Thermal and solutal Rayleigh-Bénard-Marangoni convection induced by solvent evaporation in polymer solutions.

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During the drying of a solution with a volatile solvent and a non-volatile solute, the solvent evaporation has two main consequences at the upper free surface : 1) the formation of a temperature gradient due to the cooling induced by vaporization latent heat; 2) the formation of a density gradient of solvent due to the local evaporation flux. Each of these gradients might generate in turn several instability mechanisms producing convective cells: a) Buoyancy effects or b) Marangoni effects, due to thermal or solutal origin in both cases.

To analyse the respective part of these driving mechanisms, we have developed separately a thermal model [1, 2] and a solutal one. In this transient problem, comparison of instability thresholds is not sufficient to conclude on the dominant mechanism. The purpose of this paper is to perform a detailed comparison of the critical times and of the velocities to determine which phenomenon (thermal or solutal, surface tension or buoyancy driven convection) dominates and at what stage of the drying process. Numerical results are then compared to experiments performed on PIB/toluene [3] or PS/toluene [4] solutions, for various initial thicknesses and polymer concentrations. We show that numerical simulations are in agreement with experiments in order of magnitude. However, significant overestimation of fluid velocity predicted by simulations shows that more work is needed to improve model reliability.

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