

Microscale interactions of EOR chemicals at the crude oil-water interface and their implications for oil recovery

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Abstract. The conventional experimental techniques used for the performance evaluation of enhanced oil recovery (EOR) chemicals, mainly polymers and surfactants, have been mostly limited to bulk viscosity and interfacial tension measurements. Furthermore, fundamental studies exploring the different microscale interactions instigated by the EOR chemicals at the crude oil-water interface are very scanty. The objective of this experimental study is to fill this existing knowledge gap and deliver an important understanding on underlying interfacial mechanisms and their potential implications for oil recovery in chemical EOR.

Different microscale interactions of EOR chemicals, at crude oil-water interface, were studied by using a suit of novel instruments such as Langmuir trough, interfacial shear rheometer and coalescence time measurement apparatus. The reservoir crude oil and high salinity injection water (57,000 ppm TDS) were used. Two chemicals, an amphoteric surfactant (at 2000 ppm) and a sulfonated polyacrylamide polymer (at 500 ppm), were chosen since they are tolerant to high salinity and high temperature conditions. Interface pressures, compression energy, interfacial viscous and elastic moduli and coalescence time between crude oil droplets are the major experimental data measured.

The results showed that interfacial pressures slightly decreased with polymer, however remained almost in the same order of magnitude as the plain high salinity aqueous brine. In contrast, a significant reduction in interfacial pressures with surfactant was observed. The interface compression energies showed the same trend and were reduced by about two orders of magnitude when surfactant is added to the aqueous brine. The surfactant was also able to retain similar interface behavior under compression even in the presence of polymer. Interfacial rheology measurements demonstrated only minor changes in interface viscous/elastic moduli (G' and G'') and the absence of G'/G'' crossover point with both surfactant and polymer chemicals. These insignificant effects of EOR chemicals on interface viscoelasticity can be attributed to the very low content of asphaltenes present in the crude oil. The coalescence times between crude oil droplets were slightly increased by polymer whereas substantially decreased by the surfactant. These findings indicate negligible interactions of polymer at crude oil-water interface, while demonstrating the high efficiency of the surfactant to soften the interfacial film, promote the oil droplets coalescence and mobilize substantial amounts of incremental oil in chemical EOR.