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Experimental Investigation of Imbibition Process in a Hybrid Low Salinity-Surfactant EOR Method

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INTRODUCTION

In the recent years, many studies have been conducted on the application of low salinity water flooding and surfactant flooding, however, many aspects still require further research. For the first time in this study, the imbibition of anionic surfactant in the presence of low salinity water was investigated. In addition, the effect of different oil properties such as viscosity, density, and asphaltene content has been investigated more precisely by examining two different oil types.

METHODOLOGY

In this work, a series of imbibition experiments were done using two Iranian carbonates reservoir core samples. Properties are mentioned in Table 1. XRD analysis of this core plugs shows that calcite is the most prominent component of the samples. Furthermore, crude oil properties are listed in Table 2. The surfactant used in this study was Dioctyl Sulfosuccinate Sodium Salt (AOT, Sigma Corporation, purity> 97%). The atomic weight of this chemical is 444.56 g/mol, and CMC is 2.55 mmol/l. Also, it should be noted that the synthesis of formation brine was done according to Iranian reservoir salinity analysis.

Imbibition experiments have been carried out using glass imbibition cells. Formulation of imbibition fluids are listed in Table 3. First, each core was immersed in formation brine, oil recovery after 40 days was 10% OOIP of C1 oil and 4% OOIP of C2. After formation brine imbibition, cores were immersed in a low salinity aqueous solution of 0.025 M NaCl. The final step was imbibition of low salinity surfactant solution into the cores and the final oil recovery determined from the weighting of the cores after 90 days.

Table 1: core properties and specification.

Properties	Core A	Core B
Length (cm)	7.53	7.53
Diameter (cm)	3.8	3.8
Bulk volume (cm^3)	85.01	85.01
Pore volume (cm^3)	7.84	17.81
Porosity (%)	9.22	20.95
Residual water saturation (%)	27.3	38.8
Permeability (D)	0.023	0.079

Table 2: crude oil properties.

properties	Crude oil C1	Crude oil C2
Asphaltene content (%)	2.9	9.72
Acid number (mg KOH/g oil)	0.91	1.24
Density (g/cm3)	0.899	0.92
API	25.89	22.3
Dynamic viscosity (cp)	14.52	87.05
IFT in presence of High salinity water (mN/m)	38	28
IFT in presence of High salinity water (mN/m)	10	8

Table 3: formulation of imbibition fluids.

Experiment Name	Used core	Used oil	Imbibition formulation	Viscosity of formulation (cP)
C1-FB	A	C1	Formation brine (FB)	1.2
C2-FB	B	C2	Formation Brine (FB)	1.2
C1-LS	A	C1	Low salinity brine 0.025 M NaCl	0.8
C2-LS	B	C2	Low Salinity brine 0.025 M NaCl	0.8
C1-LSS	A	C1	Low Salinity Brine + Surfactant (LSS) 0.025 M NaCl+3.7 CMC AOT	5
C2-LSS	B	C2	Low Salinity Brine + Surfactant (LSS) 0.025 M NaCl+2.1 CMC AOT	4.5

RESULTS AND DISCUSSION

In the case of LSS imbibition, practically all of the oil was expelled from the core as the emulsion. To increase the accuracy of measurements, a relationship was established between volume fraction of oil in emulsion and density of that emulsion formulation. Measured oil volume was corrected using control samples with different oil volume fractions by mixing known volumes of oil and surfactant solution. Figure 1 depicts a comparison of measured oil volume of oil with known oil volume. Figure 2 presents the oil recovery results for the spontaneous imbibition experiments listed in Table 3.

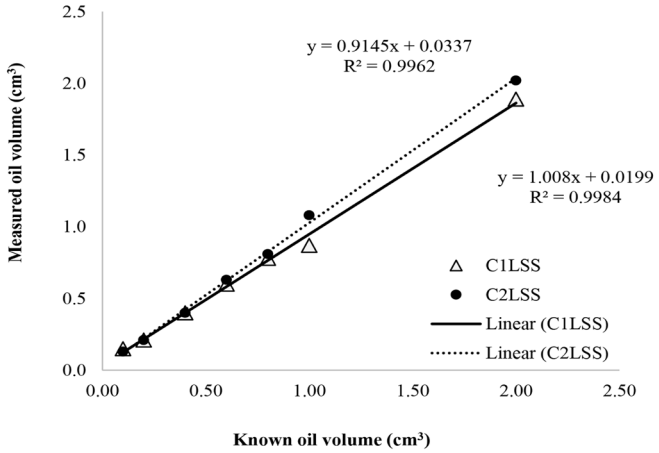

Figure 1: Comparison of measured oil volume with known oil volume.

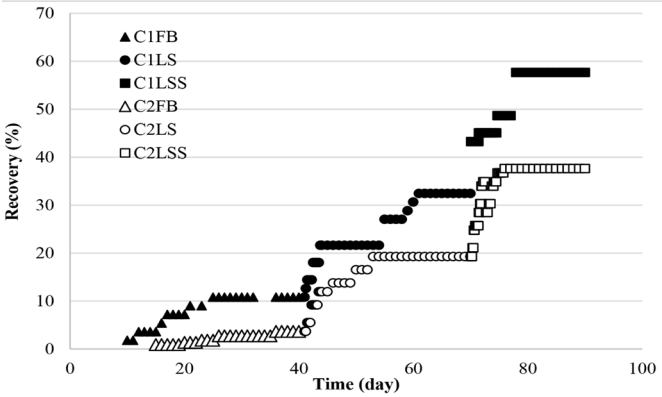

Figure 2: Recovery of different imbibition formulation versus time.

CONCLUSIONS

The remarkable remaining oil volume in carbonate reservoirs is an important objective for exploring new EOR methods. This research was tried to provide an effective way to increase the oil production of these reservoirs. For this purpose, imbibition process of different aqueous solution was studied in the presence of two different oil samples. The oil recovery for formation brine is less than 10% in both types of oil samples. In addition, low salinity water produces 37% of C1 and 20% of C2 oil. Moreover, anionic surfactant in low salinity environment with a low content yields 56% of crude oil C1 and 37% crude oil C2. Finally, these experiments show that the synergistic effect of the surfactant and the low salinity water could enhance the oil recovery.

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