Proceeding of Chemistry Conferences, Volume 2 (2017) ISSN: 2541-108X

The Screening Test Interfacial Tension of Palm Based Surfactant for Enhanced Oil Recovery (EOR) Application

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Abstract. Sodium Methyl Ester Sulfonate (SMES) surfactant is one type of anionic surfactant which has advantages in terms of detergency, hardness, renewable and environment-friendly. Excess surfactant SMES could be utilized in the process of oil displacement through EOR technology (Enhanced Oil Recovery / Tertiary Recovery) which is a technology that involves the injection of a material that can cause changes in fluid properties and reservoir rocks such as oil composition, temperature, ratio mobility and characteristics rock-fluid interactions. The use of SMES Surfactant is intended to determine the value of interfacial tension (IFT) between oil-water so as to lift the oil to come out of the pores of reservoir rocks. The EOR surfactant must meet one of the testing parameter screening is the IFT measurement. The surfactant formulation determining by optimum range concentration from 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7%, 0.8%, 0.9% and 1% of SMEs w/w dissolved with formation water or water injection by heating to 50 °C solution temperature is reached. The best screening results contained at a concentration of 0.3% with a IFT value $<10^{-3}$ dyne / cm.

1. Introduction

Surfactant are compounds that lower the surface tension or interfacial tension between two liquids or between a liquid and a solid. Surfactants are usually organic compounds that are amphipilic, meaning they contain both hydropobic groups (their tails) and hydrophilic (their heads) [1][2]. Therefore, a surfactant contains both a water insoluble (or oil soluble) component and a water soluble component. Surfactants will diffuse in water and absorb at interfaces between air and water or at the interface between oil and water. The water insoluble hydrophobic group may extend out of the bulk water phase, into the air or into the oil phase, while the water soluble head group remains in the water phase [3].

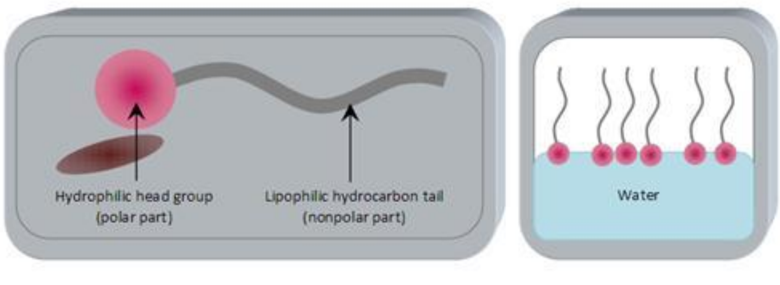

Figure 1. Surfactant molecule and surfactant orientation in water. Surfactant are also referre to as amphiphile molecules because they contain a nonpolar "tail" and a polar "head"- gropu within molecule, [3].

Surfactants is used in EOR application other than petroleum sulfonate i.e surfactants derived from palm based oil is called Methyl Ester Sulfonate (MES). Methyl Ester Sulfonate (MES) is one type of anionic surfactants produced from raw materials from palm oil produced using reactant gas this loses at a temperature of 80-90 °C process [4][5]. Surfactants MES developed are eco-friendly from Palm oil. Several important factors for determining the quality of the resulting including MES surfactants ratio of moles of reactants, the reaction temperature, reaction, concentration of old cluster sulfate is added, the time of neutralization, the type and concentration of catalyst neutralization, pH and temperature [6].

Surfactants MES made using methyl ester from Palm oil. Research on the production of MES has been continuously performed by the SBRC-IPB. Production of MES is done in several stages, namely the stage of sulfonasi process starts with the intake of methyl ester raw material and SO^3 gas to sulfonasi reactor and subsequently followed by the stage of aging and the stage of neutralization [7][8].

Figure 2. Product of Methyl Ester Sulfonic

Figure 3. Formulations of surfactants formulated using water formation or water injection

MES products obtained are very acidic, high viscosity and black color. The black color is nature produced by the process of sulfonasi Methyl Ester (ME) and these surfactant has a lower perfomance interfacial tension (IFT) [9].

2. Relation of EOR Technology and Interfacial Tension

Indonesia's oil reserves dwindling each year. The amount of oil that is manufactured is larger when compared with the value of new reserves are found. In anticipation these imbalances, the Government has undertaken various efforts in increasing the lifting of oil. In addition to exploration activities, another attempt could be made to increase the lifting of oil is through Enhanced Oil Recovery (EOR). Several mechanism contribute to the primary production of oil.

Primary production is in general understood as rather inefficient, as it produces less than 20% of the original oil in place [10]. With the goal of improving oil recovery, EOR is introduced, employing more efficeient recovery methods. Oil recovery methods usually fall into one of the following three categories :

- Primary recovery : Recovery by depletion
- Secondary recovery :Recovery by water or gas flooding
- Tertiary recovery : Recovery of the residual oil (also known as Enhanced Oil Receovery, EOR)

One of the EOR methods applied is a chemical injection-based surfactants. Surfactant flooding is an example of chemical flooding. The technique creates low interfacial tension (IFT), where especially an ultra low IFT (0.001mN/m) between the displacing fluid and the oil is a requirement in order to mobilize the oil residual. On the EOR application, surfactants S-MES will interact with water formation and or water injection, oil, and reservoir rocks at a specific temperature and pressure [11].

Interfacial tension is a energy at the interface of two liquid phases that cannot miscible. Interfacial tension is proportional to the surface tension of the interfacial tension. But the value, will always be smallert than the surface tension at the same concentration [12]. IFT is the ones of the most important parameter for chemical EOR [13][14]. This paper aims to found the effectiveness performance of surfactant-based Palm oil S-MES in lowering the value of IFT in various concentrations of surfactants for various oil field in Indonesia.

3. Methodology

This test is done in the laboratory of Surfactant and Bioenergy Research Center (SBRC) LPPM IPB, Bogor-West Java. The methodology is testing optimal formula of surfactants with a range of different concentration on temperature reservoir. Surfactants S-MES formulated with water injection or water formation each field of X, Y, and Z and mixed above the hot plate with temperature ± 50 °C warming while 30-45 minutes, then the sample of formulation was tested IFT values with each crude oil (X,Y,and Z Field) with different reservoir temperature using Spinning Drop Tensiometer TX500C with 6000 RPM spin speed.

4. Results and Discussion

The formula used is surfactants S-MES. Test screening formula surfactants S-MES was IFT tested against three oil field i.e., X, Y, and Z.S-MES surfactants formulated using water injection and water formations each field and tested. The best formulation chosen i.e. a formula that is able to provide the lowest decrease IFT 10^{-3} dyne/cm.This test is equipped with supporting data reservoir of oil field "X", “Y”, and “Z” because oil composition is very important to surfactants, as is affects the range of salinity within which the interfacial tension is low.

4.1. Screening IFT Results on “X” Field at Reservoir Temperature of 60 °C and 70 °C

On “X” field conducted a IFT test against two different reservoir temperature i.e 60 °C and 70 °C with fluid characteristics is presented in table 1.

Table 1. Fluid Properties of Crude Oil “X” Field Used Interfacial Tension Measurement.

Density (g/cm³)		API Gravity		Viscosity (cP)	
60 °C	70 °C	60 °C	70 °C	60 °C	70 °C
0.7542	0.7735	46.34	41.89	0.82	0.77

IFT test results in Figure 2 on the concentration of surfactants 0.1%, 0.2%, 0.3% and 0.4% give the lowest value IFT 10^{-3} dyne/cm. Lowest value is showed concentration 0.3% i.e. ranges of 2.62 x 10^{-3} dyne/cm for reservoir temperature 70 °C and 1.05 x 10^{-3} dyne/cm for reservoir temperature 60 °C. In the field “X” S-MES surfactants formulated with water injection, optimal surfactants results are presented in figure 4.

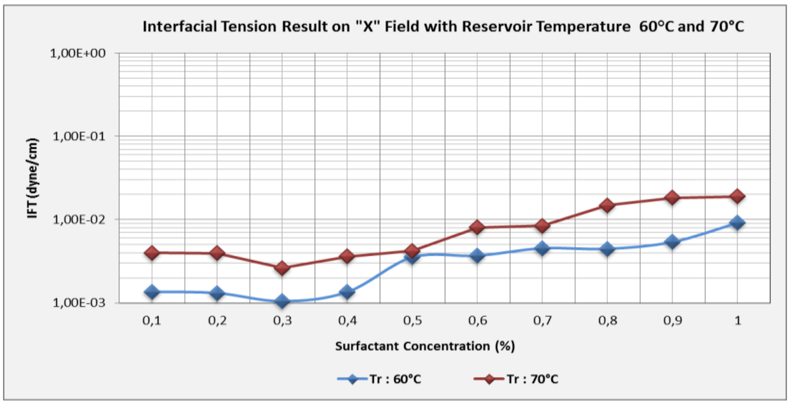

Figure 4. Interfacial tension vs surfactant concentration on”X” Field

4.2. Screening IFT Results on “Y” Field at Reservoir Temperature of 60 °C

On “Y” Field conducted a IFT test against with reservoir temperature i.e 60 °C with fluid characteristics is presented in table 2. Oil field "Y" has four well monitors, therefore testing IFT measured against four types of crude oil from each oil wells i.e. CO Y02, CO Y03, CO Y04 and CO Y05, formulated with water formation.

Table 2. Fluid Properties of Crude Oil "Y" Field Used Interfacial Tension Measurement.

"Y" Well	Density (g/cm³)	API Gravity	Viscosity (cP)
CO Y-02	0.8282	32.80	3.16
CO Y-03	0.8307	32.33	2.94
CO Y-04	0.8292	32.60	2.96
CO Y-05	0.8295	32.61	2.66

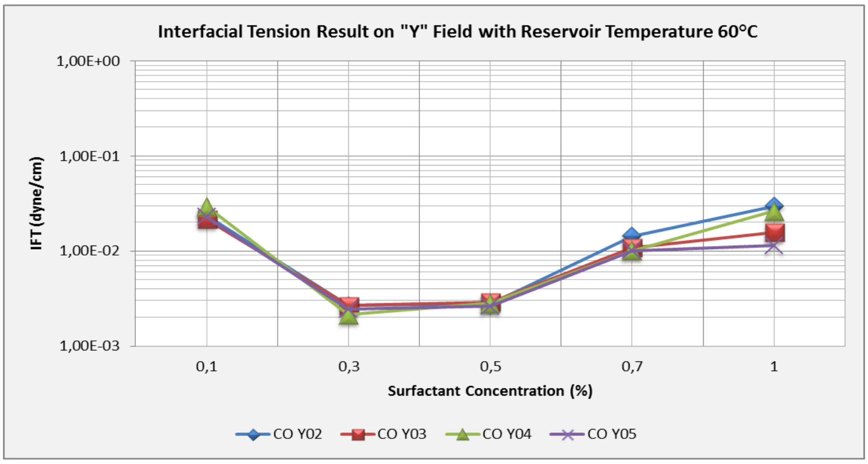

Figure 5. Interfacial tension vs surfactant concentration on"Y" Field

The test results at Figure 5 of IFT with surfactant concentration 0.3% giving the lowest value 10^{-3} dyne/cm. Value of IFT surfactant concentration is showed 0.3% i.e. range from 2.14 $x10^{-3}$ dyne/cm consisting of up to $2.91x10^{-3}$ dyne/cm. IFT will Value will increase if the concentration of the surfactant is added.

4.3. Screening IFT Results on "Z" Field at Reservoir Temperature of 60 °C

On oil field "Z" screening test conducted at a temperature of IFT reservoir 60 °C fluid characteristic six wells is presented in table 3. The temperature measured at IFT test with six different types of crude oil. Types of crude oil field owned by the "Z" is the value of the average is around 40API gravity which means that "Z" field is a category of light oil.

Table 3. Fluid Properties of Crude Oil "Z" Field Used Interfacial Tension Measurement.

"Z" Well	Density (g/cm³)	API Gravity	Viscosity (cP)
CO Z-A1	0.79729	38.66	0.88
CO Z-A2	0.79355	39.38	0.85
CO Z-09	0.77958	42.23	1.06
CO Z-16	0.78275	41.58	1.05
CO Z-21	0.78771	40.58	0.98
CO Z-64	0.78406	41.32	1.24

In the field "Z", S-MES surfactants formulated with water formation and optimal surfactants results are presented in figure 6. The presence addition of surfactant concentrations up to 1% makes the value of IFT is getting up. The optimal concentration of surfactant concentration range are at a low 0.3% with a value of IFT consisting of $2.91x10^{-3}$ dyne/cm to $4.47x10^{-3}$ dyne/cm.

Surfactants S-MES could be stable up to 150°C with optimal salinities up to 30.000 PPM. The application conditions of a surfactant mean that not only is the surfactant stable at these conditions, but it also must be able to satisfy other conditions which can lead to a high oil recovery at a low cost, such as low adsorption and higher solubilization ratios.

Surfactant S-MES formulation has been done in the laboratory and having properties very low interfacial tension 10^{-3} dyne/cm. In addition this surfactant has also very good properties that fullfill the criteria for enhanced oil recovery. Surfactant S-MES produced from palm oil will be very potential for subtitusing surfactant-crude oil based normally used in oil industries and the palm is available in Indonesia.

These surfactants candidats are available at low and have been tested in different reservoir temperature resulting in enhanced oil recovery and low surfactant retention.

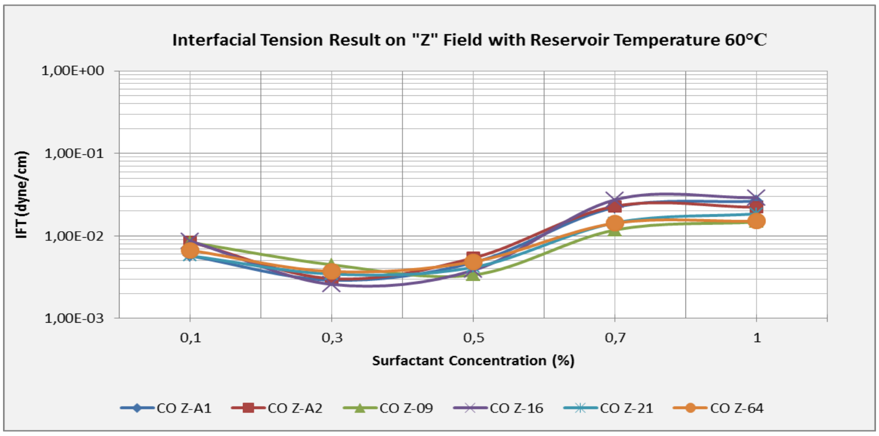

Figure 6. Interfacial tension vs surfactant concentration on"Z" Field

5. Conclusion and Recomendation

The best of surfactant S-MES formulation is preffered 0.3% optimal concentration.The value of IFT will be high if the concentration of the surfactant is added, so this formula can be applied as chemical flooding to injected into the reservoir. The ability of surfactant S-MES in the application of EOR is expected not only to increase the efficiency of oil impostion but can also supress the high cost of chemicals. The advantages of surfactant S-MES is a very cheap, eco friendly, and renewable able to lower the interfacial tension compare with petroleum sulfonate. Further development of surfactant needed for the reservoir that has the type of heavy oil. The surfactant formula must be specific and adjusted with the characteristics of the reservoir in Indonesia are very diverse.

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