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Flow behavior of charged nanoparticle stabilized emulsions in a glass micromodel

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Nanoparticle stabilized emulsions have attracted interest for enhanced oil recovery (EOR) because of their improved stability to coalescence over emulsions stabilized with surfactants. This behavior is due to the irreversible adsorption of nanoparticles to the oil/water interface which can inhibit droplet coalescence. However, characterization of nanoparticle stabilized emulsions for EOR has been poor, and there is a need to understand the relationship between the static properties of emulsions (drop size and zeta potential) and their flowing properties (e.g., whether drops remain stable as they flow through pore restrictions). Therefore, the objective of this work was to visually study the flowing behavior of nanoparticle stabilized emulsions –with different static properties - using a glass micromodel.

Nanoparticles modified with the hydrophilic silane (3-Glycidyloxypropyl)trimethoxysilane (glymo) were used to stabilize bromohexadecane-in-water emulsions. We selected glymo as a surface modifier because of its demonstrated ability to sterically stabilize nanoparticles while in the presence of API brine at 80 oC. The static properties of our emulsions were altered by using different concentrations of glymo in our reaction mixtures or by varying the salt concentration in the brine. We visually monitored the flowing behavior of the emulsions using 2-dimensional glass micromodel. The micromodel consists of a single 200 μm channel that reduces to a 50 μm pore restriction. We characterized the build-up and collapse of the flowing emulsions at the pore restriction.

Our results suggest differences in the flowing behavior of emulsions with different static properties (high vs. low zeta potential). We show that emulsions with a high zeta potential (~-18-30 mV) have a strong tendency to block the 50 μm pore restriction whereas those with a low zeta potential (~0-5 mV) have much less of a tendency to block and build-up at the restriction. Between the two, there was a reduction in the column build-up height by a factor of 3.4. This different qualitiative behavior has implications for the intended use of emulsions for enhanced oil recovery.

References

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