Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Evaporation driven Rayleigh-Taylor instabilities in aqueous polymer solutions

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Understanding the mechanics of detrimental convective instabilities in drying polymer solutions is crucial in many applications such as the production of film coatings. It is well known that solvent evaporation in polymer solutions can lead to Rayleigh-Benard or Marangoni-type instabilities. Here we demonstrate another mechanism, namely that evaporation can cause the interface to display Rayleigh-Taylor instabilities due to the build-up of a dense layer at the air-liquid interface. We study experimentally the onset time (t_p) of the instability as a function of the initial polymer concentration (c_0) and molecular weight. In dilute solutions, t_p shows two limiting behaviors. For high diffusivity polymers (low molecular weight), the pluming time scales as $c_0^{-2/3}$, while in the absence of diffusion, the pluming time scales as c_0^{-1}. Above a critical concentration, $\hat{c}$, viscosity delays the growth of the instability, resulting in t_p scaling as $(\nu/c_0)^{2/3}$. These scaling results are not restricted to polymer solutions or evaporation driven instabilities, but are transferable to other binary systems undergoing gravity driven instabilities.

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Date submitted: 01 Aug 2019 Electronic form version 1.4