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Modeling Wettability Alteration Induced by Asphaltene and Fluid Behaviors at the Interface

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Wettability is a paramount factor in multiphase flow through porous media. The preference of the rock mineral surface to oil or brine determines fundamental flow functions in reservoir engineering like irreducible saturations, critical saturations, relative permeability and capillary pressure. Its implications affect all processes in oil and gas recovery, from primary production, waterflooding, to enhanced oil recovery. Except for a few specialized cases (low salinity waterflooding), reservoir modeling is done without considering wettability alteration during these processes.

There is experimental evidence in the literature that the presence of asphaltene can alter rock wettability towards more oil-wet. However, on one hand, modeling wettability of porous rocks is difficult because many complex factors interact in the system, which cannot be considered independently. Even a perfect independent description of rock, and two fluid phases is not sufficient to accurately model the wettability of a rock. On the other hand, asphaltenes (the heaviest, most polar component of crude oils) are a class of complex, not well-defined molecules, with behaviors that affect the water/oil/solid interactions and hence wettability. At the current state of the art, there is no comprehensive model that can predict wettability, not even without the complexity of asphaltene behaviors.

We present here a model based on the DLVO theory with fundamental forces in the equilibrium of a flat solid surface with two fluids (brine/oil, wetting/non-wetting) at nanoscopic scale. The force equilibrium results in a macroscopic contact angle formed by a drop of oil over a thin film of brine over a solid surface. With the inputs of physical parameters, such as asphaltene content, oil/water interfacial tension, electric surface potentials, and brine composition, the developed model is able to predict contact angle alteration as function of changes in any of the inputs.

References

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