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Phase-field modeling of viscous fingering in a Hele-Shaw cell LUIS CUETO-FELGUEROSO, RUBEN JUANES, Massachusetts Institute of Technology — When a viscous fluid is displaced by a less viscous one in the gap between two parallel plates, or Hele-Shaw cell, the interface between the two fluids is unstable. For low injection rates the system evolves towards a single channel, known as the Saffman-Taylor finger, while for high rates the interface forms a complicated, branched pattern. Here we present a phase-field model for two-phase displacements that captures the viscous instability. The model reproduces the transition from stable displacement to the Saffman-Taylor finger, and from the latter to a dendritic structure, depending on the viscosity contrast and injection rate. The model is a system of two partial differential equations: a nonlinear, fourth-order equation for the transport of the order parameter, and an elliptic equation for the pressure of the mixture. The interface thickness is maintained through a double-well bulk potential. We present numerical simulations and a linear stability analysis of the model. Continuum modeling of wetting phenomena is necessary in many scientific and engineering applications, from microfluidics and multiphase flow, to flow and transport in permeable media. The present model is also the first step towards an extended model of multiphase displacements in porous media.

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