

# Influence of middle phase emulsion and surfactant concentration to oil recovery using SLS surfactant synthesized from bagasse

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**Abstract.** The purpose of this study was to determine the effect of surfactant concentration and middle-phase emulsion on oil recovery in EOR process. In this research, the phase-behavioral test with observation of SLS surfactant of bagasse of three kinds of crude oil is light oil (42°API), intermediate oil (25°API) and heavy oil (18°API). From the results of these observations, it turns out SLS surfactant bagasse to form emulsion on light oil. The surfactant composition of SLS bagasse which mostly forming the middle phase emulsion (microemulsion) which is 10% is in the proportion of 10.000 ppm -1.5% composition while the surfactant composition of SLS is the smallest emulsion the middle phase (0%) is in the proportion of the composition of 20,000 ppm 4.5% and 40,000 ppm 4%. The highest injection result occurred in the surfactant composition of 1.5% with salinity 80.000 ppm which resulted in addition of recovery factor of 10.71%. While the lowest SLS surfactant injection occurred at a surfactant composition of 4.5% at salinity 20,000 ppm which only gained 1.05% recovery factor. Thus, it can be concluded that the recovery factor in the EOR process is determined by the formation of a sufficient middle phases emulsion at a small concentration of SLS surfactant.

**Keywords:** bagasse, microemulsion, middle phasa emulsion, oil recovery, surfactant SLS

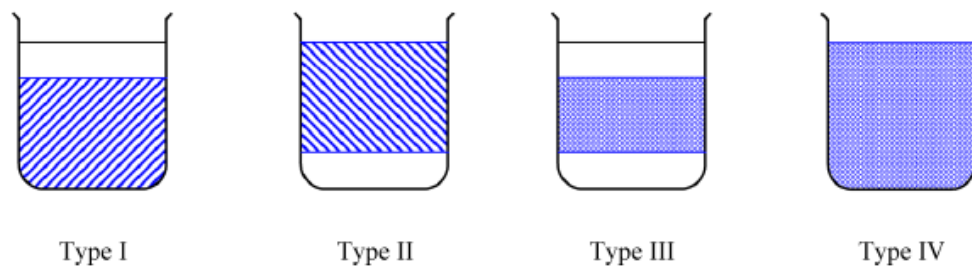
## 1. Introduction

The current surfactant injection is an anionic surfactant [8] with one of the most commonly used materials in the world being lignosulfonate [3]. The commonly used sulfonate is petroleum sulfonate based petroleum [7] and this is not cheap because of fluctuation oil prices. The presence of a sulphonate unit increases the long-term stability of the surfactant at higher reservoir temperatures (Hirasaki, 2011). Actually lignosulfonate can be synthesized from bagasse. Lignin contained in bagasse is processed by sulfonation process into lignosulfonate. This lignosulfonate product is known as sodium lignosulfonate (SLS) surfactant. Thus, this study used SLS surfactants synthesized from the bagas as a chemical liquid injected into the core.



## 2. Methodology

This research uses laboratory method, using SLS surfactant synthesized from bagasse as chemical fluid which is injected into cores containing light crude oil. Characteristic tests performed on surfactant include aqueous stability test, phase behavior test, middle emulsion test and IFT test. Microemulsions, as investigated by Winsor [12] observed that when water (or aqueous salt solution) and organic liquids (either mixtures or single substances) are mixed with the corresponding quantity of the surfactant balance system may be IV result. There are four main types of balance systems; type I, II, III and IV as seen in the picture below.



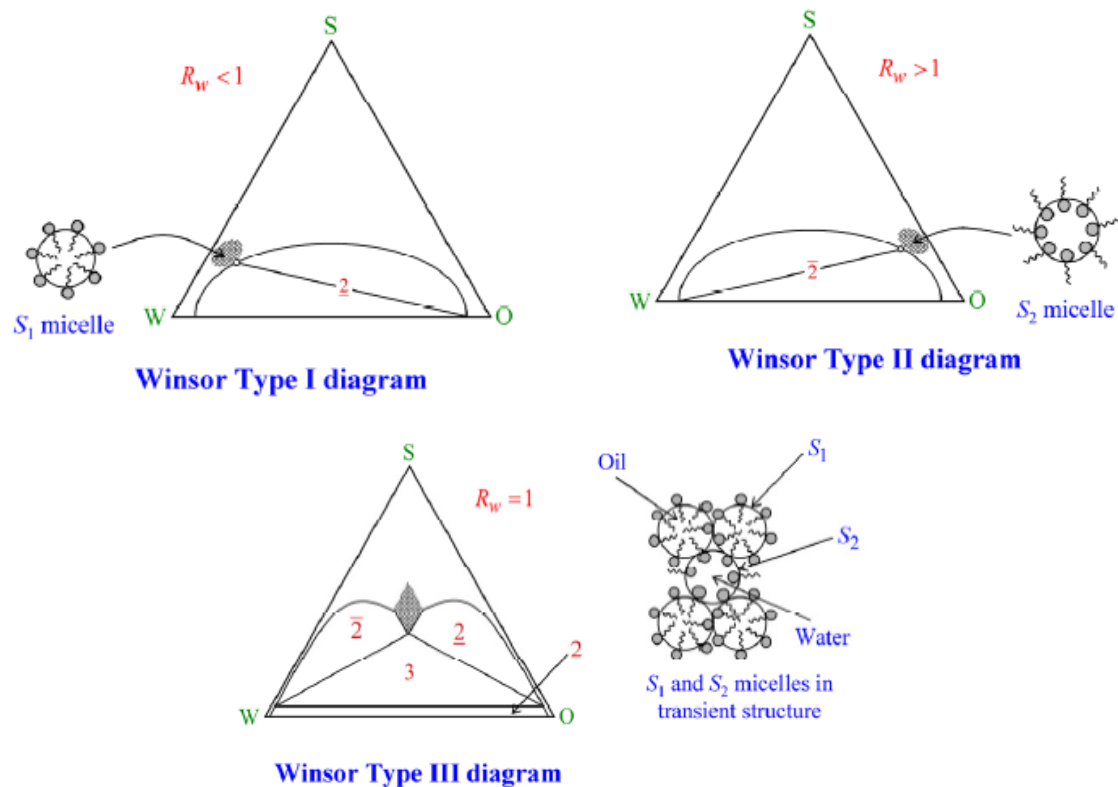
**Figure 1.** Winsor systems of types I–IV [12]

$R_w$ , (termed *Winsor ratio*) is defined as,

$$R_w = \frac{\text{solvent attraction between surfactant and oil in the solubilized phase}}{\text{solvent attraction between surfactant and water in the solubilized phase}}$$

Type III is a system that is expected system of the mechanism the injection surfactant. The microemulsion phase in this equilibrium is also known as middle phase microemulsion. In this condition free organic and aqueous phases are in equilibrium with a third solubilized phase containing the three components. Therefore, the middle phase emulsion coexists with both the phases [12].

Between type I and II, it is expected that the tie line as a horizontal line to the same surfactant conditions in both phases. The type III phase behavior shown in Figure 2, the polyphic region contains a three phase zone surrounded by two phase zones. The composition system is located in a separate three-phase zone into a surfactant-rich phase in the middle of the diagram at the boundary of a single-phase microemulsion (shaded area), and the remaining two phases, which are essentially liquid and oils. This microemulsion phase is called the middle phase as occurs between the oil and water phases when prepared in the reaction tube because of the medium density. This three-phase system has been extensively studied for their interest in improving oil recovery [1]. So for an improved oil recovery process preferred type III emulsion.



**Figure 2.** Diagram Ternary for Type I, II and III [1]

### 2.1 The materials used

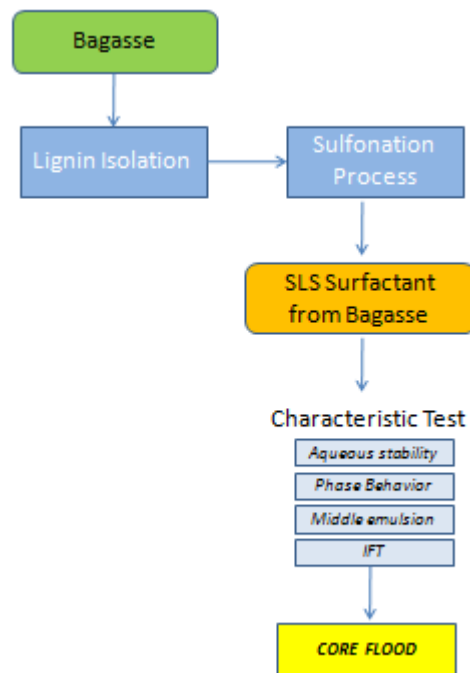
The materials used in this research include light crude oil as sample crude oil, SLS surfactant from bagasse as chemical injection, and NaCl as raw material of brine synthetic.

### 2.2 Tools used

The tools used include test tubes for aqueous stability testing, scala reaction tubes for measuring phase behavior and emulsions. Ovens are used in phase behavior measurements for emulsion stability and spinning drop are used IFT measurement.

### 2.3 Research scheme

This research step can be seen like the scheme below.



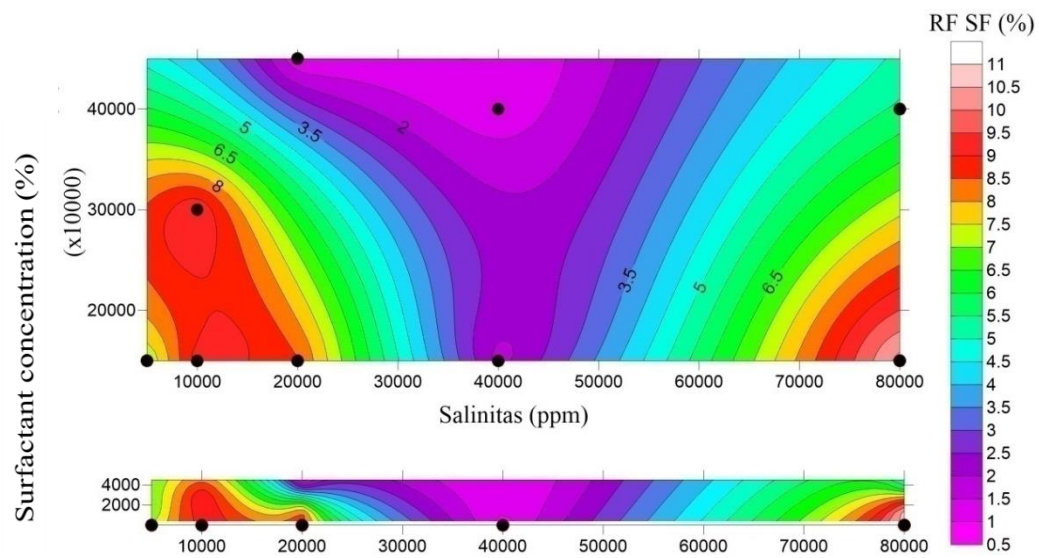
**Figure 3.** Research scheme

Bagasse as raw material is processed first into SLS surfactant using isolation process and sulfonation process. Then test the characteristics of the SLS surfactant before the injection process in the core injection. Test performed include aqueous stability test, phase behavior test, middle emulsion test and IFT test.

### 3. Result

**Table 1** The result of surfactant injection using SLS Surfactant Bagasse

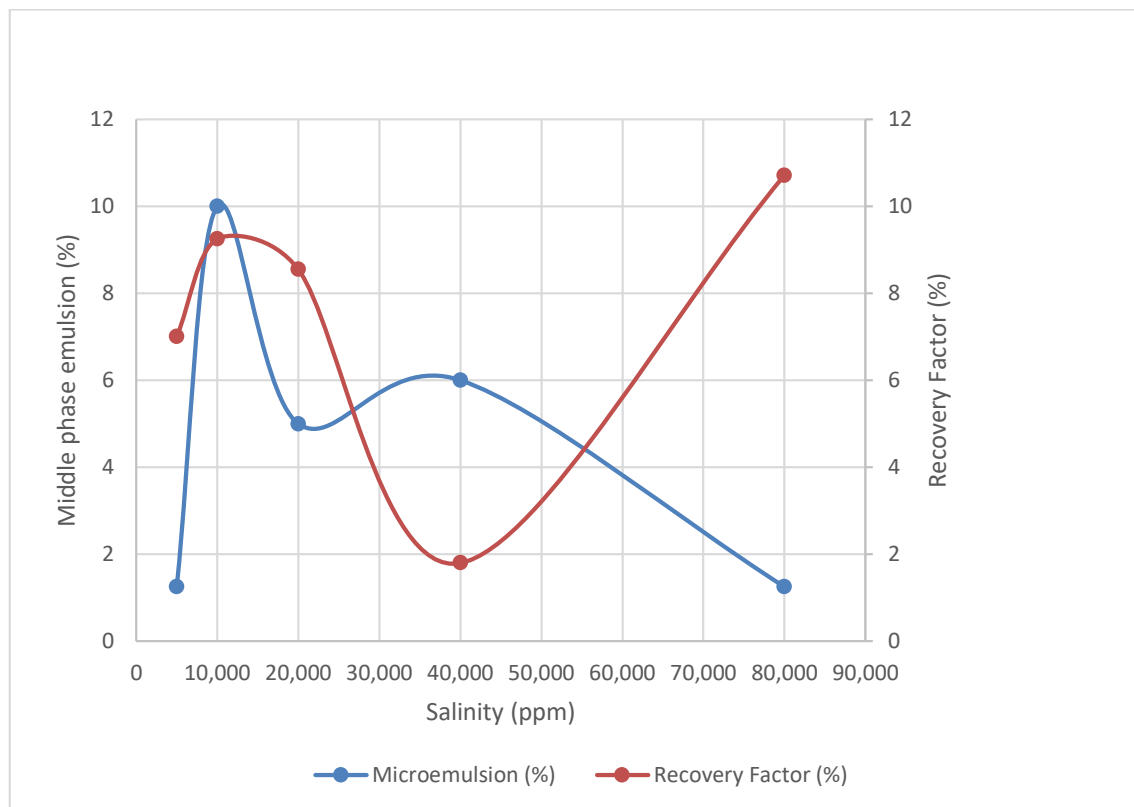
No.	Salinity (ppm)	Surfactant Concentration(%)	Middle Phase Emulsion	Recovery Factor (%)
1.	5.000	1,5	1,25 %	7,00
2.	10.000	1,5	10,00 %	9,25
3.	10.000	3	7,50 %	9,50
4.	20.000	1,5	5,00 %	8,55
5.	20.000	4,5	0,00 %	1,05
6.	40.000	1,5	6,00 %	1,80
7.	40.000	4,0	0,00 %	1,16
8.	80.000	1,5	1,25 %	10,71
9.	80.000	4,0	1,00%	5,60



**Figure 4** Relationship of salinity, surfactant concentration and Recovery Factor (RF) surfactant injection SLS bagasse

**Table 2** Recovery Factor vs Middle Phase Emulsion (1.5% surfactant concentration)

No.	Salinity (ppm)	Middle Phase Emulsion	Recovery Factor (%)
1.	5.000	1,25 %	7,00
2.	10.000	10,00 %	9,25
3.	20.000	5,00 %	8,55
4.	40.000	6,00 %	1,80
5.	80.000	1,25 %	10,71



**Figure 5.** Correlation of salinity, middle phase emulsion and recovery factor

#### 4. Discussions

From figure 4, the largest recovery factor is seen in the red - orange area. In the picture, there are 2 areas that have large recovery that is left area with salinity 5,000 - 20,000 ppm and right area with salinity 70,000 - 80,000 ppm. These areas form large recovery at 1% - 3% surfactant concentration (low salinity) and 1% - 2% surfactant concentration (high salinity). When associated with table 1 of the surfactant injection results, a high increase in enhanced oil recovery occurred at a surfactant concentration of 1.5%. According to Shah [11] the concentration of certain surfactants will form self aggregates and form the critical micelle concentration (CMC) which makes it function as surface agent (surfactant). CMC usually shows a small range of areas, meaning that the surfactant can formed of misellar and reacting as an emulsion.

There are two mechanisms, in which micelles can be formed and destroyed, that is, at low salt concentrations, ionic changes of their aggregate amounts regularly, whereas for high salt concentrations, micelles can also join and break into pieces [5]. The critical micelle concentration (CMC) is the most widely used parameter for characterizing surfactants. This CMC parameter characterizes the molecular surface activity. The CMC shows the micelles present in the surfactant solution that determine the use of the surfactant [2].

Thus at higher salt concentrations there is an ionic change in the surfactant with micelles that are fragmented so as to make less emulsion well. The blue curve shown in Figure 5 shows the condition. But the recovery factor results in an increase of 80,000 ppm salinity. Gosh [1] explain, if the salt concentration increases, the factor becomes less and the average droplet radius increases. At certain salt concentrations, the contribution of the electrostatic double layer and hydrocarbon chains will balance each other, and the structure with zero means the expected curvature occurs at this point. Some structures like flat monolayer and cubic phase can be here. Since fluctuations around curvature

mean are expected to exist, it is not easy to predict a stable structure. If the salt concentration increases further, the positive water-in-oil microemulsion (ie, Winsor Type II system) and becomes stable and switch to type III (middle phase emulsion).

In this study it appears that the concentration of the surfactant is low enough to obtain a good recovery factor. As seen in Table 1, surfactant concentrations exceeding 1.5% resulted in a smaller recovery factor as well. Higher salt concentrations will become fragmented and produce emulsions (7.5%) at salinity 10,000 ppm-3% surfactant, at salinity 20,000 ppm-4.5% surfactant does not produce emulsion (0%). So the addition of salinity makes the micelles also able to join and but breaks into some parts so the middle phase emulsion becomes unstable. In general, the emulsion can be stable due to the presence of an emulsifying agent located in the interface. Surfactants may play an important role in the formation and stability of the emulsion, which can lead to several things: lowering the interfacial tension; increase surface elasticity; increase the electric double layer repulsion (ionic surfactant); lowering Hamaker's effective constants; and increase surface viscosity. For maximum efficiency and maximum effectivity a good emulsifying agent has limited solubility in both the oil and water phase of the system. Emulsions also tend to be more stable when there is a package tighter than the hydrophobic group on the oil / water interface

The value of the middle-phase emulsion may increase in salinity increase but does not result in a decrease in interfacial tension so that under these conditions the SLS does not work effectively as a surfactant. The microemulsion composition according to Winsor III is characterized by very low interfacial tension and the maximum solubilization of oil and water for the quantity of surfactant provided. The system is said to be optimized or balanced. Transitions from Type I and Type II systems to Type III systems can be achieved by varying some parameters such as temperature, salinity, pH, oil / water ratio and molecular geometry [4]. From the results of this study, greater middle-phase emulsion values in greater salinity and surfactant concentration did not improve enhanced oil recovery.

## 5. Conclusion

Based on the research results can be taken some conclusions are:

1. Middle phase emulsion as a characteristic SLS surfactant affects the performance of the SLS surfactant in the enhanced oil recovery process.
2. Middle phase emulsion 1.25% good enough for enhanced oil recovery for injection core at low salinity.
3. Surfactant concentration is low 1.5% is good enough to produce good performance on SLS surfactant injection.

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