The Effect of Interfacial Tension and Thermal Stability on Surfactant Injection

(Pengaruh Tegangan Antarmuka dan Kestabilan Suhu Pada Injeksi Surfaktan)

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Abstract

In this research, bagasse NaLS surfactant was used as an injecting reservoir fluid at low salinity. The purpose of this study was to observe the effect of IFT and thermal stability on oil recovery factors in various compositions. The material used in this study isbagasse based NaLS surfactant, light oil and sandstone, while spinning drop is used to measure the interface tension. The oven was used for thermal stability testing and core flooding equipment for the surfactant injection. The success in this study was based on the value of the recovery factor, the small IFT value, and stability of IFT in the thermal stability test. The IFT results obtained for CF1, CF5, and CF7 were 10.4 mN/m, 4.09 mN/m, and 4.34 mN/m, respectively. Based on The results of the thermal stability test only the CF7 was stable with an IFT value of 2.11 mN/m, while the other two variations were unstable. The recover factor of CF1, CF5, and CF7 was 3.24%, 3.52%, and 5.34%, respectively. It can be concluded that IFT as well as thermal stability affect the frecovery factor.

Keywords: NalS Surfactant, Bagasse, Sodium Lignosulfonat, IFT, Thermal Stability.

Sari

Pada penelitian ini surfaktan NaLS ampas tebu sebagai fluida injeksi reservoir pada salinitas rendah. Tujuan dari penelitian ini adalah untuk mengamati pengaruh dari IFT dan kestabilan suhu terhadap faktor perolehan minyak pada berbagai komposisi. Bahan yang digunakan pada penelitian ini adalah surfaktan NaLS ampas tebu, minyak ringan dan batupasir, sedangkan untuk alat yang digunakan adalah spinning drop untuk mengukur tegangan antar muka. Oven digunakan untuk pengujian kestabilan terhadap thermal dan peralatan core flooding untuk injeksi surfaktan. Keberhasilan dalam penelitian ini ditandai dengan besarnya nilai faktor perolehan, kecilnya nilai IFT, dan kestabil IFT pada pengujian kestabilan suhu. Hasil IFT yang didapat adalah untuk CF1, CF5, dan CF7 berturut-turut sebesar 10.4 mN/m, 4.09 mN/m, dan 4.34 mN/m.B CF1 sebesar 10.4 mN/m, CF5 sebesar 4.09 mN/m, CF7erdasarkan uji kestabilan suhu hanya CF7 yang stabil dengan nilai IFT sebesar 2.11 mN/m, sedangkan dua variasi yang lain tidak stabil. Faktor perolehan dari injeksi surfaktan untuk CF1, CF5, dan CF7 berturut-turut sebesar 3.24%, 3.52%, dan 5.34%. Dapat disimpulkan bahwa IFT dan kestabilan suhu mempengaruhi faktor perolehan.

Kata-kata kunci: Surfaktan NaLS, ampas tebu, natrium lignosulfonat, IFT, Kestabilan suhuy

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I. INTRODUCTION

Enhanced oil recovery is a technology that can take oil residues that cannot be produced at the secondary recovery stage (Abadli, Septoratno, 2000). The injection of chemical such as alkali, surfactant, and is one of the EOR methods which has been intensively observed in laboratory scale. The surfactant is able to reduce the oil-water interfacial tension so that the oil can pass through the pores and produce (Aladasani & Bai, 2010; Nageh, Ela, Tayeb, & Sayyouh, 2015; Sandersen, 2012). The bagasse NaLS surfactant which is a vegetable material whose raw materials are widely available in Indonesia (Setiati, Wahyuningrum, & Siregar, 2016).

In this research, The IFT and thermal stability of the bagasse based NaLS surfactant were investigated for 90 day observation. In addition, the surfactant was injected for core flooding in order to find the correlation between IFT and thermal stability on recovery factor.

II. BASIC THEORY

Surfactants or surface active agents are substances that are surface active or a molecule that works on a surface plane that can reduce the tension between two liquid interfaces that do not mix together. The surfactant binds the two fluids to an emulsion, the surfactant is soluble in water (Green D.W., 1998; Gao & Sharma, 2012).

Figure 1 is a surfactant structure consisting of two groups, namely hydrophilic and lipophilic, where in this bagasse NalS surfactant the hydrophilic group is a hydrocarbon group while the lipophilic group is a sulphonate group and its salt (Ismiyati, Suryani, Mangunwidjaya, Machfud, & Hambali, 2009).

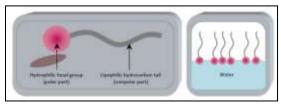


Figure 1. Structure of Surfactant (Sandersen, 2012)

IFT measurements using a spinning drop that can measure the interface voltage up to 10^{-6} mN/m. According to Drelich J (2002) "using a spinning drop tensiometer is based on the fact that Earth's gravity has little effect on the form of fluid drop suspended in the liquid when it is in a rotary tube. The spinning drop method is based on the balance of centrifugal force and interface voltage. When the rotational speed is low, the fluid drop will be elliptical, if the rotation speed is high, the fluid drop will be cylindrical, so the measurement of the cylinder radius (r) is needed, the difference in density drop and the surrounding liquid drop $(\Delta \rho)$ and the speed of drop drop (ω)"(Drelich, 2002; Gao & Sharma, 2012). Temperature stability testing aims to see whether NaLS surfactants are resistant to heat and can affect the results of surfactant injection (Setiati, 2017).

III. RESEARCH METHODOLOGY

The materials used in this study were:

- 1. Bagasse NaLS surfactant
- 2. Light oil
- 3. Sandstone Berea

While the equipment used in this study were:

- 1. Spinning drop
- 2. Oven
- 3. Core flooding

Figure 2 shows the scheme of this research work. It started from the manufacture of surfactant solution with a composition of 1.5% NaLS 4000 ppm NaCl; 1% and 1.5% NaLS 15000 ppm. Then the interfacial tension and thermal stability tests were conducted on the three composition variations. Then the surfactant injection was carried out to determine the oil recovery factor produced.

IFT test is performed to determine the value of surfactant ability to reduce the interfacial tension between oil and brine. The steps for the process are as follows:

- 1. Preparation of tools and solutions for 30 minutes
- 2. A sample of solution and oil is inserted into the tube
- 3. Samples were measured using a spinning drop tensiometer (Figure 3) for 30 minutes with a value of 6000 rpm and a temperature of 60°C.

Thermal stability test. This test was carried out on all variations of salinity concentration. Thermal stability testing was almost the same as IFT testing, but thermal testing was carried out for 90 days of observation.

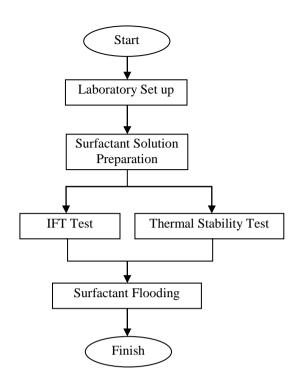


Figure 2. Research Flow Diagram



Figure 3. Spinning Drop

Figure 4 shows the schema of core flooding equipment which was used for the surfactant injection experiment. The procedure of the experiment was as follows:

- 1. Prepare cores that had been saturated with oil.
- 2. Insert the core into the rubber core holder.
- 3. Insert it into the core holder.
- 4. Close the core holder with the core holder clamp, whose function is to withstand overburden pressure of 100 psi.
- 5. When it is installed, give overburden pressure which serves to clamp the core holder rubber so that the flow rate of the injection pump is completely through the core pores and not through the side, namely by:
 - a. Close all valves: pressure, vent and vacuum in the core holder panel.

- b. Open the N₂ gas cylinder lid.
- c. Set the pressure by turning the pressure regulator valve in a clockwise direction; see the output pressure gauge until the desired pressure.
- 6. Open the valve pressure to the left, it will be seen on the pressure gauge inside the panel according to the intended pressure.
- 7. Turn on the temperature control according to the desired temperature, wait for up to 15 minutes if you have turned on the injection pump for 15 minutes and get ready for surfactant injection.
- 8. Inject surfactant solution and note the cummulative oil produced.

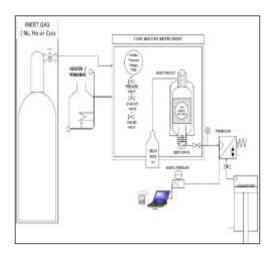


Figure 4. Schema of Core Holder Apparatus.

IV. RESULTS AND DISCUSSION

Table 1 shows a scenario for surfactant injection. The surfactant which was used for this research is shown in Figures A1 to A2. Before the injection was performed, IFT and thermal stability tests were conducted. The IFT at initial condition is indicated in Table 2.

Table 1. Scenario of Core Flooding

Core Code	Scenario	
CF1	4000 ppm 1.5%	
CF5	15000 ppm 1.0%	
CF7	15000 ppm 1.5%	

From the results obtained in Table 2 the composition of 15,000 ppm 1% and 1.5% can reduce IFT more efficiently than the other two compositions. Interfacial tension has a tendency to reduce IFT in the first test and then the IFT decreases with increasing salinity. This IFT result is also the same as the results of previous studies, which prove that the salinity and concentration of surfactants affect the decrease in the value of IFT.

Table 2. IFT of Bagasse based NaLS Surfactant

Core Code	IFT (mN/m)	
CF1	10.40	
CF5	4.09	
CF7	4.34	

Thermal stability testing was carried out to see the stability of surfactants at 60°C for 3 months of observation. In this thermal stability test IFT measurements using spinning drop at 0 days, 7 days, 60 days and 90 days were carried out. The results of thermal stability testing are shown in Figure 5.

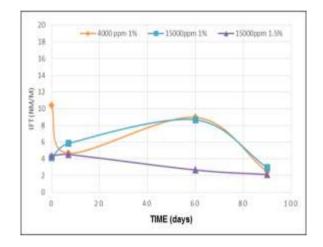


Figure 5. Thermal Stability Test Results

As can be seen in Figure 5, thermal stability results for CF7 is stable with IFT value of 2.11 mN $^{\prime}$ m which is the lowest if it is compared with others. As for CF1 IFT value at 90 days is 2.44 mN $^{\prime}$ m and IFT value at 90 days for CF 5 is 2.93 mN $^{\prime}$ m.

Table 3. Summary of Test Results

Code IFT (mN/m)	Thermal Stability		Recovery Factor	
	(mN/m)	Stability	IFT (mN/m)	RF (%)
CF1	10.4	Not stable	2.44	3.24
CF5	4.09	Not stable	2.93	3.62
CF7	4.34	Stable	2.11	5.34

Figures A.3 to A.5 show the injection results of

CF1, CF5, and CF7. While Tabel 3 shows the summary of the results of IFT, thermal stability, and core flooding tests.

Table 3 indicates that the highest RF value is 5.34%. It was obtained by injecting the composition of 15000 ppm NaCl 1.5% NaLS. The recovery factor is strongly affected by IFT. This agree with the theory of Wagner and Leach (1966) where the smallest IFT value can increase the recovery factor.

V. CONCLUSIONS

The conclusions of this study are:

- 1. Surfactant solution with a composition of 15000 ppm NaCl 1.5% NaLS is able to attain recovery factor of 5.34%...
- 2. The relationship between IFT and oil recovery factors is inversely proportional.

ACKNOWLEDGEMENTS

The author would like to thank Trisakti University and Kemenristek Dikti who have supported the authors both in terms of material and immaterial, and also the authors thank the publishers who have published this paper.

REFERENCES

- Abadli, F., "Simulation Study of Enhanced Oil Recovery by ASP (Alkaline, Surfactant and Polymer) Flooding for Norne Field C-Segment", Norwegian University of Science and Technology, 2012.
- 2. Aladasani, A., & Bai, B., "Recent Development and Updated Screening Criteria of Enhanced Oil Recovery Techniques. SPE 130726, 2010.
- 3. Drelich, J., "Measurement of Interfacial Tension in Fluid-Fluid Systems", Encyclopedia of Surface and Colloid Science, 3152–3166, 2002.
- 4. Gao, B., & Sharma, M. M., "A New Family of Anionic Surfactants for EOR Applications", SPE 159700, 2012.
- 5. Green D.W. and W. G. P., "Enhanced Oil Recovery", Texas: Richardson, 1998.
- Ismiyati, Suryani, A., Mangunwidjaya, D., Machfud, & Hambali, E., "Pembuatan Natrium Lignosulfonat Berbahan Dasar Lignin Isolat Tandan Kosong Kelapa Sawit: Identifikasi, Dan Uji Kinerjanya Sebagai Bahan Pendispersi. J. Tek. Ind. Pert., 19(1), 25–29, 2009.
- Nageh, M., Ela, M. A. E., Tayeb, E. S. E., and Sayyouh, H., "Application of Using Fuzzy Logic as an Artificial Intelligence Technique in the Screening Criteria of the EOR Technologies", SPE North Africa Technical Conference and Exhibition, 2015.
- 8. Sandersen, S. B., "Enhanced Oil Recovery with Surfactant Flooding", Ph.D Thesis, Technical University of Denmark, 1–162, 2012.

- 9. Septoratno, S., "Enhanced oil recovery", Institut Teknologi Bandung, Bandung, 2000.
- 10. Setiati, R., "Sintesis Dan Karakterisasi Surfaktan Natrium Lignosulfonat Ampas Tebu: Pengaruh Konsentrasi Dan kegaraman Larutan Terhadap Kinerja Pendesakan Minyak Dalam Batuan Inti. Disertasi, Institut Teknologi Bandung, 2017.
- 11. Setiati, R., Wahyuningrum, D., & Siregar, S., "Optimasi Pemisahan Lignin Ampas Tebu Dengan Menggunakan Natrium Hidroksida", Ethos (Jurnal Penelitian Dan Pengabdian Masyarakat), 4(2), 257–264, 2016.
- 12. Wagner, O. R. and Leach, R. O., "Effect of Interfacial Tension on Displacement Efficiency. Society of Petroleum Engineers Journal, 6(4). https://doi.org/10.2118/1564-PA, 1966.

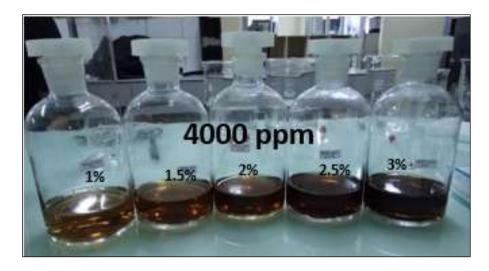


Figure A.1. NaLS Surfactant Solution 4000 ppm



Figure A.2. NaLS Surfactant Solution 15000 ppm



Figure A.3. Results of Surfactant Injection for CF1



Figure A.4. Results of Surfactant Injection for CF5



Figure A.5. Results of Surfactant Injection for CF7