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Enhanced fluid-fluid chemical reaction kinetics under dynamic multiphase flow

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Understanding reactive solute transport in natural media is critical for many applications (e.g., groundwater remediation, carbon storage, and enhanced oil recovery). It has already been confirmed that solute mixing can be significantly enhanced when decreasing the saturation, which ultimately increases effective reactivity. Most studies have been conducted in steady state conditions, i.e., constant flow rate and immobile immiscible phase (e.g., gas or oil) within the pore space. However, in a dynamic multiphase flow system, the motion of the immiscible phase constantly alters the effective flow paths and increases the complexity of the flow field. The impacts of dynamic multiphase flow on reactive solute transport remain an open question. To this end, we build up a quasi-2D porous medium using a 3D printing technique. The new device allows the injection of the reactants together with a steady multiphase flow. We directly evaluate the evolution of a mixing limited reaction by capturing the light emission from an optimized chemiluminescence reaction. Direct numerical simulations are used to infer the velocity field within the liquid phase. In steady state conditions, after an initial increase, the effective reaction rate decreases monotonically. However, while multiphase flow enhances mixing, the effective reaction rate fluctuates in time. Immiscible phase displacements suddenly put two reactants in contact, changing dramatically the local reaction rates in space and time.

Participation

In-Person

References

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