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Investigation of Cationic Nonionic Blend to Alter Wettability for Carbonate Reservoirs

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Abstract

Alteration of wettability for a carbonate reservoir is one of the complex challenges faced by petroleum engineers. Cationic surfactants are the only surface agents which have shown successful results with minor exceptions. Recently, surfactant blends has shown ability to posses stability at high temperatures with low Critical Micelle Concentration (CMC). The aim of this research work is to compare the ability of Cationic nonionic blends with cationic surfactants for improving recovery in carbonate reservoirs. The surfactant blends were chosen to alter wettability for a Carbonate core is Cetyltri Alkyl Bromide (CTAB) with Ethoxcylated Alcohol (EO). The concentration of cationic surfactant CTAB was selected based on Krafts point and for nonionic EO on phase separation process. The results were observed on core flooding apparatus. Surfactant blend has shown 0.75 pv (pore volume) of recovery with 2 pv of injection and CTAB of 0.55 pv with 3 pv injection.

Keywords: Adsorption, Cationic Surfactant, CMC, Krafts Point, Nonionic Surfactant, Surfactants Blends, Wettability

1. Introduction

Chemical EOR is gaining more attention in carbonate reservoirs worldwide. As the mature fields are getting to an edge for production, new technologies in Eor are encouraged. Understanding the complex behavior of carbonate reservoirs to alter wettability is being a great challenge for current researchers. The important factor which can produce additional amount of oil after water flooding is wettability alterations[1]. Most of the research programs were conducted on sandstone reservoirs successfully by application of anionic surfactants other than cationics, zwitterionics and nonionics. For carbonate reservoirs cationic were successful[2].

Based on electrostatic forces on carbonate reservoirs surfactants have been investigated for wettability alteration. Cationic surfactants have been successful in altering wettability for carbonate reservoirs. Carbonate reservoirs are mostly oil to mixed wet. This can be altered by aninonic through capillary imbibitions or cationic by wettabilty alteration. Nonionic surfactants have shown great capability of penetrating without electrostatic reaction and improving permeability in Yates field. Its potential has already proven in pharmaceutical industry[3]. It is non reactive in nature but it can penetrate into smaller pores. At high temperatures nonionic show hydrophobicity which will make them to into oil.

Surfactant blends have been recently an attractive area for researchers. These blends have shown potential in cosmatic industry as thickening agents. The properties of surfactants blends to posses small CMC compared to conventional surfactants and reverse micelle stability making them unique class for altering wettability. Much research work hasn't done on carbonate surfaces with surfactant blends. Choice of selecting surfactants was based on lab experiments that are cationic surfactants for altering wettability and nonionics for enhancing permeability.

1.1 Nonionic Surfactants

Nonionic surfactants achieved good progress in chemical EOR because of its non chargeability and low CMC. These surfactants have already successfully applied in stimulation process in yates field[4]**.** They are good

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blenders and have applied to increase permeability in fractures. Nonionic surfactants posses' kraft point near the room temperature. But it depends on the concentration and additives where it will rise kraft point and CMC[5].

1.2 Wettability

In carbonate reservoirs wettability depends on electrostatic charge possessed on the surface. Anionic surfactants posses negative charge which is opposite to the surface of carbonate surface results in adsorption[6]. While adsorbing into the surface it will expel oil from smaller pores to fractures. Conversely, cationic surfactants posses' positive charge which is an equivalent charges with carbonate surface. In place of adsorption, the cationic surfactants will meet oil at interface between water and oil and makes the surface water wet[7].

2. Methodology

2.1 Kraft point

It's a temperature point where micelles start to form in an aqueous surfactants solution. Below this solubility depends upon the number of surfactant monomers as shown in Figure 1. At kraft point the maximum reduction of interfacial tension or surface tension can be observed due to micillization. Beyond addition of surfactants solubilization will increase due to aggregation of micelles but of reduction IFT will minimize.

At this temperature the micelles will be stable it cannot be reversed. The concentration at krafts point will be better for IFT reduction than any other concentration[8].

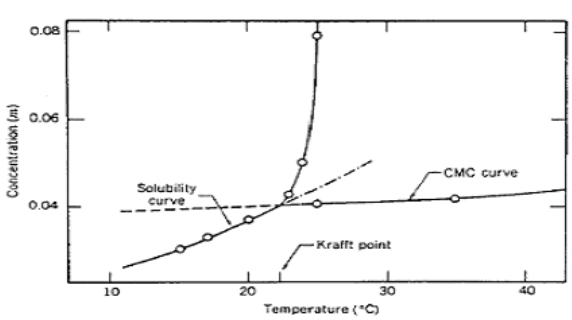

Figure 1. Phase behavior diagram for a surfactant in aqueous solution showing CMC and Kraft Points.

2.2 Selection of Surfactants

Cationic surfactants as CTAB and Non ionic surfactants as EO has been chosen for carbonate reservoir. Adsorption is a major factor which can make surfactant loss. CTAB posses same charge as carbonate, which can reduce adsorption. EO doesn't have charge to adsorb carbonate reservoirs.

3. Results and Observation

Eight aqueous concentrations of CTAB and EO were tested as shown in Table 1. The concentrations of CTAB have been observed by rising temperature. Krafts point will be noticed by presence of clear appearance after turbidity.

EO surfactants don't posses kraft point. The concentration which two phases got separated can be considered for wettability alteration. CTAB and EO were blended at high temperature for flooding process.

For CTAB clear appearance has been observed at 200ppm concentration and the krafts point can be determined by Figure 2.

200ppm of CTAB shown in Figure 2 and 350ppm of EO have been heated at 90^{0}C and kept for 2 hours for stability. This blend has been applied through core flooding apparatus.

Table 1. CMC indication of CTAB and EO by altering concentration and temperature

Sl. no.	Temperature ^{0}C	CTAB ppm	appearance	EO ppm	appearance
1	10	100	cloud	100	Single Phase
2	20	200	clear	200	Single phase
3	30	300	cloud	300	Light Two phases
4	40	400	cloud	400	Clear two phases
5	50	500	cloud	500	Clear two phases
6	60	600	cloud	600	Clear two phases
7	70	700	cloud	700	Clear two phases
8	70	800	cloud	800	Clear two phases

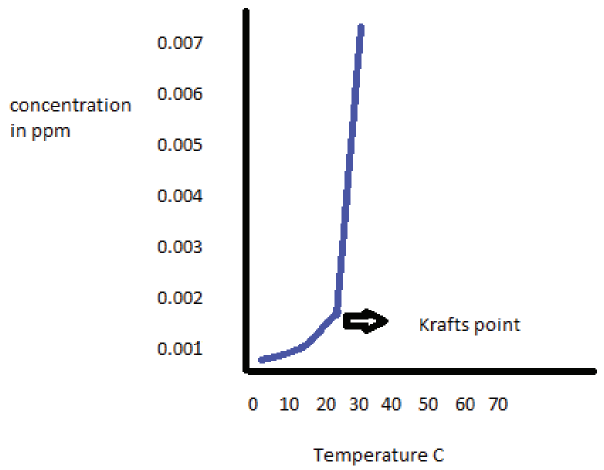

Figure 2. Kraft point for CTAB.

3.1 Core Flooding

Core flooding as shown in Figure 3 is a sophisticated equipment to simulate reservoir conditions in laboratory. Any core can be cut into 3-3 inch size which can be fitted and observed in high temperature and pressure.

Initially a carbonate core have been dried, cleaned and flooded with oil of injecting 3 pore volumes. This has been followed by water injected. 0.2pv of oil have been recovered due to oil wet. After that blend which was prepared by CTAB and EO sent slowly into the Apparatus.

The breakthrough of oil started after 1pv blend injected. This happens because of blend which has no adsorption onto the surface of carbonate reservoir. By this 0.75pv of oil have been collected by injection 2 pv. And low salinity river water has been flooded for collecting the blended surfactant. The same experiment has been repeated with CTAB. Breakthrough of oil was observed at 1.5pv CTAB injected. 0.55pv of oil have been recovered by injecting 3 pv. The additional oil besides water flooding was recovered on the basis of wettability alteration.

Figure 3. Coreflooding apparatus.

4. Conclusion

For wettability alteration cationic nonionic blend have been chosen for carbonate core. CMC for cationic CTAB and nonionic EO at 200 ppm and 350 ppm obtained respectively on conductivity test. The same surfactants have been tested in emulsion test for further confirmation. Blend of CTAB and EO have been prepared at 90^{0}C by their CMC concentrations. CMC for both surfactants was determined by krafts Temperature point. The recovery of oil by blend after water flooding is 0.75 pore volume without adsorption. This is because of no impurities inside core sample. The recovery of blend of 0.75pv rather than individual surfactants of 0.55pv by themselves. The CMC value of this blend is lower which will help to solubilize much in aqueous phase so the contact will be more. The cationic nonionic blend is a good solubilizer for wettability alteration than by its individual forms. These blends cab be tested in another form like anionic nonionic blends sandstone reservoirs.

5. References

1. Sagi AR, Puerto M, Bian Y, Miller CA, Hirasaki GJ, Salehi M, Thomas CP, Kwan JT, Morgan K. SPE 164062-MS Laboratory Studies for Surfactant Flood in Low-Temperature, Low-Salinity Fractured Carbonate Reservoir. SPE International Symposium on Oilfield Chemistry held in The Woodlands; 2013 Apr 8-10; Texas, USA: Society of Petroleum Engineers; Copyright 2013.
2. Southwick J-G, Svec Y, Chilek G and Shahin G-T. Effect of live crude on alkaline/surfactant polymer formulations: implications for final formulation design. Society of Petroleum Engineers Journal. 2012; 17(2):352–61.
3. Roshanfekr M, Johns R-T, Pope G-A, Britton L, Britton C, Vyssotski A. Simulation of the effect of pressure and solution gas on oil recovery from surfactant/polymer floods. Society of Petroleum Engineers Journal. 2012; 17(3):705–16.
4. Camesano TA, Nagarajan R. Micelle formation and CMC of Gemini Surfactants: A Thermodynamic Model. Colloids and surfaces A: Physicochemical and Engineering Aspects. 2000; 167:165–77.

5. Hirasaki G-J, Miller C-A, Puerto M-C. Recent advances in surfactant EOR. Society of Petroleum Engineers Journal. 2011; 16(4):889–907.
6. Farhadinia M-A, Delshad M. Modeling and assessment of wettability alteration processes in fractured carbonate using dual porosity and discrete fracture approaches. SPE Improved Oil Recovery Symposium; Tulsa, OK: 2010.
7. Mya KY, et al. Interactions between the nonionic surfactant and polyacrylamide studied by light scattering and viscometry. Polymer. 1999 Oct; 40(21):5741–9.
8. Wang Z. Cloud point of anionic surfactant Triton X-45 in aqueous solution. 2007; 3–4.