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Experiment on interfacial tension measurement of oil from Fang oilfield with alkaline flooding

K Maneeintr*, T Meekoch and T Boonpramote

Carbon Capture, Storage and Utilization Research Group, Department of Mining and Petroleum Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok 10330, Thailand

*Corresponding author: Krengrai.M@chula.ac.th

Abstract. Owing to the increasing world-energy demand, oil as the main source of energy, will be produced more by using technology especially alkaline flooding, one of the main enhanced oil recovery methods to produce more oil. It involves the injection of alkaline that can react with the petroleum acid to form an in-situ surfactant to reduce the interfacial tension between displacing and displaced phases and reduce the residual oil saturation, leading to the higher oil production. In Fang oilfield, Thailand, light oil production can be increased by using chemicals to reduce interfacial tension of oil and water. In this study, sodium carbonate is used as alkali to lower the interfacial tension with various conditions. Therefore, the objectives of this work are to measure the interfacial tension and to evaluate the effects of parameters such as concentration, pressure, temperature and salinity on interfacial tension reduction for oil from Thailand. The results present the effects of alkaline concentration on the interfacial tension. Also, the alkaline solution can reduce the interfacial tension significantly. Because, the alkaline can from the in-situ surfactant with the acid in oil to reduce the interfacial tension down to 0.6 mN/m. Temperature is also one of the parameters that affects the interfacial tension in the opposite direction. The increment of temperature would reduce the interfacial tension. The salinity has an effect on the interfacial tension in the same direction. The effects of these three parameters would reduce the interfacial tension. On the other hand, pressure has relatively less effect of IFT reduction. The results of this work can apply to increase more oil production for Fang oilfield with the optimum conditions.

1. Introduction

Due to an increasing world-energy consumption, oil as a major source of energy, will be produced more by means of the advanced technology to increase oil production. However, a water injection method is not the practical technology to produce more oil due to the high interfacial tension or IFT [1]. Therefore, the chemical injection especially alkaline flooding, one of the main enhanced oil recovery methods (EOR) become more significant in order to increase the oil production [1]. EOR processes involve injection of chemical solution into the reservoir. This fluid helps to displace oil to producing wells because it creates favorable conditions for oil recovery such as lowering interfacial tension or IFT, oil swelling, oil viscosity reduction, wettability modification [2].

Chemical flooding is one of the most commonly used for EOR processes which have joined in many research and pilot testing. However, its commercial implementation has been facing several technical, operational and economic concerns [3]. Chemical processes relate to the injection of chemical solution that displaces oil effectively. Chemical flooding consists of polymer, surfactant,



alkaline and alkaline-surfactant-polymer (ASP) flooding. For alkaline flooding, an in-situ surfactant is created by the in-situ chemical reaction between an alkaline solution and the organic acids in oil. Furthermore, the in-situ surfactant causes the reduction of IFT between crude oil and water. At low IFT, the surface force tends to form oil-in-water or water-in-oil emulsion phase depending on pH, temperature, salinity and concentration [4,5]. The flow characteristics of this type of emulsion permit a high, non-uniform pressure gradient to generate across the narrow region in the vicinity of the emulsion front. The pressures are enough to surpass the reduced capillary forces and move the oil from the pore space. The displacement efficiency of alkaline flooding can be higher than the typical water flooding efficiency [6]. Furthermore, the alkaline can be easily found in the market and is cheap comparing with the other kinds of surfactant or polymer which makes an alkaline flooding is more practical. Therefore, the alkaline flooding can be considered as a first choice for oil production. Moreover, there are few of the studies specifically on pre-flooding that relates directly to oil field in Thailand. To enhance the oil production and save the operating expense, chemical injection with sodium carbonate can decrease the cost of chemicals used for flooding operation because of availability and high performance.

With the usage and significance of alkaline flooding, there are many researches working on this method and try to use in the practical work like that in Thailand. Furthermore, the effects of alkaline concentration, salinity in brine, temperature and pressure play the important roles in alkaline performance on enhanced oil recovery. Consequently, the objectives of this research are to investigate the effects of these parameters such as the effects of alkaline concentration, salinity in brine, temperature and pressure on oil production and to measure the IFT from rising drop method. The results can present how IFT reduction can be attained for oil recovery. Also, this chemical and operating conditions can be used as a fundamental knowledge to apply this method in the real field in the future.

2. Materials and methods

2.1 Materials

The oil for this study is obtained from oilfield in Thailand with 0.84 g/cm^3 density. Brine is prepared from distilled water and sodium chloride purchased from Ajax with AR grade. An alkaline solution of sodium carbonate is obtained from distilled water mixed with sodium carbonate purchased from Ajax with AR grade. The rising oil droplet of this study is shown in Figure 1.



Figure 1. Rising oil drop in IFT cell.

2.2 Equipment

An interfacial tension cell (IFT), Model 700, Vinci Technologies, with transparent windows is used for this study. The chamber volume of the IFT is $1 \times 10^{-5} \text{ m}^3$ and the maximum working pressure and

temperature are 69 MPa (or 10,000 psi) and 180 °C (or 350 °F), respectively. Oil is fed to the system through a sample cylinder by using a pump. The oil drop can be formed by using a stainless steel syringe needle connected with IFT machine. A temperature controller is connected to the IFT cell to control the temperature. The pressure inside the IFT cell is measured by a pressure gauge with 0.5 percent of span accuracy.

2.3 Experimental procedures

Initially, brine is fed to the cell and the system is kept the pressure and temperature constant. Then, a light oil sample is fed to the system by a pump to form a rising oil drop at the tip of the needle. Once the drop is formed, a program is measured and analyzed the drop. This process is repeated for 3 times to get the average result. The operating conditions for this study are presented in Table 1.

Table 1. Operating conditions for IFT measurement

IFT Measurement	Operating conditions
1. Type of solvent	Na ₂ CO ₃
2. Solution concentration (%wt)	0.00, 0.025, 0.05 and 0.075
3. Salinity (ppm)	0, 500, 750 and 1,000
4. Pressure (MPa)	3.45, 6.89 and 10.34
5. Temperature (°C)	70, 80 and 90

3. Results and discussion

The interfacial tension between oil and brine is measured at various conditions. The effects of parameters, temperature, pressure, alkaline concentration and brine salinity are studied as shown below.

3.1 Effect of temperature on IFT

The temperature for this study is ranging from 70 to 90 °C. The result is shown in Figure 2. From the results, it is investigated that the IFT values reduce as the temperature increases because the intermolecular force at the oil and aqueous phase becomes lower. However, at higher temperature, temperature has less effect on IFT reduction because there is less space for in-situ surfactant to occupy in the monolayer between oil and aqueous phase.

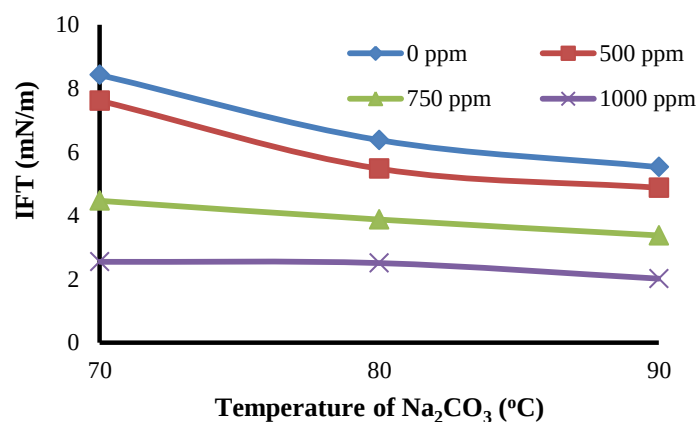


Figure 2. The effect of temperature on IFT reduction for pressure at 1000 psi, 0.075%wt of Na₂CO₃

3.2 Effect of pressure on IFT

The pressure used for this research ranges from 3.50 to 10.30 MPa (from 500 to 1,500 psi) and the result of the effect of pressure on IFT is presented in Figure 3. From the result, it is shown that IFT does not change much when pressure changes at constant parameters. This is because the oil-brine system is in liquid phase and has less effect with pressure.

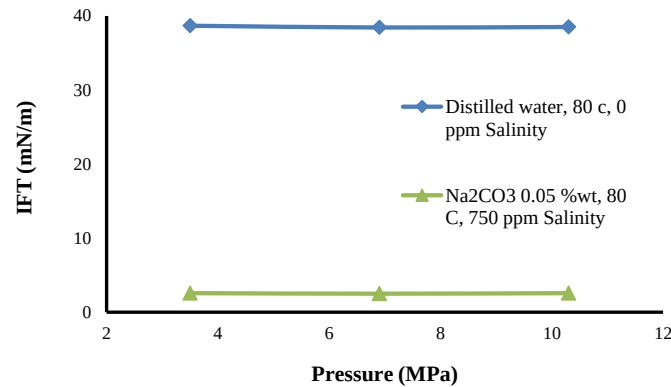


Figure 3. Effect of pressure on interfacial tension reduction

3.3 Effect of solution concentration on IFT

This work uses sodium carbonate or Na₂CO₃ as an alkaline solution to reduce interfacial tension and the concentration of Na₂CO₃ is varied from 0 to 0.075 % by weight. The result is measured and presented in Figure 4. It is obvious that Na₂CO₃ helps to reduce interfacial tension of oil and brine down to 0.6 mN/m and comparatively constant at higher Na₂CO₃ concentration. It is because the alkaline solution can react with the acid in oil in order to form the in-situ surfactant.

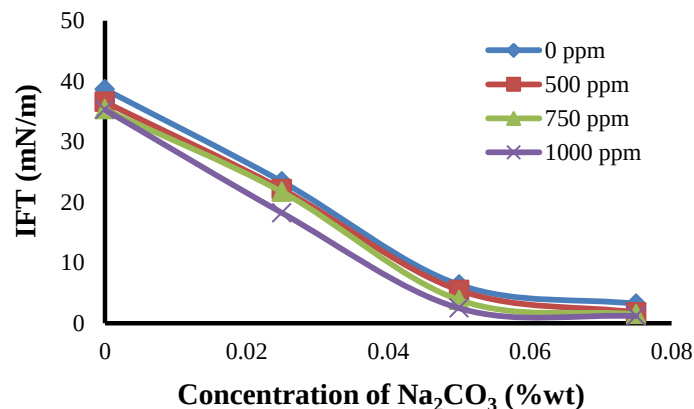


Figure 4. Effect of alkaline concentration of Na₂CO₃ solution at 80 °C

3.4 Effect of brine salinity on IFT

This work applies sodium chloride or NaCl as a component to produce brine with various concentrations from 0 to 1,000 ppm. The result is obtained and shown in Figure 5. In this study, the IFT value is lower when the salinity increases from 0 to 1,000 ppm. The higher salinity would help to balance the in-situ surfactant in both oil and aqueous phases by increasing the charges in the aqueous phase.

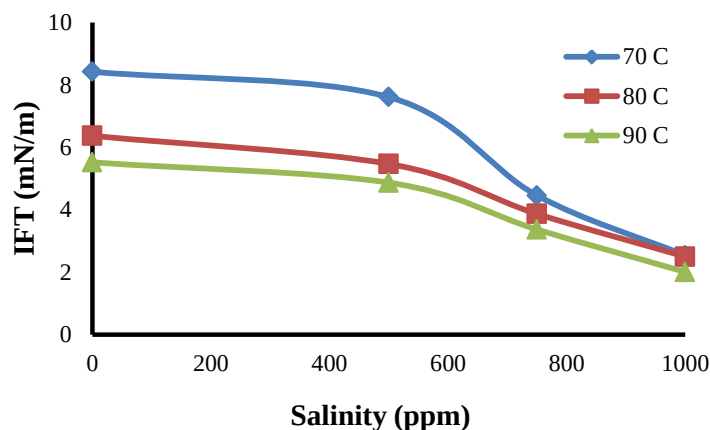


Figure 5. Effect of salinity on interfacial tension reduction

From the results, they can be used in the real oilfield to reduce the interfacial tension by applying the chemicals such as sodium carbonate with the lower cost as well as its availability. Furthermore, the operating conditions are applicable with the real application of oil production in Fang oilfield.

4. Conclusion

Due to an increasing demand and use of oil, an enhanced oil recovery technology such as the chemical flooding becomes more important to produce more oil by reducing interfacial tension or IFT to make oil flow easily. Chemical flooding like alkaline flooding by means of sodium carbonate, is applied to enhance oil production in Thailand. Therefore, the effects of various parameters such as alkaline concentration, salinity in brine, temperature and pressure are studied. These parameters play significant roles in alkaline performance on enhanced oil recovery. From the results, it can be concluded that IFT is reduced from 58.65 down to 0.60 mN/m with the increases of temperature, alkaline concentration and brine salinity. Nevertheless, pressure has less effect on IFT reduction. The results can be used as fundamental data for the design of the oil production process in Thailand in the future.

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