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Phase Behavior in EOR Surfactant Flooding

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1. Introduction

About 50 % of the crude oil is still remained in mature oil reservoirs and as the demand for oil is increasing enhanced recovery methods is widely applied. To improve the oil recovery by natural drive mechanism the most common approach is waterflooding, considered as a secondary oil recovery technique. The oil left in the swept zone after waterflood then becomes the main target for the following enhanced oil recovery (EOR) process also called tertiary oil recovery, [1]. Therefore EOR is introduced, where one among several techniques is surfactant flooding, which is studied in this work. The main target in EOR is to displace or alter the mobility of the oil remained in the reservoir, which is often distributed in pores where it is trapped thanks to capillary and viscous forces.

2. Surfactant Flooding

The main concept in surfactant flooding is that surfactants are injected into the reservoir to control the phase behaviour properties inside the oil reservoir. The aim of this process is to lower the interfacial tension (IFT) between oil and water and thus displace or mobilize the trapped oil. However, it must be taken into account that adsorption and chromatographic separation of the surfactant to the rock will happen and therefore it is desired to develop as simple surfactant blends as possible. Also it is well known that surfactant systems are sensitive to both salinity and temperatures and therefore the demand for systems that can resist these physical conditions are demanded, [2]. It is crucial for this approach that the surfactant systems forms a three phase system when injected into the reservoir, where it is desired to form a microemulsion phase, which is where the ultra low IFT (0.001 dynes /cm) between oil and water is obtained.

In this work the focus has been on simple surfactant systems and then it handles another physical condition than temperature and salinity. It has been experimentally studied what effect pressure has on a chosen model surfactant system. From literature it is debatable what the general view is about the effect of pressure on surfactant systems and as mentioned it is important to this approach, that the microemulsion phase is formed during operation, why the pressure effect must be clarified.

3. Pressure Effect

The demanded ultra low IFT for surfactant flooding is usually discovered by the examination of the phase behaviour of the microemulsion system. This involves a number of parameters, such as the type of surfactant, the surfactant concentration, effect from temperature and pressure, the microemulsion properties, etc. The phase behaviour is the single most critical factor determining the success of a chemical flood,[3]. Phase behaviour is not properly described by EOS and therefore experimental work has been conducted.

This work examines the following model surfactant system, table 1:

Table 1. Model surfactant system with two different compositions in wt%.

Comp.	water	NaCl	SDS	1-butanol	heptane
#1	0,616	0,043	0,025	0,051	0,265
#2	0,532	0,037	0,022	0,044	0,365

This system is tested to achieve a more satisfactory understanding of the effect of pressure on the phase behaviour. The present system in table 1 has been tested earlier at room temperature and atmospheric pressure, [4]. Experimentally high pressure equipment has been used, where a DBR JEFRI PVT cell has been used. This equipment allows the system to undergo a wide range of temperatures and pressures and there is a window available allowing visual observations of the surfactant system as experiments are conducted. Experimental work has initially lead to the results, that the equilibrated system is effected by pressure, as the system changed from 3 to 2 phases only dependent on pressure.

The continuation of this work confirms the initial observations shown in figure 1, that the phase behaviour of the model surfactant system is dependent on the pressure in the pressure range of 1 to 400 bars. Further more experimental work also shows that this pressure effect is enhanced when temperature is increased, where temperature range were 40 to 60˚C. All experimental observations are reversible. Comparison with previously workers result, [4], this work indicates that pressure effect displace the phase envelope for the present surfactant system.

4. Conclusion

The aim in this work is to study the phase behaviour of simple surfactant systems.

A model system, earlier studied at room temperature and atmospheric pressure is in this work studied at higher temperatures and elevated pressures. Results from experimental work have uniquely shown that pressure increase has an effect on the phase behaviour of the present surfactant system, which at equilibrium shifts from e.g. 3 phases to 2 phases, depending on your system composition.

As the pressure range is 1 to 400 bars this is higly relevant, as these kinds of pressures are common for reservoir conditions.

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