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Wettability Behavior of Crude Oil-Silica Nanofluids-Sandstone Systems

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Mobilizing and recovering crude oils from geological formations is critical for the management and exploitation of petroleum reservoirs. Nanoparticles, with their unique physico-chemical properties can increase the efficiency of enhanced oil recovery (EOR) by decreasing interfacial tension (IFT) between the oil and aqueous phase systems, and altering rock wettability. Our research examines the potential use of nanoparticles as a means of EOR by studying the influence of silicon oxide (SIO_2) nanoparticles on the wettability and interfacial tension of different crude oil-silica nanofluids-sandstone systems. We designed nanofluid treatments to manipulate changes in wettability of Berea and Boise sandstones simulating petroleum reservoir. Experiments were performed to measure the IFT and wettability involving different concentrations of nanoparticles with and without the addition of surfactant to determine which nanofluids produced the most favorable wettability changes for optimal EOR with light crude oil (e.g., West Texas, API: 40), medium crude oil (Prudhoe Bay, API: 28), and heavy crude oil (e.g., Lloydminster, API: 20). We investigated the addition of Tween 20 nonionic surfactant to the nanoparticle dispersions—made from SiO_2 nanoparticles—that allows the optimum mobility in porous media through optimization of interfacial tension (IFT) and contact angle, and conducted tests. Batch studies were conducted to measure the IFT and wettability of the nanofluids of different range of nanoparticle concentrations (0-0.1 wt. %) in different reservoir conditions, i.e. brine and brine-surfactant systems made with 5% brine and 2CMC of Tween 20 nonionic surfactants. The dynamic behavior of IFT was monitored using a pendant drop method. Five percent brine-nanoparticle systems containing 0.001 and 0.01 wt.% of nanoparticles resulted in a significant decrease of IFT for light and medium crude oils, while the highest decrease of IFT for heavy crude oil was observed with 0.1 wt.% nanoparticles. IFT decrease was also enhanced by surfactant, and the addition of nanoparticles at 0.001 wt.% to surfactant resulted in significant decrease of IFT in many of the selected crude oil-silica nanofluid systems. The sessile drop method was utilized to characterize the dynamic behavior of the contact angle of crude oil droplets on Berea and Boise sandstones surface. Different nanofluids were used for the optimization of changes in wettability of the selected systems. Differences have been observed in preliminary data analysis of the IFT and wettability properties between nanofluids indicating that the surfactant and/or nanoparticles is impacting the fluid-surface interactions in crude oil-silica nanofluids-sandstone systems.