Contribution ID: **191**

Type: **Oral Presentation**

Effect of nanoparticles on the water-soluble polymers flow in porous media

Tuesday, 31 May 2022 17:45 (15 minutes)

The addition of a small amount of water-soluble polymers (e.g. polyacrylamides and polyethylene glycol) to water can significantly affect the rheological response of aqueous solutions. These aqueous polymeric solutions have frequently been used to control the flow response of working solutions in several porous media applications, including chemical enhanced oil recovery. However, polymer chains are susceptible to degradation in high ionic strength (I) mediums which hinder their successful implementation and performance. Hybrid mixtures of hydrophobically modified polyacrylamide (HMPAM) with hydrophobic silica nanoparticles (NPs) appeared as an alternative approach to achieve enhanced stability and high viscosity in mediums having extremely high ionic strength (I > 3800 mM).

The utilized silica nanoparticles (with an average size of 7 nm) were modified by grafting an organic ligand (gamma-glycidoxypropyltrimethoxysilane) onto its surface to ensure the colloidal stability at high ionic strength. The rheological response of the hybrids at various concentrations of HMPAM and NPs was studied to investigate the synergic effects. Core-flood experiments were performed by injection of either HMPAM solution, NPs suspension, or an HMPAM–NPs hybrid at superficial velocities of 1 and 10 ft/day to assess their retention and injectivity.

The colloidal stability of NPs was successfully explained by an extended DLVO theory. Hybridization of HMPAM with NPs resulted in a higher viscosity at high ionic strength and elevated temperature (T= 70 degree Celsius). Viscosity improvement was more noticeable when the concentration of HMPAM was in the semi-dilute regime and the concentration of NPs was higher than a critical threshold where the viscosity increased roughly by a factor of 1.5. The underlying mechanisms are discussed by rheological measurements. The rheological data suggest the role of NPs in inter-chain associations of HMPAM chains through hydrophobic – hydrophobic interactions leading to increase hydrodynamic radius and therefore viscosity of the hybrids.

It was observed that the flow of HMPAM and NPs in the same solution in porous media has the following benefits: (a) the HMPAM–NPs hybrid has a higher flow resistance as compared to the injection of HMPAM alone (b) the HMPAM–NPs hybrid prevents filtration of the NPs in the inlet while the injection of NPs alone results in significant filtration in the inlet and (c) the co-injection of HMPAM and NPs also decreases the retention of both HMPAM and NPs as compared to when they are injected individually.

This study provides insights on the interaction of polymer molecules and nanoparticles in hybrid systems for enhancing stability and improving the viscosity opening a pathway for developing other polymer-based systems at harsh conditions for porous media applications.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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Session Classification: MS06-B

Track Classification: (MS06-B) Interfacial phenomena in multiphase systems