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Biosurfactan Injection of "U-Champ" on Heavy Oil Sample in Laboratory for Preliminary to Pilot Project

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Abstract*: *Biosurfactants "U-Champ" is made by microorganisms, it could be changes the fluid characteristics which are, viscosity and Interfacial tension (IFT). In this study, will be presented the effect of Biosurfactan "U-Champ" injection into the heavy oil sample on laboratory experiment. Viscosity and IFT measurement was carried out in this experiment to analyze the characteristic changes. Coreflooding experiment also occur to measure the incremental of oil recovery. We used some of concetration of Biousrfactant "U-Champ" (1%;2,5%;5%;10%). In this experiment, we found 5% concetration of Biosurfactant "U-Champ" as the CMC value. The result of observation indicates the reduction of viscosity from 5.57 cp to 1.76 cp at 30°C, and from 1 cp to 0.95 cp at 80°C, and reduced the IFT value from 10.05 mN/m to 3.81 mN/m. Based on the result, Coreflooding experiment was occur to measure the incremental of oil recovery and obtained the increasing of recovery factor from 37,5% after waterflooding process to 81,25%. Finally, this studies feasible to continue in pilot project.

Keywords*: *Biosurfactant "U-Champ", Enhanced Oil Recovery, Heavy Oil.

I. INTRODUCTION

The enhanced oil recovery research laboratory Petroleum Engineering Department UPN "Veteran" Yogyakarta, Indonesia has been succees in developing a bisourfactant product named "U-Champ" and tested will oil sample from several oilfields in Indonesia. Laboratory test were carried out for the physical properties of the fluid in the form of viscosity and interfacial tension before and after "U-Champ" treatment. The addition of "U-Champ" was started by using 1%, 2.5%, 5% and 10% concentration. This is done to determine the optimal concentration used [1]. This study tested the suitability of biosurfactant "U-Champ" in heavy oil sample. Compatibility of "U-Champ" can be seen from the decrease in the viscosity and IFT value. Furthermore, the corefolooding test is carried out on the artificial core to determine the incremental of oil recovery. This test carried out at several stages, which are waterflooding stage to measure the amount of oil recovery in the secondary recovery stage. The next stage is the process of biosurfactant "U-Champ" injection to measure the incremental of oil recovery after the secondary stages. The soaking process carried out to give a time for Biosurfactant "U-Champ" to react with the fluid in the rock sample. After that, Formation Water injected to sweep the remaining oil in the rock sample.

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II. BASIC THEORY

A. Biosurfactant

Biosurfactants are surfactants made by microorganisms, especially if they are grown on substrates that are not soluble in water. Unlike oil-based surfactants which are classified according to their natural polar group, biosurfactants are categorized according to their chemical structure and producing bacteria. In general, the biosurfactant chemical structure consists of hydrophilic groups containing amino acids or anions and cations of peptides, mono-, di-, or polysaccharides; and hydrophobic groups containing saturated and unsaturated fatty acids [2]. Based on its molecular size, biosurfactants can be divided into biosurfactants with low molecular weight and high molecular weight. Glycolipids and lipopeptides are low molecular weight biosurfactants, which function to reduce surface tension and tension between surfaces. While high molecular weight biosurfactants such as lipoproteins, lipopolysaccharides, and amphipatic polysaccharides are very effective for stabilizing oil emulsions in water. Based on its chemical structure, biosurfactants are classified as glycolipids; lipopeptide or lipoprotein; fatty acids, phospholipids, polymeric biosurfactants; and particulate biosurfactants.

III. METHODOLOGY

This study is conducted at Enhanced Oil Recovery Laboratory in Universitas Pembangunan Nasional "Veteran" Yogyakarta. Biosurfactant "U-Champ" formulated by previous researcher form Laboratory experiment. Oil Sample and brine sample for this study is obtained from kawengan oilfield in Cepu , East Java. Experiment of the sample was observed in the laboratory to measure its viscosity and IFT of this sample.

A. Viscosity Measurement

Brookfield Viscometer was used for viscosity measurement. The procedure is put the solution into the silinder tube and put the silinder tube into the Spindel.

Spindel ULA was used for this measurement. When the tube and spindel is installed put the parameter into the console and the measurement can be started. Do the measurement in several temperature to test the durability of the biosurfactant resistant to the temperature. In this study the measure temperature is 30-80°C.

B. IFT Measurement

Phase behavior dictates the selection of suitable components for use in a product. Components of liquid detergents, which are ordinarily concentrated solutions, must be selected with both phase behavior and utility in mind.

Microemulsions are thermodynamically stable dispersion of two immiscible liquids (oil and water) stabilized by surfactant films. Microemulsions can exist in four forms (Figure 2), known as Winsor type microemulsions. Type I (oil-in-water or O/W) microemulsions solubilize oil in spherical normal micelles within the water-continuous phase while Type II (water-in-oil or W/O) microemulsions solubilize water in reverse micelles within the oil-continuous phase. Type III microemulsions are three-phase systems in which the middle phase microemulsions are in equilibrium with both excess oil and excess water phases. Type IV microemulsions are the expansion of the middle phase microemulsions at high surfactant concentrations such that all the excess oil and excess water are incorporated into a single phase.

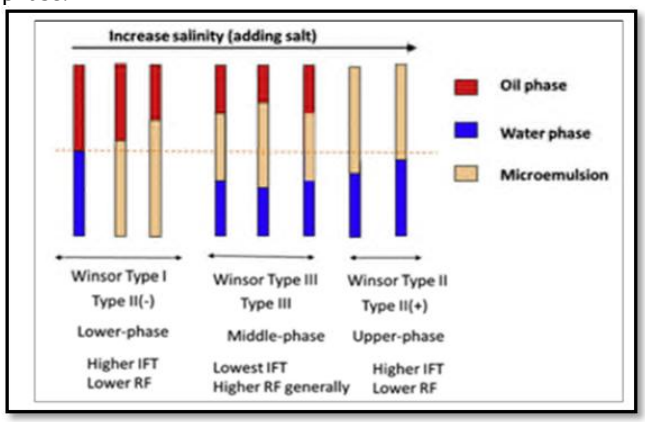

Figure 1. Four types of Winsor microemulsions [3].

The type of emulsion most expected in the EOR / surfactant injection process is the middle phase emulsion (phase form III) or microemulsion or at least a lower phase emulsion. In this condition, the resulting interfacial stress value is a very low IFT value so that the petroleum pressing process can be ascertained to be effective [3], [4].

C. Parameters considered in core flooding experiment

In this core flooding experiment, there are four important parameters that need to be considered Coreflooding Experiment.

Reservoir rock characteristics The composition of petroleum rocks varies in many materials which are from very loose and unconsolidated sand to very hard and dense limestone, dolomite and sandstone. The grains in petroleum rocks are cemented or bonded together due to chemical propertiesof several materials such as silica, clay and calcite. In order to evaluate the performance of a reservoir, it is very important to understand the interaction between petroleum and reservoir formation and the knowledge of reservoir rocks and fluid properties itself

Table-1: Core plug sample characterictic

Core Sample	Pore Volume, cc	Porosity, %	Permeability , mD
30-7	2,52	18,20	128
40-7	2,88	16,52	90

For research purpose, rock properties are analyzed using in this study was an artificial core. This core plug sampel made with some composition which are quartz sand and cement. This experiment used two different sampels of core plug that is differentiated by grain sorting from quartz sands. Grain sorting that used im this study was mesh 30 and mesh 40. Table below is show the characteristic of core plug sample used in the experiment.

D. Permeability

Permeability is being referred as the ability of the fluid to be transmitted through a formation. K, which is rock permeability, is the most important rock property that should be considered as this property controls the direction and flow rate of reservoir fluids in the formation. An equation was developed by Henry Darcy in 1856 to define permeability in terms of measurable quantities in order to express rock characterization which is being known as Darcy law [5]. In order to apply Darcy law equation, there are several assumptions that need to be considered which are Core Plug should be 100% saturated with flowing fluid. The fluid flow should be incompressible. The fluid flow should be horizontal, steady state and under laminar

E. Porosity

Porosity is referred at the measure of storage capacity of a reservoir rock to store fluids. Porosity is also defined as the ratio of the pore volume in a reservoir to the total volume (bulk volume) and is expressed as percentage. There are three types of porosity which are absolute porosity, effective porosity and ineffective porosity. Absolute porosity is the ratio of the total void space in the reservoir rock to the bulk volume of the rock. Effective porosity is defined as the ratio of the volume of the interconnected pores to the bulk volume. Ineffective porosity is defined as the ratio of the volume of isolated disconnected pores to the bulk volume. Effective porosity will be the focus in this experiment because, if the porosity of a rock is determined by saturating the rock sample in 100% of fluid with known density and there is increment in weight of the rock sample after being weighed.

F. Fluid Saturation

Saturation is defined as ratio of the volume of a fluid phase in a reservoir rock to the pore volume (gas, oil, water) of the sample.

G. Coreflooding Experiment

This experiment is done in several steps. First step is oil saturation to calculated the original oil in place (OOIP) or the initial oil volume in core.

OOIP is calculated by measure the produced water from core. This step is carried out to ensure that the pore spaces are saturated with oil and brine known as initial saturation.

Once the initial amount of oil that saturates the porous medium can be determined and critical water saturation, Swc is achieved, produced water is displaced by oil that injected into the core. Injection rate that is used in this step 0,5 ml/minutes. After that brine will be injected continuously into the porous medium with the same concentration at the flow rate of 0,5 ml/min to carry out the secondary recovery stage. This is called a water flooding process. During secondary recovery stage is being carried out, it is estimated that 40% of initial oil in place will be displaced out during this stage before reaching residual oil saturation, Sor, and leaving remaining oil to be recovered in the next stage Waterflood is done until no further oil was displaced. Total volume of oil displaced is calculated to measure the recovery factor and residual oil saturation at these stages. Then, the next step was injected 5 PV Biosurfactant "U-Champ" into the core with injection rate 0.5 ml/min. Same as waterflood total volume of oil displaced is calculated to measure the recovery factor and residual oil saturation at these stages. After Biosurfactant "U-Champ" was injected, the core is soaking in Biosurfactant "U-Champ" for several time. It is done to make the fluid in the core react with "U-Champ". The reaction between oil sample and Biosurfactant "U-Champ" can change the characteristic of the oil sample. After that, water is injected into the core with injection rate 0.5 ml/min to produce oil after react with "U-Champ". Same as the other steps total volume of oil displaced is calculated to measure the recovery factor and residual oil saturation at these stages. All of the coreflood steps were conducted at 60°C to mimic the average temperature of the reservoir. This experiment is used two artificial core sampels Then this experiment used the same oil sample and brine from well in kawengan oilfield in Cepu , East Java.

IV. MATERIAL

In this experiment some material is needed, which is oil and brine sample. Also core plug is used to do the coreflooding experiment. And there is the detailed characteristics from material that is used.

A. Oil Sample, Product Biosurfactant "U-Champ" and Water Sample.

The oil sample is obtained from well in Kawengan Field that located in Cepu, East Java. Also the brine is obtained from same well as oil sample is obtained. **Table-I** show the characteristic of the oil sample. **Table-II** show the characteristic of the brine sample.

Table-II: Oil Sample Characteristic

No	Sample	Density gr/cc	$SG_{60/60^{o}F}$	^{o}API
1	KW-58	0,88597	0,8949	24,974

Table-III: Brine Sample Characteristic

No	Sample	Brine Density (gr/cc)	Salinity ppm	pH
1	Kw-58 Brine	0	17000	8,45

V. RESULT AND DISCUSSION

A. Viscosity Reduction

This measurement carried out to know the influence of temperature and the addition of "U-Champ". The higher temperature affect the reduction of viscosity. These three oil solution (oil sample, oil sample + 1% of "U-Champ", oil sample + 2,5% of "U-Champ", Oil sample +5% of "U-Champ"+ Oil sample +10% of "U-Champ") is measure with the viscometer (Figure 1). Biosurfactant "U-Champ" gave a maximum viscosity reduction from 5.57 cp to 1.76 cp at 30oC and from 1 cp to 0.95 cp at 80oC at 5% concentration of biosurfactant "U-Champ". This result indicates the influence of the addition of Biosurfactant "U-Champ" to the oil sample to reduce its viscosity. As mentioned before in the Basic theory, Biosurfactant "U-Champ" sample can reduce the oil viscosity because the reaction betwee Biosurfactant "U-Champ" reduce the heavy component on hydrocarbon..

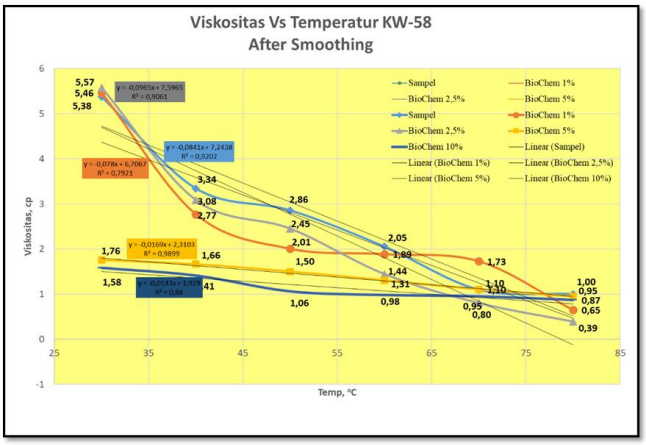

Figure 2. Viscosity vs Temperature Chart Plot

B. IFT Measurement

Interfacial Tension (IFT) is the long union force found at the boundary of two immiscible phases. IFT is an indication of the smooth running of two fluids. The greater IFT value, make this two fluid more difficult to unite each other, or often referred to as immiscible. whereas if the IFT value is getting smaller, the two fluids will be easier to unite or it is often called a miscible. IFT measurements were carried out at a temperature of 70°C to mimic the reservoir temperature.

Table-IV: The IFT of oil sample in variety percentage of "U-Champ" at 70^{0}C

Sample	Concentration (%)	IFT mN/m
KW-58	0	10,05
	1	7,46
	2,5	6,17
	5	3,81
	10	5,76

There are two parts of the Biosurfactant "U-Champ" molecular structure. One part is called the hydrophilic part (hydroxyl and amino groups) which can dissolve in the water phase, and the other part is called the hydrophobic part (hydrocarbon chain) which can dissolve in the oil phase. At a concentration of 0%, 1%, 2.5%, the IFT results obtained were high when the surfactant concentration was more than 5%, the IFT value was low by 3.81 mN / m.

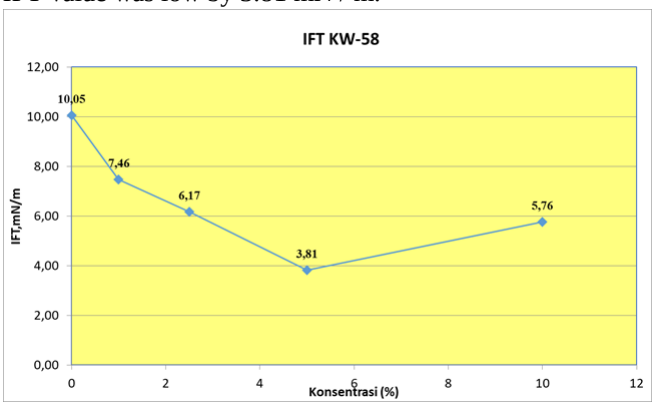

Figure 3. IFT vs U-Champ Concentration Chart Plot.

Then the 5% concentration is used as the CMC value. but when 10% concentration is added, the interfacial tension increases. The reason is that the surfactants added in the aqueous solution excessively cause the surfactants to aggregate into new micelles.

C. Phase behavior

Phase behavior dictates the selection of suitable components for use in a product. Components of liquid detergents, which are ordinarily concentrated solutions, must be selected with both phase behavior and utility in mind.

Figure 4. Behavior phases in various concentrations (A; 1%, B; 2.5%, C; 5%)

From the analysis, it is known that the microemulsion phase formed is the upper phase or Type II (+) because Biochemistry begins to mix with oil. This is in accordance with the theory described. that the brine samples used had high salinity tended to form the upper or oil phase. and make Biosurfactant "U-Champ" more oil-soluble and produce top microemulsion or Winsor type II +. so that the IFT test results showed a decrease in the IFT value at a concentration of 5% which was not too significant at 3.81 mN/m.

D. Coreflooding Experiment

which oil is recovered at each stage of oil production. Oil saturation is carried out to calculate OOIP from the core. This experiment is carried out in several stages. The first is oil saturation to calculate the original oil in place (OOIP) or the volume of initial oil in the core. OOIP is calculated by measuring the water produced from the core. This step is taken to ensure that the pore space is saturated with oil and saltwater, which are the initial saturation points in Table 5. After that, the brine is continuously injected into the porous medium with the same concentration with a flow rate of 0.5 ml/min to carry out the secondary recovery stage. This is known as the floodwater process. While the secondary recovery phase is in progress, it is estimated that the initial 40% oil on site will be displaced during this sage before reaching saturation of the residual oil, Sor, leaving the remaining oil to be recovered at a later stage. oil was transferred.

The total volume of oil transferred is calculated to measure the recovery factor and residual oil saturation at this stage. However, this water flooding only provides 30-37% RF value, because the oil used is heavy oil. So that in waterflooding only a little oil is produced, because the water has to push the oil, because the oil that is injected is classified as heavy oil, then the water only penetrates the oil or a gap occurs. Then 5 PV Biosurfactant "U-Champ" was injected into the core at an injection rate of 0.5 ml/minute. After the injection of "U-Champ", the core will be immersed in Biosurfactant "U-Champ" for some time. This is done so that the fluid in the core reacts with "U-Champ". The reaction between the oil sample and the Biosurfactant "U-Champ" can change the characteristics of the oil sample. After that, water is injected into the core at an injection rate of 0.5 ml/minute to produce oil after being reacted with Biosurfactant "U-Champ" to increase oil recovery as seen from the increase in oil production after the waterflooding process.

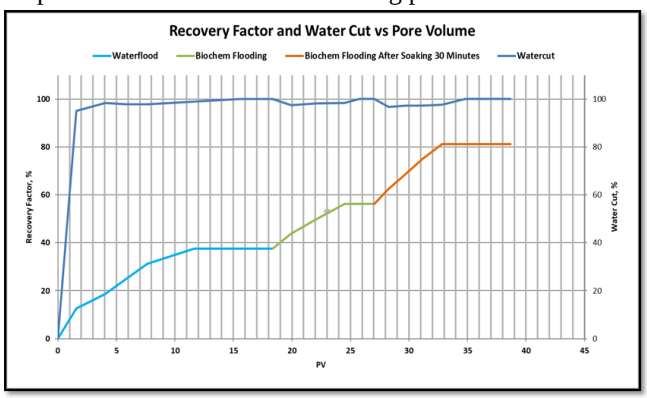

Figure 5. PV Injected vs Recovery Factor for Core Mesh 30

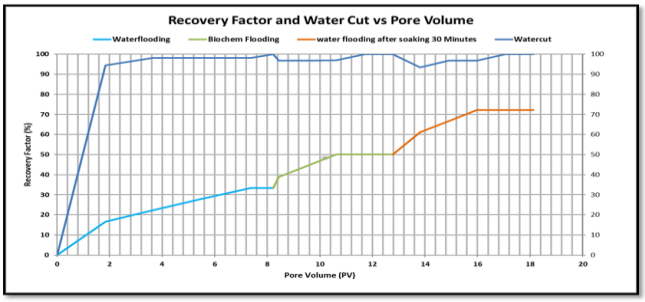

Figure 6. PV Injected vs Recovery Factor for Core Mesh 40

at the waterflooding stage of 30 mesh rock core samples gave a recovery factor of 37.50 and mesh 40 rock core samples of 33.33%. The soaking process also improves oil recovery. From the mesh of 30 rock core samples, has a recovery factor value of 81.25% and from mesh 40 artificial core. Samples have a recovery factor value of 72,22%.

Table-VI: The resulting recovery factor results in the Core Flooding simulation process

Core	Waterflood Recovery Factor (%)	"U-Champ" Injection RF (%)	RF after Soaking (%)
Core 30-7	37,50	56,25	81,25
Core 40-7	33,33	50	72,22

Based on the results of the core flooding experiment, it shows that the Biosurfactant "U-Champ" shows the incremental of recovery factor on a laboratory, this research is feasible to do in testing on a larger scale by applying it to a pilot project.

VI. CONCLUSION

It was concluded from this study that:

1) The addition of biosurfactant "U-Champ" reduce the oil viscosity from 5.57 cp to 1.76 at 30°C with 5% concentration. This reduction also occurs at high temperature which from 1 cp to 0.95 cp at 80°C. biosurfactant "U-Champ" also reduce the IFT with maximum reduction from 10.05 mN/m to 3.81 mN/m at 5% concentration.
2) Coreflooding experiment show the incremental RF in "U-Champ" injection from 37,50% to 56,25% for mesh 30 and from 33,33% to 50% for mesh 40. Then the incremental RF after soaking process was from 56,25% to 81,25% for mesh 30 and from 50% to 72,22% for mesh 40.
3) Biosurfactant "U-Champ" sample can reduce the oil viscosity because the reaction between "U-Champ" and oil reduce the heavy component on hydrocarbon and degrade the longer chain hydrocarbon into shorter chain hydrocarbon. The reduction of IFT value between oil and water caused by the amphiphilic compound in "U-Champ" that has a hydrophilic group that soluble in water and a hydrophobic group that soluble in oil. the reduction is not too significant because the brine sample used had high salinity and make the Biosurfactant "U-Champ" is more soluble in oil and produce upper microemulsion or Winsor type II +. With the Incremental of oil production after "U-Champ" Injection, this study indicates the possibility for the injection of "U-Champ" into the oil field

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