Thin-film Coating of Surfactant-laden Liquids on Rotating Cylinders

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Motivated by the need to improve fundamental understanding of the coating of discrete objects, the influence of surfactants on the flow of thin liquid films around rotating cylinders is considered in this work. The lubrication approximation is applied to derive three coupled nonlinear evolution equations describing the variation of the film thickness, surfactant surface concentration, and surfactant bulk concentration as a function of time and the angular coordinate. In the absence of gravitational effects, linear stability analysis reveals that Marangoni stresses suppress the growth rate of instabilities driven by centrifugal forces and hinder the leveling of perturbations to the film thickness. When gravitational effects are present, Marangoni stresses lower the critical rotation rate needed to cause motion of a liquid lobe around the cylinder. These stresses also lead to faster damping of oscillations in the film thickness at relatively short times, but at longer times can increase the oscillation amplitude. In all cases examined, surfactant solubility has the effect of weakening the influence Marangoni stresses.

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