346	348	x	347	1.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.22	341	350	x	345.5	4.50
5:5	Dead	Na_2CO_3	HQ	5,000	0.32	334	340	x	337	3.00
5:5	Dead	Na_2CO_3	HQ	5,000	0.46	326	333	x	329.5	3.50
5:5	Dead	Na_2CO_3	HQ	5,000	0.68	318	324	x	321	3.00
5:5	Dead	Na_2CO_3	HQ	5,000	1.00	310	317	x	313.5	3.50
5:5	Dead	Na_2CO_3	HQ	5,000	1.47	302	310	x	306	4.00
5:5	Dead	Na_2CO_3	HQ	5,000	2.15	294	300	x	297	3.00
5:5	Dead	Na_2CO_3	HQ	5,000	3.16	286	293	x	289.5	3.50
5:5	Dead	Na_2CO_3	HQ	5,000	4.64	277	281	x	279	2.00
5:5	Dead	Na_2CO_3	HQ	5,000	6.81	267	278	x	272.5	5.50
5:5	Dead	Na_2CO_3	HQ	5,000	10.00	256	263	x	259.5	3.50
5:5	Dead	Na_2CO_3	HQ	5,000	14.70	243	253	x	248	5.00
5:5	Dead	Na_2CO_3	HQ	5,000	21.50	226	237	x	231.5	5.50
5:5	Dead	Na_2CO_3	HQ	5,000	31.60	206	215	x	210.5	4.50
5:5	Dead	Na_2CO_3	HQ	5,000	46.40	188	196	x	192	4.00
5:5	Dead	Na_2CO_3	HQ	5,000	68.10	175	183	x	179	4.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.01	389	391	x	390	1.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.01	378	421	x	399.5	21.50
5:5	Dead	Na_2CO_3	HQ	7,500	0.02	375	434	x	404.5	29.50
5:5	Dead	Na_2CO_3	HQ	7,500	0.03	376	413	x	394.5	18.50
5:5	Dead	Na_2CO_3	HQ	7,500	0.05	374	410	x	392	18.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.07	364	411	x	387.5	23.50
5:5	Dead	Na_2CO_3	HQ	7,500	0.10	380	368	x	374	6.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.15	375	362	x	368.5	6.50
5:5	Dead	Na_2CO_3	HQ	7,500	0.22	370	358	x	364	6.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.32	367	353	x	360	7.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.46	364	350	x	357	7.00
5:5	Dead	Na_2CO_3	HQ	7,500	0.68	359	344	x	351.5	7.50
5:5	Dead	Na_2CO_3	HQ	7,500	1.00	354	340	x	347	7.00
5:5	Dead	Na_2CO_3	HQ	7,500	1.47	349	335	x	342	7.00
5:5	Dead	Na_2CO_3	HQ	7,500	2.15	343	331	x	337	6.00
5:5	Dead	Na_2CO_3	HQ	7,500	3.16	335	325	x	330	5.00
5:5	Dead	Na_2CO_3	HQ	7,500	4.64	324	315	x	319.5	4.50
5:5	Dead	Na_2CO_3	HQ	7,500	6.81	311	304	x	307.5	3.50
5:5	Dead	Na_2CO_3	HQ	7,500	10.00	295	290	x	292.5	2.50
5:5	Dead	Na_2CO_3	HQ	7,500	14.70	278	274	x	276	2.00
5:5	Dead	Na_2CO_3	HQ	7,500	21.50	259	257	x	258	1.00

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	Na_2CO_3	HQ	7,500	31.60	239	238	x	238.5	0.50
5:5	Dead	Na_2CO_3	HQ	7,500	46.40	217	218	x	217.5	0.50
5:5	Dead	Na_2CO_3	HQ	7,500	68.10	197	198	x	197.5	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	0.01	366	328	x	347	19.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.01	363	353	x	358	5.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.02	371	365	x	368	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.03	380	362	x	371	9.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.05	382	369	x	375.5	6.50
5:5	Dead	Na_2CO_3	HQ	10,000	0.07	382	366	x	374	8.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.10	573	570	x	571.5	1.50
5:5	Dead	Na_2CO_3	HQ	10,000	0.15	557	552	x	554.5	2.50
5:5	Dead	Na_2CO_3	HQ	10,000	0.22	539	541	x	540	1.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.32	526	527	x	526.5	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	0.46	512	512	x	512	0.00
5:5	Dead	Na_2CO_3	HQ	10,000	0.68	497	498	x	497.5	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	1.00	482	481	x	481.5	0.50
5:5	Dead	Na_2CO_3	HQ	10,000	1.47	467	464	x	465.5	1.50
5:5	Dead	Na_2CO_3	HQ	10,000	2.15	450	444	x	447	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	3.16	429	422	x	425.5	3.50
5:5	Dead	Na_2CO_3	HQ	10,000	4.64	406	399	x	402.5	3.50
5:5	Dead	Na_2CO_3	HQ	10,000	6.81	382	375	x	378.5	3.50
5:5	Dead	Na_2CO_3	HQ	10,000	10.00	357	351	x	354	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	14.70	331	325	x	328	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	21.50	305	311	x	308	3.00
5:5	Dead	Na_2CO_3	HQ	10,000	31.60	278	286	x	282	4.00
5:5	Dead	Na_2CO_3	HQ	10,000	46.40	250	259	x	254.5	4.50
5:5	Dead	Na_2CO_3	HQ	10,000	68.10	226	230	x	228	2.00
5:5	Dead	K_2CO_3	HQ	5,000	0.01	444	460	x	452	8.00
5:5	Dead	K_2CO_3	HQ	5,000	0.01	491	402	x	446.5	44.50
5:5	Dead	K_2CO_3	HQ	5,000	0.02	398	365	x	381.5	16.50
5:5	Dead	K_2CO_3	HQ	5,000	0.03	379	352	x	365.5	13.50
5:5	Dead	K_2CO_3	HQ	5,000	0.05	369	357	x	363	6.00
5:5	Dead	K_2CO_3	HQ	5,000	0.07	369	360	x	364.5	4.50
5:5	Dead	K_2CO_3	HQ	5,000	0.10	361	359	x	360	1.00
5:5	Dead	K_2CO_3	HQ	5,000	0.15	353	355	x	354	1.00
5:5	Dead	K_2CO_3	HQ	5,000	0.22	347	350	x	348.5	1.50
5:5	Dead	K_2CO_3	HQ	5,000	0.32	344	345	x	344.5	0.50
5:5	Dead	K_2CO_3	HQ	5,000	0.46	340	341	x	340.5	0.50
5:5	Dead	K_2CO_3	HQ	5,000	0.68	335	336	x	335.5	0.50
5:5	Dead	K_2CO_3	HQ	5,000	1.00	332	331	x	331.5	0.50
5:5	Dead	K_2CO_3	HQ	5,000	1.47	327	327	x	327	0.00
5:5	Dead	K_2CO_3	HQ	5,000	2.15	323	323	x	323	0.00
5:5	Dead	K_2CO_3	HQ	5,000	3.16	319	318	x	318.5	0.50
5:5	Dead	K_2CO_3	HQ	5,000	4.64	315	312	x	313.5	1.50
5:5	Dead	K_2CO_3	HQ	5,000	6.81	309	304	x	306.5	2.50
5:5	Dead	K_2CO_3	HQ	5,000	10.00	300	293	x	296.5	3.50

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	K_2CO_3	HQ	5,000	14.70	289	280	x	284.5	4.50
5:5	Dead	K_2CO_3	HQ	5,000	21.50	276	265	x	270.5	5.50
5:5	Dead	K_2CO_3	HQ	5,000	31.60	261	249	x	255	6.00
5:5	Dead	K_2CO_3	HQ	5,000	46.40	245	232	x	238.5	6.50
5:5	Dead	K_2CO_3	HQ	5,000	68.10	227	213	x	220	7.00
5:5	Dead	K_2CO_3	HQ	7,500	0.01	231	366	x	298.5	67.50
5:5	Dead	K_2CO_3	HQ	7,500	0.01	289	347	x	318	29.00
5:5	Dead	K_2CO_3	HQ	7,500	0.02	341	356	x	348.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	0.03	371	371	x	371	0.00
5:5	Dead	K_2CO_3	HQ	7,500	0.05	374	371	x	372.5	1.50
5:5	Dead	K_2CO_3	HQ	7,500	0.07	379	365	x	372	7.00
5:5	Dead	K_2CO_3	HQ	7,500	0.10	380	365	x	372.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	0.15	378	358	x	368	10.00
5:5	Dead	K_2CO_3	HQ	7,500	0.22	372	356	x	364	8.00
5:5	Dead	K_2CO_3	HQ	7,500	0.32	367	352	x	359.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	0.46	362	348	x	355	7.00
5:5	Dead	K_2CO_3	HQ	7,500	0.68	356	341	x	348.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	1.00	351	337	x	344	7.00
5:5	Dead	K_2CO_3	HQ	7,500	1.47	346	332	x	339	7.00
5:5	Dead	K_2CO_3	HQ	7,500	2.15	341	327	x	334	7.00
5:5	Dead	K_2CO_3	HQ	7,500	3.16	335	320	x	327.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	4.64	327	311	x	319	8.00
5:5	Dead	K_2CO_3	HQ	7,500	6.81	315	300	x	307.5	7.50
5:5	Dead	K_2CO_3	HQ	7,500	10.00	301	287	x	294	7.00
5:5	Dead	K_2CO_3	HQ	7,500	14.70	286	272	x	279	7.00
5:5	Dead	K_2CO_3	HQ	7,500	21.50	268	256	x	262	6.00
5:5	Dead	K_2CO_3	HQ	7,500	31.60	250	238	x	244	6.00
5:5	Dead	K_2CO_3	HQ	7,500	46.40	230	218	x	224	6.00
5:5	Dead	K_2CO_3	HQ	7,500	68.10	209	199	x	204	5.00
5:5	Dead	K_2CO_3	HQ	10,000	0.01	477	502	x	489.5	12.50
5:5	Dead	K_2CO_3	HQ	10,000	0.01	459	457	x	458	1.00
5:5	Dead	K_2CO_3	HQ	10,000	0.02	456	446	x	451	5.00
5:5	Dead	K_2CO_3	HQ	10,000	0.03	465	426	x	445.5	19.50
5:5	Dead	K_2CO_3	HQ	10,000	0.05	456	426	x	441	15.00
5:5	Dead	K_2CO_3	HQ	10,000	0.07	448	419	x	433.5	14.50
5:5	Dead	K_2CO_3	HQ	10,000	0.10	440	416	x	428	12.00
5:5	Dead	K_2CO_3	HQ	10,000	0.15	431	408	x	419.5	11.50
5:5	Dead	K_2CO_3	HQ	10,000	0.22	420	404	x	412	8.00
5:5	Dead	K_2CO_3	HQ	10,000	0.32	411	396	x	403.5	7.50
5:5	Dead	K_2CO_3	HQ	10,000	0.46	402	387	x	394.5	7.50
5:5	Dead	K_2CO_3	HQ	10,000	0.68	393	378	x	385.5	7.50
5:5	Dead	K_2CO_3	HQ	10,000	1.00	383	369	x	376	7.00
5:5	Dead	K_2CO_3	HQ	10,000	1.47	375	360	x	367.5	7.50
5:5	Dead	K_2CO_3	HQ	10,000	2.15	365	349	x	357	8.00
5:5	Dead	K_2CO_3	HQ	10,000	3.16	355	338	x	346.5	8.50
5:5	Dead	K_2CO_3	HQ	10,000	4.64	342	324	x	333	9.00

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Dead	K_2CO_3	HQ	10,000	6.81	327	309	x	318	9.00
5:5	Dead	K_2CO_3	HQ	10,000	10.00	311	292	x	301.5	9.50
5:5	Dead	K_2CO_3	HQ	10,000	14.70	292	274	x	283	9.00
5:5	Dead	K_2CO_3	HQ	10,000	21.50	272	253	x	262.5	9.50
5:5	Dead	K_2CO_3	HQ	10,000	31.60	250	231	x	240.5	9.50
5:5	Dead	K_2CO_3	HQ	10,000	46.40	228	209	x	218.5	9.50
5:5	Dead	K_2CO_3	HQ	10,000	68.10	207	192	x	199.5	7.50

8.TH: Viscosity Results - Real Water mixed with Alkalis @ 49°C

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	5,000	0.01	202	223	x	212.5	10.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.01	201	182	x	191.5	9.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.02	210	172	x	191	19.00
5:5	Modified	Na_2CO_3	HQ	5,000	0.03	182	183	x	182.5	0.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.05	166	181	x	173.5	7.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.07	166	175	x	170.5	4.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.10	169	172	x	170.5	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.15	168	174	x	171	3.00
5:5	Modified	Na_2CO_3	HQ	5,000	0.22	165	170	x	167.5	2.50
5:5	Modified	Na_2CO_3	HQ	5,000	0.32	161	163	x	162	1.00
5:5	Modified	Na_2CO_3	HQ	5,000	0.46	157	161	x	159	2.00
5:5	Modified	Na_2CO_3	HQ	5,000	0.68	154	156	x	155	1.00
5:5	Modified	Na_2CO_3	HQ	5,000	1.00	151	152	x	151.5	0.50
5:5	Modified	Na_2CO_3	HQ	5,000	1.47	149	149	x	149	0.00
5:5	Modified	Na_2CO_3	HQ	5,000	2.15	146	146	x	146	0.00
5:5	Modified	Na_2CO_3	HQ	5,000	3.16	143	143	x	143	0.00
5:5	Modified	Na_2CO_3	HQ	5,000	4.64	140	140	x	140	0.00
5:5	Modified	Na_2CO_3	HQ	5,000	6.81	136	136	x	136	0.00
5:5	Modified	Na_2CO_3	HQ	5,000	10.00	131	132	x	131.5	0.50
5:5	Modified	Na_2CO_3	HQ	5,000	14.70	126	127	x	126.5	0.50
5:5	Modified	Na_2CO_3	HQ	5,000	21.50	119	122	x	120.5	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	31.60	112	115	x	113.5	1.50
5:5	Modified	Na_2CO_3	HQ	5,000	46.40	104	108	x	106	2.00
5:5	Modified	Na_2CO_3	HQ	5,000	68.10	95	99	x	97	2.00
5:5	Modified	Na_2CO_3	HQ	7,500	0.01	156	173	x	164.5	8.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.01	157	171	x	164	7.00
5:5	Modified	Na_2CO_3	HQ	7,500	0.02	159	154	x	156.5	2.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.03	171	164	x	167.5	3.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.05	188	155	x	171.5	16.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.07	177	156	x	166.5	10.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.10	169	155	x	162	7.00
5:5	Modified	Na_2CO_3	HQ	7,500	0.15	162	150	x	156	6.00
5:5	Modified	Na_2CO_3	HQ	7,500	0.22	160	149	x	154.5	5.50

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	Na_2CO_3	HQ	7,500	0.32	157	147	x	152	5.00
5:5	Modified	Na_2CO_3	HQ	7,500	0.46	152	145	x	148.5	3.50
5:5	Modified	Na_2CO_3	HQ	7,500	0.68	149	142	x	145.5	3.50
5:5	Modified	Na_2CO_3	HQ	7,500	1.00	146	140	x	143	3.00
5:5	Modified	Na_2CO_3	HQ	7,500	1.47	144	137	x	140.5	3.50
5:5	Modified	Na_2CO_3	HQ	7,500	2.15	141	135	x	138	3.00
5:5	Modified	Na_2CO_3	HQ	7,500	3.16	138	132	x	135	3.00
5:5	Modified	Na_2CO_3	HQ	7,500	4.64	135	130	x	132.5	2.50
5:5	Modified	Na_2CO_3	HQ	7,500	6.81	132	127	x	129.5	2.50
5:5	Modified	Na_2CO_3	HQ	7,500	10.00	128	123	x	125.5	2.50
5:5	Modified	Na_2CO_3	HQ	7,500	14.70	123	120	x	121.5	1.50
5:5	Modified	Na_2CO_3	HQ	7,500	21.50	118	115	x	116.5	1.50
5:5	Modified	Na_2CO_3	HQ	7,500	31.60	111	110	x	110.5	0.50
5:5	Modified	Na_2CO_3	HQ	7,500	46.40	103	103	x	103	0.00
5:5	Modified	Na_2CO_3	HQ	7,500	68.10	94	96	x	95	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	0.01	225	238	x	231.5	6.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.01	210	238	x	224	14.00
5:5	Modified	Na_2CO_3	HQ	10,000	0.02	209	223	x	216	7.00
5:5	Modified	Na_2CO_3	HQ	10,000	0.03	212	219	x	215.5	3.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.05	216	211	x	213.5	2.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.07	198	209	x	203.5	5.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.10	189	200	x	194.5	5.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.15	186	195	x	190.5	4.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.22	184	188	x	186	2.00
5:5	Modified	Na_2CO_3	HQ	10,000	0.32	180	187	x	183.5	3.50
5:5	Modified	Na_2CO_3	HQ	10,000	0.46	178	184	x	181	3.00
5:5	Modified	Na_2CO_3	HQ	10,000	0.68	175	181	x	178	3.00
5:5	Modified	Na_2CO_3	HQ	10,000	1.00	173	179	x	176	3.00
5:5	Modified	Na_2CO_3	HQ	10,000	1.47	171	175	x	173	2.00
5:5	Modified	Na_2CO_3	HQ	10,000	2.15	168	172	x	170	2.00
5:5	Modified	Na_2CO_3	HQ	10,000	3.16	166	168	x	167	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	4.64	164	164	x	164	0.00
5:5	Modified	Na_2CO_3	HQ	10,000	6.81	161	159	x	160	1.00
5:5	Modified	Na_2CO_3	HQ	10,000	10.00	156	153	x	154.5	1.50
5:5	Modified	Na_2CO_3	HQ	10,000	14.70	151	147	x	149	2.00
5:5	Modified	Na_2CO_3	HQ	10,000	21.50	145	139	x	142	3.00
5:5	Modified	Na_2CO_3	HQ	10,000	31.60	137	131	x	134	3.00
5:5	Modified	Na_2CO_3	HQ	10,000	46.40	129	122	x	125.5	3.50
5:5	Modified	Na_2CO_3	HQ	10,000	68.10	119	112	x	115.5	3.50
5:5	Modified	K_2CO_3	HQ	5,000	0.01	175	126	x	150.5	24.50
5:5	Modified	K_2CO_3	HQ	5,000	0.01	185	134	x	159.5	25.50
5:5	Modified	K_2CO_3	HQ	5,000	0.02	210	157	x	183.5	26.50
5:5	Modified	K_2CO_3	HQ	5,000	0.03	220	159	x	189.5	30.50
5:5	Modified	K_2CO_3	HQ	5,000	0.05	203	155	x	179	24.00
5:5	Modified	K_2CO_3	HQ	5,000	0.07	188	162	x	175	13.00

WOR	Oil Type	Alkali	Alkali Quality	Alkali Conc. (ppm)	Shear Rate (s^{-1})	Meas. 1 (cP)	Meas. 2 (cP)	Meas. 3 (cP)	Mean (cP)	Standard Deviation (cP)
5:5	Modified	K_2CO_3	HQ	5,000	0.10	191	166	x	178.5	12.50
5:5	Modified	K_2CO_3	HQ	5,000	0.15	191	166	x	178.5	12.50
5:5	Modified	K_2CO_3	HQ	5,000	0.22	182	166	x	174	8.00
5:5	Modified	K_2CO_3	HQ	5,000	0.32	179	164	x	171.5	7.50
5:5	Modified	K_2CO_3	HQ	5,000	0.46	175	163	x	169	6.00
5:5	Modified	K_2CO_3	HQ	5,000	0.68	171	162	x	166.5	4.50
5:5	Modified	K_2CO_3	HQ	5,000	1.00	167	160	x	163.5	3.50
5:5	Modified	K_2CO_3	HQ	5,000	1.47	163	158	x	160.5	2.50
5:5	Modified	K_2CO_3	HQ	5,000	2.15	159	157	x	158	1.00
5:5	Modified	K_2CO_3	HQ	5,000	3.16	156	154	x	155	1.00
5:5	Modified	K_2CO_3	HQ	5,000	4.64	152	152	x	152	0.00
5:5	Modified	K_2CO_3	HQ	5,000	6.81	147	149	x	148	1.00
5:5	Modified	K_2CO_3	HQ	5,000	10.00	142	146	x	144	2.00
5:5	Modified	K_2CO_3	HQ	5,000	14.70	136	142	x	139	3.00
5:5	Modified	K_2CO_3	HQ	5,000	21.50	129	136	x	132.5	3.50
5:5	Modified	K_2CO_3	HQ	5,000	31.60	121	130	x	125.5	4.50
5:5	Modified	K_2CO_3	HQ	5,000	46.40	112	122	x	117	5.00
5:5	Modified	K_2CO_3	HQ	5,000	68.10	103	114	x	108.5	5.50
5:5	Modified	K_2CO_3	HQ	7,500	0.01	165	204	x	184.5	19.50
5:5	Modified	K_2CO_3	HQ	7,500	0.01	165	200	x	182.5	17.50
5:5	Modified	K_2CO_3	HQ	7,500	0.02	174	193	x	183.5	9.50
5:5	Modified	K_2CO_3	HQ	7,500	0.03	193	178	x	185.5	7.50
5:5	Modified	K_2CO_3	HQ	7,500	0.05	182	181	x	181.5	0.50
5:5	Modified	K_2CO_3	HQ	7,500	0.07	182	174	x	178	4.00
5:5	Modified	K_2CO_3	HQ	7,500	0.10	175	173	x	174	1.00
5:5	Modified	K_2CO_3	HQ	7,500	0.15	168	168	x	168	0.00
5:5	Modified	K_2CO_3	HQ	7,500	0.22	166	164	x	165	1.00
5:5	Modified	K_2CO_3	HQ	7,500	0.32	162	164	x	163	1.00
5:5	Modified	K_2CO_3	HQ	7,500	0.46	159	162	x	160.5	1.50
5:5	Modified	K_2CO_3	HQ	7,500	0.68	156	161	x	158.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	1.00	154	159	x	156.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	1.47	152	157	x	154.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	2.15	150	155	x	152.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	3.16	148	152	x	150	2.00
5:5	Modified	K_2CO_3	HQ	7,500	4.64	145	150	x	147.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	6.81	142	147	x	144.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	10.00	139	143	x	141	2.00
5:5	Modified	K_2CO_3	HQ	7,500	14.70	134	139	x	136.5	2.50
5:5	Modified	K_2CO_3	HQ	7,500	21.50	129	133	x	131	2.00
5:5	Modified	K_2CO_3	HQ	7,500	31.60	123	126	x	124.5	1.50
5:5	Modified	K_2CO_3	HQ	7,500	46.40	116	119	x	117.5	1.50
5:5	Modified	K_2CO_3	HQ	7,500	68.10	108	111	x	109.5	1.50
5:5	Modified	K_2CO_3	HQ	10,000	0.01	217	211	x	214	3.00
5:5	Modified	K_2CO_3	HQ	10,000	0.01	221	215	x	218	3.00
5:5	Modified	K_2CO_3	HQ	10,000	0.02	227	235	x	231	4.00

WOR	**Oil Type**	**Alkali**	**Alkali Quality**	**Alkali Conc. (ppm)**	**Shear Rate (s^{-1})**	**Meas. 1 (cP)**	**Meas. 2 (cP)**	**Meas. 3 (cP)**	**Mean (cP)**	**Standard Deviation (cP)**
5:5	Modified	K_2CO_3	HQ	10,000	0.03	219	221	x	220	1.00
5:5	Modified	K_2CO_3	HQ	10,000	0.05	209	209	x	209	0.00
5:5	Modified	K_2CO_3	HQ	10,000	0.07	204	205	x	204.5	0.50
5:5	Modified	K_2CO_3	HQ	10,000	0.10	196	202	x	199	3.00
5:5	Modified	K_2CO_3	HQ	10,000	0.15	197	197	x	197	0.00
5:5	Modified	K_2CO_3	HQ	10,000	0.22	193	193	x	193	0.00
5:5	Modified	K_2CO_3	HQ	10,000	0.32	189	188	x	188.5	0.50
5:5	Modified	K_2CO_3	HQ	10,000	0.46	187	186	x	186.5	0.50
5:5	Modified	K_2CO_3	HQ	10,000	0.68	185	182	x	183.5	1.50
5:5	Modified	K_2CO_3	HQ	10,000	1.00	182	179	x	180.5	1.50
5:5	Modified	K_2CO_3	HQ	10,000	1.47	179	176	x	177.5	1.50
5:5	Modified	K_2CO_3	HQ	10,000	2.15	177	173	x	175	2.00
5:5	Modified	K_2CO_3	HQ	10,000	3.16	174	169	x	171.5	2.50
5:5	Modified	K_2CO_3	HQ	10,000	4.64	170	165	x	167.5	2.50
5:5	Modified	K_2CO_3	HQ	10,000	6.81	166	160	x	163	3.00
5:5	Modified	K_2CO_3	HQ	10,000	10.00	161	155	x	158	3.00
5:5	Modified	K_2CO_3	HQ	10,000	14.70	155	148	x	151.5	3.50
5:5	Modified	K_2CO_3	HQ	10,000	21.50	149	141	x	145	4.00
5:5	Modified	K_2CO_3	HQ	10,000	31.60	141	133	x	137	4.00
5:5	Modified	K_2CO_3	HQ	10,000	46.40	132	123	x	127.5	4.50
5:5	Modified	K_2CO_3	HQ	10,000	68.10	123	113	x	118	5.00

Alkali-Oil Interaction: Basic oil data and concentration ratios of compounds and compound groups within the investigated oils

	Ali (%)	Aro (%)	NSO (%)	Asph. (%)	Pr/Phy (-)	C_{27} (%)	C_{28} (%)	C_{29} (%)	C_{29} S/S+R	C_{29} I/I+R	C_{31} S/S+R	C_{32} S/S+R	C_{33} S/S+R	MN (-)	DMN (-)	TMN (-)
Crude Oils																
S	43	14	42	1	1.90	48	22	30								
M	39	20	39	2	1.48	57	23	20	0.63	0.57	0.60	0.60	0.61	14	50	36
H	29	19	50	3	na.	54	30	16	0.67	0.58	0.61	0.59	0.60	03	46	51
Na_2CO_3 Alkali-equilibrated Oil Phase																
M	40	21	38	2	1.91	na.	na.	na.	0.64	0.84	0.61	0.61	0.61	10	45	44
H	25	16	56	3	na.	na.	na.	na.	0.76	0.84	0.60	0.62	0.61	0	30	69
K_2CO_3 Alkali-equilibrated Oil Phase																
M	37	18	44	1	1.98	na.	na.	na.	0.44	0.56	0.60	0.59	0.61	10	42	47
H	27	17	54	2	na.	na.	na.	na.	0.47	0.58	0.59	0.60	0.60	0	28	71
Na_2CO_3 Emulsion Phase																
M	17	10	70	3	1.98	na.	na.	na.	0.99	0.83	0.70	0.71	nd	04	46	48
H	16	10	71	3	na.	na.	na.	na.	0.96	0.84	0.71	0.70	0.70	0	21	78
K_2CO_3 Emulsion Phase																
M	16	9	73	2	2.09	na.	na.	na.	0.41	0.51	0.62	0.63	0.62	01	40	58
H	17	8	73	2	na.	na.	na.	na.	0.46	0.52	0.63	0.62	0.61	0	20	79

Ali: aliphatic fraction as part of the SARA-data of the sample; Aro: aromatic fraction as part of the SARA-data of the sample; NSO: Nitrogen, Sulphur and Oxygen bearing compound fraction as part of the SARA-data of the sample; Asph: asphaltene fraction as part of the SARA-data of the sample; Pr: pristane; Ph: phytane; C_{27}, C_{28}, C_{29} : fractions of C_{27}, C_{28} and C_{29} steranes normalized to total steranes; C_{29} S/S+R: Isomerization ratio of the S and R C_{29} Steranes, C_{29} I/I+R: Isomerization of the αββ (I) and ααα (R) C_{29} Steranes, C_{31}, C_{32}, C_{33} S/S+R: Isomerization ratio of the C_{31}, C_{32} and C_{33} Homohopanes; MN: Methylnaphtalens fraction; DMN: Dimethylnapthalens fraction; TMN: Trimethylnaphtalenes fraction; S: Slightly degraded oil, M: Moderatly degraded oil; Heavy degraded oil

Appendix A2 (Alkali-Rock Study)

16.TH: Short-term Study with Berea Plugs @ 60°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	10,000	17.10.2017	0	09:30	1,000	13	254	276	13,362	39.8	0.99	12.9	1.30	1.38	10.60
NaOH	10,000	17.10.2017	1	13:30	200	13	225	247	11,860	34.5	0.5	7.13	0.02	0.18	9.95
NaOH	10,000	18.10.2017	2	10:30	195	13	247	271	13,144	37.7	0.5	3.07	0.02	4.78	25.60
NaOH	10,000	19.10.2017	3	08:45	190	13	249	273	12,995	37.1	0.5	2.17	0.02	3.12	45.80
NaOH	10,000	20.10.2017	4	08:00	185	13	251	275	13,079	35.5	0.5	3.63	0.42	3.83	64.60
NaOH	10,000	23.10.2017	7	09:00	180	13	245	270	12,653	35.2	0.5	1.7	0.02	6.77	123.00
Na_2CO_3	10,000	17.10.2017	0	09:30	1,000	11	95.6	213	12,087	40.2	12.2	11.4	0.10	0.90	10.80
Na_2CO_3	10,000	17.10.2017	1	13:30	200	11	89.8	201	11,418	33.6	11.4	14	0.02	0.14	2.01
Na_2CO_3	10,000	18.10.2017	2	10:30	195	11	93	209	11,564	37.4	5.71	15.3	0.02	0.11	1.94
Na_2CO_3	10,000	19.10.2017	3	08:45	190	11	91.7	206	11,682	35.1	3.12	1.52	0.02	0.03	1.89
Na_2CO_3	10,000	20.10.2017	4	08:00	185	11	93.9	211	11,715	34.1	1.95	3.23	0.02	0.05	2.07
Na_2CO_3	10,000	23.10.2017	7	09:00	180	11	95	213	11,866	36.7	1.01	1.84	0.02	0.18	1.91
K_2CO_3	10,000	17.10.2017	0	09:30	1,000	10.85	72	166	7,616	5,676	11.8	14.8	0.32	0.56	10.80
K_2CO_3	10,000	17.10.2017	1	13:30	200	10.85	68.8	159	7,417	5,506	10.4	15	0.02	0.10	2.04
K_2CO_3	10,000	18.10.2017	2	10:30	195	10.85	69	160	7,304	5,403	5.57	15.8	0.02	0.10	1.82
K_2CO_3	10,000	19.10.2017	3	08:45	190	10.85	69.5	162	7,506	5,561	3.34	1.51	0.02	0.03	1.77
K_2CO_3	10,000	20.10.2017	4	08:00	185	10.85	70.2	164	7,500	5,559	1.76	1.99	0.02	0.03	1.81
K_2CO_3	10,000	23.10.2017	7	09:00	180	10.85	70.5	164	7,427	5,529	0.71	2.09	0.02	0.18	1.73

16.TH: Short-term Study with Reservoir Plugs @ 60°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	10,000	31.10.2017	0	11:30	1,000	13	240	263	13,575	37.2	0.5	12.1	0.10	1.00	10.50
NaOH	10,000	31.10.2017	1	14:00	200	13	225	248	12,714	34.8	2.3	9.6	0.02	0.20	0.45
NaOH	10,000	02.11.2017	3	08:30	195	13	230	253	13,457	40.3	0.44	2.8	0.04	0.37	1.99
NaOH	10,000	03.11.2017	4	09:00	190	13	233	256	13,544	39.6	0.5	2.03	0.20	0.63	3.18
NaOH	10,000	06.11.2017	7	08:45	185	13	227	252	13,472	84.7	0.59	2.13	0.05	0.66	6.98
NaOH	10,000	07.11.2017	8	09:00	180	13	229	253	13,818	44.5	0.5	2.52	0.05	0.73	9.00
NaOH	10,000	20.11.2017	21	08:50	170	13	228	254	12,894	41.9	0.5	2.27	0.04	0.93	24.70
NaOH	10,000	27.11.2017	28	09:10	165	13	227	255	12,933	41.3	0.5	3.7	0.12	0.92	33.19
NaOH	10,000	04.12.2017	35	09:00	160	13	226	257	13,512	41	0.5	2.59	0.10	0.95	43.99
Na_2CO_3	10,000	31.10.2017	34	11:30	1,000	11	94	209	12,195	36.2	13.1	11.6	0.10	1.00	10.80
Na_2CO_3	10,000	31.10.2017	38	14:00	200	11	86.9	195	11,540	34.1	13.2	11.3	0.02	0.20	0.41
Na_2CO_3	10,000	02.11.2017	42	08:30	195	11	89.1	202	12,583	39.9	2.9	3	0.02	0.20	0.33
Na_2CO_3	10,000	03.11.2017	47	09:00	190	11	87.9	201	12,541	42.1	1.54	1.33	0.02	0.11	0.36
Na_2CO_3	10,000	06.11.2017	51	08:45	185	11	89.8	205	12,620	44.9	1.16	1.97	0.02	0.11	0.51
Na_2CO_3	10,000	07.11.2017	55	09:00	180	11	87.7	202	12,617	43.4	0.8	1.97	0.02	0.11	0.58
Na_2CO_3	10,000	20.11.2017	60	08:50	170	11	87	202	11,929	43	0.73	5.02	0.02	0.10	0.88
Na_2CO_3	10,000	27.11.2017	64	09:10	165	11	86.1	201	11,846	37.9	1.6	3.9	0.44	0.11	0.96
Na_2CO_3	10,000	04.12.2017	68	09:00	160	11	84.4	199	1,983	248	0.5	1.55	0.02	0.08	0.98
K_2CO_3	10,000	31.10.2017	73	11:30	1,000	10.85	70.4	162	7,909	5,606	14.5	29.1	0.10	1.00	10.90
K_2CO_3	10,000	31.10.2017	77	14:00	200	10.85	66.4	152	7,617	5,358	13.8	12.2	0.02	0.20	0.42
K_2CO_3	10,000	02.11.2017	81	08:30	195	10.85	65.3	155	7,940	5,568	3	5.4	0.02	0.20	0.32
K_2CO_3	10,000	03.11.2017	86	09:00	190	10.85	65.2	155	7,951	5,562	1.6	4.2	0.02	0.10	0.33

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
K_2CO_3	10,000	06.11.2017	90	08:45	185	10.85	65.8	158	8,214	5,767	0.94	4.07	0.02	0.09	0.59
K_2CO_3	10,000	07.11.2017	95	09:00	180	10.85	64.7	156	8,209	5,732	0.51	2.35	0.02	0.09	0.66
K_2CO_3	10,000	20.11.2017	99	08:50	170	10.85	64	157	7,697	5,631	1	2.6	0.02	0.09	0.98
K_2CO_3	10,000	27.11.2017	103	09:10	165	10.85	62.1	155	7,486	5,496	0.5	2.1	0.02	0.08	1.02
K_2CO_3	10,000	04.12.2017	108	09:00	160	10.85	61.9	155	7,704	5,676	0.5	2	0.02	0.07	1.03

16.TH: Long-term Study with Water-saturated Plugs @ 60°C

Alkali Lye	Alkali Con. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	7,500	28.02.2018	0	14:00	1,000	13	199	228	11,575	43.2	11.24	8.34	0.44	0.05	10.20
NaOH	7,500	07.03.2018	7	09:30	200	13	n.a.	n.a.	11,698	37.1	n.d.	n.d.	0.10	0.53	70.80
NaOH	7,500	14.03.2018	14	10:15	195	13	n.a.	n.a.	16,132	89.5	n.d.	3.36	0.16	0.91	170.24
NaOH	7,500	21.03.2018	21	13:30	190	13	n.a.	n.a.	23,991	137	n.d.	n.d.	0.44	1.17	365.75
NaOH	7,500	30.03.2018	30	10:00	185	13	n.a.	n.a.	12,629	40	n.d.	n.d.	0.09	0.49	216.27
NaOH	7,500	04.04.2018	35	08:30	180	13	165	214	12,555	37.6	n.d.	n.d.	0.11	0.47	232.56
NaOH	7,500	11.04.2018	42	08:30	170	13	n.a.	n.a.	11,718	35	n.d.	2.13	0.08	0.35	227.46
NaOH	7,500	18.04.2018	49	09:00	165	13	n.a.	n.a.	11,971	37.4	n.d.	1.75	0.05	0.29	248.33
NaOH	7,500	25.04.2018	56	11:00	160	13	n.a.	n.a.	12,319	42	n.d.	n.d.	0.06	0.28	295.20
NaOH	7,500	02.05.2018	63	11:00	155	13	153	190	12,016	36	n.d.	1.69	0.02	0.25	310.78
NaOH	7,500	09.05.2018	70	11:00	145	13	n.a.	n.a.	11,712	38.5	n.d.	5.23	0.02	0.23	284.49
NaOH	7,500	16.05.2018	77	10:00	140	13	n.a.	n.a.	12,702	41.8	n.d.	2	0.04	0.12	318.36
NaOH	7,500	23.05.2018	84	10:45	135	13	n.a.	n.a.	11,956	38.9	n.d.	1.25	0.04	0.10	333.59
NaOH	7,500	01.06.2018	92	10:30	130	13	n.a.	n.a.	11,574	34.6	n.d.	n.d.	0.03	0.06	301.08
Na_2CO_3	7,500	28.02.2018	0	14:00	1,000	11	70.1	164	10,439	38.3	11.2	8.37	0.36	0.01	10.20
Na_2CO_3	7,500	07.03.2018	7	09:30	200	11	n.a.	n.a.	10,861	40.9	n.d.	n.d.	0.01	0.02	2.30
Na_2CO_3	7,500	14.03.2018	14	10:15	195	11	n.a.	n.a.	12,228	42.7	n.d.	3.67	0.04	0.27	2.65
Na_2CO_3	7,500	21.03.2018	21	13:30	190	11	n.a.	n.a.	12,145	46.1	n.d.	n.d.	0.02	0.01	3.17
Na_2CO_3	7,500	30.03.2018	30	10:00	185	11	n.a.	n.a.	12,132	43.7	0.88	1.45	0.28	0.03	3.74
Na_2CO_3	7,500	04.04.2018	35	08:30	180	11	59.7	151	11,714	38.6	n.d.	n.d.	0.02	0.02	4.03
Na_2CO_3	7,500	11.04.2018	42	08:30	170	11	n.a.	n.a.	11,420	45.8	n.d.	n.d.	0.10	0.01	3.76
Na_2CO_3	7,500	18.04.2018	49	09:00	165	11	n.a.	n.a.	12,357	43	n.d.	n.d.	0.02	0.01	3.78
Na_2CO_3	7,500	25.04.2018	56	11:00	160	11	n.a.	n.a.	12,165	40.9	n.d.	n.d.	0.03	0.03	4.30
Na_2CO_3	7,500	02.05.2018	63	11:00	155	11	55.9	144	11,261	43.8	0.78	2.59	0.03	0.06	4.37
Na_2CO_3	7,500	09.05.2018	70	11:00	145	11	n.a.	n.a.	11,711	42.9	0.64	2.08	0.03	0.06	3.97
Na_2CO_3	7,500	16.05.2018	77	10:00	140	11	n.a.	n.a.	12,727	51.2	n.d.	n.d.	0.03	0.01	6.23
Na_2CO_3	7,500	23.05.2018	84	10:45	135	11	n.a.	n.a.	11,826	43.3	n.d.	1.81	0.03	0.11	5.67
Na_2CO_3	7,500	01.06.2018	92	10:30	130	11	n.a.	n.a.	11,264	37.4	n.d.	n.d.	0.01	0.00	3.32
K_2CO_3	7,500	28.02.2018	0	14:00	1,000	10.85	52.1	128	7,437	3,902	7.72	8.69	0.37	0.01	10.50
K_2CO_3	7,500	07.03.2018	7	09:30	200	10.85	n.a.	n.a.	7,744	3,907	n.d.	1.52	0.01	0.03	1.56
K_2CO_3	7,500	14.03.2018	14	10:15	195	10.85	n.a.	n.a.	8,728	4,340	n.d.	3.65	0.02	0.18	2.09
K_2CO_3	7,500	21.03.2018	21	13:30	190	10.85	n.a.	n.a.	8,499	3,962	1.16	2.22	0.01	0.01	3.31
K_2CO_3	7,500	30.03.2018	30	10:00	185	10.85	n.a.	n.a.	9,233	4,748	0.77	1.69	0.12	0.02	3.25
K_2CO_3	7,500	04.04.2018	35	08:30	180	10.85	39.9	110	8,165	4,145	n.d.	n.d.	0.02	0.01	3.96
K_2CO_3	7,500	11.04.2018	42	08:30	170	10.85	n.a.	n.a.	8,019	3,991	n.d.	1.48	0.02	0.01	3.72
K_2CO_3	7,500	18.04.2018	49	09:00	165	10.85	n.a.	n.a.	8,596	4,292	n.d.	n.d.	0.01	0.01	3.84
K_2CO_3	7,500	25.04.2018	56	11:00	160	10.85	n.a.	n.a.	8,564	4,290	4.18	n.d.	0.02	0.01	4.18
K_2CO_3	7,500	02.05.2018	63	11:00	155	10.85	39.6	112	8,250	3,987	n.d.	1.47	0.02	0.03	4.34

Alkali Lye	Alkali Con. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
K_2CO_3	7,500	09.05.2018	70	11:00	145	10.85	n.a.	n.a.	8,306	4,140	n.d.	n.d.	0.01	0.01	3.90
K_2CO_3	7,500	16.05.2018	77	10:00	140	10.85	n.a.	n.a.	8,659	4,328	n.d.	1.8	0.01	0.02	4.07
K_2CO_3	7,500	23.05.2018	84	10:45	135	10.85	n.a.	n.a.	8,508	4,416	n.d.	n.d.	0.03	0.07	3.92
K_2CO_3	7,500	01.06.2018	92	10:30	130	10.85	n.a.	n.a.	8,054	3,972	n.d.	n.d.	0.01	0.01	3.00

16.TH: Long-term Study with Oil-saturated Plugs @ 60°C

Alkali Lye	Alkali Conc. (ppm)	Sampling Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicium (mg/l)
NaOH	7,500	07.06.2018	0	11:00	1,000	12.85	184	205	11,346	49.8	9.74	9.97	0.51	0.07	11.40
NaOH	7,500	13.06.2018	6	08:00	200	12.85	n.a.	n.a.	13,184	49.3	n.d.	n.d.	0.14	0.94	37.80
NaOH	7,500	20.06.2018	13	09:00	195	12.85	181	210	12,418	57.5	n.d.	4.36	0.12	1.25	83.46
NaOH	7,500	27.06.2018	20	10:15	185	12.85	n.a.	n.a.	11,563	70.3	n.d.	n.d.	0.11	0.95	113.59
NaOH	7,500	04.07.2018	27	10:00	180	12.85	170	195	11,502	42.4	5	16.9	0.10	1.51	146.34
NaOH	7,500	11.07.2018	34	09:50	170	12.85	n.a.	n.a.	11,609	44	n.d.	2.13	0.08	0.90	151.64
NaOH	7,500	18.07.2018	41	10:00	165	12.85	n.a.	n.a.	11,313	41.2	n.d.	n.d.	0.05	0.55	189.59
NaOH	7,500	25.07.2018	48	09:00	160	12.85	n.a.	n.a.	10,945	37.6	3.57	13.88	0.04	0.48	225.44
NaOH	7,500	01.08.2018	55	12:30	155	12.85	167	196	11,740	44.4	n.d.	10.7	0.04	0.48	203.05
NaOH	7,500	09.08.2018	63	14:15	145	12.85	n.a.	n.a.	11,885	48.4	n.d.	0.92	0.03	0.35	217.21
NaOH	7,500	16.08.2018	70	10:04	138	12.85	n.a.	n.a.	11,430	50	0.52	2.27	0.01	0.23	231.84
NaOH	7,500	22.08.2018	76	10:00	133	12.85	n.a.	n.a.	11,182	43.4	0.24	1.41	0.02	0.17	219.32
NaOH	7,500	29.08.2018	83	11:30	128	12.85	164	193	11,767	46.4	n.d.	1.7	0.01	0.08	252.54
Na_2CO_3	7,500	07.06.2018	0	11:00	1,000	10.5	70	161	10,386	60.1	11.1	11	0.50	0.38	10.90
Na_2CO_3	7,500	13.06.2018	6	08:00	200	10.5	n.a.	n.a.	10,412	65.1	n.d.	n.d.	0.01	0.01	2.88
Na_2CO_3	7,500	20.06.2018	13	09:00	195	10.5	67.7	162	11,152	68.3	1.16	6.32	0.02	0.39	2.25
Na_2CO_3	7,500	27.06.2018	20	10:15	185	10.5	n.a.	n.a.	10,669	63.4	n.d.	n.d.	0.04	0.01	2.53
Na_2CO_3	7,500	04.07.2018	27	10:00	180	10.5	64	155	10,562	57.6	1.73	6.21	0.05	0.47	4.18
Na_2CO_3	7,500	11.07.2018	34	09:50	170	10.5	n.a.	n.a.	11,448	69	n.d.	3.44	0.04	0.05	3.86
Na_2CO_3	7,500	18.07.2018	41	10:00	165	10.5	n.a.	n.a.	11,203	62.4	n.d.	5.39	0.02	0.00	3.61
Na_2CO_3	7,500	25.07.2018	48	09:00	160	10.5	n.a.	n.a.	11,173	68	n.d.	n.d.	0.02	0.01	4.48
Na_2CO_3	7,500	01.08.2018	55	12:30	155	10.5	64.2	158	11,571	79	n.d.	2.02	0.00	0.01	4.39
Na_2CO_3	7,500	09.08.2018	63	14:15	145	10.5	n.a.	n.a.	11,905	74.2	n.d.	1.48	0.01	0.03	4.44
Na_2CO_3	7,500	16.08.2018	70	10:04	138	10.5	n.a.	n.a.	11,144	64.9	0.74	2.12	0.01	0.00	4.26
Na_2CO_3	7,500	22.08.2018	76	10:00	133	10.5	n.a.	n.a.	11,053	62.4	0.74	1.85	0.01	0.01	3.88
Na_2CO_3	7,500	29.08.2018	83	11:30	128	10.5	60.4	153	10,930	63.9	n.d.	1.2	0.01	0.00	3.70
K_2CO_3	7,500	07.06.2018	0	11:00	1,000	10.3	50.6	122	7,214	4,210	10.8	12.8	0.25	0.37	10.60
K_2CO_3	7,500	13.06.2018	6	08:00	200	10.3	n.a.	n.a.	7,243	3,893	n.d.	n.d.	0.00	0.01	1.56
K_2CO_3	7,500	20.06.2018	13	09:00	195	10.3	48.7	124	7,807	4,130	0.83	2.67	0.01	0.13	2.22
K_2CO_3	7,500	27.06.2018	20	10:15	185	10.3	n.a.	n.a.	7,945	4,169	n.d.	n.d.	0.02	0.00	2.74
K_2CO_3	7,500	04.07.2018	27	10:00	180	10.3	47.1	121	7,734	3,994	n.d.	5.12	0.02	0.15	3.46
K_2CO_3	7,500	11.07.2018	34	09:50	170	10.3	n.a.	n.a.	8,108	4,671	n.d.	3.83	0.02	0.01	3.60
K_2CO_3	7,500	18.07.2018	41	10:00	165	10.3	n.a.	n.a.	7,786	4,178	n.d.	n.d.	0.01	0.00	4.09
K_2CO_3	7,500	25.07.2018	48	09:00	160	10.3	n.a.	n.a.	7,439	4,017	n.d.	n.d.	0.01	0.01	3.92
K_2CO_3	7,500	01.08.2018	55	12:30	155	10.3	39.1	104	7,748	4,139	n.d.	6.19	0.01	0.00	4.53
K_2CO_3	7,500	09.08.2018	63	14:15	145	10.3	n.a.	n.a.	8,432	4,449	n.d.	1.45	0.01	0.01	4.36
K_2CO_3	7,500	16.08.2018	70	10:04	138	10.3	n.a.	n.a.	7,736	4,046	0.58	2.7	0.00	0.00	3.96
K_2CO_3	7,500	22.08.2018	76	10:00	133	10.3	n.a.	n.a.	7,815	4,099	0.59	1.55	0.00	0.01	3.78
K_2CO_3	7,500	29.08.2018	83	11:30	128	10.3	41.7	116	7,702	4,208	n.d.	2.14	0.00	0.00	3.83

8.TH: Short-term Study with Berea Plugs @ 49°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	10,000	17.10.2017	0	09:30	1,000	13	260	279	14,666	43.7	0.5	20.7	0.10	1.06	10.60
NaOH	10,000	17.10.2017	1	13:30	200	13	247	266	14,076	41.7	0.8	32	0.02	0.19	10.30
NaOH	10,000	18.10.2017	2	10:30	195	13	254	275	14,289	98.8	0.5	2.95	0.02	5.19	27.20
NaOH	10,000	19.10.2017	3	08:45	190	13	264	287	15,186	42.3	0.5	2	0.02	2.68	40.10
NaOH	10,000	20.10.2017	4	08:00	185	13	268	292	15,260	44	0.5	1.99	0.02	3.18	50.80
NaOH	10,000	23.10.2017	7	09:00	180	13	280	303	15,464	44.8	0.5	3.19	0.02	6.26	52.50
Na_2CO_3	10,000	17.10.2017	0	09:30	1,000	11	99	214	13,192	41.9	17.7	20.5	0.10	1.22	10.70
Na_2CO_3	10,000	17.10.2017	1	13:30	200	11	92.6	204	12,607	39.5	16	33.3	0.02	0.27	2.08
Na_2CO_3	10,000	18.10.2017	2	10:30	195	11	93.6	206	12,691	42.5	11.1	26	0.02	0.22	1.93
Na_2CO_3	10,000	19.10.2017	3	08:45	190	11	91.4	202	12,564	39.9	7.61	0.5	0.02	0.05	1.73
Na_2CO_3	10,000	20.10.2017	4	08:00	185	11	92.1	204	12,596	38.9	6.14	4.71	0.02	0.04	1.66
Na_2CO_3	10,000	23.10.2017	7	09:00	180	11	95.2	211	12,791	41.4	2.04	2.52	0.02	0.18	1.54
K_2CO_3	10,000	17.10.2017	0	09:30	1,000	10.85	72.4	164	9,011	5,740	15.9	21.4	0.10	1.02	10.50
K_2CO_3	10,000	17.10.2017	1	13:30	200	10.85	63.5	145	7,804	5,055	14.8	7.47	0.02	0.17	1.94
K_2CO_3	10,000	18.10.2017	2	10:30	195	10.85	70.2	161	8,611	5,620	10.9	1.86	0.02	0.09	1.80
K_2CO_3	10,000	19.10.2017	3	08:45	190	10.85	69.8	160	8,684	5,665	8.68	0.5	0.02	0.02	1.66
K_2CO_3	10,000	20.10.2017	4	08:00	185	10.85	70.8	162	8,681	5,644	6.63	1.07	0.02	0.02	1.53
K_2CO_3	10,000	23.10.2017	7	09:00	180	10.85	69.6	160	8,438	5,551	2.65	1.17	0.02	0.05	1.48

8.TH: Short-term Study with Reservoir Plugs @ 49°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	10,000	31.10.2017	0	11:30	1,000	13	251	271	15,126	43.4	0.5	25.1	0.50	1.00	10.50
NaOH	10,000	31.10.2017	1	14:00	200	13	238	258	14,368	41.7	1.47	20.3	0.02	0.20	1.06
NaOH	10,000	02.11.2017	3	08:30	195	13	236	257	15,205	44	0.48	4.7	0.02	0.90	1.70
NaOH	10,000	03.11.2017	4	09:00	190	13	239	264	15,646	44.8	0.5	1.84	0.08	0.83	2.18
NaOH	10,000	06.11.2017	7	08:45	185	13	238	263	15,468	45.1	0.5	3.59	0.02	0.80	4.15
NaOH	10,000	07.11.2017	8	09:00	180	13	232	256	15,279	45.7	0.5	2.37	0.02	0.73	5.17
NaOH	10,000	20.11.2017	21	08:50	170	13	237	264	14,802	44.4	0.5	3.31	0.02	0.70	17.84
NaOH	10,000	27.11.2017	28	09:10	165	13	234	261	14,203	42.1	4.4	3.6	1.25	0.65	18.76
NaOH	10,000	04.12.2017	35	09:00	160	13	221	247	14,964	44.4	0.5	2.21	0.04	0.56	17.20
Na_2CO_3	10,000	31.10.2017	34	11:30	1,000	11	94.7	207	13,906	47.5	20.8	28.9	0.10	1.00	10.90
Na_2CO_3	10,000	31.10.2017	38	14:00	200	11	90.7	199	13,266	43.9	19.5	7.5	0.02	0.20	10.60
Na_2CO_3	10,000	02.11.2017	42	08:30	195	11	85.7	193	13,489	43.1	7.7	8.3	0.02	0.20	7.96
Na_2CO_3	10,000	03.11.2017	47	09:00	190	11	87	197	14,021	44.6	5.82	1.2	0.02	0.13	7.51
Na_2CO_3	10,000	06.11.2017	51	08:45	185	11	Reactor Leakage								
Na_2CO_3	10,000	07.11.2017	55	09:00	180	11	Reactor Leakage								
Na_2CO_3	10,000	20.11.2017	60	08:50	170	11	Reactor Leakage								
Na_2CO_3	10,000	27.11.2017	64	09:10	165	11	Reactor Leakage								
Na_2CO_3	10,000	04.12.2017	68	09:00	160	11	Reactor Leakage								
K_2CO_3	10,000	31.10.2017	73	11:30	1,000	10.85	72	163	9,530	5,840	21.7	30.7	0.10	1.00	11.20
K_2CO_3	10,000	31.10.2017	77	14:00	200	10.85	66.8	152	8,693	5,438	20.4	8.7	0.02	0.20	0.41
K_2CO_3	10,000	02.11.2017	81	08:30	195	10.85	64.9	152	9,577	5,956	8.9	1.3	0.02	0.20	0.25
K_2CO_3	10,000	03.11.2017	86	09:00	190	10.85	64.5	150	9,427	5,768	5.61	1.4	0.02	0.10	0.22
K_2CO_3	10,000	06.11.2017	90	08:45	185	10.85	63.1	150	9,522	5,920	2.73	1.67	0.02	0.09	0.23

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
K_2CO_3	10,000	07.11.2017	95	09:00	180	10.85	62.1	149	9,573	5,946	2.74	3.31	0.02	0.09	0.27
K_2CO_3	10,000	20.11.2017	99	08:50	170	10.85	61.7	150	8,928	5,757	0.86	3.25	0.02	0.07	0.45
K_2CO_3	10,000	27.11.2017	103	09:10	165	10.85	59.4	146	8,607	5,572	0.6	5.2	0.03	0.05	0.46
K_2CO_3	10,000	04.12.2017	108	09:00	160	10.85	68.5	169	8,892	5,795	0.5	2.13	0.02	0.09	0.51

8.TH: Long-term Study with Water-saturated Plugs @ 49°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	7,500	28.02.2018	0	14:00	1,000	13	190	206	13,143	43.9	13.5	16.5	0.03	0.02	10.10
NaOH	7,500	07.03.2018	7	09:30	200	13	n.a.	n.a.	14,877	85.7	n.d.	2.06	0.09	2.78	43.80
NaOH	7,500	14.03.2018	14	10:15	195	13	n.a.	n.a.	14,268	79.2	n.d.	5.35	0.14	2.20	88.73
NaOH	7,500	21.03.2018	21	13:30	190	13	n.a.	n.a.	13,402	118	n.d.	4.12	0.10	1.59	112.86
NaOH	7,500	30.03.2018	30	10:00	185	13	n.a.	n.a.	13,601	71.1	1	4.71	0.10	1.23	153.00
NaOH	7,500	04.04.2018	35	08:30	180	13	167	195	13,717	69.2	n.d.	2.95	0.10	1.21	163.98
NaOH	7,500	11.04.2018	42	08:30	170	13	n.a.	n.a.	13,175	69.9	n.d.	3.02	0.05	0.95	166.09
NaOH	7,500	18.04.2018	49	09:00	165	13	n.a.	n.a.	13,522	171	n.d.	n.d.	0.04	0.83	164.67
NaOH	7,500	25.04.2018	56	11:00	160	13	n.a.	n.a.	13,555	72.3	n.d.	1.54	0.04	0.84	180.00
NaOH	7,500	02.05.2018	63	11:00	155	13	163	194	13,597	72.8	n.d.	2.87	0.03	0.81	187.55
NaOH	7,500	09.05.2018	70	11:00	145	13	n.a.	n.a.	21,921	4243	n.d.	n.d.	0.03	0.66	168.20
NaOH	7,500	16.05.2018	77	10:00	140	13	n.a.	n.a.	27,719	153	n.d.	3.2	0.13	1.81	351.12
NaOH	7,500	23.05.2018	84	10:45	135	13	n.a.	n.a.	13,533	71.4	n.d.	2.21	0.07	0.59	168.35
NaOH	7,500	01.06.2018	92	10:30	130	13	n.a.	n.a.	12,150	64.2	n.d.	n.d.	0.04	0.42	107.38
Na_2CO_3	7,500	28.02.2018	0	14:00	1,000	11	70	155	12,149	51.9	15.9	17.6	0.03	0.02	10.00
Na_2CO_3	7,500	07.03.2018	7	09:30	200	11	n.a.	n.a.	10,640	90	n.d.	n.d.	0.03	0.04	1.26
Na_2CO_3	7,500	14.03.2018	14	10:15	195	11	n.a.	n.a.	11,719	114	1.56	4.13	0.03	0.16	1.14
Na_2CO_3	7,500	21.03.2018	21	13:30	190	11	n.a.	n.a.	11,690	30.49	1.16	2.31	0.03	0.00	1.29
Na_2CO_3	7,500	30.03.2018	30	10:00	185	11	n.a.	n.a.	11,410	98.2	2.63	3.43	0.22	0.04	1.52
Na_2CO_3	7,500	04.04.2018	35	08:30	180	11	52.8	134	11,956	102	1.27	3	0.05	0.00	1.68
Na_2CO_3	7,500	11.04.2018	42	08:30	170	11	n.a.	n.a.	11,785	100	n.d.	1.29	0.02	0.01	1.41
Na_2CO_3	7,500	18.04.2018	49	09:00	165	11	n.a.	n.a.	11,742	99.7	0.58	2.32	0.03	0.01	1.56
Na_2CO_3	7,500	25.04.2018	56	11:00	160	11	n.a.	n.a.	11,976	104	n.d.	n.d.	0.05	0.02	1.70
Na_2CO_3	7,500	02.05.2018	63	11:00	155	11	49.7	132	11,631	98.2	1.22	1.78	0.03	0.03	1.75
Na_2CO_3	7,500	09.05.2018	70	11:00	145	11	n.a.	n.a.	11,114	166	1.47	2.22	0.05	0.01	1.52
Na_2CO_3	7,500	16.05.2018	77	10:00	140	11	n.a.	n.a.	11,550	97.2	1.43	1.97	0.03	0.00	1.88
Na_2CO_3	7,500	23.05.2018	84	10:45	135	11	n.a.	n.a.	11,563	94.1	2.4	2.38	0.05	0.02	2.28
Na_2CO_3	7,500	01.06.2018	92	10:30	130	11	n.a.	n.a.	11,020	91.9	n.d.	n.d.	0.03	0.00	0.93
K_2CO_3	7,500	28.02.2018	0	14:00	1,000	10.85	53.4	124	8,792	4,004	12.58	13.3	0.25	0.37	10.60
K_2CO_3	7,500	07.03.2018	7	09:30	200	10.85	n.a.	n.a.	8,845	3,773	n.d.	n.d.	0.05	0.02	1.10
K_2CO_3	7,500	14.03.2018	14	10:15	195	10.85	n.a.	n.a.	9,684	4,150	2.4	3.29	0.01	0.05	1.17
K_2CO_3	7,500	21.03.2018	21	13:30	190	10.85	n.a.	n.a.	9,585	3,752	1.51	1.73	0.02	0.01	6.12
K_2CO_3	7,500	30.03.2018	30	10:00	185	10.85	n.a.	n.a.	9,267	4,026	1.92	2.12	0.20	0.01	1.50
K_2CO_3	7,500	04.04.2018	35	08:30	180	10.85	38.1	104	9,260	3,977	1.59	1.99	0.02	0.01	1.91
K_2CO_3	7,500	11.04.2018	42	08:30	170	10.85	n.a.	n.a.	9,260	3,915	0.74	2.42	0.02	0.01	1.43
K_2CO_3	7,500	18.04.2018	49	09:00	165	10.85	n.a.	n.a.	9,534	4,046	n.d.	n.d.	0.02	0.01	1.48
K_2CO_3	7,500	25.04.2018	56	11:00	160	10.85	n.a.	n.a.	9,426	3,996	n.d.	n.d.	0.04	0.01	1.52
K_2CO_3	7,500	02.05.2018	63	11:00	155	10.85	36.1	102	9,326	3,830	n.d.	2.29	0.02	0.01	1.77
K_2CO_3	7,500	09.05.2018	70	11:00	145	10.85	n.a.	n.a.	9,139	3,928	n.d.	4.02	0.01	0.01	1.43

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
K_2CO_3	7,500	16.05.2018	77	10:00	140	10.85	n.a.	n.a.	9,152	3,908	n.d.	2	0.03	0.01	1.60
K_2CO_3	7,500	23.05.2018	84	10:45	135	10.85	n.a.	n.a.	9,460	4,119	n.d.	n.d.	0.03	0.01	1.46
K_2CO_3	7,500	01.06.2018	92	10:30	130	10.85	n.a.	n.a.	8,995	3,772	n.d.	n.d.	0.04	0.00	0.78

Short-term Study with Glass Beads @ 60°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Volume (ml)	pH Value	Alkal. $_{8.2}$ (mmol/l)	Alkal. $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	7,500	04.07.2018	0	10:00	2,000	13	179	210	11,902	32	1.66	28.4	0.08	0.06	28.60
NaOH	7,500	06.07.2018	2	09:30	1,200	13	n.a.	n.a.	12,106	39.8	n.d.	n.d.	0.12	0.46	71.16
NaOH	7,500	09.07.2018	5	09:00	1,195	13	n.a.	n.a.	11,801	37.2	n.d.	n.d.	0.05	1.72	137.43
NaOH	7,500	11.07.2018	7	09:50	1,190	13	182	213	12,256	33.1	1.56	6.5	0.11	5.43	173.74
NaOH	7,500	13.07.2018	9	09:00	1,180	13	n.a.	n.a.	12,367	34.8	n.d.	1.95	0.05	3.21	205.32
NaOH	7,500	16.07.2018	12	08:55	1,175	13	n.a.	n.a.	12,069	35.1	n.d.	2.86	0.05	3.58	235.00
NaOH	7,500	18.07.2018	14	10:00	1,170	11	180	214	12,348	36.9	n.d.	0.95	0.05	3.33	255.06
NaOH	7,500	20.07.2018	16	08:50	1,160	11	n.a.	n.a.	12,478	61.77	0.56	2.52	0.02	4.16	245.92
NaOH	7,500	23.07.2018	19	09:10	1,155	11	Pump leakage --> no sampling possible								
NaOH	7,500	25.07.2018	21	09:00	1,150	11									
Na_2CO_3	7,500	04.07.2018	0	10:00	2,000	11	68	167	11,053	33.6	27.9	26.9	0.56	0.06	13.90
Na_2CO_3	7,500	06.07.2018	2	09:30	1,200	11	n.a.	n.a.	11,428	41.4	19	n.d.	0.07	0.04	23.88
Na_2CO_3	7,500	09.07.2018	5	09:00	1,195	11	n.a.	n.a.	10,913	43.6	12.2	n.d.	0.03	0.20	36.57
Na_2CO_3	7,500	11.07.2018	7	09:50	1,190	11	67.4	167	11,494	35	15.9	5.07	0.03	1.82	53.43
Na_2CO_3	7,500	13.07.2018	9	09:00	1,180	11	n.a.	n.a.	11,756	52.1	8.05	2.08	0.03	0.04	74.69
Na_2CO_3	7,500	16.07.2018	12	08:55	1,175	11	n.a.	n.a.	11,061	37.5	3.43	1.86	0.03	0.04	111.74
Na_2CO_3	7,500	18.07.2018	14	10:00	1,170	11	66.1	167	11,252	37.9	1.98	n.d.	0.03	0.04	143.56
Na_2CO_3	7,500	20.07.2018	16	08:50	1,160	11	n.a.	n.a.	11,442	58	2.39	1.32	0.02	0.02	169.36
Na_2CO_3	7,500	23.07.2018	19	09:10	1,155	11	n.a.	n.a.	11,611	65	2.6	1.8	0.02	0.01	191.73
Na_2CO_3	7,500	25.07.2018	21	09:00	1,150	11	61	152	10,929	33.4	n.d	2.93	0.02	0.05	193.20
K_2CO_3	7,500	04.07.2018	0	10:00	2,000	10.85	49.8	131	7,929	3,813	25.7	31.7	2.26	2.12	11.20
K_2CO_3	7,500	06.07.2018	2	09:30	1,200	10.85	n.a.	n.a.	8,300	4,107	19	n.d.	0.17	0.02	18.84
K_2CO_3	7,500	09.07.2018	5	09:00	1,195	10.85	n.a.	n.a.	8,573	4,214	18.5	n.d.	0.04	0.50	32.03
K_2CO_3	7,500	11.07.2018	7	09:50	1,190	10.85	50.2	136	8,588	4,427	13.6	2.79	0.05	0.65	47.12
K_2CO_3	7,500	13.07.2018	9	09:00	1,180	10.85	n.a.	n.a.	8,378	4,122	8.31	n.d.	0.04	0.02	68.56
K_2CO_3	7,500	16.07.2018	12	08:55	1,175	10.85	n.a.	n.a.	8,227	4,092	3.58	n.d.	0.04	0.02	92.59
K_2CO_3	7,500	18.07.2018	14	10:00	1,170	10.85	48.8	133	8,549	4,093	5.42	1.34	0.04	0.02	109.04
K_2CO_3	7,500	20.07.2018	16	08:50	1,160	10.85	n.a.	n.a.	8,187	4191	3.91	1.88	0.01	0.01	120.64
K_2CO_3	7,500	23.07.2018	19	09:10	1,155	10.85	n.a.	n.a.	8,295	4245	4.63	2.32	0.01	0.01	145.53
K_2CO_3	7,500	25.07.2018	21	09:00	1,150	10.85	48.1	131	8,013	3960	n.d.	2.82	0.00	0.03	158.70

Short-term Study with Carbolite Beads @ 60°C

Alkali Lye	Alkali Conc. (ppm)	Sampl. Date	Days	Sampl. Time	Filling Vol. (ml)	pH Value	Alkalinity $_{8.2}$ (mmol/l)	Alkalinity $_{4.3}$ (mmol/l)	Natrium (mg/l)	Potassium (mg/l)	Magnesium (mg/l)	Calcium (mg/l)	Iron (mg/l)	Aluminium (mg/l)	Silicon (mg/l)
NaOH	7,500	07.06.2018	0	11:00	2,000	13	184	205	11,346	49.8	9.74	9.97	1.02	0.03	22.80
NaOH	7,500	11.06.2018	4	07:30	1,200	13	n.a.	n.a.	11,454	43.3	n.d.	n.d.	0.02	3.11	71.40
NaOH	7,500	13.06.2018	6	08:00	1,195	13	n.a.	n.a.	12,342	51.7	n.d.	1.55	0.06	3.39	107.07
NaOH	7,500	15.06.2018	8	08:15	1,190	13	n.a.	n.a.	12,488	50.1	n.d.	1.31	0.06	4.19	148.75
NaOH	7,500	18.06.2018	11	08:30	1,185	13	n.a.	n.a.	11,945	46.2	n.d.	1.28	0.06	3.42	191.97
NaOH	7,500	20.06.2018	13	09:00	1,180	13	174	205	12,115	45.2	n.d.	n.d.	0.06	4.99	194.70
NaOH	7,500	22.06.2018	15	08:30	1,170	13	n.a.	n.a.	11,251	42.6	n.d.	n.d.	0.06	5.18	207.09
NaOH	7,500	25.06.2018	18	09:30	1,165	13	n.a.	n.a.	11,682	48.9	n.d.	3.89	0.17	7.05	239.99
NaOH	7,500	27.06.2018	20	10:15	1,160	13	173	205	11,780	43.2	n.d.	n.d.	0.17	6.26	255.20
NaOH	7,500	29.06.2018	22	09:20	1,150	13	n.a.	n.a.	11,604	46.1	n.d.	n.d.	0.13	6.82	274.85
NaOH	7,500	02.07.2018	25	08:15	1,145	13	n.a.	n.a.	11,915	44	n.d.	n.d.	0.05	7.49	301.14
Na_2CO_3	7,500	07.06.2018	0	11:00	2,000	11	70	161	10,386	60.1	11.1	11	1.00	0.19	21.80
Na_2CO_3	7,500	11.06.2018	4	07:30	1,200	11	n.a.	n.a.	10,525	48.6	5.46	n.d.	0.02	0.38	15.12
Na_2CO_3	7,500	13.06.2018	6	08:00	1,195	11	n.a.	n.a.	11,249	50.6	8.05	5.48	0.06	0.14	15.65
Na_2CO_3	7,500	15.06.2018	8	08:15	1,190	11	n.a.	n.a.	11,224	49	9.95	1.09	0.06	0.06	16.18
Na_2CO_3	7,500	18.06.2018	11	08:30	1,185	11	n.a.	n.a.	10,912	49.4	6.45	3.27	0.06	0.10	16.95
Na_2CO_3	7,500	20.06.2018	13	09:00	1,180	11	65.8	156	10,939	47.2	5.65	1.5	0.06	0.03	14.87
Na_2CO_3	7,500	22.06.2018	15	08:30	1,170	11	n.a.	n.a.	10,714	45.1	5.71	0.69	0.06	0.03	15.44
Na_2CO_3	7,500	25.06.2018	18	09:30	1,165	11	n.a.	n.a.	10,808	54.1	3.79	1.92	0.06	0.95	15.94
Na_2CO_3	7,500	27.06.2018	20	10:15	1,160	11	65.2	158	10,472	41	2.31	n.d.	0.05	0.24	15.89
Na_2CO_3	7,500	29.06.2018	22	09:20	1,150	11	n.a.	n.a.	10,239	45.4	3.41	3.34	0.05	0.03	17.37
Na_2CO_3	7,500	02.07.2018	25	08:15	1,145	11	n.a.	n.a.	10,497	45.1	3.21	1.81	0.05	0.03	16.95
K_2CO_3	7,500	07.06.2018	0	11:00	2,000	10.85	50.6	122	7,214	4,210	10.8	12.8	1.12	0.90	21.60
K_2CO_3	7,500	11.06.2018	4	07:30	1,200	10.85	n.a.	n.a.	7,311	3,853	7.82	2.89	0.01	0.76	12.96
K_2CO_3	7,500	13.06.2018	6	08:00	1,195	10.85	n.a.	n.a.	8,146	4,259	13	n.d.	0.04	0.39	12.67
K_2CO_3	7,500	15.06.2018	8	08:15	1,190	10.85	n.a.	n.a.	8,014	4,181	14.3	1.34	0.04	0.33	12.73
K_2CO_3	7,500	18.06.2018	11	08:30	1,185	10.85	n.a.	n.a.	7,632	4,224	11.1	13	0.04	4.54	12.80
K_2CO_3	7,500	20.06.2018	13	09:00	1,180	10.85	48	124	7,968	4124	8.27	3.91	0.04	1.12	11.56
K_2CO_3	7,500	22.06.2018	15	08:30	1,170	10.85	n.a.	n.a.	7,744	4131	7.55	n.d.	0.04	1.04	12.99
K_2CO_3	7,500	25.06.2018	18	09:30	1,165	10.85	n.a.	n.a.	7,676	3976	4.93	n.d.	0.06	0.45	11.50
K_2CO_3	7,500	27.06.2018	20	10:15	1,160	10.85	48.6	119	7,619	3913	4.64	n.d.	0.05	0.23	12.76
K_2CO_3	7,500	29.06.2018	22	09:20	1,150	10.85	n.a.	n.a.	7,586	3,915	3.05	n.d.	0.03	0.02	12.42
K_2CO_3	7,500	02.07.2018	25	08:15	1,145	10.85	n.a.	n.a.	7,679	4,150	3.71	n.d.	0.03	0.02	12.82

Appendix A3 (Treatment Study)

Well Combinations	Polymer Concentration (ppm)
S95+S110+S135+Ma108	5.4
S95+S110+S135	6.0
S95+S135	8.2
S95+S110+Ma108	8.9
S95+S135+Ma108	7.2
S66+S110+S135+Ma108	22.36
S66+S110+S135	24.99
S66+S135+Ma108	30.87

Analytic Data – Part I

			Conc. Flopaam 3630S	Chemical Package				Sampling Inlet Separator HV 3106		Sampling Inlet CPI HV 3110		
Sampling Date	Sampling Time	Flow Rate (m^3/h)	(ppm)	Coagulant	Concentration (ppm)	Flocculation Aid	Concentration (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Measured Polymer Concentration (ppm)
30.08.16	10:50	5.02	0	--	--	--	--	Emulsion with small oil droplets	541	yellow-brownish, high turbidity	239	--
31.08.16	08:20	5.01	0	--	--	--	--	Emulsion with small oil droplets	310	yellow-brownish, high turbidity	120	--
31.08.16	11:10	5.02	0	--	--	--	--	Emulsion with small oil droplets	369	yellow-brownish, high turbidity	234	--
31.08.16	15:00	5.02	0	--	--	--	--	Emulsion with small oil droplets	407	yellow-brownish, high turbidity	239	--
01.09.16	09:30	5.03	0	--	--	--	--	Emulsion with small oil droplets	221	yellow-brownish, high turbidity	247	--
01.09.16	11:30	5.03	0	--	--	--	--	Emulsion with small oil droplets	234	yellow-brownish, high turbidity	246	--
01.09.16	14:00	5.03	0	--	--	--	--	Emulsion with small oil droplets	410	yellow-brownish, high turbidity	287	--
02.09.16	09:15	5.01	0	--	--	--	--	Emulsion with small oil droplets	334	yellow-brownish, high turbidity	274	--
05.09.16	11:00	5.01	0	--	--	--	--	Emulsion with small oil droplets	339	yellow-brownish, high turbidity	269	--
05.09.16	15:15	5.01	0	--	--	--	--	Emulsion with small oil droplets	408	yellow-brownish, high turbidity	272	--
06.09.16	08:20	5	0	--	--	--	--	Emulsion with small oil droplets	451	yellow-brownish, high turbidity	228	--
06.09.16	13:30	4.99	0	--	--	--	--	Emulsion with small oil droplets	471	yellow-brownish, high turbidity	233	--
07.09.16	08:45	4.99	0	--	--	--	--	Emulsion with small oil droplets	473	yellow-brownish, high turbidity	253	--
07.09.16	18:00	4.98	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	545	yellow-brownish, high turbidity	301	--

Sampling Date	Sampling Time	Flow Rate (m^3/h)	Conc. Flopaam 3630S (ppm)	Coagulant	Concentration (ppm)	Flocculation Aid	Concentration (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Measured Polymer Concentration (ppm)
08.09.16	09:15	4.98	0	Chimec 5763	20	Chimec 5566	0.15	Emulsion with small oil droplets	398	yellow-brownish, high turbidity	240	--
08.09.16	11:15	4.98	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	392	yellow-brownish, high turbidity	245	--
08.09.16	13:15	4.98	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	321	yellow-brownish, high turbidity	297	--
08.09.16	15:15	4.98	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	484	yellow-brownish, high turbidity	304	--
08.09.16	17:15	4.98	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	385	yellow-brownish, high turbidity	302	--
12.09.16	09:00	5.01	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	417	yellow-brownish, high turbidity	299	--
12.09.16	11:00	5.03	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	480	yellow-brownish, high turbidity	293	--
12.09.16	14:45	5.03	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	417	yellow-brownish, high turbidity	292	--
13.09.16	09:00	5	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	498	yellow-brownish, high turbidity	267	--
13.09.16	11:00	4.95	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	394	yellow-brownish, high turbidity	285	--
13.09.16	13:00	4.94	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	519	yellow-brownish, high turbidity	315	--
13.09.16	15:00	4.94	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	514	yellow-brownish, high turbidity	298	--
14.09.16	10:30	5.04	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	514	yellow-brownish, high turbidity	249	--
14.09.16	14:00	5.04	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	500	yellow-brownish, high turbidity	340	--
20.09.16	09:00	5.04	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	410	yellow-brownish, high turbidity	274	--
20.09.16	14:45	5.01	0	Chimec 5762	20	Chimec 5565	0.15	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	281	--
21.09.16	07:30	5.01	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	412	yellow-brownish, high turbidity	271	--

Sampling Date	Sampling Time	Flow Rate (m^3/h)	Flopaam 3630S (ppm)	Coagulant	Concentration (ppm)	Flocculation Aid	Concentration (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Measured Polymer Concentration (ppm)
21.09.16	11:00	5.01	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	450	yellow-brownish, high turbidity	266	--
21.09.16	13:30	5	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	420	yellow-brownish, high turbidity	273	--
22.09.16	10:00	5.01	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	442	yellow-brownish, high turbidity	242	--
22.09.16	13:30	5.02	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	--	yellow-brownish, high turbidity	238	--
22.09.16	14:30	5.02	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	--	yellow-brownish, high turbidity	268	--
27.09.16	08:15	5.02	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	1060	yellow-brownish, high turbidity	405	6.0
27.09.16	11:00	5.02	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	--	yellow-brownish, high turbidity	401	-
27.09.16	14:30	5.02	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	--	yellow-brownish, high turbidity	392	-
28.09.16	08:45	5.04	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	914	yellow-brownish, high turbidity	387	5.6
29.09.16	13:00	5.04	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	1118	yellow-brownish, high turbidity	303	5.2
29.09.16	14:30	4.94	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	310	-
30.09.16	09:00	4.94	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	1177	yellow-brownish, high turbidity	341	5.8
03.10.16	14:30	4.98	6	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	1678	yellow-brownish, high turbidity	419	7.7
06.10.16	14:00	4.96	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	526	yellow-brownish, high turbidity	88	6.1
07.10.16	08:45	5.01	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	489	yellow-brownish, high turbidity	119	7.8
07.10.16	11:00	5.01	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	114	8.8

Sampling Date	Sampling Time	Flow Rate (m^3/h)	Flopaam 3630S (ppm)	Coagulant	Concentration (ppm)	Flocculation Aid	Concentration (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Measured Polymer Concentration (ppm)
10.10.16	10:30	5.02	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	615	yellow-brownish, high turbidity	198	8.0
10.10.16	12:45	5.01	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	279	8.4
10.10.16	15:00	5.05	8.2	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	263	-
11.10.16	11:00	5.07	8.2	Chimec 5762	80	Chimec 5565	0.3	Emulsion with small oil droplets	568	yellow-brownish, high turbidity	257	8.0
11.10.16	14:00	5.04	8.2	Chimec 5762	80	Chimec 5565	0.3	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	128	8.5
12.10.	10:00	5.01	0	Chimec 5762	35	Chimec 5565	0.3	Emulsion with small oil droplets	374	yellow-brownish, high turbidity	244	<1
19.10.	10:30	5.04	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	490	yellow, turbidity	324	-
19.10.	12:30	5.05	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	241	-
19.10.	14:30	4.98	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	260	-
20.10.	11:30	4.99	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	523	yellow, turbidity	341	-
20.10.	14:30	5.01	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	263	-
20.10.	16:30	5.03	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	276	-
21.10.	09:30	5.02	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	811	yellow, turbidity	250	-
21.10.	11:15	4.99	0	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	277	-
24.10.	15:30	5.01	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	496	yellow, turbidity	188	2.1
2.11.	11:00	4.95	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	166	6.3
2.11.	15:15	5	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	464	yellow, turbidity	163	-
2.11.	16:15	4.96	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	138	-

Sampling Date	Sampling Time	Flow Rate (m³/h)	Flopaam 3630S (ppm)	Coagulant	Concentration (ppm)	Flocculation Aid	Concentration (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Optical Evaluation	Hydrocarbon Content (ppm)	Measured Polymer Concentration (ppm)
3.11.	09:00	5	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	338	yellow, turbidity	312	6.0
3.11.	10:30	5	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	153	5.8
3.11.	12:30	4.96	8.2	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow, turbidity	175	-
7.11.	16:00	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	573	yellow-brownish, high turbidity	206	18.4
8.11.	09:00	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	580	yellow-brownish, high turbidity	175	18.3
8.11.	11:00	4.98	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	216	-
8.11.	14:30	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	200	18.8
9.11.	09:30	4.98	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	479	yellow-brownish, high turbidity	114	19.8
9.11.	11:00	4.94	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	165	19.2
9.11.	14:00	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	155	-
10.11.	09:30	4.93	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	400	yellow-brownish, high turbidity	179	18.9
10.11.	11:30	4.92	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	185	-
10.11.	14:30	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	215	20.3
11.11.	09:00	4.9	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	549	yellow-brownish, high turbidity	175	18.8
11.11.	11:00	4.96	19.7	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	188	-
14.11.	14:00	4.96	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	389	yellow-brownish, high turbidity	205	27.2
14.11.	15:30	4.95	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	208	27.6

Sampling Date	**Sampling Time**	**Flow Rate (m³/h)**	**Flopaam 3630S (ppm)**	**Coagulant**	**Concentration (ppm)**	**Flocculation Aid**	**Concentration (ppm)**	**Optical Evaluation**	**Hydrocarbon Content (ppm)**	**Optical Evaluation**	**Hydrocarbon Content (ppm)**	**Measured Polymer Concentration (ppm)**
15.11.	09:30	5.02	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	483	yellow-brownish, high turbidity	82	28.1
15.11.	11:30	4.99	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	123	-
15.11.	14:30	4.98	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	220	28.7
16.11.	10:00	5	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	501	yellow-brownish, high turbidity	213	28.4
16.11.	11:30	4.96	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	239	29.0
16.11.	14:00	4.97	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	220	-
17.11.	09:30	4.93	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	593	yellow-brownish, high turbidity	251	29.1
17.11.	11:00	4.95	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	236	-
17.11.	14:30	4.98	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	246	28.5
18.11.	09:00	4.96	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	514	yellow-brownish, high turbidity	241	28.6
18.11.	11:00	4.95	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	-	yellow-brownish, high turbidity	248	27.9
21.11.	14:00	4.9	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	572	yellow-brownish, high turbidity	270	27.7
22.11.	09:00	4.94	31	Floquat 2949/Feralco FD1465	100	Chimec 5565	0.6	Emulsion with small oil droplets	542	yellow-brownish, high turbidity	241	26.3

Analytic Data – Part II

		Sampling Outlet CPI/ Inlet Flotation HV 3112					Operating Parameters										
Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
30.08.16	10:50	yellow, high turbidity	149	37.7%	--	--	--	--	1.20	27.93	107.5	75	--	--	--	--	--
31.08.16	08:20	yellow, high turbidity	75	37.5%	--	--	--	--	1.06	27.83	107.8	75	--	--	--	--	--
31.08.16	11:10	yellow, high turbidity	147	37.2%	--	--	--	--	0.96	27.92	107.6	75	--	--	--	--	--
31.08.16	15:00	yellow, high turbidity	146	38.9%	--	--	--	--	0.96	27.96	107.9	75	--	--	--	--	--
01.09.16	09:30	yellow, high turbidity	146	40.9%	--	--	--	--	1.30	27.91	107.6	75	--	--	--	--	--
01.09.16	11:30	yellow, high turbidity	155	37.0%	--	--	--	--	1.10	27.94	107.7	75	--	--	--	--	--
01.09.16	14:00	yellow, high turbidity	165	42.5%	--	--	--	--	1.28	27.98	107.7	75	--	--	--	--	--
02.09.16	09:15	yellow, high turbidity	154	43.8%	--	--	8	7.0	1.08	27.93	107.9	75	--	--	--	--	--
05.09.16	11:00	yellow, high turbidity	164	39.0%	--	--	8	6.8	1.01	27.91	107.6	73	--	--	--	--	--
05.09.16	15:15	yellow, high turbidity	161	40.8%	--	--	8	6.5	1.13	27.95	107.7	74	--	--	--	--	--
06.09.16	08:20	yellow, high turbidity	168	26.3%	--	--	8	7.0	1.03	27.86	107.5	73	--	--	--	--	--
06.09.16	13:30	yellow, high turbidity	145	37.8%	--	--	8	7.0	1.10	27.19	108.1	74	--	--	--	--	--
07.09.16	08:45	yellow, high turbidity	160	36.8%	--	--	8	7.0	1.07	27.88	107.6	72	--	--	--	--	--
07.09.16	18:00	yellow, high turbidity	177	41.2%	--	--	8	7.0	1.40	28.00	107.7	72	--	--	--	--	--
08.09.16	09:15	yellow, high turbidity	160	33.3%	--	--	8	7.0	1.27	27.91	107.6	72	275	34.0	0.22	0.15	--
08.09.16	11:15	yellow, high turbidity	161	34.3%	--	--	8	7.0	1.34	27.81	107.6	73	280	33.0	0.23	0.16	--
08.09.16	13:15	yellow, high turbidity	174	41.4%	--	--	8	7.0	1.33	27.83	107.9	72	270	33.0	0.23	0.16	--
08.09.16	15:15	yellow, high turbidity	177	41.8%	--	--	8	7.0	1.39	27.99	107.7	74	290	33.0	0.24	0.18	--

Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
08.09.16	17:15	yellow, high turbidity	179	40.7%	--	--	8	7.0	1.40	27.98	107.7	74	300	38.0	0.24	0.18	--
12.09.16	11:00	yellow, high turbidity	188	35.8%	--	--	8	7.0	1.25	27.96	108.1	85	270	37.0	0.70	0.60	--
12.09.16	14:45	yellow, high turbidity	158	45.9%	--	--	8	7.0	1.21	28.31	107.5	91	285	38.0	0.60	0.50	--
13.09.16	09:00	yellow, high turbidity	166	37.8%	--	--	8	7.0	1.20	27.91	107.6	100	240	38.0	0.70	0.65	--
13.09.16	11:00	yellow, high turbidity	169	40.7%	--	--	8	7.0	1.22	27.96	107.9	74	330	38.0	0.65	0.60	--
13.09.16	13:00	yellow, high turbidity	174	44.8%	--	--	8	7.0	1.22	28.00	107.7	74	310	38.0	0.55	0.49	--
13.09.16	15:00	yellow, high turbidity	170	43.0%	--	--	8	7.0	1.13	28.01	108.0	74	240	38.0	0.58	0.49	--
14.09.16	10:30	yellow, high turbidity	164	34.1%	--	--	8	7.0	1.18	27.95	107.7	74	235	38.0	0.65	0.63	--
14.09.16	14:00	yellow, high turbidity	192	43.5%	--	--	8	7.0	1.17	27.99	107.7	73	235	38.0	0.50	0.40	--
20.09.16	09:00	yellow, high turbidity	163	40.5%	--	--	8	7.0	1.35	27.87	107.8	72	--	--	--	--	--
20.09.16	14:45	yellow, high turbidity	120	57.3%	--	--	8	7.0	1.06	27.80	107.9	73	220	38.0	0.70	0.60	--
21.09.16	07:30	yellow, high turbidity	174	35.8%	--	--	8	7.0	1.07	27.85	107.7	73	--	--	--	--	--
21.09.16	11:00	yellow, high turbidity	140	47.4%	--	--	8	7.0	1.07	27.91	107.8	74	200	37.0	0.70	0.65	--
21.09.16	13:30	yellow, high turbidity	124	54.6%	--	--	8	7.0	1.05	27.94	107.6	73	230	37.0	0.60	0.55	--
22.09.16	10:00	yellow, high turbidity	151	37.6%	--	--	8	7.0	1.20	27.74	107.8	74	280	37.0	0.70	0.60	--
22.09.16	13:30	yellow, high turbidity	157	34.0%	--	--	8	7.0	1.20	27.93	107.9	75	280	37.0	0.70	0.60	--
22.09.16	14:30	yellow, high turbidity	160	40.3%	--	--	8	7.0	1.20	27.94	107.6	74	270	37.0	0.70	0.55	--
27.09.16	08:15	yellow, high turbidity	167	58.8%	--	--	8	7.0	1.20	27.71	107.9	90	--	--	--	--	--
27.09.16	11:00	yellow, high turbidity	168	58.1%	--	--	8	7.0	1.11	27.90	107.8	89	200	38.0	0.60	0.50	--
27.09.16	14:30	yellow, high turbidity	174	55.6%	--	--	8	7.0	1.16	27.96	107.6	89	200	38.0	0.60	0.50	--

Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
28.09.16	08:45	yellow, high turbidity	153	60.5%	--	--	8	7.0	1.08	27.91	107.8	90	200	37.5	0.68	0.60	high oil load at separator inlet, higher back-produced polymer concentration than calculated
29.09.16	13:00	yellow, high turbidity	153	49.5%	-	-	8	7.0	1.11	27.99	107.7	96	200	37.5	0.77	0.70	high oil load at separator inlet, higher back-produced polymer concentration than calculated
29.09.16	14:30	yellow, high turbidity	153	50.6%	-	-	8	7.0	1.10	28.01	107.7	96	200	37.0	0.60	0.50	high oil load at separator inlet, higher back-produced polymer concentration than calculated
30.09.16	09:00	yellow, high turbidity	173	49.3%	-	-	8	7.0	1.08	27.86	107.6	96	190	36.0	0.75	0.75	high oil load at separator inlet, higher back-produced polymer concentration than calculated
03.10.16	14:30	yellow, high turbidity	196	53.2%	-	-	8	7.0	1.05	28.06	107.3	96	-	-	-	-	high oil load at separator inlet, higher back-produced polymer concentration than calculated
06.10.16	14:00	yellow, high turbidity	60	31.8%	-	-	8	7.0	1.03	27.91	107.7	96	-	-	-	-	--
07.10.16	08:45	yellow, high turbidity	86	27.7%	-	-	8	7.0	1.17	27.57	107.1	96	-	-	-	-	--
07.10.16	11:00	yellow, high turbidity	64	43.9%	-	-	8	7.0	1.14	27.98	107.0	83	-	-	-	-	--
10.10.16	10:30	yellow, high turbidity	109	44.9%	-	-	8	7.0	1.13	28.29	108.5	61	-	-	-	-	--
10.10.16	12:45	yellow, high turbidity	134	52.0%	-	-	8	7.0	1.15	27.87	107.6	61	-	-	-	-	--
10.10.16	15:00	yellow, high turbidity	125	52.5%	-	-	8	7.0	1.16	27.87	107.5	73	-	-	-	-	--

Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
11.10.16	11:00	yellow, high turbidity	118	54.1%	-	-	8	7.0	1.18	27.21	102.8	73	-	-	-	-	--
11.10.16	14:00	yellow, high turbidity	96	25.0%	-	-	8	7.0	1.18	28.12	108.0	73	190	36.0	0.70	0.65	flock formulation at the top of nutshell granulate
12.10.	10:00	yellow, high turbidity	129	47.1%	-	-	8	7.0	1.19	28.32	108.3	100	-	-	-	-	--
19.10.	10:30	light yellow, high turbidity	148	54.3%	-	-	8	7.0	1.10	27.86	107.5	82	190	36.0	0.79	0.75	--
19.10.	12:30	light yellow, high turbidity	155	35.7%	-	-	8	7.0	1.09	27.74	107.6	82	190	36.0	0.75	0.70	small flocks, overdosage of Chimec 5565
19.10.	14:30	light yellow, high turbidity	97	62.7%	-	-	8	7.0	1.09	28.03	107.5	82	190	36.0	0.75	0.67	small flocks, overdosage of Chimec 5566
20.10.	11:30	light yellow, high turbidity	150	56.0%	-	-	8	7.0	1.13	28.18	109.8	82	190	36.0	0.80	0.75	--
20.10.	14:30	light yellow, high turbidity	129	51.0%	-	-	8	7.0	1.11	28.07	108.5	82	190	36.0	0.80	0.73	--
20.10.	16:30	light yellow, high turbidity	168	39.1%	-	-	8	7.0	1.08	27.99	107.2	82	190	36.0	0.90	0.72	--
21.10.	09:30	light yellow, high turbidity	150	40.0%	-	-	8	7.0	1.09	27.89	107.7	82	190	36.0	0.70	0.70	--
21.10.	11:15	light yellow, high turbidity	109	60.6%	-	-	8	7.0	1.10	27.89	107.8	82	190	36.0	0.75	0.68	--
24.10.	15:30	light yellow, high turbidity	105	44.1%	-	-	8	7.0	1.09	27.93	107.7	82	190	36.0	0.76	0.70	--
2.11.	11:00	light yellow, high turbidity	116	30.1%	-	-	8	7.0	1.08	27.87	107.8	74	190	35.0	0.70	0.60	--
2.11.	15:15	light yellow, high turbidity	79	51.5%	-	-	8	7.0	1.19	27.83	107.8	74	190	35.0	0.70	0.60	--
2.11.	16:15	light yellow, high turbidity	69	50.0%	-	-	8	7.0	1.09	27.86	107.8	74	190	35.0	0.70	0.65	--
3.11.	09:00	light yellow, high turbidity	89	71.5%	-	-	8	7.0	1.10	27.89	107.8	74	190	35.0	0.70	0.65	--

Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
3.11.	10:30	light yellow, high turbidity	92	39.9%	-	-	8	7.0	1.06	27.92	107.9	74	190	35.0	0.70	0.60	--
3.11.	12:30	light yellow, high turbidity	76	56.6%	-	-	8	7.0	1.06	27.90	107.8	74	190	35.0	0.70	0.60	--
7.11.	16:00	light yellow, high turbidity	87	57.8%	-	-	8	7.0	1.19	27.90	107.5	82	190	35.0	0.70	0.70	--
8.11.	09:00	light yellow, high turbidity	71	59.4%	-	-	8	7.0	1.13	27.98	107.5	82	190	35.0	0.60	0.60	--
8.11.	11:00	light yellow, high turbidity	114	47.2%	-	-	8	7.0	1.15	28.16	107.8	84	190	35.0	0.60	0.58	--
8.11.	14:30	light yellow, high turbidity	85	57.5%	-	-	8	7.0	1.16	27.77	107.7	84	190	35.0	0.60	0.55	--
9.11.	09:30	light yellow, high turbidity	94	17.5%	-	-	8	7.0	1.18	27.73	107.6	84	190	35.0	0.70	0.70	--
9.11.	11:00	light yellow, high turbidity	106	35.8%			8	7.0	1.16	27.86	107.5	84	190	35.0	0.60	0.55	--
9.11.	14:00	light yellow, high turbidity	92	40.6%			8	7.0	1.17	27.72	107.6	84	190	35.0	0.70	0.50	--
10.11.	09:30	light yellow, high turbidity	94	47.5%			8	7.0	1.19	27.70	107.7	82	190	35.0	0.75	0.70	clear aqueous phase
10.11.	11:30	light yellow, high turbidity	103	44.3%			8	7.0	1.18	27.87	107.8	82	190	35.0	0.70	0.68	clear aqueous phase
10.11.	14:30	light yellow, high turbidity	94	56.3%			8	7.0	1.14	28.50	107.5	83	190	35.0	0.70	0.65	clear aqueous phase
11.11.	09:00	light yellow, high turbidity	104	40.6%			8	7.0	1.15	27.71	107.5	83	190	35.0	0.70	0.69	clear aqueous phase
11.11.	11:00	light yellow, high turbidity	114	39.4%			8	7.0	1.16	27.86	107.9	83	190	35.0	0.70	0.65	clear aqueous phase
14.11.	14:00	light yellow, high turbidity	128	37.6%			8	7.0	1.15	27.79	107.7	72	190	35.0	0.60	0.55	clear aqueous phase

Sampling Date	Sampling Time	Optical Evaluation	Hydrocarbon Content (ppm)	Efficiency (%)	Fe Total (mg/l)	Fe Solution (mg/l)	Pressure N_2 Bundle (bar)	Pressure Inlet GDR (bar)	Cycle Stream Flotation (m^3/h)	Level Flotation (cm)	Level CPI (cm)	Level Separator (cm)	Flow Rate NSF (L/h)	Filter Hight (cm)	Pressure before NSF(bar)	Pressure after NSF (bar)	Comments
14.11.	15:30	light yellow, high turbidity	104	50.0%			8	7.0	1.17	27.93	107.5	72	190	35.0	0.60	0.50	clear aqueous phase
15.11.	09:30	light yellow, high turbidity	58	29.3%			8	7.0	1.29	27.66	107.8	58	190	35.0	0.68	0.58	clear aqueous phase
15.11.	11:30	light yellow, high turbidity	48	61.0%			8	7.0	1.16	27.81	107.6	59	190	35.0	0.70	0.65	clear aqueous phase
15.11.	14:30	light yellow, high turbidity	107	51.4%			8	7.0	1.27	27.84	107.8	59	190	35.0	0.70	0.65	clear aqueous phase
16.11.	10:00	light yellow, high turbidity	94	55.9%			8	7.0	1.16	27.85	107.5	59	190	35.0	0.70	0.60	clear aqueous phase
16.11.	11:30	light yellow, high turbidity	108	54.8%			8	7.0	1.14	28.30	108.2	59	190	35.0	0.70	0.60	clear aqueous phase
16.11.	14:00	light yellow, high turbidity	100	54.5%			8	7.0	1.17	27.85	107.8	59	190	35.0	0.70	0.60	clear aqueous phase
17.11.	09:30	light yellow, high turbidity	118	53.0%			8	7.0	1.12	27.83	107.5	61	190	35.0	0.70	0.65	clear aqueous phase
17.11.	11:00	light yellow, high turbidity	107	54.7%			8	7.0	1.14	27.83	106.5	61	190	35.0	0.75	0.70	clear aqueous phase
17.11.	14:30	light yellow, high turbidity	101	58.9%			8	7.0	1.13	27.83	107.8	61	190	35.0	0.80	0.75	clear aqueous phase
18.11.	09:00	light yellow, high turbidity	121	49.8%			8	7.0	1.18	27.83	107.8	61	190	35.0	0.70	0.60	clear aqueous phase
18.11.	11:00	light yellow, high turbidity	122	50.8%			8	7.0	1.17	27.85	107.5	61	185	35.0	0.70	0.60	clear aqueous phase
21.11.	14:00	light yellow, high turbidity	124	54.1%			8	7.0	1.17	29.00	107.9	61	190	35.0	0.70	0.60	clear aqueous phase
22.11.	09:00	light yellow, high turbidity	110	54.4%			8	7.0	1.24	28.90	107.8	61	190	34.0	0.70	0.65	clear aqueous phase

Analytic Data – Part III

		Sampling Outlet Flotation HV 3212						Gas Dissolving ReactorV-5202		Nutshell Filter				
Sampling Date	**Sampling Time**	**Optical Visualisation**	**Hydrocarbon Content (ppm)**	**Efficiency (%)**	**Total Iron Content (mg/l)**	**Dissolved Iron Content (mg/l)**	**Measured Polymer Conc. (ppm)**	**Circulation Flow (Nl/min)**	**Pressure (bar)**	**Hydrocarbon Content (ppm)**	**Efficiency (%)**	**WBF >3µm**	**Wells**	**Calculated Flow Separator V-3101 (m^3/h)**
30.08.16	10:50	yellow, turbidity	--	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
31.08.16	08:20	yellow, turbidity	--	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
31.08.16	11:10	yellow, turbidity	150	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
31.08.16	15:00	yellow, turbidity	145	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
01.09.16	09:30	yellow, turbidity	136	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
01.09.16	11:30	yellow, turbidity	143	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
01.09.16	14:00	yellow, turbidity	150	--	--	--	--	--	6.0	--	--	--	Ma108, S135, S110	6.5
02.09.16	09:15	yellow, turbidity	134	13%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
05.09.16	11:00	yellow, turbidity	153	7%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
05.09.16	15:15	yellow, turbidity	142	12%	--	--	--	1.4	6.5	--	--	--	Ma108, S135, S110	6.5
06.09.16	08:20	yellow, turbidity	135	20%	--	--	--	1.4	6.5	--	--	--	Ma108, S135, S110	6.5
06.09.16	13:30	yellow, turbidity	145	0%	--	--	--	1.4	6.5	--	--	--	Ma108, S135, S110	6.5
07.09.16	08:45	yellow, turbidity	140	13%	--	--	--	1.4	6.5	--	--	--	Ma108, S135, S110	6.5
07.09.16	18:00	yellow, turbidity	33	81%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
08.09.16	09:15	yellow, turbidity	31	81%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
08.09.16	11:15	yellow, turbidity	31	81%	--	--	--	1.5	6.5	8.0	74.2%	--	Ma108, S135, S110	6.5
08.09.16	13:15	yellow, turbidity	37	79%	--	--	--	1.5	6.5	8.0	78.4%	--	Ma108, S135, S110	6.5

Sampling Date	Sampling Time	Optical Visualisation	Hydrocarbon Content (ppm)	Efficiency (%)	Total Iron Content (mg/l)	Dissolved Iron Content (mg/l)	Measured Polymer Conc. (ppm)	Circulation Flow (Nl/min)	Pressure (bar)	Hydrocarbon Content (ppm)	Efficiency (%)	WBF >3µm	Wells	Calculated Flow Separator V-3101 (m^3/h)
08.09.16	15:15	yellow, turbidity	38	79%	--	--	--	1.5	6.5	9.0	76.3%	--	Ma108, S135, S110	6.5
08.09.16	17:15	yellow, turbidity	33	82%	--	--	--	1.5	6.5	9.0	72.7%	--	Ma108, S135, S110	6.5
12.09.16	09:00	yellow, turbidity	37	79%	--	--	--	1.5	6.5	20.0	45.9%	--	Ma108, S135, S110	6.5
12.09.16	11:00	yellow, turbidity	31	84%	--	--	--	1.5	6.5	7.0	77.4%	--	Ma108, S135, S110	6.5
12.09.16	14:45	yellow, turbidity	26	84%	--	--	--	1.5	6.5	8.0	69.2%	--	Ma108, S135, S110	6.5
13.09.16	09:00	yellow, turbidity	36	78%	--	--	--	1.5	6.5	10.0	72.2%	--	Ma108, S135, S110	6.5
13.09.16	11:00	yellow, turbidity	35	79%	--	--	--	1.5	6.5	13.0	62.9%	--	Ma108, S135, S110	6.5
13.09.16	13:00	yellow, turbidity	34	80%	--	--	--	1.5	6.5	26.0	23.5%	--	Ma108, S135, S110	6.5
13.09.16	15:00	yellow, turbidity	17	90%	--	--	--	1.5	6.5	16.0	5.9%	--	Ma108, S135, S110	6.5
14.09.16	10:30	yellow, turbidity	31	81%	--	--	--	1.5	6.5	7.0	77.4%	--	Ma108, S135, S110	6.5
14.09.16	14:00	clear	33	83%	--	--	--	1.5	6.5	7.0	78.8%	--	Ma108, S135, S110	6.5
20.09.16	09:00	clear	49	70%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
20.09.16	14:45	clear	28	77%	--	--	--	1.5	6.5	16.0	42.9%	--	Ma108, S135, S110	6.5
21.09.16	07:30	clear	12	93%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
21.09.16	11:00	clear	17	88%	--	--	--	1.5	6.5	3.0	82.4%	--	Ma108, S135, S110	6.5
21.09.16	13:30	clear	13	90%	--	--	--	1.5	6.5	3.0	76.9%	--	Ma108, S135, S110	6.5
22.09.16	10:00	clear	28	81%	--	--	--	1.5	6.5	--	--	--	Ma108, S135, S110	6.5
22.09.16	13:30	clear	24	85%	--	--	--	1.5	6.5	5.0	79.2%	--	Ma108, S135, S110	6.5
22.09.16	14:30	clear	26	84%	--	--	--	1.5	6.5	8.0	69.2%	--	Ma108, S135, S110	6.5

Sampling Date	Sampling Time	Optical Visualisation	Hydrocarbon Content (ppm)	Efficiency (%)	Total Iron Content (mg/l)	Dissolved Iron Content (mg/l)	Measured Polymer Conc. (ppm)	Circulation Flow (Nl/min)	Pressure (bar)	Hydrocarbon Content (ppm)	Efficiency (%)	WBF >3µm	Wells	Calculated Flow Separator V-3101 (m^3/h)
27.09.16	08:15	clear	9	95%	--	--	<1	1.5	6.5	--	--	--	Ma108, S95, S110, S135	8.92
27.09.16	11:00	clear	12	93%	--	--	-	1.5	6.5	4.0	66.7%	--	Ma108, S95, S110, S135	8.92
27.09.16	14:30	clear	6	97%	--	-	-	1.5	6.5	1.0	83.3%	--	Ma108, S95, S110, S135	8.92
28.09.16	08:45	clear	1	99%	--	-	<1	1.5	6.5	1.0	0.0%	--	Ma108, S95, S110, S135	8.92
29.09.16	13:00	clear	18	88%	--	-	-	1.8	6.5	--	--	--	Ma108, S95, S110, S135	8.92
29.09.16	14:30	clear	14	91%	--	-	-	1.8	6.5	3.6	74.3%	--	Ma108, S95, S110, S135	8.92
30.09.16	09:00	clear	7	96%	--	-	<1	1.8	6.5	1.2	82.9%	--	Ma108, S95, S110, S135	8.92
03.10.16	14:30	turbidity, small flocks	118	40%	--	-	<1	1.8	6.5	--	--	--	Ma108, S95, S110, S135	8.92
06.10.16	14:00	turbidity, small flocks	24	60%	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
07.10.16	08:45	turbidity, small flocks	25	71%	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
07.10.16	11:00	turbidity, small flocks	--	--	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
10.10.16	10:30	turbidity, small flocks	46	58%	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
10.10.16	12:45	turbidity, small flocks	102	24%	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
10.10.16	15:00	turbidity, small flocks	131	--	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
11.10.16	11:00	turbidity, small flocks	--	--	--	-	<1	1.8	6.5	--	--	--	S95, S135	5.88
11.10.16	14:00	turbidity, small flocks	88	8%	--	-	<1	1.8	6.5	72.0	18.2%	--	S95, S135	5.88
12.10.	10:00	turbidity, small flocks	51	60%	-	-	<1	1.8	6.5	--	--	--	S110, S135	5.66

Sampling Date	Sampling Time	Optical Visualisation	Hydrocarbon Content (ppm)	Efficiency (%)	Total Iron Content (mg/l)	Dissolved Iron Content (mg/l)	Measured Polymer Conc. (ppm)	Circulation Flow (Nl/min)	Pressure (bar)	Hydrocarbon Content (ppm)	Efficiency (%)	WBF >3µm	Wells	Calculated Flow Separator V-3101 (m³/h)
19.10.	10:30	clear	19	87%	-	-	--	1.8	6.5	1.0	94.7%	--	S110, S135	5.66
19.10.	12:30	clear	29	81%	-	-	--	1.8	6.5	1.0	96.6%	--	S110, S135	5.66
19.10.	14:30	clear	23	76%	-	-	--	1.8	6.5	2.4	89.6%	--	S110, S135	5.66
20.10.	11:30	clear	13	91%	-	-	--	1.8	6.5	1.0	90.1%	--	S110, S135	5.66
20.10.	14:30	clear	22	83%	-	-	--	1.8	6.5	1.9	91.4%	--	S110, S135	5.66
20.10.	16:30	clear	22	87%	-	-	--	1.8	6.5	1.0	95.5%	--	S110, S135	5.66
21.10.	09:30	clear	22	85%	-	-	--	1.8	6.5	1.0	95.5%	--	S110, S135	5.66
21.10.	11:15	clear	18	83%	-	-	--	1.8	6.5	1.0	94.4%	0.8	S110, S135	5.66
24.10.	15:30	clear	38	64%	-	-	1.0	1.8	6.5	4.3	88.7%	-	S95, S135	5.88
2.11.	11:00	clear	29	75%	-	-	1.0	1.8	6.5	6.8	76.5%	--	S95, S135	5.88
2.11.	15:15	clear	35	56%	-	-	--	1.8	6.5	--	--	--	S95, S135	5.88
2.11.	16:15	clear	29	58%	-	-	--	1.8	6.5	4.6	84.1%	--	S95, S135	5.88
3.11.	09:00	clear	12	87%	-	-	<1	1.8	6.5	1.0	91.7%	--	S95, S135	5.88
3.11.	10:30	clear	22	76%	-	-	<1	1.8	6.5	1.0	95.5%	--	S95, S135	5.88
3.11.	12:30	clear	22	71%	-	-	--	1.8	6.5	1.0	95.5%	--	S95, S135	5.88
7.11.	16:00	clear	2	98%	-	-	<1	1.8	6.5	1.0	50.0%	--	S66, S110, S135	7.15
8.11.	09:00	clear	4	94%	-	-	1.6	1.8	6.5	1.0	75.0%	--	S66, S110, S135	7.15
8.11.	11:00	clear	3	97%	-	-	--	1.8	6.5	1.0	66.7%	--	S66, S110, S135	7.15
8.11.	14:30	clear	3	96%	-	-	<1	1.8	6.5	1.0	66.7%	--	S66, S110, S135	7.15

Sampling Date	Sampling Time	Optical Visualisation	Hydrocarbon Content (ppm)	Efficiency (%)	Total Iron Content (mg/l)	Dissolved Iron Content (mg/l)	Measured Polymer Conc. (ppm)	Circulation Flow (Nl/min)	Pressure (bar)	Hydrocarbon Content (ppm)	Efficiency (%)	WBF >3µm	Wells	Calculated Flow Separator V-3101 (m^3/h)
9.11.	09:30	clear	1	99%	-	-	<1	1.8	6.5	1.0	0.0%	--	S66, S110, S135	7.15
9.11.	11:00	clear	2	98%	-	-	<1	1.8	6.5	1.0	50.0%	--	S66, S110, S135	7.15
9.11.	14:00	clear	3	97%	-	-	--	1.8	6.5	1.0	66.7%	--	S66, S110, S135	7.15
10.11.	09:30	clear	1	99%	-	-	<1	1.8	6.5	1.0	0.0%	0.74	S66, S110, S135	7.15
10.11.	11:30	clear	1	99%	-	-	--	1.8	6.5	1.0	0.0%	--	S66, S110, S135	7.15
10.11.	14:30	clear	1	99%	-	-	<1	1.8	6.5	2	0.0%	--	S66, S110, S135	7.15
11.11.	09:00	clear	1	99%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S110, S135	7.15
11.11.	11:00	clear	1	99%	-	-	--	1.8	6.5	1	0.0%	--	S66, S110, S135	7.15
14.11.	14:00	clear	1	99%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
14.11.	15:30	clear	1	99%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
15.11.	09:30	clear	1	98%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
15.11.	11:30	clear	1	98%	-	-	--	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
15.11.	14:30	clear	3	97%	-	-	<1	1.8	6.5	1	66.7%	--	S66, S95, S110	6.11
16.11.	10:00	clear	4	96%	-	-	1.5	1.8	6.5	1	75.0%	--	S66, S95, S110	6.11
16.11.	11:30	clear	1	99%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
16.11.	14:00	clear	1	99%	-	-	--	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
17.11.	09:30	clear	1	99%	-	-	1.0	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
17.11.	11:00	clear	1	99%	-	-	--	1.8	6.5	1	0.0%	1.55	S66, S95, S110	6.11
17.11.	14:30	clear	4	96%	-	-	1.0	1.8	6.5	4	0.0%	--	S66, S95, S110	6.11

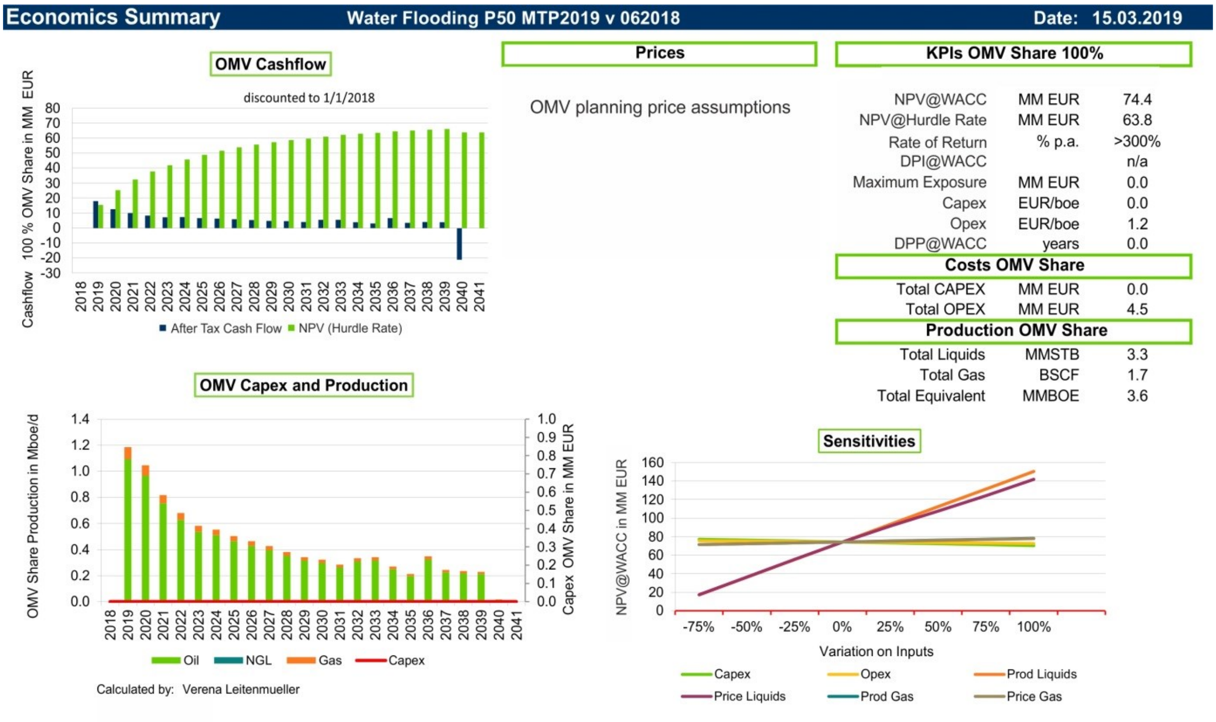
Sampling Date	Sampling Time	Optical Visualisation	Hydrocarbon Content (ppm)	Efficiency (%)	Total Iron Content (mg/l)	Dissolved Iron Content (mg/l)	Measured Polymer Conc. (ppm)	Circulation Flow (Nl/min)	Pressure (bar)	Hydrocarbon Content (ppm)	Efficiency (%)	WBF >3µm	Wells	Calculated Flow Separator V-3101 (m^3/h)
18.11.	09:00	clear	5	96%	-	-	10.4	1.8	6.5	3	40.0%	--	S66, S95, S110	6.11
18.11.	11:00	clear	3	98%	-	-	2.7	1.8	6.5	1	66.7%	--	S66, S95, S110	6.11
21.11.	14:00	clear	1	99%	-	-	<1	1.8	6.5	1	0.0%	--	S66, S95, S110	6.11
22.11.	09:00	clear	1	99%	-	-	<1	1.8	6.5	2	0.0%	--	S66, S95, S110	6.11

Analytic Data – Part IV

	Date	Time	HV3110	HV3112	HV3212	HV3319
Turbidity (NTU)	06.09.2016	09:15	301.00	227.00	28.00	--
Turbidity (NTU)	06.09.2016	11:15	306.00	227.00	29.50	5.91
Turbidity (NTU)	06.09.2016	13:15	340.00	247.00	34.00	5.25
Turbidity (NTU)	06.09.2016	15:15	334.00	246.00	28.70	7.15
Turbidity (NTU)	08.09.2016	17:15	334.00	246.00	30.30	7.08
pH	08.09.2016	17:15	7.15	7.14	7.11	7.04
Temperatur (°C)	08.09.2016	17:15	30.60	30.50	31.10	30.80
Leitfähigkeit [mS/cm]	08.09.2016	17:15	36.80	36.50	36.40	36.80
TDS (g/l)	08.09.2016	17:15	23.50	23.40	23.30	23.60
Turbidity (NTU)	12.09.2016	09:00	326.00	240.00	29.90	10.30
Turbidity (NTU)	12.09.2016	11:00	326	248	24.5	6.14
Turbidity (NTU)	12.09.2016	14:45	337	242	27	8.91
Turbidity (NTU)	13.09.2016	09:00	304	237	32.9	7.25
Turbidity (NTU)	13.09.2016	11:00	323	224	34.1	9.75
pH	13.09.2016	11:00	7.52	7.59	7.46	7.27
Temperatur (°C)	13.09.2016	11:00	32.70	32.00	32.40	31.50
Conductivity (mS/cm)	13.09.2016	11:00	36.70	35.00	36.00	36.00
TDS (g/l)	13.09.2016	11:00	23.5	22.4	23.1	23
Turbidity (NTU)	13.09.2016	13:00	339	241	26.3	24.3
pH	13.09.2016	13:00	7.32	7.08	7.22	7.28
Temperatur (°C)	13.09.2016	13:00	31.6	31.5	31.2	31.9
Conductivity (mS/cm)	13.09.2016	13:00	32.9	35	35.2	34.8
TDS (g/l)	13.09.2016	13:00	21.1	22.4	22.5	2.3
Turbidity (NTU)	13.09.2016	14:30	348	244	18.3	15.5
pH	13.09.2016	14:30	7.21	7.25	7.33	7.28
Temperatur (°C)	13.09.2016	14:30	31.4	31.7	32.6	32.3
Conductivity (mS/cm)	13.09.2016	14:30	36.6	36.2	36.7	36.6
TDS (g/l)	13.09.2016	14:30	23.4	23.2	23.5	23.4

	Date	Time	HV3110	HV3112	HV3212	HV3319
Turbidity (NTU)	14.09.2016	10:30	292	230	24	7.86
pH	14.09.2016	10:30	7.47	7.5	7.43	7.49
Temperatur (°C)	14.09.2016	10:30	31.8	31.2	32.8	31.1
Conductivity (mS/cm)	14.09.2016	10:30	36.5	35.7	36.5	36.2
TDS (g/l)	14.09.2016	10:30	23.4	22.8	23.3	23.2
Turbidity (NTU)	14.09.2016	14:00	356	249	23.3	4.73
pH	14.09.2016	14:00	7.8	7.68	7.77	7.92
Temperatur (°C)	14.09.2016	14:00	33.4	32.7	34.1	33.9
Conductivity (mS/cm)	14.09.2016	14:00	37.2	36.2	36	36.2
TDS (g/l)	14.09.2016	14:00	23.2	23.1	23	23.1
Turbidity (NTU)	20.09.2016	09:00	312	235	47.2	--
pH	20.09.2016	09:00	7.37	7.24	7.44	--
Temperatur (°C)	20.09.2016	09:00	25.2	27	23.6	--
Conductivity (mS/cm)	20.09.2016	09:00	36.5	36.5	36.6	--
TDS (g/l)	20.09.2016	09:00	23.4	23.3	23.4	--
Turbidity (NTU)	20.09.2016	14:45	346	238	28.6	14.4
pH	20.09.2016	14:45	--	--	7.42	7.64
Temperatur (°C)	20.09.2016	14:45	--	--	29.8	29.1
Conductivity (mS/cm)	20.09.2016	14:45	--	--	36.5	36.5
TDS (g/l)	20.09.2016	14:45	--	--	23.3	23.4
Turbidity (NTU)	21.09.2016	07:30	273	190	13.9	--
Turbidity (NTU)	21.09.2016	11:00	292	196	15.4	2.69
Turbidity (NTU)	21.09.2016	13:30	288	199	15.2	4.4
Turbidity (NTU)	22.09.2016	10:00	328	254	26.6	--
Turbidity (NTU)	22.09.2016	13:30	360	262	24.8	5.57
pH	22.09.2016	13:30	7.24	7.32	7.34	7.25
Temperatur (°C)	22.09.2016	13:30	29.1	29	29.4	28.7
Conductivity (mS/cm)	22.09.2016	13:30	33.4	33.8	34	33.6
TDS (g/l)	22.09.2016	13:30	21.4	21.6	21.8	21.5
Turbidity (NTU)	22.09.2016	14:30	352	260	21.1	7.47
Turbidity (NTU)	27.09.2016	11:00	470	264	19.9	11.7
Turbidity (NTU)	27.09.2016	14:30	494	257	2.19	0.76
Turbidity (NTU)	28.09.2016	08:45	458	272	1.82	0.51
Turbidity (NTU)	29.09.2016	13:00	422	226	28.5	8.16
Turbidity (NTU)	29.09.2016	14:30	401	225	22.2	8.61
Turbidity (NTU)	30.09.2016	09:00	381	230	3.66	1.6
Turbidity (NTU)	02.10.2016	14:30	507	341	61.1	--
Turbidity (NTU)	07.10.2016	08:45	200	158	33.7	--
Turbidity (NTU)	07.10.2016	11:00	263	179	63.6	--
Turbidity (NTU)	10.10.2016	10:30	286	172	72.8	--
Turbidity (NTU)	10.10.2016	12:45	339	222	110	--
Turbidity (NTU)	10.10.2016	15:00	284	200	151	--
Turbidity (NTU)	11.10.2016	11:00	240	165	104	--
Turbidity (NTU)	11.10.2016	14:00	254	170	110	--
Turbidity (NTU)	12.10.2016	10:00	244	184	44.4	--

Appendix A4 (Economic Study)



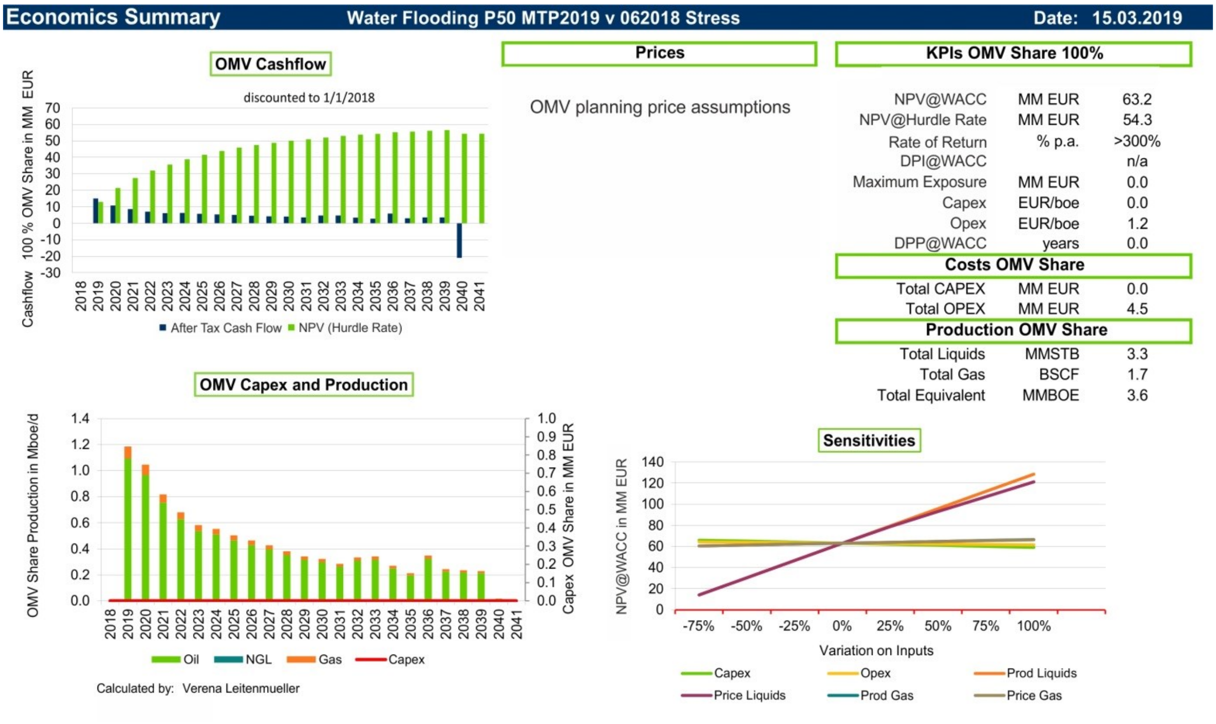
Economics Summary **Water Flooding P50 MTP2019 v 062018** **Date: 15.03.2019**

Prices

OMV planning price assumptions

KPIs OMV Share 100%		
NPV@WACC	MM EUR	74.4
NPV@Hurdle Rate	MM EUR	63.8
Rate of Return	% p.a.	>300%
DPI@WACC		n/a
Maximum Exposure	MM EUR	0.0
Capex	EUR/boe	0.0
Opex	EUR/boe	1.2
DPP@WACC	years	0.0
Costs OMV Share		
Total CAPEX	MM EUR	0.0
Total OPEX	MM EUR	4.5
Production OMV Share		
Total Liquids	MMSTB	3.3
Total Gas	BSCF	1.7
Total Equivalent	MMBOE	3.6

Calculated by: Verena Leitenmueller



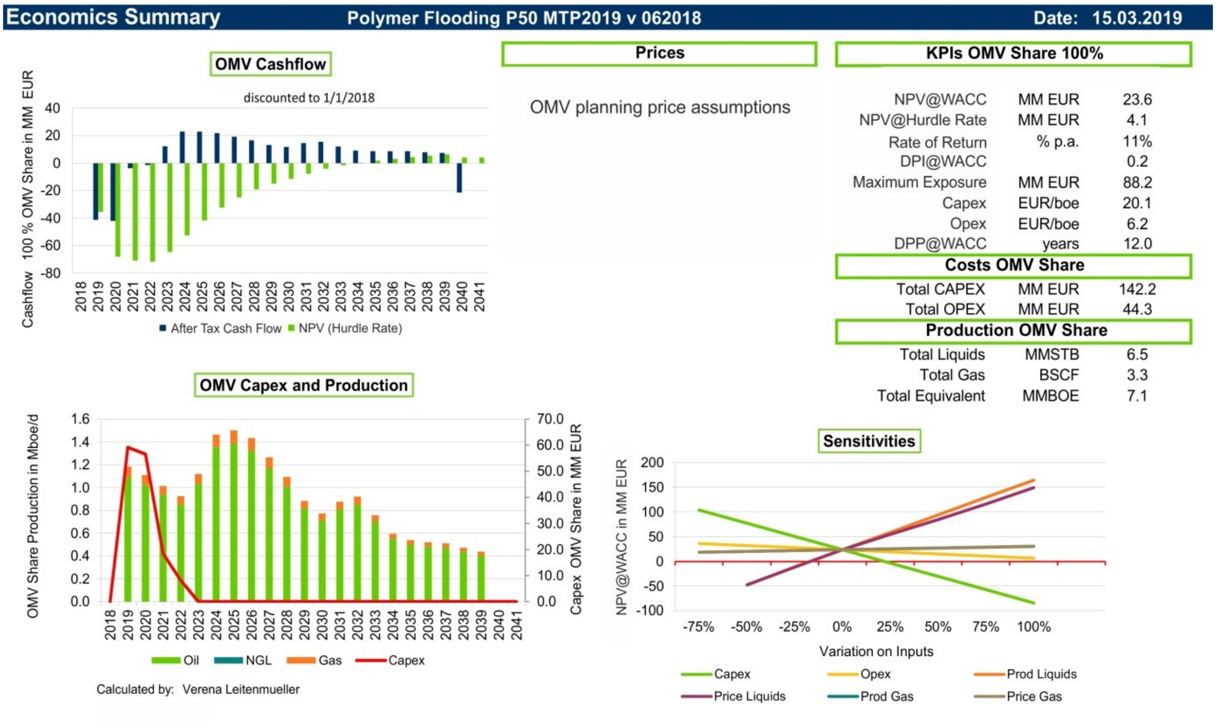
Economics Summary **Water Flooding P50 MTP2019 v 062018 Stress** **Date: 15.03.2019**

Prices

OMV planning price assumptions

KPIs OMV Share 100%		
NPV@WACC	MM EUR	63.2
NPV@Hurdle Rate	MM EUR	54.3
Rate of Return	% p.a.	>300%
DPI@WACC		n/a
Maximum Exposure	MM EUR	0.0
Capex	EUR/boe	0.0
Opex	EUR/boe	1.2
DPP@WACC	years	0.0
Costs OMV Share		
Total CAPEX	MM EUR	0.0
Total OPEX	MM EUR	4.5
Production OMV Share		
Total Liquids	MMSTB	3.3
Total Gas	BSCF	1.7
Total Equivalent	MMBOE	3.6

Calculated by: Verena Leitenmueller



Economics Summary **Polymer Flooding P50 MTP2019 v 062018** **Date: 15.03.2019**

Prices

OMV planning price assumptions

KPIs OMV Share 100%

NPV@WACC	MM EUR	23.6
NPV@Hurdle Rate	MM EUR	4.1
Rate of Return	% p.a.	11%
DPI@WACC		0.2
Maximum Exposure	MM EUR	88.2
Capex	EUR/boe	20.1
Opex	EUR/boe	6.2
DPP@WACC	years	12.0

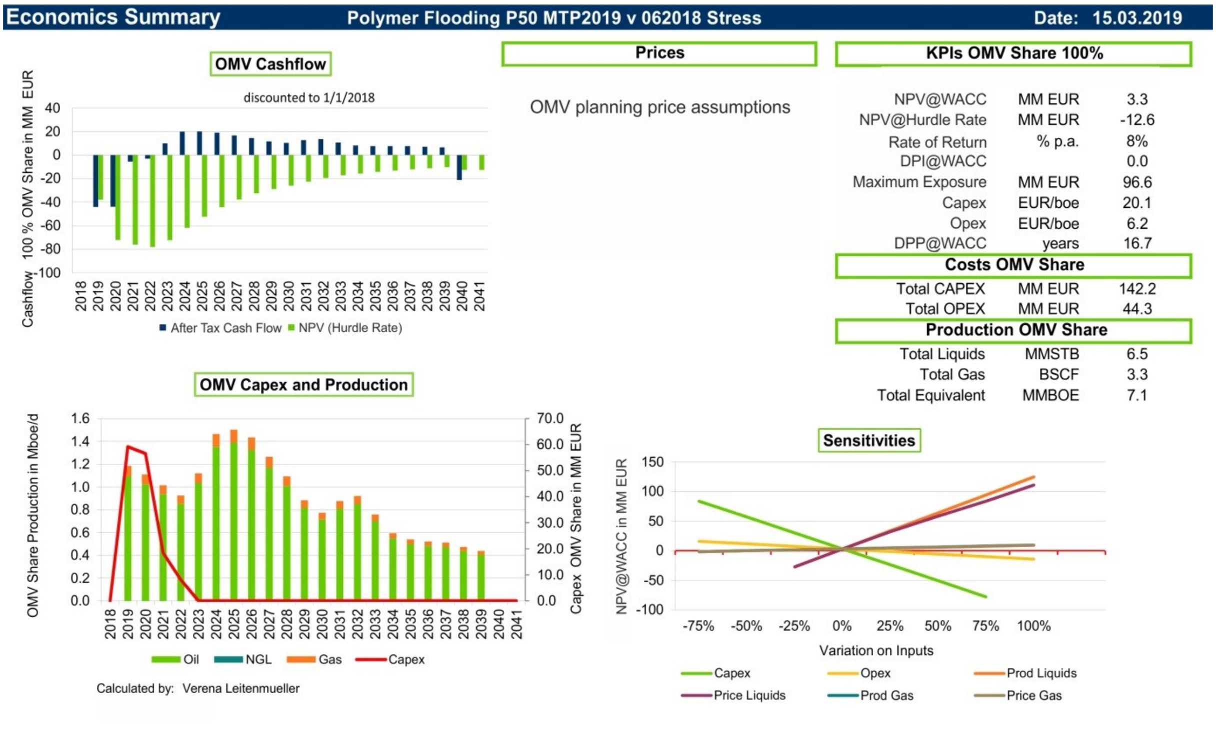
Costs OMV Share

Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	44.3

Production OMV Share

Total Liquids	MMSTB	6.5
Total Gas	BSCF	3.3
Total Equivalent	MMBOE	7.1

Calculated by: Verena Leitenmueller



Economics Summary **Polymer Flooding P50 MTP2019 v 062018 Stress** **Date: 15.03.2019**

Prices

OMV planning price assumptions

KPIs OMV Share 100%

NPV@WACC	MM EUR	3.3
NPV@Hurdle Rate	MM EUR	-12.6
Rate of Return	% p.a.	8%
DPI@WACC		0.0
Maximum Exposure	MM EUR	96.6
Capex	EUR/boe	20.1
Opex	EUR/boe	6.2
DPP@WACC	years	16.7

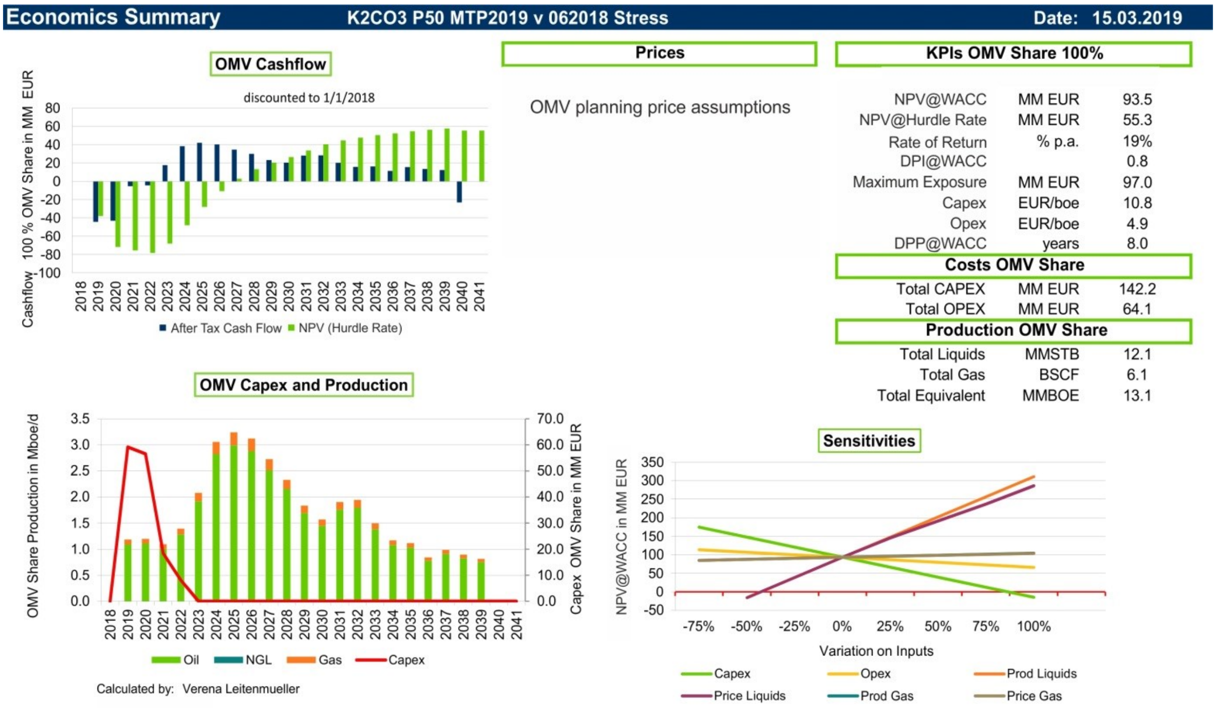
Costs OMV Share

Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	44.3

Production OMV Share

Total Liquids	MMSTB	6.5
Total Gas	BSCF	3.3
Total Equivalent	MMBOE	7.1

Calculated by: Verena Leitenmueller



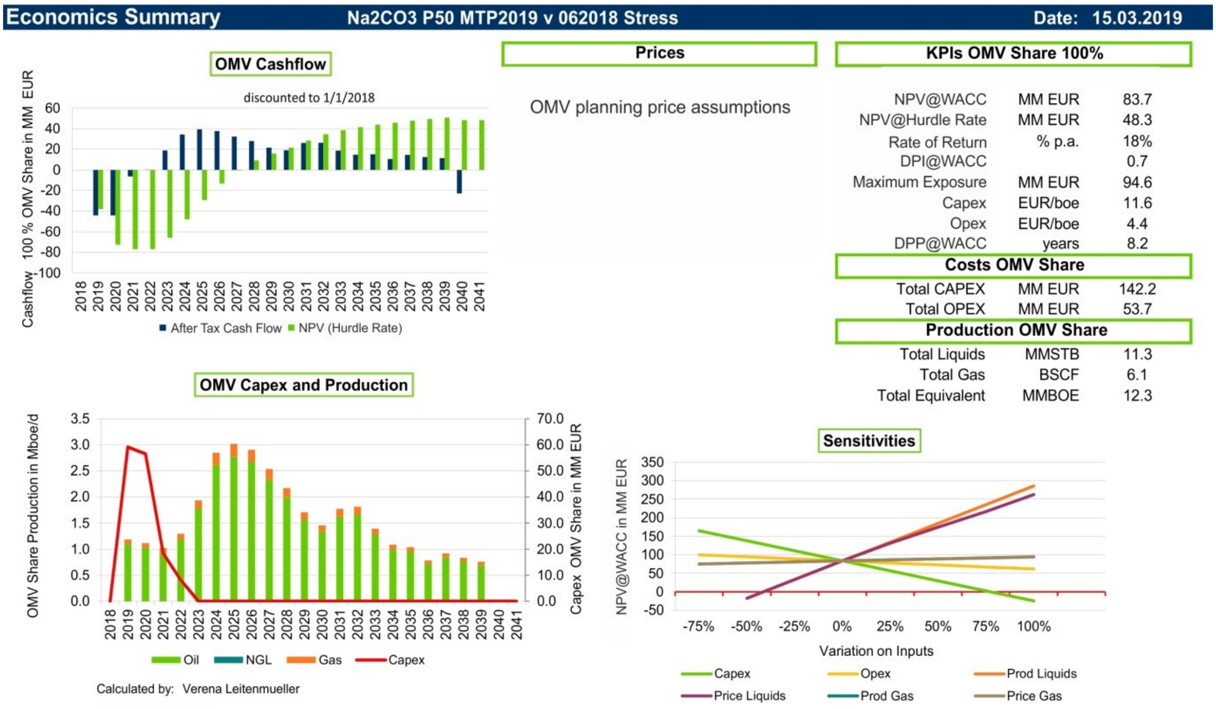
Economics Summary **K2CO3 P50 MTP2019 v 062018 Stress** **Date: 15.03.2019**

Calculated by: Verena Leitenmueller

Prices

OMV planning price assumptions

KPIs OMV Share 100%		
NPV@WACC	MM EUR	93.5
NPV@Hurdle Rate	MM EUR	55.3
Rate of Return	% p.a.	19%
DPI@WACC		0.8
Maximum Exposure	MM EUR	97.0
Capex	EUR/boe	10.8
Opex	EUR/boe	4.9
DPP@WACC	years	8.0
Costs OMV Share		
Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	64.1
Production OMV Share		
Total Liquids	MMSTB	12.1
Total Gas	BSCF	6.1
Total Equivalent	MMBOE	13.1



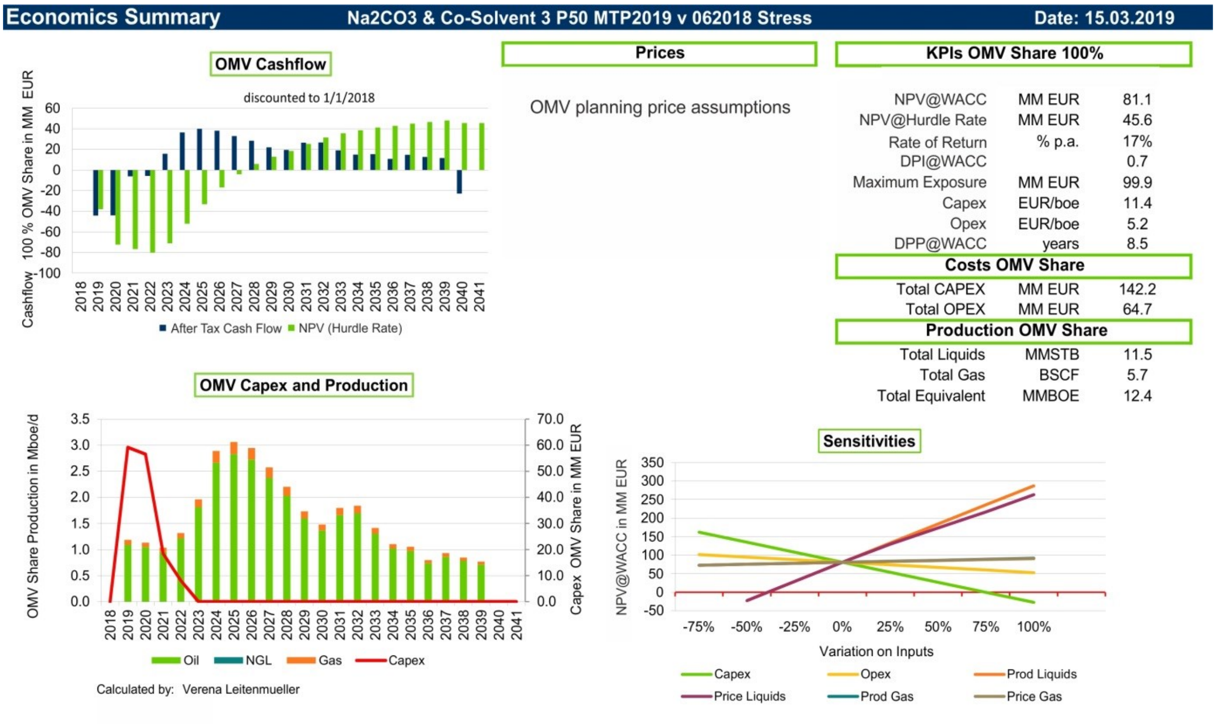
Economics Summary **Na2CO3 P50 MTP2019 v 062018 Stress** **Date: 15.03.2019**

Calculated by: Verena Leitenmueller

Prices

OMV planning price assumptions

KPIs OMV Share 100%		
NPV@WACC	MM EUR	83.7
NPV@Hurdle Rate	MM EUR	48.3
Rate of Return	% p.a.	18%
DPI@WACC		0.7
Maximum Exposure	MM EUR	94.6
Capex	EUR/boe	11.6
Opex	EUR/boe	4.4
DPP@WACC	years	8.2
Costs OMV Share		
Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	53.7
Production OMV Share		
Total Liquids	MMSTB	11.3
Total Gas	BSCF	6.1
Total Equivalent	MMBOE	12.3



Economics Summary **Na2CO3 & Co-Solvent 3 P50 MTP2019 v 062018 Stress** **Date: 15.03.2019**

OMV Cashflow

discounted to 1/1/2018

Prices

OMV planning price assumptions

KPIs OMV Share 100%

NPV@WACC	MM EUR	81.1
NPV@Hurdle Rate	MM EUR	45.6
Rate of Return	% p.a.	17%
DPI@WACC		0.7
Maximum Exposure	MM EUR	99.9
Capex	EUR/boe	11.4
Opex	EUR/boe	5.2
DPP@WACC	years	8.5

Costs OMV Share

Total CAPEX	MM EUR	142.2
Total OPEX	MM EUR	64.7

Production OMV Share

Total Liquids	MMSTB	11.5
Total Gas	BSCF	5.7
Total Equivalent	MMBOE	12.4

OMV Capex and Production

Calculated by: Verena Leitenmueller

Sensitivities