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Thermodynamic properties of ganglia in heterogeneous porous media

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Ganglia (bubbles, or droplets) are widespread in porous media of various industrial applications. Thermodynamic properties of a ganglion, such as its morphology, free energy, capillary pressure, surface energy, etc., are crucial in determining its transport and reactive performance. Although these in homogeneous porous media have been recently resolved [1, 2], it is still challenging to quantitatively describe the thermodynamic properties of ganglia in heterogeneous media [3-5].

We develop a pore-scale numerical algorithm for determining the thermodynamic properties of hydrostatic ganglia in heterogeneous porous media. We track cycles of quasi-static growth and quasi-static shrinkage of a ganglion in a two-dimensional heterogeneous porous media, as shown in Figure.1(a). The algorithm is as follows:
(1) Create a heterogeneous porous medium and set the initial capillary pressure (Pc) and pore occupancy of the ganglion.
(2) Find the hydrostatic morphology of the ganglia with set Pc and pore occupancy, and record its properties including ganglion volume (V), free energy (F), surface area (A), etc.
(3) Make a small change in Pc while keeping pore occupancy unchanged, and then check whether a new hydrostatic morphology can be achieved. If so, the change is reversible and we go back to step (2) and continue. If not, an irreversible event emerges that changes pore occupancy while keeping V unchanged, and we search for the new stable morphology.

This algorithm may be used to simulate degassing and dissolution process in heterogeneous porous media and enhance our understanding of these processes. In addition, this algorithm may be used to construct the energy landscape of the entire heterogeneous porous media. We believe that this work helps better understand the behaviors of the dispersed phase in heterogeneous porous media.

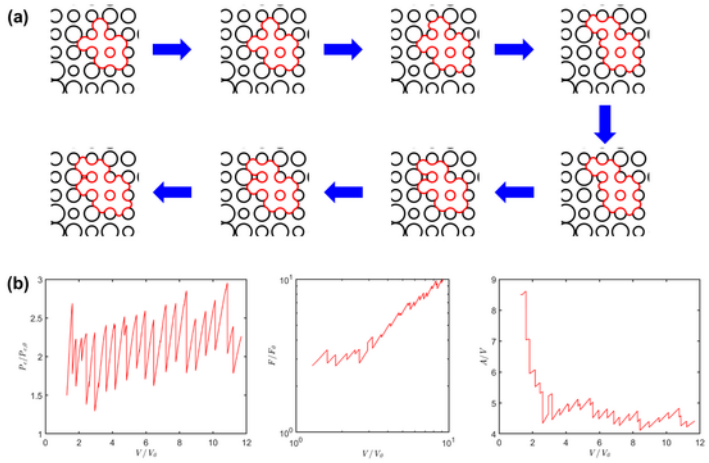

Figure 1: (a) Snapshots of ganglion growth in heterogeneous porous media. (b) Evolution of the capillary pressure, surface free energy, and specific surface area with ganglion volume during ganglion growth in heterogeneous porous media.

Participation

In-Person

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