APPLICATION OF PALM METHYL ESTER SULFONATE AS GREEN SURFACTANT FOR INTERFACIAL TENSION AND WETTABILITY ALTERATION FOR ENHANCED OIL RECOVERY

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ABSTRACT

Oil productions keep depleting due to production problems such as high surface tension and interfacial tension reservoirs. Therefore, chemical flooding is one of the methods used in enhanced oil recovery. Injection of surfactant into an exhausted hydrocarbon (HC) reservoir is one method of lowering remaining oil saturation and thereby increasing crude oil production. These industrial and chemical substances may pose some economic and environmental risks. Stability under hard (or normal) reservoir conditions and excessive adsorption are still problems with surfactant flooding. The Palm (MES), and the synergy between (MES) and Sodium Carbonate has been proposed as a compound for chemical flooding in enhanced oil recovery in this project. The major aim of this study was to measure the effectiveness of Palm (MES), and the synergization between (MES), and Na_2CO_3 in oil recovery using chemical flooding. After the synergization of surfactant with alkali solution take place, the surface tension and interfacial tension test have been conducted to identify the optimum concentration when various concentrations have been used. The results showed that the optimum concentration for MES is 2000 ppm with surface tension (ST) and interfacial tension (IFT) are 38.5 and 10mN/m respectively. When the Sodium Carbonate alkali were added, it showed that 5000 ppm was the optimum concentration with reduction in surface tension and IFT to 36.5 and 8 mN/m respectively. Palm (MES), and Synergy of Palm (MES) with Na_2CO_3 changed the oil-wet sandstone to water-wet, and Palm (MES) droplet the contact angle from 96^0 to 34^0, and Palm (MES) with Na_2CO_3 changed the contact angle from 96^0 to 25^0. The 5000ppm brine and paraffin oil have been injected into the sand pack followed by waterflooding and chemical flooding to measure the oil recovery. The results from the experiment presented that the oil recovery for waterflooding were in between 27% to 31% therefore, more oil left in the sand pack. Then, surfactant with alkali solution was injected with 5000 ppm of brine as a slug as tertiary recovery. It showed that after Palm (MES) solution the oil recovery increase up to 48%, but after injection of Palm (MES) and alkali the oil recovery increase up to 53%. As a conclusion, it is proved that the synergization of Palm (MES) and Sodium Carbonate is applicable for chemical flooding as tertiary recovery because it can recover up to 68% of oil production.

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LIST OF ABBREVIATIONS

EOR	-	Enhance Oil Recovery
IFT	-	Interfacial Tension
SFT	-	Surface Tension
CMC	-	Critical Micelle Concentration
CEOR	-	Chemical Enhance Oil Recovery
OOIP	-	Original Oil in Place
MES	-	Methyl Ester Sulfonate
HC	-	Hydrocarbon
RF	-	Recovery Factor

LIST OF SYMBOLS

NC	-	Capillary Number
M	-	Mobility ratio
μ	-	Viscosity
v	-	Velocity
θ	-	Angle
σ	-	Interfacial Tension
Krw	-	Relative permeability to water
Kro	-	Relative permeability to oil
μo	-	Viscosity of oil
μw	-	Viscosity of water
ϕ	-	Porosity
V_p	-	Pore volume
V_b	-	Bulk volume
Q	-	Injection rate
K	-	Permeability
ΔP	-	Pressure difference
L	-	Length

CHAPTER 1

INTRODUCTION

1.1 Background of Study

For the past three centuries, fossil fuel has been the main source of energy when compared to other alternative energy sources. However, finding new reserves has grown more difficult due to financial constraints. Only about a third of the total oil in the reservoir can be extracted using primary and secondary procedures, leaving the rest trapped in the reservoir (Sukesh and Deka, 2017). The leftover oil is critical after the floods, and it cannot be overlooked at this time of increased energy demand. As a result, large oil corporations prefer to meet energy demands through enhanced oil recovery (Alvarado & Manrique, 2010).

Chemical flooding, miscible and immiscible CO2 flooding, nanoparticle applications in tertiary recovery, and in-situ thermal recovery technologies are all important strategies for takeout residual crude oil from remaining carbonate reservoirs. One of the most important tertiary recovery technologies in Chemical Enhance Oil Recovery. It lowers the water-oil interfacial tension (surfactant/alkaline) to reduce residual oil saturation and increases volumetric sweep efficiency by lowering the water-oil mobility ratio (polymer). Chemically enhanced oil recovery flooding is becoming increasingly popular due to its capacity to lower interfacial, and alteration wettability to more water-wet conditions, all while saving money (Nowrouzi et al., 2020).

However, recent improvements in surfactants for enhanced oil recovery methods, on the other hand, have substantially reduced the amount of surfactant required for successful oil recovery. In the 1970s and 1980s, surfactant concentrations ranged from 2% to 12%, which, when paired with the cost of the surfactants, proved too expensive. Surfactant flooding works by reducing the interfacial tension between the crude oil and the surfactant slug, which improves oil recovery by lowering capillary pressure (Lee, 2012). However, the recovered oil is often inadequate to offset the high expense of creating a significant quantity of surfactant, making it unsuitable for widespread use. Surfactants, also known as surface-active agents, are chemical compounds that, when present in low concentrations, are adsorbed onto the surfaces or interfaces of a system. They can improve oil recovery by changing the hydrophobic character of the rock matrix to hydrophilic, and by lowering interfacial tension (IFT), which can induce stuck crude oil in microscopic pore seats to be removed, and changed via water. This pore-scale recovery mechanism is linked to sweeping effectiveness, which is influenced by, capillary forces, and viscous, and may be deduced from the connection between interfacial tension (IFT), and contact angle (wettability quantities) (Haghighi et al., 2020).

Natural surfactants, also known as polar lipids, are surfactants that come from renewable bases such as plants or animals. They are either taken directly from natural sources without slightly chemically produced using either the head or non-polar portions. Natural raw bases for the manufacture of natural surfactants include polyols, such as amino acid residues, glucose, and simple sugars. They're called green surfactants because they're environmentally friendly and biodegradable (K. Holmberg, 2001).

At a concentration of 4wt% as the critical micelle concentration, Alfalfa natural surfactant reduced 29.29mN/m of IFT (63.39% IFT optimization) (Eslahati et al., 2020). Also, owing to the 86.84° drop-in contact angle caused by the addition of Alfalfa, the wettability of rock tends to be more water-wet from the initial oil-wet state (49.91 % wettability alteration). The noxious weed water hyacinth was used to create an anionic surfactant that effectively changed the wettability of oil-wet kaolin clay. The wettability changes at high temperatures, and salinity must be investigated to gain a better knowledge of how well synthetic surfactants function in EOR applications (Machale et al., 2019). The Anabasis Setifera plant was employed as a natural surfactant source, and this green surfactant reduced the IFT value at CMC to 1.066 m N/m. The contact angle tests further reveal that this surfactant can change the wettability to a poor water-wetting state (a contact angle of 56.5^0). Finally, flooding the surfactant solution at CMC, and optimum formation brine resulted in a 15.4 percent oil recovery (Nowrouzi et al., 2020). The interfacial tension values between oil and ordinary surfactant solution were assessed using the pendant drop method after three natural-based surfactants were remote from the leaves of the plants of the targeted plants. The olive extract was shown to reduce the IFT between kerosene and distilled water from 36.5m N/m to 14 m N/m, while Spistan and Prosopis extract reduced the IFT from 36.5mN/m to 20.15mN/m, and 36.5mN/m to 15.11mN/m, respectively.(Khurram Ghahfarokhi et al., 2015).

In contrast to earlier research, this study has focused on the effects of a new synthetic surfactant made from Palm Plant Oil in the presence of an alkaline on interfacial tension (IFT) and wettability alteration, and oil recovery performance on a sandstone reservoir.

1.2 Problem Statement

One of the Chemical Enhanced Oil Recovery (CEOR) processes is surfactant flooding. Injection of surfactant into an exhausted hydrocarbon (HC) reservoir is one method of lowering remaining oil saturation and thereby increasing crude oil manufacture. These industrial and chemical substances may pose some economic and environmental risks (Atta et al., 2021). Stability under hard (or normal) reservoir conditions and excessive adsorption are still problems with surfactant flooding. These concerns have an impact on predicted oil recovery, lowering the economic returns of EOR projects (Massarweh & Abushaikha, 2020).

However, the majority of regularly used surfactants are hazardous, non-biodegradable, and can attach to porous rock surfaces (Machale et al., 2019). As a result, various ongoing studies are aiming to replace them with greener and less expensive alternatives (Bachari et al., 2019). Several attempts have recently been made to investigate the use of natural surfactants the enhance oil recovery. Natural surfactants have lower poisonousness and well biodegradability than synthetic surfactants. They also have a better foam-forming capability and are constant at high temperatures and in saline conditions (Machale et al., 2019). Zizyphus Spina-Christi leaves were used to extract a natural surfactant that could change the wettability of carbonate and sandstone rocks (Sofla SJD et al., 2016). The sulfonate surfactant of Jatropha Carcus, which is derived from C16-18 fatty acid, can lower interfacial tension (IFT) and boost oil recovery. Only a minor change in IFT is noticed at very low surfactant concentrations. IFT drops as more surfactant is added and until it reaches its lowest point of 0.63 m N/m. Micellar structures arise as the surfactant concentration is increased, increasing IFT. The IFT can be reduced to 0.19 m N/m using a synthetic surfactant. With produce water, there is no precipitation or cloudiness. In the addition of sodium carbonate, the surfactant solution can recover 11.11 percent of the generated water (Lee, 2012).

Researchers have recently proposed that injecting natural surfactants provides new routes to overcome unsolved difficulties as new ecologically friendly EOR agents for enhancing oil recovery. In this study, a natural surfactant made from Palm Oil is utilized to reduce interfacial tension (IFT) and change the wettability of the rock to a strong water-wet system, enhancing oil recovery on sandstone rock.

1.3 Objectives

The objectives of this research are as follow:

a) To evaluate the surface tension and interfacial tension of Palm Plant Oil and Palm Plant Oil with alkali in identifying its optimum concentration.

b) To measure the effect of Palm Plant Oil, and Palm Plant Oil with alkali in altering the wettability (contact angle) of sandstone rock.

c) To evaluate the effectiveness of Palm Plant Oil, and Palm Plant Oil with alkali in improving oil recovery factor for sandstone rock.

1.4 Scope of Study

I. This study covered the Methyl Ester Sulfonate of Palm Oil, and the synergy of Methyl Ester Sulfonate of Palm Oil and Sodium Carbonate alkali as chemical flooding in enhance oil recovery application later.

II. The element that has been identified in this study was the surface tension of the Methyl Ester Sulfonate of Palm Oil, and the synergy between the Methyl Ester Sulfonate (MES) and Sodium Carbonate alkali to identify the critical micelle concentration (CMC). The other element that was measured is the effectiveness the interfacial tension of the reservoirs.

III. The study conducted under room condition at 14.7 psia and 27°C. The concentrations of surfactant were in range of (1000, 2000, 3000, 4000, 5000, 6000,7000, and 8000) ppm to get the optimum concentrations that also known as critical micelle concentration (CMC). After that, the optimum concentration presented as a base in adding the different concentration of Na_2CO_3 in between 1000 ppm to 7000 ppm also to identify the optimum concentration after the syenergization of the surfactant and alkali.

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