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Nanoparticle-based suspensions and emulsions for enhanced oil recovery

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The aqueous extracts obtained when boiling the leaves of plants (e.g. tea, parsley, coriander, etc) contain a mixture of polyphenols, which are natural polymers, and if mixed with a metal salt, they may act both as reductants and capping agents of the so-produced nanoparticles [1]. Aqueous solutions of polyphenols extracted from the leaves of parsley were mixed with aqueous solutions of ferric chloride hexahydrate to produce suspensions of iron oxide nanoparticles. The total concentration of polyphenols was measured in terms of equivalent concentration of Gallic acid by using the Folin-Ciocalteu method. The creation of iron oxide nanoparticles was confirmed with X-ray diffraction (XRD) analysis, and scanning-electron microscope (SEM) images of solid material isolated with centrifuging. The suspended nanoparticle size distribution was determined with dynamic light scattering (DLS), while the stability of the nano-colloids was confirmed by measuring the ζ-potential as a function of the concentration of mono-valent (NaCl) and di-valent (CaCl2) salts, and ionic strength. The static and dynamic surface/interfacial tension of aqueous phase/air and aqueous phase/oil were measured by using a tensiometer with DuNouy Ring, and combining the pendant drop method with the OpenDrop software of inverse modeling of Young-Laplace equation [2], respectively. These properties along with wettability, as quantified by the contact angle, 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) to prepare Pickering emulsions The rheological properties (shear viscosity, loss and storage moduli) of emulsions were measured on a stress rheometer, and their stability was inspected by observing the phase separation (macro-scale) and measuring the drop size distribution (micro-scale).
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 two types of porous media models: (i) transparent glass-etched pore networks [3]; (ii) sandpacks. In each test, the transient response of the oil displacement efficiency and pressure drop across the porous medium were recorded, and used as criteria to classify the performance of fluids as EOR agents, and select the most efficient ones for further studies in reservoir rocks.

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