Contribution ID: **14** Type: **Poster Presentation**

Rock-Fluid Interaction Mechanisms between Binary Surfactants Systems for Enhanced Oil Recovery in a Carbonate Formation

Monday, 13 May 2024 14:55 (1h 30m)

Carbonate rocks exhibit a complex surface charge, making it challenging to generalize the use of a single surfactant type. Hence, the utilization of binary surfactant mixtures is proposed as a more efficient alternative. This work focuses on static adsorption, wettability alteration, and spontaneous imbibition tests to gain comprehensive insights into the underlying fluid-rock interactions in carbonate formations. The objective is to propose more effective solutions for enhanced oil recovery in carbonate formations. Our study centered on binary surfactant systems and their interactions with carbonate rock. We conducted several laboratory experiments, including static adsorption tests on eight different surfactant systems. This aimed to compare their adsorption behaviors against individual surfactants, with the aim of studying their synergistic interactions. Additionally, wettability and spontaneous imbibition tests were conducted under the reservoir conditions of a producing oil field to understand the primary mechanisms and synergistic effects of binary surfactant systems in enhancing oil recovery from carbonate formations. Our results showed a significant influence of the non-ionic surfactant leading a considerable reduction in adsorption values of 53% and 28% in its anionic-nonionic and cationic-nonionic mixtures, respectively. The efficient synergism between binary surfactant systems to reduce surfactant adsorption in carbonate rocks was also confirmed in the physicochemical evaluations with a reduction in both zeta potential and pH values when compared to their individual surfactants. Furthermore, spontaneous imbibition results showed that binary surfactant mixtures exhibit maximum synergism, particularly when they system is composed of of zwitterionic and non-ionic surfactants. This surfactant blend resulted in the highest recovery factor of nearly 60%, signifying significant improvement in oil recovery from carbonate formations. According to the analysis of contact angle, the binary surfactant systems did not significantly change wettability. However, this can be beneficial because it implies that the surfactant molecules are not adsorbed to the rock surface within the porous medium. Instead, they are utilized to their maximum potential within the porous medium. The findings presented in this work demonstrate that careful screening, selection, and combination of binary surfactants can effectively reduce surfactant adsorption, maintain rock wettability, and substantially lower interfacial tension in carbonate rock, ultimately aiming to enhance oil recovery. This approach paves the way for the development of innovative surfactant blends that ensure the economic viability of EOR projects, suitability for CO2 foam sequestration projects, and broad applicability in carbonate formations.

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References

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Session Classification: Poster

Track Classification: (MS06-B) Interfacial phenomena across scales