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Dynamic wetting failure in surfactant solutions CHEN-YU LIU, ERIC VANDRE, University of Minnesota, MARCIO CARVALHO, PUC-Rio, SATISH KUMAR, University of Minnesota — The influence of insoluble surfactants on dynamic wetting failure during displacement of Newtonian fluids in a rectangular channel is studied in this work. A hydrodynamic model for steady Stokes flows of dilute surfactant solutions is developed and evaluated using three approaches: (i) a one-dimensional (1D) lubrication-type approach, (ii) a novel hybrid of a 1D description of the receding phase and a 2D description of the advancing phase, and (iii) an asymptotic theory of Cox. Steady-state solution families in the form of macroscopic contact angles as a function of the capillary number are determined and limit points are identified. When air is the receding fluid, Marangoni stresses are found to increase the receding-phase pressure gradients near the contact line by thinning the air film without significantly changing the capillary-pressure gradients there. As consequence, the limit points shift to lower capillary numbers and the onset of wetting failure is promoted. The model predictions are then used to interpret decades-old experimental observations concerning the influence of surfactants on air entrainment. The hybrid modeling approach developed here can readily be extended to more complicated geometries where a thin air layer is present near a contact line.

Satish Kumar
University of Minnesota

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