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EFFECTS OF SURFACTANT CONCENTRATION ON INTERFACIAL PROPERTIES

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Annotation

Recovering more oil from existing oil reservoirs using enhanced oil recovery methods holds the key for meeting future energy demands. Even though wettability is a cornerstone in oil recovery, few studies have focused on increasing oil recovery in sandstone reservoirs through wettability alteration. The objective of this thesis is to prove that altering the wettability of a sandstone rock to preferentially water-wet condition will reduce the remaining oil saturation and thus increase the percentage of recovered oil. Two commercial surfactants were selected after studying both the phase behavior and the interfacial properties of 30 surfactants with oil and 1.00% sodium chloride brine systems. Both surfactants then were tested for their ability to alter the wettability of sandstone rocks. This alteration was measured based on the contact angles of different surfactant solutions on oil-treated glass chips. In all cases, the surfactant solutions were able to alter the wettability of the oil-treated glass chips from weakly water-wet to strongly water-wet.

Keywords

surfactants, mhe objective hydrotreating, aluminate-sulfonic acid, tablets, thiophene hydrogenolysis, heat treatment, aluminum oxide.

Introduction.

The ability of both selected surfactants to increase the percentage of recovered oil then was examined using oil-treated sands. The oil recovery tests from both oil-wet and water-wet sand showed that both surfactants can change the wettability of oil- wet sand to water-wet and increase oil recovery. Both surfactants also were shown to significantly improve oil recovery from oil-wet sandstone through

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spontaneous imbibition. Considering that up to half of all sandstone reservoirs are possibly oil-wet, the results of this work could enhance oil recovery from oil-wet, water-flooded, mature

sandstone reservoirs.

Methods. Core vacuum apparatus set-up. A vacuum pump, pressure gauge, and 1000 ml Pyrex® flask were all used to create a vacuum apparatus. The Pyrex® flask with sandstone cores was connected to the vacuum system (see Figure 1). Nalgene vacuum tubing (30 ~ 40 cm) was used to connect a bottle of 600 ml of prepared oil with the Pyrex® flask containing core samples. The tubing was closed with a tubing clip. Both the bottle and the tube on the oil side were filled with oil to remove air from that side. The end of this part of the tubing was put into the bottom of the bottle containing 600 ml of oil without any air re-entering the tubing.

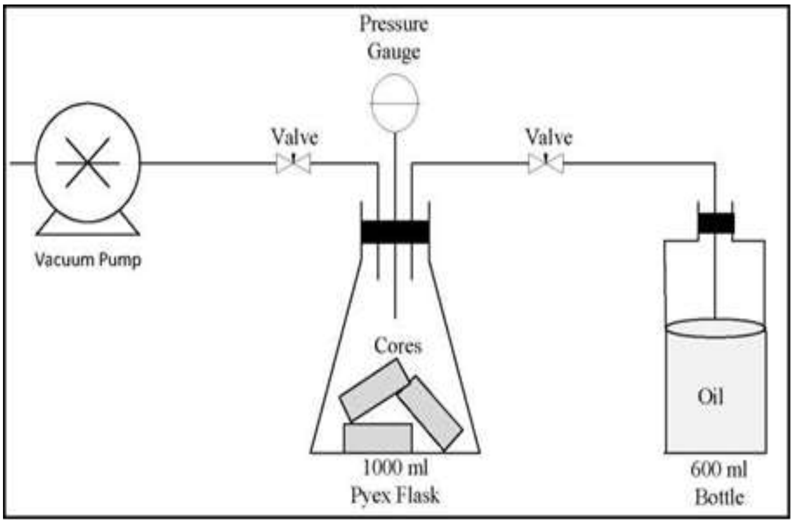

Figure 1. Vacuum System for Saturating Core Samples with Oil.

After creating this apparatus, the vacuum pump was turned on. The reading on the pressure gauge quickly decreased from 0 MPa to -100 KPa (~ -1 atm). This low pressure was maintained for 4 hours to remove the air trapped in the sandstone cores. Once all air was removed, the vacuum tubing clip was opened very slowly to allow oil to flow into the flask and be sucked by the sandstone cores because of the reduced pressure in the vacuum system. Once all of the sandstone cores were covered in the flask, the vacuum pump was turned off. After 30 minutes, the flask was disconnected from the vacuum system and allowed to site overnight. As a result, the sandstone cores were able to suck more oil at regular air pressure.

The IFT and the surfactant concentration in the brine-surfactant-oil system were measured and compared. IFT results (see Table.1) for different surfactant solutions are illustrated in Figure 2. This experiment demonstrated that increasing the surfactant concentration in the solution to 0.25 wt% reduced the IFT to the ultra-low value of 0.001mN/m. Increasing the concentration of the surfactant

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beyond the 0.25 wt% did not produce any significant effect on the IFT value. The phase behavior of the surfactant solutions are presented in Figure 1.

Table 1. IFT vs. Surfactant Concentration with Different Solutions

Concentration (ppm)	100	250	500	1000	2000	2500	5000
IFT (mN/m)	0.437	0.383	0.3056	0.1929	0.032	0.001	0.001

IFT results (see Table .2) for the different surfactant solutions are illustrated in Figure 3. The experiment demonstrated that increasing the surfactant concentration in the solution to 0.20 wt% reduced the IFT to the ultra-low value of 0.001mN/m, increasing the concentration of the surfactant beyond the 0.20 wt% did not produce any significant effect on the IFT value. The phase behavior of the surfactant solutions are presented in Figure 4.

Table2. IFT vs. Surfactant Concentration with Different Solutions

Concentration (ppm)	100	250	500	1000	2000	2500	5000
IFT (mN/m)	0.744	0.593	0.488	0.312	0.001	0.001	0.001

Effects of surfactant solutions on wettability. The effects of surfactant concentration in the brine-surfactant-oil system on wettability have been investigated through contact angle measurements.

Contact angles for different surfactant solutions on oil-treated glass chips, with a comparison to the brine contact angle are presented in

All of the surfactant solutions tested on the oil-treated glass resulted in the contact angle being reduced to zero, thus altering the weakly water-wet glass to strongly water- wet. Increasing the surfactant concentration in the surfactant solutions resulted in a reduced amount of time required for the contact angle to reach zero. These measurements were repeated at least three times and produced the same results, keeping in mind that contact angle results have an accuracy of ± 5 degrees.

Results:

• An ultra-low IFT of 0.001mN/m was achieved using both selected surfactants.

• Strong water-wet properties were attained using low concentrations of surfactant solutions.

• Low concentrations of surfactant solutions showed a high ability to increase oil recovery from sandstone cores through spontaneous imbibition.

• Surfactants showed a high ability to recover oil from oil-wet sand samples.

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• showed better performance using lower surfactant concentrations compared to. A surfactant concentration of 0.2 wt% was successful in reaching an ultra-low IFT and maximum recovery from both sandstone cores and sand samples.

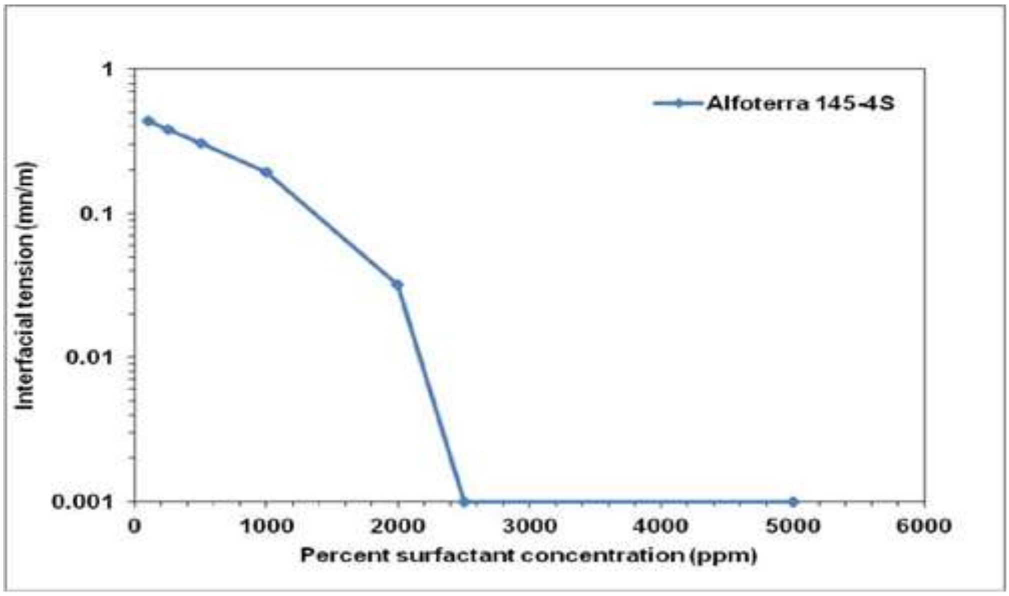

Figure 1. IFT vs. Surfactant Concentration with Different.

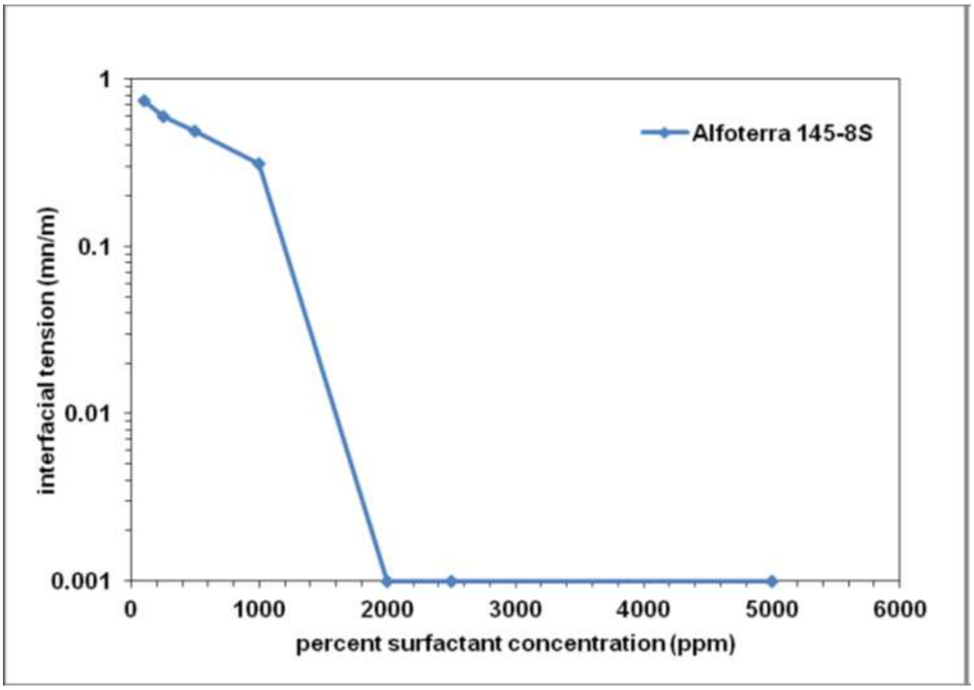

Figure 2. IFT vs. Surfactant Concentration with Different Solutions

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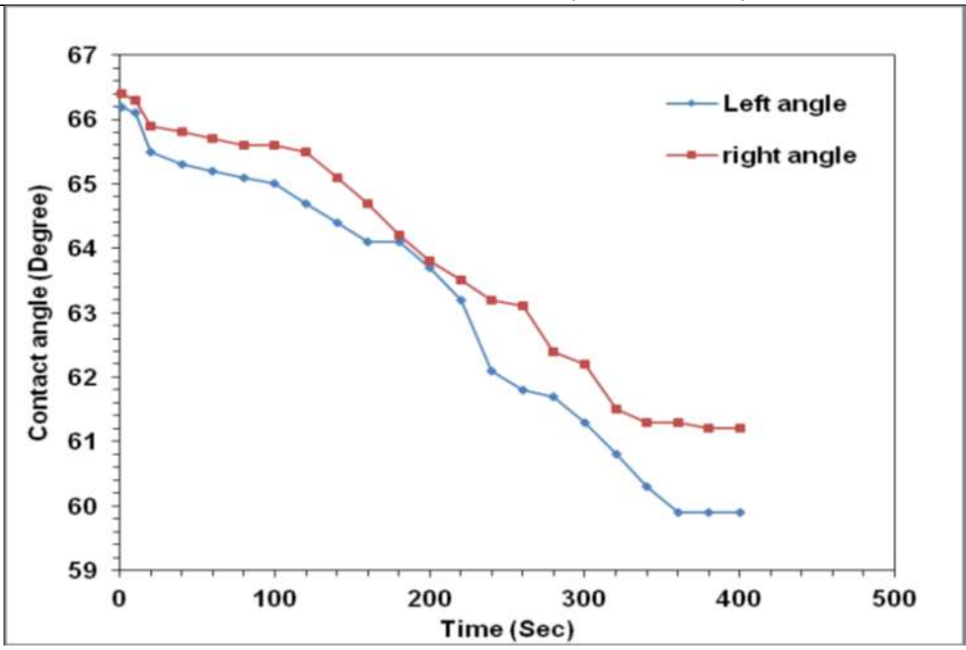

Figure 3. Left and Right Contact Angles for Synthetic Brine Solution.

Wettability measurements. As one of the most significant properties controlling oil recovery, the reservoir wettability must be studied sufficiently. Measuring the wettability of an oil/water/rock system is not an easy task. Different measurement methods can yield different results.

A variety of methods has been proposed to measure the wettability of a system. These methods can be classified as either quantitative or qualitative. The contact angle, modified Amott test, and U.S. Bureau of Mines (USBM) methods are all examples of quantitative methods used to measure the wettability of a system. Capillary pressure curves, reservoir logs, and imbibitions rates are examples of qualitative methods.

The methods most widely used in determining the wettability of an oil/water/rock system are the contact angle, Amott test and USBM. The contact angle measures the wettability of a liquid drop on a solid surface but does not consider the heterogeneity of the reservoir or surface roughness. The Amott test and USBM measure the average wettability of a core. As a result, they are applied when studying reservoir properties.

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