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Experimental assessment of emulsification stability during enhanced oil recovery in the presence of polymer (PMMA) and nanoparticles (ZnO)

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Abstract

Among several methods proposed as secondary or tertiary recovery techniques, water flooding has proven to be less costly in terms of operating costs but often results in lower recovery value and sweep efficiency. Water flooding may be preferred when limited economic resources exist and/or for the displacement of oils with similar mobility to water. In heavy oil reservoirs the low mobility of the oil makes this method inefficient as water mobility is much greater than the oil leading to unfavorable mobility ratio, large viscosity difference which may cause channeling or fingering in the reservoir sweep and an early water breakthrough. Surfactant injection has been considered as an attractive alternative in order to attain higher oil recovery volumes. For instance when a stable oil-in-water emulsion is injected in a reservoir after a secondary recovery with water flooding, it tend to flow through the same high permeable water-wet zone previously covered by water flooding and the oil droplets get trapped in the pore throats changing the wettability of the rock surface and decreasing the permeability of the invaded zone. As a result water injected afterwards is forced to flow through less permeable zones that were not swept previously and lead to an oil recovery increase. Often surfactant injection is useful for improving the sweep in the reservoir.

It has been found that polymer injection may decrease further water mobility, thus contributing to a favorable mobility ratio and optimized volumetric sweep efficiency. Though injection of polymer may not reduce the residual oil saturation in the reservoir, it results in an improvement of displacing front stability and better oil recovery compared to other techniques such as water flooding. Polyacrylamide copolymers or hydrolyzed polyacrylamide (HPAM) polymers are by far the most widely used polymer for EOR but they are still

expensive. Poly (methyl methacrylate) or PMMA was considered for this work since it's relatively cheaper and readily available. On the other hand emulsions can be typically stabilized by the use of emulsifiers that are usually added in volumes (up to less than 1%wt) in order to lower the operational cost of the recovery process. In particular, emulsions stabilized by solid particles (nanoparticles) have become recently an attractive alternative that provides stabilization in oil-in-water and water-in-oil emulsions by reducing the interfacial tension and the capillary pressure, but are still relatively less covered in open literature. Therefore this dissertation considers oil-in-water/water-in-oil emulsions stabilized by nanoparticles and polymers to extent knowledge in this area. Therefore; this study investigates the stability of crude oil/water emulsions in the presence and absence of polymer and nanoparticles using crude oil blend received from NATREF with average API gravity of 35 and in particular assess the influences of the temperatures, brine concentration, polymer/nanoparticle concentration, oil/water ratio and stirring mechanism. It further investigates whether or not the combination of polymers and nanoparticle can provide a more stable emulsion than polymers only. Poly (methyl methacrylate) or PMMA polymer and zinc oxide (ZnO) nanoparticle were used. Furthermore droplet size distribution was analyzed using a microscope to see how tight the emulsions are and the droplets distribution.