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« Previous | T o C | Next »

Abstract

Summary

After drainage of brine-filled rock pores with an asphaltenic crude oil, the wettability state of a sandstone or limestone subjected to a high capillary pressure eventually changes from strongly water-wet to mixed-wet. A partial reversal of this mostly irreversible change of reservoir rock wettability is the condition necessary to increasing field-scale recovery of asphaltenic crudes.

In this work, we propose asphaltene molecule proxies that possess many asphaltene properties and satisfy reservoir adsorption conditions. We quantify the irreversible adsorption of these analogs with carboxylic, amino, or sulfate groups onto the silica using a quartz crystal microbalance with dissipation (QCM-D). We explore conditions for desorption of the irreversibly adsorbed analogs.

We use aqueous-soluble functionalized dextran polymers of variable chain length as asphaltene analogs. Adsorption was studied in brines with varying salts and pH. QCM-D results reveal that positively charged ammonia-functionalized poly-dextrans adsorb on silica irreversibly regardless of chain length and brine composition. However, sufficiently long chains and the presence of calcium ions are required for negatively charged sulfate- and carboxylate-modified poly-dextrans to adsorb irreversibly onto silica surface. Such a phenomenon is explained by calcium ion bridging of two negatively charged moieties. Experiment duration is found to be important for irreversible adsorption as well.

After the polymers have irreversibly adsorbed to silica, we attempt to desorb them by changing the brine composition. Desorption tests included combinations of 10, 100 and 300 mM of NaCl, KCl and CsCl. Preliminary results suggest that dextran polymers adsorbed via the bridging mechanism (i.e., sulfate- and carboxylate-modified) desorb using salt solutions with monovalent cations of potassium and cesium in obedience to the Hofmeister series. A similar result, but to a lesser extent, applies to ammonia-functionalized poly-dextrans yielding far less desorption.

In summary, positively charged amines adsorb irreversibly on the negatively charged silica surface. However, three factors are important to achieve irreversible adsorption of carboxylates and sulfates: a sufficient chain length, presence of calcium ions, and time. For monovalent cations, desorption efficiency seems to follow the Hofmeister series but to different extents depending on the adsorption mechanism.

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