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The Frankel Law for the Thickness of Vertically Withdrawn Soap Films: Reconsidering the Basic Fluid Dynamical Assumptions E.A. VAN NIEROP, B. SCHEID, H.A. STONE, School of Engineering and Applied Sciences, Harvard University — The formation of soap films by vertical withdrawal from a bath is typically described by the Frankel law. This law is based on an assumption of rigid film "walls," with the idea that the dynamics are shear-like (as in the Landau-Levich description of the fluid film produced by plate withdrawal from a liquid bath). Since most soap films have boundaries that are not actually rigid, and as the usual flow in thin free films and fibers is extensional, a revision of the theory of the formation of soap films is provided. We review the old and recent literature on this topic, and present analytical results from a new approach that relies on surface viscosity. Surprisingly, the main result of the Frankel law, namely that film thickness scales as the two-thirds power of the withdrawal speed, is also obtained through this extensional flow characterization with surface viscosity. When bulk viscous stresses are included, the speed dependence can vary between $V^{(2/3)}$ and V^2. Comparison with existing data in the literature will be given.

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