DROPLET EVAPORATION DYNAMICS ON HETEROGENEOUS SURFACES

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ABSTRACT

Sessile droplet evaporation on solid substrates is a fundamental phenomenon ever present in numerous processes in industry and technology, varing from spray cooling [1] to ink jet printing [2] and DNA deposition [3]. The physical mechanisms that govern droplet evaporation are very complicated, including heat transfer between the solid, the ambient and the liquid phase, vapor transfer from the water/ambient interface, buoyancy and capillary flows inside the droplet. These transport phenomena become even more interesting when the chemical and geometrical heterogeneity of the substrate are considered. In the case of real substrates, it is widely acceptable experimentally [4] that droplets evaporate following a mixed evaporation mode. Both the contact radius and the apparent contact angle decrease with time and the contact line follows a stick-slip motion, as a result of the pinning and depinning on the surface heterogeneities. Better understanding of the above mechanisms is critical for the control of the final particle distribution in solid deposition applications.

In this study we model in detail the sessile droplet evaporation on geometrically and chemically complex surfaces by utilizing a recently proposed computational approach [5] which treats the entire droplet surface (both the liquid/vapor and liquid/solid interfaces) in a unified context and allows the capture of the realistic movement of the contact line.

We study the relative importance of the transport phenomena involved, and compare our results with experimental measurements. Smooth and rough surfaces are studied and the effect of their chemical and geometrical features, on the evaporation and shape dynamics is shown.

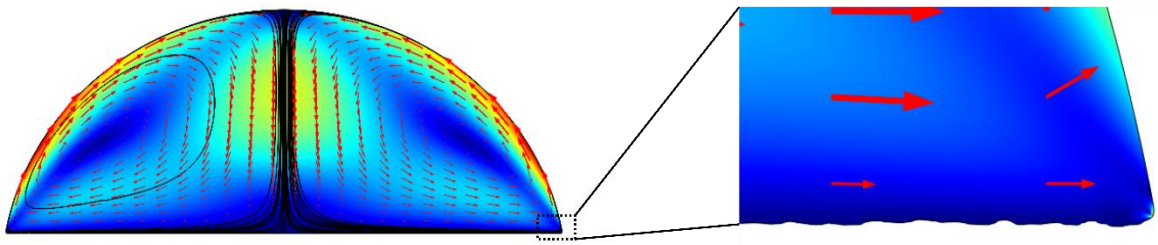

Figure 1. Simulation of a sessile droplet evaporating on a rough hydrophilic substrate.

KEYWORDS: Sessile droplet evaporation, substrate heterogeneity, mixed evaporation mode, stick-slip motion

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