Mechanisms of Dynamic Wetting Failure in the Presence of Soluble Surfactants

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Extended Abstract

A hydrodynamic model and flow visualization experiments are used to understand the mechanisms through which soluble surfactants can influence the onset of dynamic wetting failure. In the model, a Newtonian liquid displaces air in a rectangular channel in the absence of inertia. A Navier-slip boundary condition and constant contact angle are used to describe the dynamic contact line, and surfactants are allowed to adsorb to the interface and moving channel wall (substrate). The Galerkin finite element method is used to calculate steady states and identify the critical capillary number at which wetting failure occurs. It is found that surfactant solubility weakens the influence of Marangoni stresses, which tend to promote the onset of wetting failure. Adsorption of surfactants to the substrate can delay the onset of wetting failure due to the emergence of Marangoni stresses that thicken the air film near the dynamic contact line. The experiments indicate that the critical capillary number increases with surfactant concentration. For the more viscous solutions used, this behavior can largely be explained by accounting for changes to the mean surface tension and static contact angle produced by surfactants. For the lowest-viscosity solution used, comparison between the model predictions and experimental observations suggests that other surfactant-induced phenomena such as Marangoni stresses may play a more important role.