Pore-Level Effect of Contact Angle on Fluid Displacements in Porous Media

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Abstract

Wettability affects two-phase displacements in porous media by determining the microscopic distribution of fluids in pore spaces. The impact of wettability on transport properties at macro-scales has been widely addressed in literature; however a deeper understanding of wettability effects demands pore-level investigations which are still limited. The degree of wettability is usually related to the contact angle, which is a boundary condition in determining the interfacial shape.

In this paper, COMSOL Multiphysics® software was used to investigate the influence of contact angle on two phase (water and oil) flow in porous medium at micro-scale. Cahn-Hilliard phase field equation was solved using finite element method with adaptive mesh refinement in 2D modeling done in the present work. The applicability of the model was also studied at 3D porous media.

Fluid distributions and saturations are completely different for water wet and oil wet systems, as shown in Figure 1. It is observed that in general, the water fingers become thinner and stabilized water saturation becomes less as the medium becomes less water wet (Figure 1). Different pore-scale mechanisms were observed in water wet and oil wet conditions which affected the efficiency of the displacements. Oil film thinning and rupture, fluids' contact line movement and oil drop detachment were recognized as the main pore-level mechanisms in strongly water wet system. Two pore-scale displacement mechanisms of water finger thinning/splitting and water blob trapping were identified in strongly oil wet medium.

Reference

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Figures used in the abstract

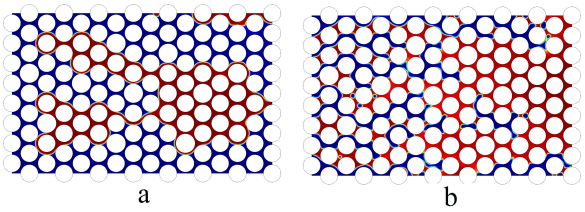

Figure 1: Snapshots of fluid distributions at water breakthrough times for the 2D porous medium at a) strongly water wet and b) strongly oil wet conditions. Blue and red colors represent water and oil phases, respectively.