

PROCEEDINGS

Molecular Simulation of Multiphase Interface Characteristics and Microscale Flow Mechanisms of Oil and Brine in Carbonate Reservoir

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ABSTRACT

Pore structures of carbonate reservoirs are complicated leading to the indistinguishable two-phase flow mechanisms of oil and brine. This work from the molecular perspective investigates the interfacial tension of oil-brine two-phase system, the contact angle of oil-brine-carbonatite three-phase system, as well as the microscale flow mechanisms of oil and brine in carbonate nanopores, especially focusing on the effects of ion species, salinity, and carbonate surface. The following conclusions can be drawn. (1) Oil-brine interfacial tension increases with salinity for the same ion species, and increases in the order of KCl, NaCl, CaCl₂ and MgCl₂ for the same salinity. The cation mainly affects the interfacial tension, and a larger cation size corresponds to a lower interfacial tension. (2) The neutral carbonate surface is super-hydrophilic with a water film between oil droplet and carbonatite. As the salinity increases from 0 mol/L to 3.8 mol/L, the thickness of the water film increases from 0.6 nm to 1.05 nm, and the contact angle of oil droplet increases from 145° to 170°. For the same salinity, both the water film thickness and the contact angle in CaCl₂ brine system are larger than those in NaCl brine system. The charged carbonate surface makes the water molecules oriented, stretching the oil droplet vertically, even with the tendency to strip the oil droplet from the carbonatite. For CaCl₂ and NaCl brine systems, there are critical salinities of 0.82 mol/L and 1.23 mol/L, respectively. The cross section of the oil droplet is oval when the salinity is smaller than the critical value, while it becomes circular when the salinity exceeds the critical value. (3) In neutral carbonate nanopores, water film forms near the nanopore wall which cannot flow, while oil prefers the nanopore center which will flow under the pressure gradient. Increasing the salinity will decrease the velocity. In charged carbonate nanopores, both oil and water adsorb on the nanopore wall. There is no velocity slip on the nanopore wall. Increasing the salinity will strip the oil droplet and a water film will form between the oil droplet and carbonatite. Besides, the velocity will be enhanced. This work can provide microscale understanding and theoretical basis for enhancing carbonate reservoir recovery factors.

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