The effect of middle phase emulsion and interfacial tension of Sodium Lignosulfonate surfactant synthesized from bagasse to Enhanced Oil Recovery

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Abstract. Enhanced Oil Recovery (EOR) is an effort to increase oil recovery after primary recovery and secondary recovery. One method used is chemical injection using surfactants. Sodium Lignosulfonate (SLS) is one of the anionic surfactants commonly used in the EOR process. Sodium Lignosulfonate can be made by bagasse synthesis, as an alternative to the use of lignosulfonate surfactant. The purpose of this study was to determine the effect of the middle phase emulsion and interfacial tension on the recovery factor results. The method used is the core injection. The injection fluid used is Sodium Lignosulfonate surfactant which has been tested for its characteristics. This research uses core flood devices and synthesized Berea cores. Core injection is carried out in several variations of salinity and surfactant concentration. The results of the study show that the largest recovery result is at 1.5% 15000 ppm with a recovery factor of 5.34% where the emulsions are the least among other compositions but the emulsions are stable at 48 hours and the IFT value is also relatively low at 4.34 mN/m. The lowest recovery results are at 1.5% 4000 ppm with a recovery factor of 3.24% where the emulsions are highest but the emulsions are stable at 336 hours, and the IFT value is relatively high at 10.40 mN / m. Based on this study it can be concluded that if the middle phase emulsion is quickly stable and the IFT value is low it will result in enhanced oil recovery.

1. Introduction
Enhanced oil recovery (EOR) is the final stage to increase the oil recovery factor after going through the stages of primary recovery and secondary recovery. EOR has several methods that can be used such as miscible gas injection, immiscible gas injection, chemical injection, thermal injection, and microbial. The selection of compatible methods to be applied in a field must go through a screening stage [1-3].

In this study using one of the EOR methods, namely chemical injection using surfactants. The surfactant used is Sodium Lignosulfonate (SLS) which is one of the anionic surfactants commonly used in the EOR process. Sodium Lignosulfonate can be made by synthesizing sugarcane bagasse, as an alternative to the use of petroleum sulfonate surfactants [4-6].
Before the SLS surfactant is injected into the reservoir, a screening step is first performed which aims to determine whether the surfactant composition is good for injection. The screening stages to be discussed in the paper are the phase behavior test and the interfacial tension test [7,8].

The purpose of this study was to determine the effect of the middle phase emulsion and interfacial tension on the recovery factor results.

2. Methods

The methodology used in this study is experimental and analytic research using the relationship between concentration and salinity which serves to determine the causal relationship between the two variables.

This research uses a laboratory study method with reservoir conditions. The concentration of surfactant NaLS Sugarcane Bag that is used is 1%; 1.5%; 2%; 2.5% and 3% NaLS and salinity used are 4000 ppm, 5000 ppm, and 15000 ppm NaCl. Surfactant solution will be measured at a temperature of 60°C. In the implementation of core flooding, the type of rock used is synthetic sandstone and the type of oil used is light oil [7–9].

Figure 1. Research workflow.

Figure 1 is a research workflow that begins with the laboratory set-up of making surfaces, oil and sandstone solutions, then conducts a surfactant compatibility test, core flooding and ends with an analysis of the data recovery factor obtained. The surfactant compatibility test is a phase behaviour test and an interfacial tension test.

The phase behavior test aims to determine the correct salinity and type of emulsion that can mix with crude oil to reduce interface tension [10].
Interfacial tension test (IFT) uses a tool called spinning drop that can measure the value of the interface tension of 10-6 mN/m [10,11].

3. Results and discussion
Table 1 shows the results of the phase behaviour test in various variations of the composition which only form the middle phase which is one of the main mechanisms that shows the success of EOR in using surfactants [12].
Variations in the composition of the three salinities for this phase behavior test can be concluded that emulsification is better at 1.5% concentrations in all salinity variations. the lower the salinity with a concentration of 1.5%, the greater the number of middle emulsions [12].

| Salinity, ppm | Concentration, % | Emulsion Stability, hour | Total Emulsion, % |
|----------------|----------------|--------------------------|------------------|
| 4000           | 1.5            | 336                      | 28.8             |
| 5000           | 1.5            | 1                        | 10.0             |
| 15000          | 1.0            | 336                      | 8.75             |
| 15000          | 1.5            | 48                       | 3.75             |

Table 2 is the result of the IFT surfactant SLS test where all concentrations at a salinity of 15000 ppm can reduce IFT more efficiently than the other two compositions. Based on this research a good determinant of surfactant does not depend only on low IFT but also based on good emulsion capability [12,13].

| Salinity (ppm) | Concentration (%) | IFT (mN/m) |
|----------------|------------------|------------|
| 4000           | 1.5              | 10.40      |
| 15000          | 1.0              | 4.09       |

| Salinity (ppm) | Concentration (%) | Code | Primary OOIP (ml) | Secondary RF (%) | Tertiary RF (%) | Recovery Factor Total RF (%) |
|----------------|------------------|------|------------------|------------------|----------------|-----------------------------|
| 4000           | 1.5              | CF 1 | 1.9              | 27.37            | 3.24           | 30.61                       |
| 15000          | 1                | CF 5 | 2.4              | 36.25            | 3.62           | 39.87                       |
| 15000          | 1.5              | CF 7 | 1.9              | 37.37            | 5.34           | 42.71                       |

Table 3 is the result of core flooding from a variety of compositions which only form the middle phase. Primary recovery is the initial value of oil saturation in the rock. The secondary recovery stage is carried out by water flooding, while the tertiary recovery is carried out by surfactant injection. So to find out the results of recovery factors from surfactant injection can be seen at the stage of tertiary recovery.

Table 3 explains that, the highest recovery results are at 1.5% 15000 ppm with a recovery factor of 5.34% where the emulsions are the least among the other compositions but the emulsions are stable at 48 hours and the IFT value is also relatively low at 4.34 mN/m. The lowest recovery results are at 1.5% 4000 ppm with a recovery factor of 3.24% where the emulsions are highest but the emulsions are stable at 336 hours, and the IFT value is relatively high at 10.40 mN/m.
4. Conclusion
The Effect of Middle Phase Emulsion and Interfacial Tension of Sodium Lignosulfonate Surfactant Synthesized from Bagasse to Enhanced Oil Recovery is if the middle phase emulsion is quickly stable and the IFT value is low it will result in enhanced oil recovery.

References
[1] Al-Adasani A and Bai B 2010 Recent developments and updated screening criteria of enhanced oil recovery techniques *International Oil and Gas Conference and Exhibition in China* (Society of Petroleum Engineers)
[2] Taber J J, Martin F D and Seright R S 1996 EOR screening criteria revisited *SPE/DOE tenth symposium on improved oil recovery: Tulsa OK, 21-24 April 1996* pp 387–415
[3] Abadli F 2012 Simulation study of enhanced oil recovery by ASP (alkaline, surfactant and polymer) flooding for Norne field C-segment
[4] Setiati R 2017 Synthesis And Characterization Of Surfactant Sodium Lignosulfonate Bagasse: Cane Concentration And Solution Of Solution Towards Performance Of Oil Pressure In The Core Rock *Institute Teknol. Bandung*
[5] R. Setiati, E. Aryani, M. Putri and D W 2016 Sulfonation of bagasse lignin into sodium lignosulfonate surfactant *Pros. Semin. Lignoselulosa* 35–41
[6] F. M. Farham H M Saleh A D C J 2016 Manufacture of Sodium Ligno Sulfonate Surfactants from Sugarcane Bagasse *Teknoin* 22 1–4
[7] Fattahanisa A 2018 Determination Of The Composition Of Bagasse Surfactant Nals With Surfactant Stability Consideration And Phase Behavior Test *Semin. Nas. Cendekiawan* 103–9
[8] Fattahanisa A, Setiati R and Kasmungin S 2018 The Effect of Interfacial Tension and Thermal Stability on Surfactant Injection *J. Earth Energy Sci. Eng. Technol.* 1
[9] Fattahanisa A, Setiati R, Kasmungin S and Ristawati A 2019 The alternative solutions of bagasse to improve Indonesian oil production in low salinity *Journal of Physics: Conference Series* vol 1402 (IOP Publishing) p 33001
[10] Gao B and Sharma M M 2012 A new family of anionic surfactants for EOR applications *SPE Annual Technical Conference and Exhibition* (Society of Petroleum Engineers)
[11] Drelich J, Fang C and White C L 2002 Measurement of interfacial tension in fluid-fluid systems *Encycl. Surf. colloid Sci.* 3 3158–63
[12] Fattahanisa A 2018 *Optimization Of Surfactant Injection Of Nals Bagasse In Low Salinity To Improve Recovery Factor* (Universitas Trisakti)
[13] Haiyang Y U, Yefei W, ZHANG Y, ZHANG P and Wuhua C 2011 Effects of displacement efficiency of surfactant flooding in high salinity reservoir: interfacial tension, emulsification, adsorption *Adv. Pet. Explor. Dev.* 1 32–9