A CORRELATION OF NON IONIC SURFACTANT CONCENTRATION, WATER SALINITY, AND OIL RECOVERY IN SANDSTONE IMBIBITIONS

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Abstract
The non ionic surfactant concentration is observed in a laboratorial experiment in order to find its relations to the oil recovery. The integral part to this study is the effect of water salinity on sandstone, which is used as core sample. In general, this experiment has proved the injection of non-ionic surfactant concentration into the sandstone-core sample throughout the imbibitions linearly correlates to the oil recovery. Simultaneously, the study further concludes that the Nonionic Surfactant Concentration works effectively in low saline oil formation.

Keywords: non ionic surfactant, water salinity, sandstone and oil recovery

Introduction
The trend of oil recovery in the imbibitions process of an EOR activity can be affected by surfactant concentration and water salinity. In this study, the experiment is run through a surfactant imbibitions process that aims to reduce the interface tension (IFT) of water oil in the reservoir. It is expected that the effect will weaken the bond of oil molecule stuck in the pores, and then can subsequently be movable.

Literature Review
Before proceeding to the experiments, literatures covering variables used in this particular study are essentially needed.

1. Surfactants
Surfactant is an active agent that can reduce surface tension between two different phases of oil and water. Surfactants are molecules that have different molecular structures. For instant, the hydrophil group that likes water. Others are the lipофоб (refuse oil), lipophilic (oil-like) and hydrophobic (water-resisting).

In this particular experiment, nonionic surfactants is being used. This surfactant is an unionized surfactant if dissolved in the water. This type of surfactant is generally used as a co-surfactant and is suitable for high water salinity. Generally, water-soluble nonionic surfactants, for example, are polymer ethylene oxide. The nonionic surfactant is a synthesis produced by condensation of Fatty alcohol, Fatty acids with Ethylene oxide. An example of this type of surfactant is dodecylhexaoxyethylene glycol monoether (C₁₂H₂₅[OCH₂CH₂]₆OH).
2. Water Salinity
Salinity of the formation water also affects the decrease of water-water interface tension by the surfactant. For the concentrations of certain salts, such as NaCl will cause a decrease in the oil-water interface tension. This might cause the chemical bonds that make up NaCl ionic bonds that are decomposed into Na + and Cl- ions. Thus, the surfactant molecules in water, will break down easily into RSO3- and H + ions. Consequently, when the surfactant conforming operation contains the NaCl salt, it will form HCl and RSO3Na and become non-surface active agent and can not decrease the oil-water interface tension.

3. Sandstone
Sandstone is the most important and most common type of reservoir rock, in percentage, 60% of all reservoir rocks are sandstones. The porosity obtained within these sandstones is only intergranular, the pores are present between the grains and especially occur in the primary, so the cavities occur at the time of settling. It can not be denied, however, that after the precipitation process there may be various modifications to the cavities, such as cementation or dissolution of the cement as well as other secondary processes such as cracking.

Methodology
A series of preparations and experiments carried out among others are as follows.

Figure 1 Workflow

1. Preparation of synthetic water formation (brine).
2. Preparation of the solution (18 samples) for several salinity (10,000 ppm, 15,000 ppm and 20,000 ppm).
3. Measurement of the physical properties of the solution.
4. Imbibitions (Figure 2). The process of increasing recovery as the effect of surfactant imbibitions.

Result And Discussions
This study closely looks into details of the affect of different reservoir formation type, non ionic surfactant concentration and salinity of formation water to oil recovery in laboratorial imbibitions process.

The next stage is to monitor any additional concentration of surfactant solution and its effect on the interfacial tension. The experiment discovers that the addition of a surfactant solution concentration does lower the surfactant solution's interfacial tension. The optimum point visually divides the rapidly declining concentration rate regime and a more constantly stabilized region. As seen the graphical plot (Figure 3) suggests that any additional surfactant concentration in the solution does rapidly lower the interfacial tension.

![Figure 3 Concentration vs IFT](image)

Until reaching certain point, which in this particular experiment is at 1.5% of surfactant concentration, the interfacial tension is in the state of a more stabilized decline rate despite the fact that the surfactant concentration is constantly added into the solution.

Before the optimum point, the concentration of surfactant is continuously aggregated and forms a micelle until it reaches a certain state known as the critical micelle concentration (cmc). Accordingly, after breaking through the cmc, the decline rate of the interfacial tension is gradually reduced as sign of the weakening the molecular bound.

In this study, salinity is also equally important. First, the non ionic surfactant is dissolved into several brines of different concentrations.

The result, the interfacial tension is reduced as the salinity concentration decreases (Figure 4). The range of salinity between 140 thousand parts per million and 20 thousand part per million is where the rapid reduction in the interfacial tension occurs. As for the salinity of the brine, the concentration directly correlates to the depth of the oil formation. Therefore, the non ionic surfactant concentration can be utilized in the deep formation.
Next procedure is to run the imbibitions test. The selected non ionic surfactant solution is applied to a sand stone based – core sample.

In the early stage, the oil recovery is set at time zero. Then, non ionic surfactant is constantly injected into the core sample. The process is to be logged for sixty hours. The recorded results shows of an upward trend in oil yield. However, after a sixty-hour period the rate of oil recovery appears to be stabilizing.

The explanation to such observable fact is that in the early stage, nonionic surfactant solutions work effectively binding granular molecules as well as lowering the interfacial stress. As shown in the graph (Figure 5), the process produces a high oil yield. The observation further explains, at some point after the fifty hour (approximately 65 hour), the surfactant soaking time is reachead. In that interval, the surface tension attracts lesser oil molecules. Therefore, more oil molecules becomes movable and mobile. As a result, the rate of oil recovery steadily increases.

A multi variable – regression test is then run and the results are the followings:

From figure 6, the correlation between the observed variables that yield oil recovery in experiment can be summarized as:
Figure 6 Volume Oil vs Time

**Oil Recovery** = 0.140 + 4.335 * Nonionic Concentration Surfactant– 1.525* Formation Water Salinity

Where;

Oil Recovery = (ml)
Formation Water Salinity = (MPPM)
Nonionic Surfactant Concentration = (%Surfactant)

In general, this experiment has proved the injection of non-ionic surfactant concentration into the sandstone-core sample throughout the imbibitions linearly correlates to the oil recovery. Simultaneously, the study further concludes that the Nonionic Surfactant Concentration works effectively in low saline oil formation.

**Conclusions**
1. The 1.5% surfactant concentration is found to be the most optimum for sandstone because such surfactant concentration can decrease the interfacial tension in loosening the bond between molecules of sandstone and that of the oil’s until oil becomes movable.
2. From this experiment, by conducting correlation analysis, it was found that the concentration of nonionic surfactants and the salinity of the formation water is a predictor for the acquisition of oil in an imbibitions process in sandstone.
3. The study further concludes the effect of the concentration of nonionic surfactant and the salinity of the formation water linearly correlate to the increase of oil recovery in a sandstone imbibitions process.

**Acknowledgements**
I would like to acknowledge the guidance and support provided by my supervisor, Dr. Ir. Kasmungin.MT, throughout this work. I am also grateful to Mr. Ir. Abdul Hamid, the Head of the Petroleum Engineering Department, and Dr. Ir. Afiat Anugrahadi, M.S, the Dean of the Faculty of Earth Technology and Energy, for providing strong support to any academic publication by lectures.

Special thanks to my wife and children for their moral support, prayers, and encouragement towards the successful completion of this work.
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