Robust and Efficient Evaluation of Oil/Water Contact Angles and Wettability Alteration Using a Modified Washburn Method

Alhasan B. Fuseni*, Ziyad* Kaidar*, Abdulkareem M.* AlSofi

Abstract. Wettability alteration represent a potential EOR mehansims that is especially valuable for fractured media. Initial screening of surfactants for wettability-alteration purposes rely mainly on contact angle measurements prior to further spontaneous or forced displacement experiments. In this work, we evaluate a novel sorption procedure to study wettability alteration and screen surfactants. In this method, changes in wettability of carbonate rock powder when treated with various surfactants are estimated using a modified Washburn method.

Carbonate rock, synthetic brines, crude oil and four surfactants were used. Surfactants included: anionic alfa olefin sulfonate, cationic quaternary ammonium salt, an amphoteric surfactant and a nanosurfactant. Hexane was used as a reference (completely wetting) fluid. Sorption experiments were performed. In which, powdered rock with a size between 80 and 100 mesh is coated with the surfactant and compacted in the sample holder. A chamber is then raised to the bottom of the powder pack such that the fluid sorbs by capillarity. A balance measures the mass sorbed with time. Direct contact angle measurements were also performed for benchmarking.

Plotting the square of fluid mass against time gave a slope which enabled the calculation of contact angle in air. For each coating, the results (sloped) observed for the completely wetting fluid (hexane) provided the rock constant. Sorption results of crude oil coupled with the previously determined rock constant enabled estimation of the Wasburn oil/air contact angles using the modified Washburn equation. Sorption results with brine and surfactant solutions coupled with the rock constant and oil/air enabled estimation of the Washburn water/air contact angles using the modified Washburn equation. Based on water/air and oil/air contact angles, values of the conventional oil/water contact angle were estimated. This approach, enabled a robust and rapid estimation of surfactant effects on contact angles (hence wettability). Based on the benchmark contact angle results, the sorption approach yields acceptable results especially for screening purposes. Furthermore, the results demonstrated the capacity of the surfactants for wettability alteration. Among the tested surfactants, the nanosurfactant altered wettability the most.

The use of sorption to obtain contact-angle estimates provide a novel rapid and robust procedure for evaluation and screening of wettability-alteration agents. This eliminates direct contact angle measurements that are often cumbersome. It specifically eliminates the difficulties of attaching an oil drop onto a rock surface immersed in surfactant solutions where the ultra-low interfacial tension causes the oil drop to spread prematurely.