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Co-precipitation and grafting of (3-Aminopropyl) triethoxysilane on Ferro nanoparticles to enhance oil recovery mechanisms at reservoir conditions

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ABSTRACT

After primary and secondary recovery processes, a substantial amount of oil remains trapped in the reservoir due to pressure and reservoir heterogeneity. Iron oxide nanoparticles (IONPs) are increasingly being considered for use in the oil and gas sectors for oil spill clean-up, emulsion separation, drilling and enhanced oil recovery (EOR) applications owing to their distinctive magnetic properties. However, the major drawback is that the particles quickly agglomerate to diminish their high surface energy, particularly in the presence of reservoir brine. As a result, dispersion is poor and oil recovery is limited due to reservoir pore plugging which might cause reservoir damage. Previous studies have documented the oil recovery mechanisms of bare IONPs leading to incremental oil recovery however, their research work was conducted at ambient condition, which does not present oilfield condition. Therefore, the oil recovery efficiency of functionalised IONPs at reservoir conditions is still tenuous in literature. In this work, IONPs were functionalized with 3-aminopropyltriethyloxysilane to form a novel nanohybrid with improved chemical – synergistic effects on interfacial tension (IFT), wettability alteration, and emulsion formation. The morphology, surface properties, chemical composition and stability of the functionalized IONPs was determined and compared with the conventional IONPs. Likewise, the ability of the functionalized IONPs to decrease IFT and alter the wettability of rock/fluid at reservoir conditions was examined using K20 Easy Dyne Kruss tensiometer and Kruss drop shape analyzer, respectively. Finally, a high temperature high pressure core flooding equipment (Fars EOR) was utilized to ascertain the oil recovery efficiency of the functionalized IONPs at reservoir conditions and the results compared with the conventional IONPs. High resolution transmission electron microscopy (HRTEM) images revealed that the functionalization approach did not alter the morphology of IONPs. The functionalized IONPs were stable with a zeta potential of + 31.2 mV thereby, decreasing IFT from 25.5 to 7.7 mN/m and altering wettability from oil wet (128°) to water wet (22°) at reservoir conditions. The functionalized IONPs also increased oil recovery by 13.3 % compared to 10.3 % increment by IONPs in distilled water (DW). However, at high salinity conditions, the oil recovery of IONPs decreased by 7.5 % while that of functionalized IONPs increased by 1.4 % relative to DW. Therefore, it can be concluded from this experimental study that functionalization of IONPs increased oil recovery at reservoir condition, owing to production of in-situ emulsions, reducing pore obstruction and improving sweep efficiency. These findings contribute towards understanding the influence of functionalization on the oil recovery mechanism and transportation of IONPs under reservoir conditions.

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