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Smart- and nano-hybrid chemical EOR flooding using Fe_3O_4/eggshell nanocomposites

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Highlights

- A green and economical method was used to synthesize Fe_3O_4@eggshell NCs.
- NCs CTAB and TR-880 surfactants used to prepare surfactant and surfactant nanofluids
- The effect of prepared solutions on IFT reduction and wettability alteration was studied.
- The synthesized NCs are more effective with the CTAB.
- Optimal nano-hybrid CTAB solution enabled to produce extra 8.16% OOIP.

Article preview
Abstract
Introduction
Section snippets
References (57)
Cited by (49)

Abstract

Surfactants and other chemicals are commonly used to improve oil recovery by altering wettability, improving the mobility ratio and reducing the interfacial tension (IFT). Currently, nanoparticles are widely used to enhance the performance of chemical solutions in improving oil recovery, as hybrid enhanced oil recovery (EOR) solutions. In this study, the performance of CTAB (cetyltrimethylammonium bromide) and TR-880 surfactants was improved using a synthetic Fe_3O_4/eggshell nanocomposite (NC). This NC was synthesized in an environmental-friendly manner from the extract of the *Commersonia bartramia* plant. Initially, surfactant solutions at different concentrations (CTAB: 100, 200, 500, 1000, and 2000 ppm, and TR-880: 100, 200, 500, 1000, 2000, 3000, 5000, and 7000 ppm) were prepared. Measurements of pH, viscosity and electrical conductivity were used to estimate the critical micelle concentration (CMC) of the prepared surfactant solutions, which were determined to be at 1000 ppm CTAB and 3000 ppm TR-880. According to our previous findings (Asl et al., 2020), the values of surfactant CMC would be not affected by adding the NCs. The performance of these surfactants in EOR was evaluated—in terms of the wettability of the carbonate rock and decreased IFT—under the influence of dissolved sodium chloride (NaCl) and the synthesized NC. The synthesized NC was mixed with distilled water (DW) and surfactant solutions at their CMCs to prepare nano-surfactant solutions (hybrid) with different concentrations (100, 200, 500, and 1000 ppm). The experimental IFT and contact angle (CA) results varied depending on the solution used. When each surfactant was used alone, TR-880 and CTAB decreased the IFT from 29.1 mN/m to 3.7 and 0.684 mN/m respectively. These values were further decreased to 0.42 and 0.17 mN/m, respectively, by adding 45,000 ppm of NaCl. However, the impact of both surfactants on the wettability was low: CAs of 99.61° and 111.9° were obtained with TR-880 and CTAB, respectively, which were decreased to 90° CA by adding 45,000 ppm NaCl. In addition, the prepared nanofluid from the Fe_3O_4/eggshell NC decreased the IFT from 29.1 to 13.238 mN/m and CA from 136.3° to 70.28°. A hybrid chemical solution comprising NC and surfactant gave the best performance, decreasing the IFT and CA to 0.18 mN/m and 60.7°, respectively; this solution contained 500 ppm NC and 1000 ppm CTAB surfactant and improved oil