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Inertia and 3D Flow Effects on Mixing and Reaction at Channel Intersections

Monday, 30 May 2022 11:50 (15 minutes)

Mixing and reaction at channel intersections often control various processes and applications involving porous and fractured media. Fluid inertia effects can be important in such systems, but many previous studies are limited to Stokes flow. Lee and Kang 2020 [Physical Review Letters, 124(14)] namely observed that inertia effects can induce 3D recirculating flows at channel intersections and showed that the recirculating flows initiate local reaction hot spots, that is, locations where reaction rates are locally maximum. Nevertheless, we still lack comprehensive understanding of inertia and 3D flow effects on mixing and reaction at channel intersections.

In this study, we combine laboratory microfluidic experiments, pore-scale numerical simulations, and flow topology analysis to elucidate inertia and 3D flow effects on mixing and reaction at channel intersections. We show that mixing and reaction hot spots are strongly linked with flow topological properties that form the backbone of underlying flow fields. In particular, stagnation points constitute critical topological features that imply flow separation associated with strong stretching and folding, which has a major influence on overall mixing and reaction dynamics. We systematically vary both the injection rate and channel geometry to elucidate how various flow topologies emerge at channel intersections as a function of the Reynolds number and channel geometry. We then establish a quantitative link between flow topology, mixing, and reaction rates. Finally, we estimate mixing and dispersion measures at intersections and discuss the implications of inertia effects on mixing and reactive transport at larger scale.

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References

Lee, S.H. and Kang, P.K., 2020. Three-dimensional vortex-induced reaction hot spots at flow intersections. Physical review letters, 124(14), p.144501.

Time Block Preference

Time Block C (18:00-21:00 CET)

Participation

Unsure

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