Modeling drying droplets on porous substrates

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Keywords: drying, evaporation, absorption, liquid mixtures, Marangoni flow

Inkjet-printing constitutes a versatile industrial method for printing ink on paper or protein molecules on microarray slides. In order to improve these applications in terms of print quality, cost and production speed, a detailed investigation of the underlying physical processes is required.

In the framework of a numerical model, we investigate the drying of an inkjet-printed picoliter droplet on a porous substrate [1]. The evolution of the droplet is driven by evaporation at the liquid-air interface and absorption of the liquid into the porous substrate.
Inspired by the composition of typical water-based inks, we generalize the model to account for glycerol-water mixtures. Due to the fact that water is far more volatile than glycerol, the established evaporation model of Popov [2] has to be reconsidered (Fig. 1). The preferential evaporation of water leads to a surface tension gradient that drives Marangoni flow in the droplet.
Furthermore, due to the far higher viscosity of glycerol, the preferential evaporation of water slows down the absorption into the porous substrate (Fig. 2). This can interestingly result in a slower drying for faster evaporation rates.

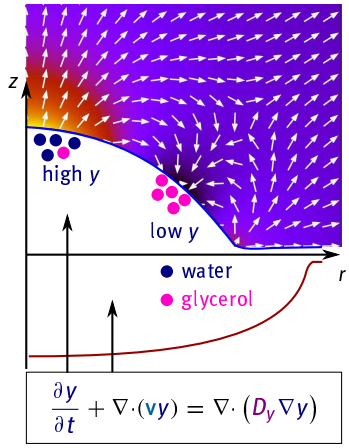

Fig. 1: Generalized evaporation model for binary mixtures with liquid water mass fraction y and vapor diffusion.

Since solute particles and their deposition to the surface are also taken into account, the present model can be utilized as predictive tool for deposition patterns in ink-jet printing processes.

The authors kindly acknowledge the funding by STW and Océ.

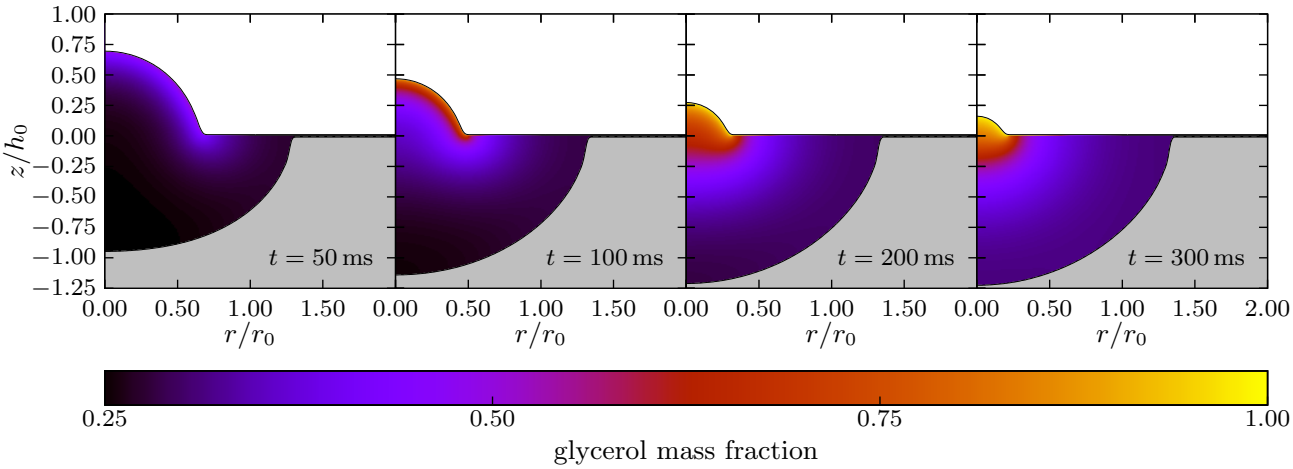

Fig. 2: Representative droplet evolution. Note the persistent viscous glycol residual at later times.

References

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