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Evolution of partially miscible ganglia in porous media: A pore-network approach

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Non-wetting bubbles trapped inside porous solids are common to many applications including geologic CO2 storage, design of optimal components for fuel cells and electrolyzers, and cleanup of non-aqueous pollutant liquids from groundwater aquifers. Their evolution is dictated, almost entirely, by the complex geometry of the pore space to which the bubbles'morphology must conform. As bubbles grow/shrink in size, they undergo a series of events such as pore-invasion, pore-retraction, snap-off, dislocation, fragmentation, and coalescence with other bubbles in the system. And if partially miscible, the bubbles can dissolve in the surrounding wetting phase and exchange mass with one another; a process known as Ostwald ripening. To engineer such systems, it is important to understand how the volume, surface area, curvature, and topology of bubbles co-evolve, and whether one can be predicted from a knowledge of the others. In this work, we present a pore network model that is capable of simulating the evolution of a population of trapped bubbles inside a heterogeneous porous material. Its novelty lies in that bubbles can span multiple pores, called ganglia, a limitation that has mired prior modeling attempts. After validating the model against microfluidic, direct simulation, and analytical results of the literature, we use it to understand growth-shrinkage cycles of ganglia inside complex porous microstructures. The outcomes generalize theoretical results derived previously by the authors for 2D homogeneous domains.

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Participation

Online

Primary authors: Dr MEHMANI, Yashar (The Pennsylvania State University); XU, Ke (Peking University)

Presenter: Dr MEHMANI, Yashar (The Pennsylvania State University)

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