International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

The Use of Palm Oil Based Surfactants for Oil Recovery Enhancement

Atalya Amartya Rantung[1], Rini Setiati[2], Arinda Ristawati[3], Onnie Ridaliani[4], Samsol[5]
[1,2,3,4,5]Petroleum Engineering, Faculty of Earth and Technology Energy, Trisakti University, Jakarta, Indonesia
Email address: rinisetiati@trisakti.ac.id

***Abstract*—*Indonesia is a large palm oil producer in the world which produces 35.36 million tons of Crude Palm Oil (CPO) (Indonesian Plantation Statistics, 2017). With large CPO production, the development of palm oil-based surfactants is very open and has great potential for use in EOR applications. Purpose: The purpose of this study was to determine whether the use of palm oil-based surfactants could be used to increase oil recovery. Method: Tests were carried out, among others, by making surfactants, EOR screening tests, characteristic tests, and core flooding tests. Other sources also carried out tests by selecting surfactants and polymers, analyzing physical & chemical properties, and measuring interfacial tension. Result: The research was conducted on fields with intermediate crude oil using 5 surfactant variants namely, MES surfactantt, BES surfactant, and PDS surfactant. There are three variants of PDS surfactants, PDSH1, PDSH2 and PDSH3. With a synthesis time of 60 minutes, a brine salinity of 18000 ppm, and a concentration of 1.0%, PDSH3 surfactant showed the most optimal performance and resulted in an oil recovery of 22.1%. On another source, PDS with 60 minutes of synthesis also produced the best increase in recovery factor with an IFT of 4.665 x 10-3 dyne/cm. Then a thermal test was carried out for 3 months at a temperature of 60°C on the composition of 0.3% Surfactant + 0.3% NaCl + 0.15% Flopaam 3630S giving IFT result of 5.39E-03 dyne/cm, filtration rate of 1.1, and viscosity of 31.73 cP and 0.3% Surfactant + 0.3% NaCl + 0.2% Flopaam 3630S giving IFT result of 6.92E-03 dyne/cm, filtration rate of 1.19, and viscosity of 56.47 cP. As well as the core flood test with Berea core media, the two formulas with an injection volume of 0.3% obtain a potential increase in recovery factor of 13-18.8%. On another source, research was conducted by sulfonation for 7 hours on MES surfactants from Palm Oil Methyl Ester (POME) and Sodium Bisulfite (NaHSO3), able to reduce the surface tension of water and emulsion stability by 33.95 dyne/cm and 89%. Conclusion: through various tests, palm oil based surfactants are proven to increase oil recovery.*

***Keywords*—** *Palm surfactant, recovery factor, core flood test, surfactant injection, water injection.*

I. INTRODUCTION

Indonesia is a large palm oil producer in the world which produces 35.36 million tons of Crude Palm Oil (CPO) [1]. With large CPO production, the development of palm oil-based surfactants is very open and has great potential for use in EOR applications [2]. According to research results, EOR technology has actually existed in Indonesia since the 1980s and the application of EOR to increase oil recovery in Indonesia has long been carried out in several fields [3]. One of the commonly used EOR methods is chemical injection which is usually carried out using surfactants, polymers, and alkalis. Surfactant injection is one way to reduce the remaining oil in the reservoir by injecting a surface active agent into the reservoir so that the oil-water interface tension can be reduced. The surfactant that has been used for the EOR process is petroleum sulfonate. However, these surfactants are non-renewable and relatively expensive [4]. Currently palm oil based surfactants are being developed. In addition to this surfactant being able to lower the interfacial tension as required by surfactants as chemical EOR, the abundant availability of palm oil and being a renewable raw material is also the reason why research on the synthesis of palm oil based surfactants was carried out for this EOR application [2]. Several surfactants based on palm oil were synthesized, namely MES, BES and PDS surfactants.

II. METHODS

The research was carried out in several stages, namely the making of surfactants, in this case there were 5 surfactant variants (1 MES surfactant variant, 1 BES surfactant variant and 3 PDS surfactant variants). The surfactant making process for the five surfactant variants basically has the same procedure, namely sulfonation, washing, bleaching, neutralization, and separation. For 3 types of PDS surfactants, the duration of the sulfonation process was distinguished, namely 120 minutes for PDSH1, 90 minutes for PDSH2, and 60 minutes for PDSH3[5]. Then the EOR screening test. Tests were carried out on surfactant solutions with formation water at concentrations of 0.3%, 0.5%, 1.0%, 1.5% and 2.0%. Tests carried out include compatibility tests, interfacial tension measurements, filtration tests, and thermal stability tests. The compatibility test is carried out by mixing the surfactant solution formula in formation water which is expected to form a homogeneous solution. Furthermore, the measurement of the interfacial tension by the spinning drop method [6] using a spinning drop device was set at 70°C. As much as 2μL (microliter) of crude oil was injected into a glass tube containing surfactant solution. There should be no air bubbles in the glass tube. Rotation speed is set at 6000 rpm. Then the thermal stability test is carried out by dissolving the surfactant in the formation water solution according to the desired concentration and then storing it in the oven at the reservoir temperature. Observe the changes that occur and measure the IFT value. Furthermore, the filtration test was carried out using a series of filtration devices connected to a nitrogen gas cylinder. The filter paper used is a 0.22 micron membrane. A total of 500 ml of surfactant solution is passed through a filter paper with a pressure of 20 psig. For every 50 ml of surfactant solution that passes through the filter paper, the time is recorded. Surfactant characterization was obtained using FTIR

Atalya Amartya Rantung, Rini Setiati, Arinda Ristawati, Onnie Ridaliani, and Samsol, "The Use of Palm Oil Based Surfactants for Oil Recovery Enhancement," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 2, pp. 204-206, 2023.

(Fourier Transform Infra Red) and TGA (Thermal Gravimetric Analysis). TGA measurements were carried out to determine the mass loss of surfactant with increasing temperature treatment. The test was carried out at a temperature range of 29-500°C with a heating rate of 10°C/minute with nitrogen. Surfactant injection test was carried out on the core flooding rig using standard Bentheimer rock, intermediate oil samples, and 18000 ppm brine. The injected surfactant is a surfactant candidate that passes the screening test and has the most optimal performance.

In addition to the above test stages, other sources also conducted tests by selecting surfactants and polymers, and analyzing the physical & chemical properties of the field fluids used as test materials.

Another source also carried out the tests sulfonation process, MES surfactant purification and product analysis. MES surfactant sulfonation was carried out by reacting POME and NaHSO3 with a mole ratio of 1:1 and the addition of 1% POME CaO catalyst. 200 ml of POME was put into the reactor, then added 63.36 gr of NaHSO3. The sulfonation reaction lasted for 5 hours at a temperature of 80ºC and a stirring speed of 450 rpm. The sulfonation process was carried out with different mole ratios, namely 1:1.5 and 1:2 and time variations of 5 hours, 7 hours and 9 hours. The MES purification process was carried out by washing using distilled water. This purification process aims to dissolve the salts and impurities that are still contained in the MES surfactant. The distilled water used was preheated to a temperature of 50ºC and added to a separatory funnel containing MES surfactant. The distilled water that has been mixed with the MES surfactant is shaken first and left for 90 minutes so that the salts and impurities still contained in the MES surfactant can be dissolved. The purification process was carried out 3 times.

III. Results and Discussion

The research was conducted on fields with intermediate crude oil using 5 surfactant variants namely, MES surfactant, BES surfactant, and PDS surfactant. There are three variants of PDS surfactants, PDSH1, PDSH2 and PDSH3. With a synthesis time of 60 minutes, a brine salinity of 18000 ppm, and a concentration of 1.0%, PDSH3 surfactant showed the most optimal performance and resulted in an oil recovery of 22.1%.

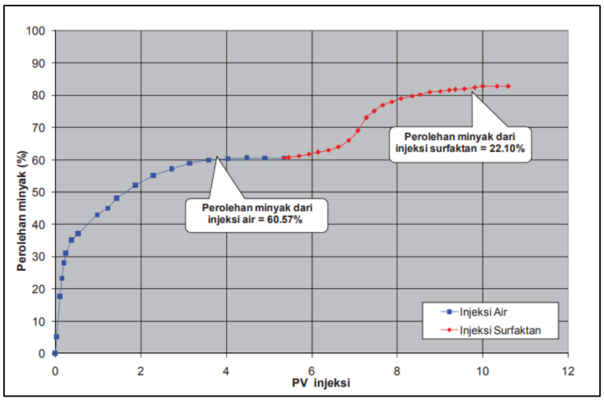

Fig. 1. Oil recovery from the PDSH3 surfactant core flooding test.

On another source, PDS with 60 minutes of synthesis also produced the best increase in recovery factor with an IFT of 4.665 x 10-3 dyne/cm. Then a thermal test was carried out for 3 months at a temperature of 60°C on the composition of 0.3% Surfactant + 0.3% NaCl + 0.15% Flopaam 3630S giving IFT result of 5.39E-03 dyne/cm, filtration rate of 1.1, and viscosity of 31.73 cP and 0.3% Surfactant + 0.3% NaCl + 0.2% Flopaam 3630S giving IFT result of 6.92E-03 dyne/cm, filtration rate of 1.19, and viscosity of 56.47 Cp.

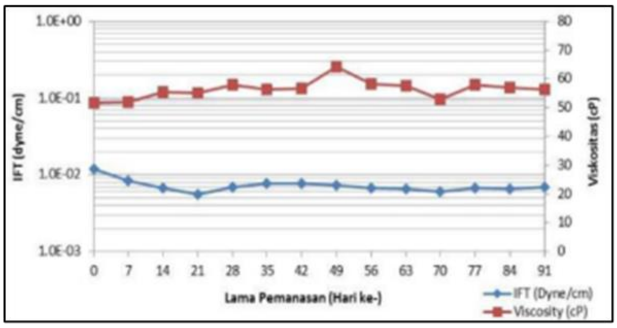

Fig. 2. Graph of thermal stability test formula S 0.3% + NaCl 0.2% + 3630S 0.15%.

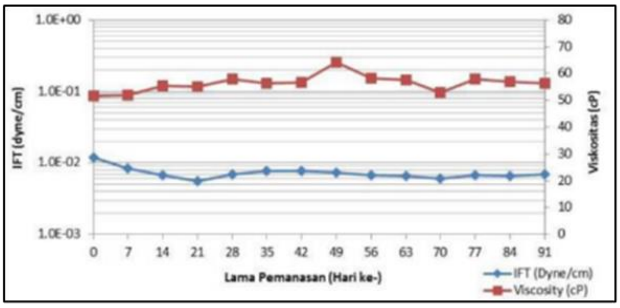

Fig. 3. Graph of thermal stability test formula S 0.3% + NaCl 0.2% 3630S 0.20%

As well as the coreflood test with Berea core media, the two formulas with an injection volume of 0.3% obtain a potential increase in recovery factor of 13-18.8%.

On another source, to determine the characteristics of the MES (Methyl Ester Sulfonate) surfactant, tests were carried out on the properties of the surfactants, namely surface tension, interfacial tension and emulsion stability. The MES surfactant produced in this study was able to reduce the surface tension of water from 71.4 dyne/cm to 37.45 dyne/cm with a surface tension reduction value of 33.95 dynes/cm. The analysis results show that the resulting surfactant is effective enough to reduce the surface tension of water. The resulting MES can act as an emulsifier when two phases with different polarities can mix homogeneously because of the presence of surfactants that are able to unite two phases with different degrees of polarity. Based on surface tension properties, MES surfactant has met commercial MES standards. The decrease in surface tension produced in the study was smaller than the commercial MES value. The stability of the emulsion produced in this study increased with increasing mole ratio and mixing speed. The highest emulsion stability value occurred in the treatment of 1:2 mole ratio and 7 hours sulfonation time, namely 89%. This is presumably due to the increasing number of surfactants formed. The higher the mole ratio and the stirring speed, the greater the amount of NaHSO3 bound to the methyl ester to form MES surfactant.

In short, research was conducted by sulfonation for 7 hours on MES surfactants from Palm Oil Methyl Ester (POME) and Sodium Bisulfite (NaHSO3), able to reduce the surface tension of water and emulsion stability by 33.95 dyne/cm and 89%. The resulting MES can act as an emulsifier when two phases with different polarities can mix homogeneously because of the presence of surfactants that are able to unite two phases with different degrees of polarity.

IV. CONCLUSION

Through various tests, palm-based surfactants have been proven to increase oil recovery. However, further research is still needed and opportunities to find new formulas for palm oil-based surfactants are very wide open, bearing in mind that the characteristics of oil in each field are very different.

ACKNOWLEDGMENT

The author would like to thank Universitas Trisakti, International Conference on Research Collaboration of Environmental Science (ICRC) 2023, and the publishers who have published this paper.

REFERENCES

[1] Darmapala, "Potensi Peningkatan Produksi Minyak Bumi dengan Chemical EOR melalui Pemanfaatan Surfaktan Berbasis Minyak Kelapa Sawit," in *Inovasi Kimia dan Pembelajarannya Era Industri 4.0*, 2019, no. November, pp. 135–191.

[2] S. Hidayati, A. Suryani, P. Permadi, E. Hambali, K. Syamsu, and Sukardi, "Optimasi Proses Pembuatan Metil Ester Sulfonat Dari Minyak Inti Sawit," *Scientific Journals of Bogor Agricultural University*, vol. 15, no. 3, pp. 274–282, 2020.

[3] A. Carcoana, *Aurel Carcoana - Applied Enhanced Oil Recovery*. Englwood Cliffs, New Jersey: Prentice Hall, In, 1992.

[4] Yuliatmi, S. Bahri, and Yelmida, "Sintesis Surfaktan Metil Ester Sulfonat (MES) dari Palm Oil Metyhl Eter (POME) dan Natrium Bisulfit (NaHSO3) dengan Variasi Suhu Sulfonasi dan Rasio Mol POME : NaHSO3," *Journal of Chemical Information and Modeling*, vol. 6, pp. 1–7, 2019.

[5] Y. Irawan and I. Juliana, "Effect Of Temperature On Manufacturing Process of Polyethylene Glycol Dioleate (PDO)," in *Proceedings of the 3rd Bali Internasional Seminar on Science and Technology (BISSTECH)*, 2015, pp. 15–17.

[6] J. E. Gardener and M. E. Hayes, *Spining Drop Interfacial Tensiometer Instruction Manual*. The University of Texas, Austin: Department of Chemistry, 1983.