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Fluid Mixing from Viscous Fingering RUBEN JUANES, BIRENDRA JHA, LUIS CUETO-FELGUEROSO, MIT — Fluid mixing is an important and complex phenomenon. It plays a fundamental role in natural processes, including groundwater flows in heterogeneous media, reactive flows, mantle convection, debris gravity currents, and bacterial locomotion. Mixing at low Reynolds numbers is a notoriously difficult problem because it cannot rely on turbulence. Mixing efficiency at low Reynolds numbers can be enhanced by exploiting hydrodynamic instabilities that induce heterogeneity and disorder in the flow. The unstable displacement of fluids with different viscosities, or viscous fingering, provides a powerful mechanism to increase fluid-fluid interfacial area and enhance mixing. Here we describe the dissipative structure of miscible viscous fingering, and propose a two-equation model for the scalar variance and its dissipation rate. Our analysis predicts the optimum range of viscosity contrasts that, for a given Péclet number, maximizes interfacial area and minimizes mixing time. In the spirit of turbulence modeling, the proposed two-equation model permits upscaling dissipation due to fingering at unresolved scales.

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