The effect of alkali type on IFT value for surfactant-alkali injection

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Abstract. The aim of this research is to acknowledge alkali effect on surfactant-alkali on IFT value and to acknowledge temperature on surfactant-alkali IFT stability. There are six surfactant-alkali solutions utilized in this research. Meanwhile solution compatibil test in this research consist of Aquos Stability, CMC, IFT, phase behaviour test by utilizing micro emulsion observation for 24 hours and thermal stability on reservoir temperature (60°C) for 7 days. There are two surfactant-alkali solution type that pass selection stage, which are 5% salinity OGEP 400 OLEAT with 0.3% concentrate and NaOH with 0.1% concentration with surface tension of 5.176x10^-3 dyne/cm, phase behaviour reading in phase 1, unstable thermal stability test with IFT measurement after thermal as much as 1.385x10^-2 to 2.416x10^-2 dyne/cm, filtration ratio of the filtration test is as much as 1.2 ml/second and recovery factor of imbibition result is as much as 75.5%. Meanwhile for alkali Na2CO3 in 0.5% concentration with surface tension test result of 3.379x10^-3 dyne/cm, phase behaviour reading in phase 1, a relatively stable thermal stability test with IFT measurement after thermal of 2.42x10^-2 to 2.871x10^-2 dyne/cm, filtration ratio of filtration test as much as 1.17 ml/second and recovery factor from imbibition result as much as 57.8%. The obtained result shows that alkali addition is proven to be able to lower surfactant IFT to 10^-3 dyne/cm. This finding can be utilized as a basic of EOR application in sand stone formation.

1. Introduction
The proven Indonesian oil reserve per January 1st 2010 measured as much as 4230 MMstb [1]. Meanwhile average oil production in 2009 is 348 MMstb. With assumption that there will be no new reserve, Indonesian oil reserve will be depleted in the next twelve years [2]. Efficient technologies and methods that would improve oil acquisition are developed consistently to improve cost production [3]. Enhanced Oil Recovery (EOR) improvement is the latest effort to increase oil acquisition in tired refineries that experience significant production decrease where the number of water cut are quite high. The known enhanced oil recovery methods are as follows [4]:

- Unmixed injection
- Mixed injection
- Chemical injection
- Thermal injection
- Microbial Enhanced Oil Recovery
One of numerous chemical EOR methods is the surfactant alkali injection that functions to lower surface tension and create emulsion, improve pH and lower adsorbs to the lowest level and create a better cost production [5]. Meanwhile the function of surfactant is to alter oil wettability from oil wet into water wet, and lower surface tension and release oils that stick on stones [5].

2. Literature study

2.1. Alkaline
Alkali flooding method is dependent to chemical reaction between chemical compound such as natrium carbonate and natrium hydroxide (the most common alkali agent) and organic acid (curable compound) in crude oil to produce in-situ surfactant (soap) that can lower surface tension. Another part that is quite important is emulsification. Alkali addition can increase pH and lower surfactant adsorption to the lowest level so that surfactant concentration can be utilized to lower cost.

2.2. Surfactant
Viriya explains that surfactant working principle of lowering IFT happens on hydrophilic that included in polar solution. After that, hydrophilic part will enter non-polar solution [6]. Based on this situation, both compounds cannot be mixed because of the surfactant working principle. Eni explains that IFT in small value solution is also has the potential to obtain minimum Saturation Oil Residual (SOR) value [7]. This situation is connected with surfactant that can improve oil acquisition with micro stimulation. Micro stimulation can be defined as stimulation efficiency that is affected by fluid and media interaction within its scope.

Based on literature study written by Nakayama, there are four kind of surfactant based on their own characteristics [8]. The classifications are anionic, cationic, amphoteric, and non-ionic surfactant, based on their polar groups, ionic charges, and molecular structures.

Surfactant molecular tendency with a hydrophilic or lipophilic nature are surfactant characteristic that act as surface active agent. These surfactant characteristic can be determined empirically from their Hydrophilic Lipophilic Balance (HLB). Based on the situation, we can acknowledge that surfactant tendency used in water or oil solution [9]. Myers explains that empiric HLB value scale is placed between 0-20 [10]. HLB value has an impact on surfactant hydrophilic nature, where water solubility is relatively high and can form oil-in-water emulsion. In low HLB value, surfactant nature tends to be lipophilic and form water-in-oil emulsion. Sheng explains that the most basic value in EOR research is phase test [5]. According to Kayali, phase test is conducted to acknowledge IFT description on surfactant from the formed microemulsion in a surfactant system, brine, and oil [11]. This situation is highly connected with IFT, which is an important factor of oil acquisition with the formed microemulsion in chemical flooding process.
3. Research methods

![Flowchart](image_url)

**Figure 1.** Research phase flow.

This research was conducted with several phases, started from brine and alkali surfactant solution making with a different salinity and concentration, compatibility test, filtration, until imbibition. Figure 1 describes the phase flow of this research.

4. Results and discussion

The utilized parameter as test consideration in determining alkali surfactant solution is salinity test on surfactant and alkali surfactant IFT, which aimed to acknowledge best salinity that can be used by surfactants in this research. IFT test is conducted to acknowledge alkali surfactant ability to flow oil on pored rocks.
Figure 2. CMC surfactant graphic.

In figure 2, because of economic and efficiency consideration on previous studies, the utilized surfactant in this research is using 0.3% concentration.

Figure 3. Salinity scan surfactant graphic.

In figure 3, we can witness that the salinity utilized on all three surfactants is placed on a 5 percent salinity level.

Figure 4. Chosen alkali surfactant IFT graphic.
From phase behavior test, compatibility, salinity scan and CMC, we acquire the best two alkali surfactant as pictured in figure 4.

- OGEP 400 OLEAT 0.3% + NaCL 5% + NaOH 0.1% with interface tension as much as 5.18×10⁻³ dyne/cm.
- OGEP 400 OLEAT 0.3% + NaCL 5% + Na₂CO₃ 0.5% with interface tension as much as 3.38×10⁻³ dyne/cm.

![Figure 5. Thermal stability graphic.](image)

In Figure 5, we can see that the surfactant alkali solution OGEP 400 OLEAT 0.3% + NaCL 5% + Na₂CO₃ 0.5% tends to be more stable on the IFT measurement value perspective which is relatively similar which is 0.024-0.028 dyne/cm. However, IFT value measurement of OGEP 400 OLEAT 0.3% + NaCL 5% + NaOH 0.1% thermal result is slightly lower on 0.013-0.017 dyne/cm.

![Figure 6. Alkali surfactant filtration.](image)

In figure 6, we can see that the filtration result of OGEP 400 OLEAT 0.3% + NaCL 5% + Na₂CO₃ 0.5% is quicker than OGEP 400 OLEAT 0.3% + NaCL 5% + NaOH 0.1% alkali surfactant solution. From filtration test phase the best result obtained is OGEP 400 OLEAT 0.3% + Na₂CO₃ 0.5% with the lowest result of 1.17 because OGEP 400 OLEAT possesses longer chemical chain if mixed with Na₂CO₃.
In Figure 7, we can see that imbibition test result produce recovery factor as follows:

- OGEP 400 OLEAT 0.3% + NaCL 5% + NaOH 0.1% = 75.5%
- OGEP 400 OLEAT 0.3% + NaCL 5% + Na2CO3 0.5% = 57.8%
- NaCL 5% = 39%

The best imbibition result produce recovery factor of 75.5%. On previous tests, OGEP 400 OLEAT 0.3% + NaCL 5% + NaOH 0.1% always produce the best result. The second best is OGEP 400 OLEAT 0.3% + NaCL 5% + Na2CO3 0.5% solution that produce recovery factor of 57.8% from imbibition process.

5. Conclusion
The best solution in this research is OGEP 400 OLEAT with 0.3% concentration with 5% salinity. Two alkali used in this research are NaOH with best concentration of 0.1% with surface tension of 5.176×10^{-3} dyne/cm, phase reading in phase 1, unstable thermal test result with IFT valuation after thermal as much as 1.385×10^{-2} to 2.416×10^{-2} dyne/cm, filtration ratio of the filtration test as much as 1.2 ml/second and recovery factor of imbibition result as much as 75.5%. Meanwhile for Na2CO3 alkali on best concentration of 0.5% with surface tension test result of 3.379×10^{-3} dyne/cm, phase behaviour test in phase 1, a relatively stable thermal test with IFT valuation after thermal as much as 2.42×10^{-2} to 2.871×10^{-2} dyne/cm, filtration ratio from filtration test as much as 1.17 ml/second and recovery factor from imbibition result as much as 57.8%.

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