Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Fingering instability down the outside of a vertical cylinder

LINDA SMOLKA, Bucknell University, MARC SEGALL, University of Central Florida — We present an experimental and numerical study of the dynamics of a gravity-driven contact line of a thin viscous film traveling down the outside of a vertical cylinder of radius R. In all of our experiments with cylinder radii ranging between 0.159 and 3.81 cm, the contact line becomes unstable to a fingering pattern. Observations are compared to inclined plane experiments in order to understand the influence curvature plays on the fingering pattern. Using lubrication theory, we derive a model for the film height that includes gravitational and surface tension effects and examine the structure and linear stability of the contact line using traveling wave solutions. For $Bo \geq O(10^1)$, our model predicts curvature's influence is negligibly weak as the shape and stability of the contact line converge to the behavior one observes for a vertical plane. For $Bo \geq 1.3$, the most unstable and cutoff wave modes and maximum growth rate scale like $Bo^{0.45}$, indicating instability of the contact line increases as gravitational effects increase or, for a specific fluid, as cylinder radius increases. The linear stability of the contact line changes at the critical value $Bo_c = 0.56$; above Bo_c the contact line is unstable and below Bo_c it is stable to fingering. We find excellent agreement between the number of fingers that form along the contact line and the range of wavelengths measured in experiments and the range of unstable modes and wavelengths predicted by our model.

Linda Smolka
Bucknell University

Date submitted: 03 Aug 2010

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