

Numerical Investigation of the Effects of Surfactant Concentrations on the Dynamics of Liquid-Liquid Interfaces

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Abstract : Theoretically, there exist two mathematical interfaces (fluid-solid and fluid-fluid) when a liquid film is present on solid surfaces. These interfaces overlap if the mineral surface is oil-wet or mixed wet, and therefore, the effects of disjoining pressure are significant on both boundaries. Hence, dewetting is a necessary process that could detach oil from the mineral surface. However, if the thickness of the thin water film directly in contact with the surface is large enough, disjoining pressure can be thought to be zero at the liquid-liquid interface. Recent studies show that the integration of fluid-fluid interactions with fluid-rock interactions is an important step towards a holistic approach to understanding smart water effects. Experiments have shown that the brine solution can alter the micro forces at oil-water interfaces, and these ion-specific interactions lead to oil emulsion formation. The natural emulsifiers present in crude oil behave as polyelectrolytes when the oil interfaces with low salinity water. Wettability alteration caused by low salinity waterflooding during Enhanced Oil Recovery (EOR) process results from the activities of divalent ions. However, polyelectrolytes are said to lose their viscoelastic property with increasing cation concentrations. In this work, the influence of cation concentrations on the dynamics of viscoelastic liquid-liquid interfaces is numerically investigated. The resultant ion concentrations at the crude oil/brine interfaces were estimated using a surface complexation model. Subsequently, the ion concentration parameter is integrated into a mathematical model to describe its effects on the dynamics of a viscoelastic interfacial thin film. The film growth, stability, and rupture were measured after different time steps for three types of fluids (Newtonian, purely elastic and viscoelastic fluids). The interfacial films respond to exposure time in a similar manner with an increasing growth rate, which resulted in the formation of more droplets with time. Increased surfactant accumulation at the interface results in a higher film growth rate which leads to instability and subsequent formation of more satellite droplets. Purely elastic and viscoelastic properties limit film growth rate and consequent film stability compared to the Newtonian fluid. Therefore, low salinity and reduced concentration of the potential determining ions in injection water will lead to improved interfacial viscoelasticity.

Keywords : liquid-liquid interfaces, surfactant concentrations, potential determining ions, residual oil mobilization

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