THE EFFECT OF A PRECURSOR FILM ON EVAPORATING INKJET DROPLETS WITH SURFACTANTS

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A common method for solving the contact line singularity of an evaporating sessile inkjet droplet is by assuming a thin liquid film that covers the substrate. The existence of this precursor film and a disjoining pressure enables the combination of the no-slip condition with the moving contact line. An assumption often made in literature is that the pressure in the precursor film can be set equal to zero. It is argued that the Laplace pressure in the macroscopic part of the droplet is negligible due to the large curvature and that thus an equilibrium solution results in a constant zero pressure [1]. However, also if there is significant curvature in the droplet, it is still commonly assumed that the pressure in the precursor film is negligible [2, 3]. This causes a pressure discontinuity at the contact line. It is shown that this discontinuity has significant influence on flow profiles in evaporating inkjet droplets, both with and without surfactants.

Using a lubrication model, it is demonstrated that the zero-pressure condition results in only flow towards the contact line, but that without this assumption a secondary flow towards the droplet apex is formed. Similarly, with the addition of insoluble surfactants a circulating Marangoni flow is formed for the zero-pressure condition, but without this condition the flow splits in a branch flowing towards the droplet apex and a part recirculating back towards the contact line. For cases with soluble surfactants even richer behavior is observed. For a zero-pressure condition only a circulating Marangoni flow is found, but without this assumption the flow direction reverses completely with occasional secondary circulations.

The additional effects that are found when the zero-pressure condition is dropped are explained by the fact that the droplet system tends towards an equilibrium pressure. Without the zero-pressure condition, the precursor film functions as a reference pressure according to which the droplet adjusts its pressure and thus curvature. This tendency towards a 'target curvature' causes a fluid flow towards the droplet apex.

This qualitative difference with and without a zero-pressure condition shows that the type of precursor film one considers has significant influence on the flow behavior in evaporating inkjet droplets.

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REFERENCES:

1. Sharma A. 'Equilibrium Contact Angles and Film Thicknesses in Apolar and Polar Systems: Role of Intermolecular Interactions in Coexistence with Drops with Thin Films' *Langmuir*, **1993**, *9*, 3580-3586.
2. Siregar D. P., Kuerten J. G. M. and Geld C. W. M. van der 'Numerical simulation of the drying of inkjet-printed droplets' *J. Colloid Interface Sci*, **2013**, *392*, 388-395.
3. Thiele U., Snoeijer J. H., Trinschek S. and John K. 'Equilibrium Contact Angle and Adsorption Layer Properties with Surfactants' *Langmuir,* **2018**, *34,* 7210-7221.