The Influence Of Adsorption In Enhanced Oil Recovery Using SLS Surfactant From Bagasse

Rini Setiati, Septoratno Siregar, Deana Wahyuningrum

Abstract: Adsorption is one of the important parameters in assessing the SLS Surfactant performance in chemical enhanced oil recovery injection due to the use of its scores to determine the number of materials absorbed in the reservoir. The purpose of this study was to determine the effect of adsorption on Enhanced Oil Recovery Using SLS Surfactant from Bagasse. A low surfactant value means lower absorption in the rock during the injection. Moreover, chemical adsorption by the rock reservoir reduces the concentration of the chemical slug and causes low-efficiency displacement. Adoption can be measured either statically or dynamically. The static adsorption was conducted by saturating rock in surfactant solvent while the dynamic was by measuring the surfactant in the solvent before and after the injection. Generally, surfactant adsorption depends on many factors such as the type, concentration, equivalent weight, ionic strength, pH, salinity, and temperature. Furthermore, at 20.000 ppm - 4,5%, more SLS surfactant was absorbed in the core rock to produce low performance while fewer surfactant were absorbed in 80.000ppm-1,5% leading to better performance. This research showed surfactant concentration, formation, and water salinity influence adsorption of surfactant in enhanced oil recovery. Therefore, in an injection process, the adsorption in the reservoir should be considered.

Index Terms: Adsorption, Enhanced oil recovery, Surfactant concentration, Surfactant injection,

1 Introduction

Adsorption is one of the most important parameters used in evaluating sodium lignosulfonate performance in chemical enhanced oil recovery injection. It is a separation process involving the movement of certain components from the fluida phase to the absorbed solid surface. It is also a material separating process of a gas or liquid mixture from the solid sorbent surface and bounded by the energy working on its surface [1]. The adsorption value is usually used to show the quantity of adsorbed material in the reservoir. A low system means the rock adsorbed lower surfactant and decrease the interfacial tension of the oil-water to make the movement of oil production easier. Moreover, in the surfactant injection process, the adsorption at the rock reservoir is a parameter to be considered. This is because the success of the process is dependent on the degradation of the surfactant in the reservoir as well as the ability of the injected slug to decrease the canalized concentration. Furthermore, a different mechanism such as adsorption, precipitation, degradation, and polymer mixing causes the surfactant to lose in the reservoir [2]. The adsorption surfactant settles on the rock surface when in contact with the reservoir leading to the decrease in the concentration, and consequently, the inability of the residue to reach the ultralow IFT needed to mobilize the springe residue oil [3]. The Chemical adsorption towards the reservoir rock causes the concentration to degrade from the chemical slug and affects the low-efficiency displacement.

• *Rini Setiati, Petroleum Engineering, Faculty of Earth Technology and Energy, Trisakti University, Jakarta, Indonesia, PH+628158848400. E-mail: rinisetiati@trisakti.ac.id*
• *Septoratno Siregar, Petroleum Engineering, Faculty of Mining anda Pertroleum Engineering, Bandung Technology Institution, Bandung, Indonesia, PH+62 8122450851. E-mail: septoratno@yahoo.com*
• *Deana Wahyuningrum, Chemistry Departement, FMIPA, Bandung Technology Institution, Bandung, Indonesia, PH+628122370560, E-mail: deana@chem.itb.ac.id*

The unit is surfactant mol per unit area (μ_{eq}/m^2), and calculated through the following equation [4] :

$$A_s = \left(\frac{C_{AS}^i - C_{AS}^f}{m_a S_a}\right)\rho V_a$$

In which,
As = adsorption, μ_{eq}/m^2
C_{AS}^i = early surfactant concentration, m_{eq}/g
C_{AS}^f = end surfactant concentration, m_{eq}/g
m_a = adsorbent period, g
S_a = adsorbent wide area, m^2/g
ρ = early fluidal density, g/cm^3
V_a = additional surfactant volume, cm^3

The adsorption surfactant to the rock surface is more than the micelle, in the form of monomer. It is possible to adsorb the molecule through the use of any mechanism such as ion association, hydrophobic bonding, the polarization of π electrons, and dispersion forces [5],[6],[7],[8]. Adsorption during the flooding process is the most crucial problem in deciding the success or failure of surfactant injection [9]. It may happen when there are electrostatic and van der Walls interactions appearing on the rock surface[10]. It also depends on several factors such as the type, concentration, equivalent weight, and ionic strength of the surfactant as well as the pH, salinity, and temperature [9], [1], [6], [11]. The significant effect of the pH in which the quantity of the adsorption is variant to another pH depends on the quantity of the surfactant interacting with the rock surface [12]. Moreover, further improvement of the pH causes drastic degradation of the percentage which may be due to the weak electrostatic pull energy between the negative adsorption and the adsorbent directed to the reduction of the absorption ability[13]. Adsorption isotherm also can be analyzed with the Langmuir model Isoterm [14].

2 METHODOLOGY RESULT

The adsorption parameters tested include static and dynamic character. The static test was the surfactant adsorption at a static condition or when there is no current. The adsorption surfactant was measured through the use of the batch equilibrium tests. This involves destroying and soaking the material in the solvent volume at a certain concentration [15]. Moreover. The solvent was mixed and placed in the thermostatic air bath and after a day, it was measured using conductometer to decide the equilibrium condition residual concentration. Furthermore, the adsorption was measured using material balance However, isotherm adsorption was used to determine the equilibrium between the adsorbed quantity and the solute adsorbate concentration. The dynamic adsorption test was conducted by injecting the surfactant on the core. This was followed by the measurement of the concentration before and after the injection process. Consequently, the surfactant performance was reduced to decrease the stress on the interface of the oil and rock and the effect of the concentration after the process due to the absorption of the surfactant by reservoir rock. The adsorption mechanism involved the microemulsion made of surfactant solvent in the water, which was injected to the reservoir to influence the stress on the interface of oil and water. Besides, the surfactant directly touched the rock particles surface and its molecules (RSO_3H) were pulled and precipitated around the surface by the reservoir rock molecules. This process was continuous up to the saturation point. Moreover, the larger adsorption effect caused by the surfactant concentration was dense in the injection process [16]. It is important to state that the adsorption test was conducted statically and dynamically using UV spectroscopy to determine the residue of the concentration. The measurement method used depends on the kind of fluid to be measured.

2.1 UV- Vis Method

UV-Vis is a method used in measuring the concentration of a sample by shooting the UV ray to the sample. The first step includes finding the wavy long of surfactant sodium lignosulfonate as the reference. This was followed by making a standard curve to determine the surfactant concentration on the adsorption test. Moreover, the standard curve was drawn for several concentration variances which form the absorbent.

2.2 Titration Method

Titration is an economical and efficient method to measure surfactant concentration. The two primary methods are two phases and potentiometric titration. Two phases titration has a relatively simple process which only needs tools assembly but has a lot of adhering problems such as difficulty in assessing the end location, time consumption, harmful to the health due to the use of organic solvent, etc. [17]. Titration is conducted by using acidity degree and NaOH concentration. Concentration variance also influences the amount of surfactant adsorbed into the rock. Such that more adsorbed surfactant leads to a higher concentration.

2.3 Pycnometer Method

The pycnometer is a tool to measure solvent density during the adsorption test to show the quantity of surfactant adsorbed by measuring the density deviation before and after the test. The process can also be conducted on brine variation due to its ability to detect mass alteration of the composition.

3 RESULT AND DISCUSSION

Surfactant injection using SLS surfactant from bagasse is carried out with a variety of surfactant concentrations and brine salinity. Surfactant concentration varies from 1% - 4.5%, while brine salinity uses variations from 5,000 ppm-80,000 ppm. Of the various variations of surfactant injection, only the highest yields and the lowest yields are discussed in this paper. The highest oil recovery was in fact the surfactant injection with a composition of 1.5% surfactant at 80,000 ppm salinity which reached a recovery factor of 10.71%. While the lowest oil recovery occurs in surfactant injection with a composition of 4.5% surfactant at a salinity of 20,000 ppm which is only 1.05%. The mechanism of SLS surfactant performance is what causes the oil recovery. The low of oil recovery could be due to the lack of SLS surfactants working in the area. It means that there are a number of SLS surfactant masses lost, some of which are absorbed into the rock. So the adsorption parameter is one of the parameters that needs to be known to maintain the success of oil recovery. Table 1 below shows the adsorption test result of the surfactant injectionat the higest and the lowest yields :

TABLE 1

Surfactant Injection and Adsorption Result[18]

No.	Surfactant Composition	Static Adsorption (%)	Dynamic Adsorption (%)	Recovery Factor (%)
1.	20,000 ppm 4.5%	20.533	29.16	1.05
2.	80,000 ppm 1.5%	8.071	1.37	10.71

At the surfactant with 20.000 ppm-4,5% salinity, a static adsorption score of about 20,533% was found and this is more than the 8,071% obtained for 80.000 ppm-1,5%. Meanwhile, dynamic adsorption test showed 20.000 ppm 4,5% composition has 29,16% while 80.000 ppm 1,5% has only 1,37%. This means surfactant composition 20.000 ppm-4,5%composition absorbed more SLS surfactant to the core rock, hence, its performance was less than for 80.000-1,5% composition which absorbed few quantities. The figure below shows the oil acquired through the surfactant injection to be as follow:

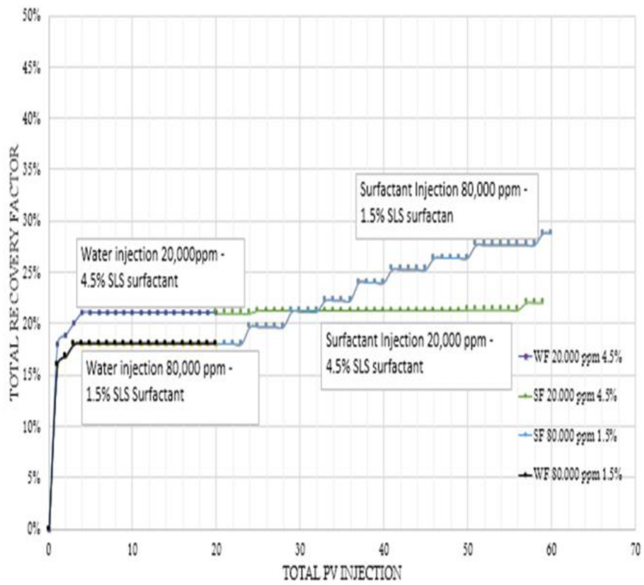

***Fig.1**. Results of SLS Surfactant Injection from Bagasse[18]*

The figure shows the highest oil acquisition of 10,71% at 80.000 ppm – 1,5% salinity and the lowest value of about 1.05% at 20.000 ppm – 4,5%.Furthermore, it was discovered that the SLS surfactant performance fron the bagasse was also influenced by the adsorption test result of the two compositions as shown in Table 1 above. A large difference was observed in their adsorption value with the 20,000 ppm – 4.5% proportion observed to have the highest values for static and dynamic adsorption at about 20.533% and 29.16% respectively. Therefore, it can be deduced that about 20% - 30% of the SLS surfactant of bagasse would be adsorbed into the rock and only 70% - 80% has the ability to form an emulsion and decrease IFT [21],[23]. Different adsorption value of about 8.07% and 1.37% were observed for 80,000 ppm 1.5%. This shows it adsorbed a little quantity of SLS surfactant into the rock and has more to form an emulsion and decrease more IFT [22],{24],[25]. As mentioned by previous researchers that adsorption is influenced by concentration [9][27]. Such that a higher concentration increases the adsorption score in the system. This is reflected in the results in Table 1 where 4.5% concentration gives a higher adsorption value [20][26][28][29]. than 1.5%. Therefore, it can be concluded that the 80,000 ppm 1.5% was able to give better performance in the EOR process and produced a higher RF result than 20,000 ppm 4.5%.

4 CONCLUSIONS

It is concluded that the adsorption parameter was found to influence the success of surfactant injection process as well as the concentration used as the injection fluidal. Moreover, low concentration generated higher oil acquisition due to the small monomer interaction of the surfactant with rock surface leading to a lot of small adsorbed surfactant. Therefore, it was discovered that a lot of surfactants are needed to decrease IFT and form microemulsion. Moreover, low concentration was found to produce good performance.

ACKNOWLEDGMENT

We are grateful to the Trisakti University and Bandung Technology Institution (Ogrindo) for the laboratory facilities and the University Directorate for the research grant. We also expresses gratitude to the Internasional Conference of Science, Education, and Humanities (ICSEH) 2019 and IJSTR for publishing this paper.

REFERENCES

[1] Baviere M, Bazin B, Noik C, Surfactants for EOR: olefin sulfonate behavior at high temperature and hardness. SPE Reserv Eng 3(2):597–603, 1988.

[2] Donaldson EC, Chilingarian GV, Yen TF , Enhanced oil recovery, II: Processes and operations. Elsevier, 1989.

[3] Trushenski SP, Dauben DL, Parrish , Micellar flooding-fluid propagation, interaction, and mobility. Amoco Production Co,Tulsa, 1974.

[4] Meyers, K.O. and Salter, S.J.: "The Effect of Oil/Brine Ratio on Surfactant Adsorption from Microemulsion," SPEJ (Aug. 1981) 500-12, 1981.

[5] Dang CTQ, Chen Z, Nguyen NTB, Bae W, Phung TH , Development of isotherm polymer/surfactant adsorption models in chemical flooding. SPE Asia pacific oil and gas conference and exhibition Held in Jakarta, Indonesia (SPE 147872), 2011.

[6] Paria S, Khilar KC , A review on experimental studies of surfactantadsorption at the hydrophilic solid–water interface. Adv Colloid Interface Sci 110(3):75–95, 2004.

[7] Somasundaran P, Huang L , Adsorption/aggregation of surfactants and their mixtures at solid–liquid interfaces. Adv Coll Interface Sci 88(1–2):179–208, 2000.

[8] Zhang R, Somasundaran P , Advances in adsorption of surfactants and their mixtures at solid/solution interfaces. Adv Colloid Interface Sci 123–126(SPEC. ISS.):213–229, 2006.

[9] Azam MR, Tan IM, Ismail L, Mushtaq M, Nadeem M, Sagir M, Kinetics and equilibria of synthesized anionic surfactant onto Berea Sandstone. J Dispers Sci Technol 35(2):223–230, 2014.

[10] Kamal MS, Hussein IA, Sultan AS , Review on surfactant flooding: phase behavior, retention, ift, and field applications. Energy Fuels 31(8):7701–7720, 2017.

[11] Siracusa PA, Somasundaran P , The role of mineral dissolution in the adsorption of dodecyl benzenesulfonate on kaolinite and alumina. Colloids Surfaces 26(C):55–77, 1987.

[12] Belhaj AF, Khaled Abdalla Elraies1 · Syed Mohammad Mahmood1 · Nazliah Nazma Zulkifli2 ·Saeed Akbari1 · Osman SalahEldin Hussien, The effect of surfactant concentration, salinity, temperature, and pH on surfactant adsorption for chemical enhanced oil recovery: a review, Journal of Petroleum Exploration and Production Technology, https://doi.org/10.1007/s13202-019-0685-y, 2013.

[13] Baral, S. N. Das, and P. Rath, "Hexavalent chromium removal from aqueous solution by adsorption on treated sawdust," Biochemical

Engineering Journal, vol. 31, no. 3, pp. 216–222, http://dspace.nitrkl..ac.in/dspace , 2006

[14] Desta Mulu Berhe, Batch Sorption Experiments: Langmuir and Freundlich Isotherm Studies for the Adsorption of Textile Metal Ions onto Teff Straw (Eragrostis tef) Agricultural Waste, Journal of Thermodynamics, Volume 2013, Article ID 375830, 6 pages, http://dx.doi.org/10.1155/ 2013/ 375830, 2013.

[15] Ahmadi, MA., Seyed Reza Shadizadeh, Experimental Studies of an Anionic Surfactant Adsorption onto Silica Surface, Journal of American Science 2018;14(8), http://www.jofamericanscience.org , 2018

[16] Makmur, T. dan R. Sudibjo, Penggunaan Surfaktan dan Cosurfactant Terhadap Peningkatan Perolehan Minyak. PPPTMGB Lemigas, Jakarta., 2000.

[17] Bian Yu, Manual for Surfactant Tritation, Rice University, http://porousmedia.rice.edu/ , 2010.

[18] Setiati, R.: Synthesis and Characterization of Sodium Lignosulfonate From Bagasse: The Effects of Concentration and Salinity toward the Performance of Oil Injection in Core, [Dissertation], Bandung, Indonesia, Bandung Institute of Technology(ITB); 2017

[19] Makmur, T. dan Nuraini. 2005. Peningkatan Perolehan Minyak dengan Metode Injeksi Surfaktan Petroleum Sulfonat Secara Skala Laboratorium. Lembaran Publikasi Lemigas Vol. 39 No. 1, September 2005 : 49-52. , 2005

[20] Fathaddin M.T.1, Rachmat Sudibjo1, Kartika Fajarwati H.1, Shabrina Riswati1,2, , 2019, Simulation Model Application to Predict the Effect of Salinity on Surfactant Adsorption and Retention in Alkali Surfactant Flooding, Journal of Earth Energy Science, Engineering, and Technology, Vol. 2, No. 2, 2019,

[21] Tahmineh Amirianshoja n, Radzuan Junin, Ahmad Kamal Idris , Omeid Rahmani, A comparative study of surfactant adsorption by clay minerals, Journal of Petroleum Science and Engineering 101 (2013) 21–27, http://dx.doi.org/10.1016 /j.petrol.2012.10.002 , 2013.

[22] Mucic Nenad, Javadi Allyard, Karbaschi M, Kovalcuk Nina M, Surfactant Adsorption Kinetics, Encyclopedia of Colloid and Interface Science, https://www. researchgate.net/ publication/ 257927976, DOI: 10.1007/ 978-3-642-20665-8_72, 2013.

[23] Andrew G. Hsieh,† Christian Punckt,†,‡ Sibel Korkut,†,‡ and Ilhan A. Aksay, Adsorption of Sodium Dodecyl Sulfate on Functionalized Graphene Measured by Conductometric Titration, American Chemical Society, dx.doi.org/10.1021/ jp403876t | J. Phys. Chem. B 2013, 117, 7950−7958 , 2013.

[24] Bogumil E. Brycki, Iwona H. Kowalczyk, Adrianna Szulc, Olga Kaczerewska and Marta Pakiet, Multifunctional Gemini Surfactants: Structure, Synthesis, Properties and Applications, Intechopen, http:// dx.doi.org/10.5772/ intechopen.68755 , 2017.

[25] Dukhin, AS, Goetz PJ, Characterization of Liquid, Dispersion, Emulsion and Porous Material Using Ultrasound, Doi http://doi.org/10.1016/C2016-0-00815-X, 2017

[26] Abbas A., Sulaiman WRW, Jaffar MZ, Augustine A., Anionic Surfactant Adsorption: Insight for Enhanced Oil Recovery, Recent Adv Petrochem Sci 1(5): RAPSCI.MS.ID.555574 , 2017.

[27] Elias SD, Rabiu AM, Oluwaseun O., Seima B., Adsorption Characteristics Of Surfactants On Different Petroluem Reservoir Materials, The Online Journal of Science and Technology - October , Volume 6, Issue 4, 2016.

[28] Tang Z., Zheng J., Han Y., Sun G., Hu S., Wang Y., Zhou J., Adsorption characteristics of surfactants on secondary wood fiber surface,, Journal of Bioresources and Bioproducts. , 1(2):64-73, 2016.

[29] Amid H, Mazé B., Flickinger MC., Pourdeyhimi B., Dynamic adsorption of ammonia: apparatus, testing conditions, and adsorption capacities, Measurement Science and Technology, Volume 28, Number 5, IOP Publishing , DOI: 10.1088 /1361-6501/aa6236, 2017