POLYMER-COATED NANOPARTICLES USED AS AGENTS FOR ENHANCED OIL RECOVERY

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ABSTRACT

Linear and comb-type copolymers comprising: a) hydrophilic, anionic monomers like 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPSA) and acrylic acid (AA) that are stable in the present of salts in aqueous media and b) hydrophobic monomers like dodecyl methacrylate (DMA), were synthesized through free radical polymerization (FRP). The synthesis of polymer-coated nanoparticles (PNPs) was accomplished by post-grafting and surface initiated FRP on commercial silica nanoparticles or magnetite (Fe_3O_4) nanoparticles synthesized by wet chemistry routes.

Mono-valent (NaCl) and di-valent ($CaCl_2$) salts were added in aqueous suspensions of PNPs to modify the ionic strength and create adverse conditions for their stability. The suspended nanoparticle size distribution was determined with dynamic light scattering (DLS) while their stability was tested by inspecting the sedimentation and measuring the ζ-potential. The dynamic surface/interfacial tension of aqueous phase/air and aqueous phase/oil were measured combining the pendant drop method with the OpenDrop software of inverse modeling of Young-Laplace equation [1]. These properties along with wettability, as quantified by measuring the contact angle on various types of solid surfaces, enabled us to assess the capacity of nano-colloids to generate stable foams and emulsions. With the aid of an ultrasound probe, the nano-colloids were mixed with oil (n-decane / n-dodecane) to prepare Pickering emulsions, measure their rheological properties, and examine their short- and long-term stability.

To assess the performance of the nano-colloid suspensions and emulsions as agents of enhanced oil recovery (EOR), tests of secondary and tertiary oil recovery were conducted in three types of porous media: (i) transparent glass-etched pore network [2]; (ii) sandpack; (iii) core plug of Bentheimer sandstone. In each test of immiscible displacement, the flow rate was kept constant, and the transient changes of fluid saturation along with the pressure drop across the porous medium were recorded. In the glass micromodel, the oil saturation was measured with image analysis of successive snap-shots captured by a CCD camera; in the sandpack and core plug, the oil saturation was determined by recording the effluent mass with a weight balance. Comparative analysis of the oil displacement efficient by an aqueous phase and PNP-based displacing fluid was used as criterion to assess the performance of PNP-based fluids as EOR agents, classify them, and select the most efficient ones.

KEYWORDS: porous media, AMPSA, polymer-coated nanoparticles, enhanced oil recovery, Pickering emulsion, immiscible displacement

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