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Experimental Investigation of the Microscopic Displacement Mechanisms of Surfactant Flooding in High Salinity and High Temperature Conditions

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INTRODUCTION

In the recent years, various studies have been carried out on the effects of surfactants flooding in porous media. In this regard, ionic surfactants showed promising results on improving oil recovery due to their capability of producing extremely low surface tensions and altering wettability [1-3]. Therefore, in this study, the microscopic displacement Mechanisms of surfactant flooding in high salinity and high temperature conditions have been investigated.

METHODOLOGY

In this work, a series of stability analysis, wettability alteration and microfluidic experiments were done using four types of anionic and cationic surfactants at their critical micellar concentrations (CMCs); which have been presented, in Table 1. Moreover, oil sample properties are listed in Table 2.

Table 1: Surfactants formulation and specification.

Number	Surfactant	Abbrevia-tion	CMC (mM)	Viscosity (cP at 25 °C)	Interfacial Tension (IFT) (mN/m)
1	Dioctyl Sodium Sulfo-succinate	DSS	2.55 [4, 5]	1.65	1.7
2	Sodium dodecylben-zenesulfonate	SDBS	1.69 [4]	1.36	2.6
3	Hexadecyltrimethyl-ammonium bromide	CTAB	1 [6, 7]	1.1	8.1
4	Cetyl pyridinium chloride	CPC	0.92 [4, 8]	2.1	10.6

Table 2: Crude oil properties.

Density (g/cm^3)	API	Viscosity (cP at 25 °C)	Acid Number (mg KOH/g oil)	Saturates (%)	Aromatics (%)	Resins (%)	Asphaltene (%)
0.92	22	89	1.24	52	11.5	26.8	9.7

In order to study the pore scale mechanisms of displacement and oil recovery measurement, a heterogeneous one-dimensional glass micromodel has been designed with the porosity of 28%. Other micromeodel's specifications are presented in Table 3.

RESULTS AND DISCUSSION

In Figure 1 (a), the stability analysis and the measured pH values for surfactant solutions with the concentration of 1 CMC are shown. The figure shows that anionic surfactant types are more stable. Unlike that, cationic types will lose their stability and cause some changes in the pH of the solutions. Moreover, the results of dynamic viscosity measurements are also depicted in Figure 1 (b).

The contact angle measurements of the aged carbonate rock samples were measured. In Figure 2, the initial contact angle of oil wet sample and also the contact angle of the samples after treating are shown

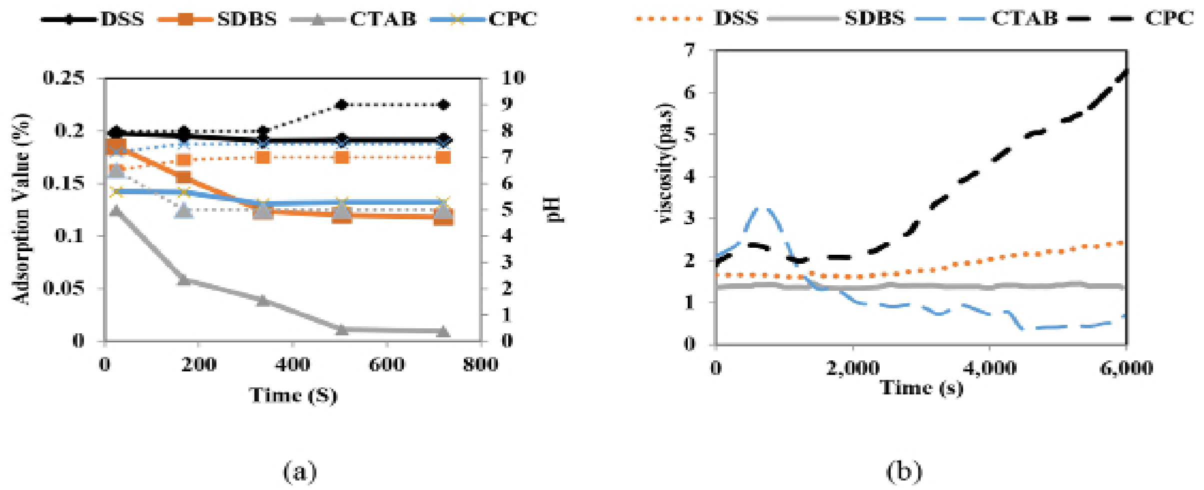

Figure 1: (a) Stability and pH variation of the surfactant solutions and (b) The results of dynamic viscosity measurements.

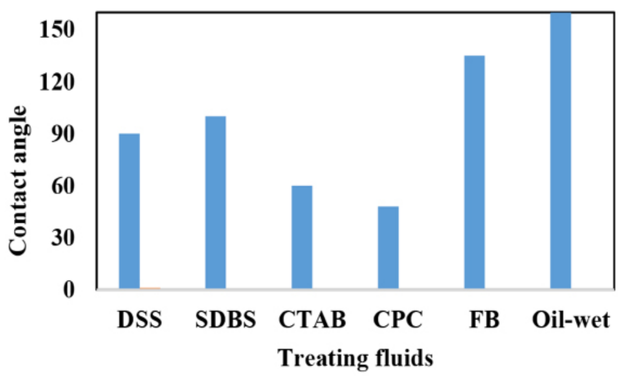

Figure 2: Contact angle measurements results.

The oil recovery during injection is obtained by images analyzing. The amount of oil recoveries versus time are shown in Figures 3. The final oil recovery coefficient of anionic surfactants is higher due to the potential effect of these materials on reducing surface tension and the formation of micro-emulsions of oil in water.

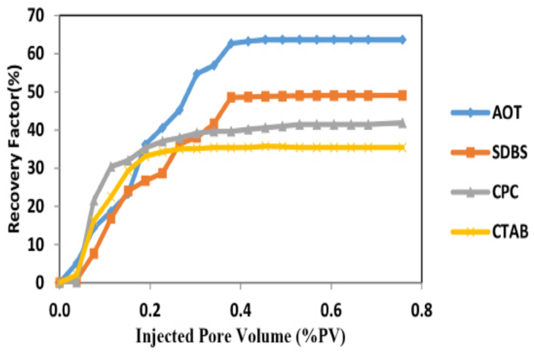

Figure 3: oil recovery versus pore volume of injected fluid.

Conclusions

In this research, the amount of recovered oil using DSS, SDBS, CTAB and CPC surfactants were obtained 63%, 48%, 44% and 35% respectively. In addition, the highest recovery factor was due to implementation of the DSS surfactant. Furthermore, obtaining results demonstrates contact angles of 100, 90, 60 and 48.7 respectively. Finally, the highest wettability alteration is due to the application of CPC which alters the contact angle from 160 degrees to 48.7.

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