Contribution ID: **911** Type: **Oral 20 Minutes**

Wettability and Quasi-Static Fluid-Fluid Displacement in Micromodels

Tuesday, 15 May 2018 09:50 (15 minutes)

Wettability of porous media has a remarkable influence on the morphology of invading fronts during fluid-fluid displacement. For example, it has been shown that when invading and defending fluids exhibit an instability-inducing viscosity ratio, the invading phase advances through viscous fingering, and the width of the fingers is dictated by the substrate wettability. When the porous medium has low affinity to the invading liquid (drainage), the width of the fingers is comparable to a pore size. In contrast, when the porous medium has high affinity to the invading liquid (imbibition), the thickness of the fingers is well above the pore size, and the invading phase advances as a more smooth and compact front [1, 2]. Recently, the experimental observations were extended to the strong imbibition regime. It was shown that, in this case, front displacement occurs via corner flow, where the invading fluid advances by coating the posts in a patterned Hele-Shaw cell [3].

Motivated by these experimental observations in patterned microfluidic cells, we build on the work of Cieplak and Robbins [3] to develop a quasi-static pore invasion model for the full range of pore wettabilities, from strong drainage to strong imbibition. We describe the pore geometry as a pore network, and explicitly calculate the critical pressures of pore invasion events to advance the fluid-fluid interface based on these pressure thresholds. This revisited formulation of fluid invasion removes the bias associated with user-dependent choices of pressure increments during the invasion, or conventions for the sequence of interface pore configurations. Our quasi-static simulations show a transition from invasion-percolation to cooperative pore filling to corner flow as the wettability of the medium to the invading fluid increases, in quantitative agreement with the experimental observations on micromodels.

Finally, we extend our model from a quasi-static to a dynamic description by accounting for viscous forces during pore invasion, and buoyancy effects from density difference between the fluids. We apply the new model to investigate impact of wettability on the morphology of unstable flow during secondary oil migration.

References

[1] J. Stokes, D. Weitz, J. Gollub, A. Dougherty, M. Robbins, P. Chaikin and H. Lindsay, "Interfacial stability of immiscible displacement in a porous medium," Physical Review Letters, 57(14), 1718-1721 (1986).

[2] M. Trojer, M. L. Szulczewski, and R. Juanes, "Stabilizing fluid-fluid displacements in porous media through wettability alteration,"Physical Review Applied, 3, 054008 (2015).

[3] B. Zhao, C. MacMinn and R. Juanes, "Wettability control on multiphase flow in patterned microfluidics," Proceedings of the National Academy of Sciences, 113(37):10251-10256 (2016).

[4] M. Cieplak and M. Robbins, "Influence of contact angle on quasistatic fluid invasion of porous media," Physical Review B, 41(16), 11508 (1990).

Acceptance of Terms and Conditions

Click here to agree

Primary authors: PRIMKULOV, Bauyrzhan (MIT); Dr TALMAN, Stephen (University of Alberta); Prof. CHALATURNYK, Rick (University of Alberta); Mr KHALEGHI, Keivan (University of Alberta); Dr RANGRIZ SHOKRI, Alireza (University of Alberta); ZHAO, Robin (Massachusetts Institute of Technology); MACMINN, Christopher (Oxford U.); JUANES, Ruben (MIT)

Presenter: PRIMKULOV, Bauyrzhan (MIT)

Session Classification: Parallel 3-H

Track Classification: MS 2.23: Network Models