Drying of colloidal dispersion in a blade coating configuration: from dilute dispersion to porous medium

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A numerical model is developed to investigate the drying of a colloidal dispersion in a blade-coating configuration, as depicted in fig. 1. The transition from the dispersed state up to the dense colloidal assembly is described through continuous models, in the framework of lubrication approximation. Beyond the evaporation length L_{ev}, air invades the porous medium and the film is dry. Meniscus profile and evaporation length L_{ev} are not imposed a priori but arise from the resolution of governing equations (momentum balance, total and particle mass balances) and from the estimation of the pressure in the film. We discuss the appropriate choice of boundary conditions at the solid/liquid interface.

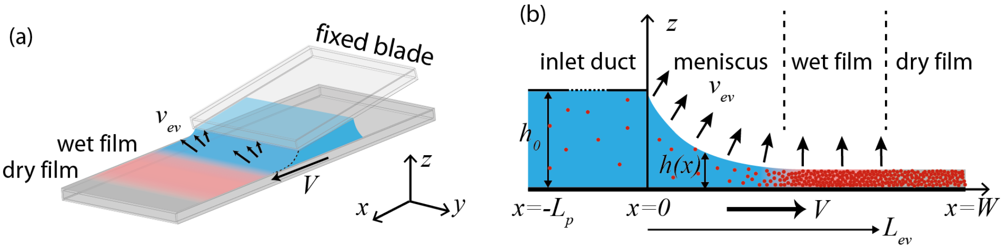

FIG. 1: Geometry

We consider "hard-spheres" colloids showing a divergence at the close packing transition for the mutual diffusion coefficient, the osmotic pressure, and the viscosity [1]. We investigate the dry deposit thickness as a function of the process parameters. It is now well documented that several regimes appear depending on the capillary number Ca. For sufficient capillary number, viscous forces are large enough to drag a film from the bath. This regime is known as the Landau-Levich regime, where the thickness of the dragged film is proportional to $Ca^{2/3}$. We focus on the evaporative regime encountered for smaller capillary numbers, for which the liquid flow into the meniscus is mainly driven by the evaporation. In contrast to the Landau-Levich regime, the dried film thickness in this evaporative regime is a decreasing function of the substrate velocity. Several experiments on various systems show that deposit thicknesses are proportional to V_{sub}^{-1} [2, 3]. However, for colloidal dispersion at very low velocity, we show that another regime appears, where the dry film thickness is no more proportional to V_{sub}^{-1} but show a V_{sub}^{-2} scaling. We analyze the apparition of this regime, which is induced by the specific properties of colloidal dispersions.

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