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Bubble Coarsening Kinetics in Porous Media

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Bubbles in subsurface porous media spontaneously coarsen to reduce free energy. Bubble coarsening dramatically changes surface area and pore occupancy, which affect the hydraulic conductivity, mass and heat transfer coefficients, and chemical reactions. Coarsening kinetics in porous media is thus critical in modeling geologic CO2sequestration, hydrogen subsurface storage, hydrate reservoir recovery, and other relevant geophysical problems.

We show that bubble coarsening kinetics in porous media fundamentally deviates from classical Lifshitz-Slyozov-Wagner theory, because porous structure quantizes the space and decouple the mass transfer coefficient from the bubble size. We develop a new coarsening theory that agrees well with numerical simulations. We further identify a pseudo-equilibrium time proportional to the cubic of pore size. In a typical CO2 sequestration scenario, local equilibrium can be achieved in 1s for media consisting of sub-micron pores so local equilibrium can be presumed, while in decades for media consisting of 1 mm pores so capillary equilibrium fails.

This work provides new insights in modeling complex fluid behaviors in subsurface environment. In addition, along with our preceding works, we demonstrate that the porous media rescale mass transport of discrete fluid systems, by 1) modifying the free energy vs. volume correlation, and 2) decoupling the mass transfer kinetics from blob size.

Participation

In-Person

References

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