

17a Rupture of Surfactant Containing Latex Films during Drying

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Latex films find wide ranging applications in a variety of fields such as paints, coatings, and adhesives. When latex dispersions, suspensions of colloidal polymer particles in water, are cast onto a substrate, they form continuous transparent films under proper drying conditions. Apart from polymer particles and water, latex dispersions also contain surfactants which provide colloidal stability to the dispersion. These surfactants remain both in solution and adsorbed onto the particles. During the film drying process, surfactant desorption from the particle-water interface takes place and the surfactant can get transported to the film surface through an upward water flux. This leads to non-uniformities in the lateral surfactant distribution at the film surface. In thin latex films, these non-uniformities induce Marangoni flow (surface tension gradient driven flow) and result in film thinning and ultimately, film rupture, a phenomenon widely reported and observed in the coating industry. In this study, we attempt to get a better understanding on the film rupture process by modeling the surfactant spreading on the surface of drying latex films. The surfactant spreading process is modeled by coupling the film height evolution equation with the conservation equations for both particles and surfactant, within the lubrication limit. Numerical solution to the coupled equations gives the film height profile along with the evolution of particle volume fraction and surface surfactant concentrations during the film drying process. Parametric analysis reveals the relative importance of surface diffusion, evaporative and Marangoni convections on the spreading process. In fast drying thin latex films, where the Marangoni and evaporative time scales are comparable, film rupture can occur even for low surface surfactant concentrations. The conditions under which film rupture can occur is determined by the dimensionless Peclet number that gives the relative strengths of Marangoni convection and surface diffusion. In slow drying thin latex films, film rupture can occur only for very high Peclet numbers and high surface surfactant concentrations. Surface profilometry results combined with analysis using a high speed camera agree well with the model predictions.