Optical Monitoring Method of Sessile Droplet Evaporation

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Abstract

Nano and pico-litre sessile droplet are of large interest in many areas including pharmaceutical and biomedical applications. In particularly it can be used for drug delivery, protein testing or to control nucleation in confined environment. Industrial and research use of such methods needs a monitoring technique determining droplet evaporation modes from an image projected on the support. There are two main modes: constant contact angle (CCA) and constant contact diameter (CCD). In the CCA mode the droplet evaporates keeping the angle of contact constant and the contact diameter vary. In the CCD mode the evaporating droplet keeps the contact diameter constant but the contact angle will change. An intermediate stick-slip or stick-slide mode combines the two methods. Till a certain critical contact angle the droplet evaporates in CCD mode and then evaporates in CCA mode. Pure CCA and CCD mode can be considered as extreme case so in this presentation we focus only on these modes.

In the present work we propose a new method of optical monitoring and image treatment to determine the mode of evaporation. Ray Optics module of COMSOL Multiphysics® is used to calculate an optical image. We consider a liquid droplet deposited on glass substrate and covered by oil. White light source illuminates the droplet from the top (see figure 1) and projected image is collected on the glass substrate. First, the evaporation mode of the droplet is fixed by geometry change. A series of images is recorded on the interface with substrate. We analyze the images and determine a parameter indicating different evaporation modes. Secondly, the obtained data are compared to experimental results [1]. Different materials of evaporation droplet are used: pure water for the first validation of model and NaCl, CaCl2 and Na2CO3 aqueous solutions. The index of refraction of the aqueous solutions depends on the concentration of the solute and is taken from the experiment [1]. Numerical simulation and experimental results are in good agreement. Our method allows determining CCA and CCD modes of evaporation in pure and intermediate modes.

Reference

[1]. I. Rodriguez-ruiz, Z. Hammadi, R. Grossier, J. Gomez-morales, S. Veesler, Monitoring Picoliter, Sessile Microdroplet Dynamics Shows That Size Does Not Matter, Langmuir 29 12628-12632 (2013)

Figures used in the abstract

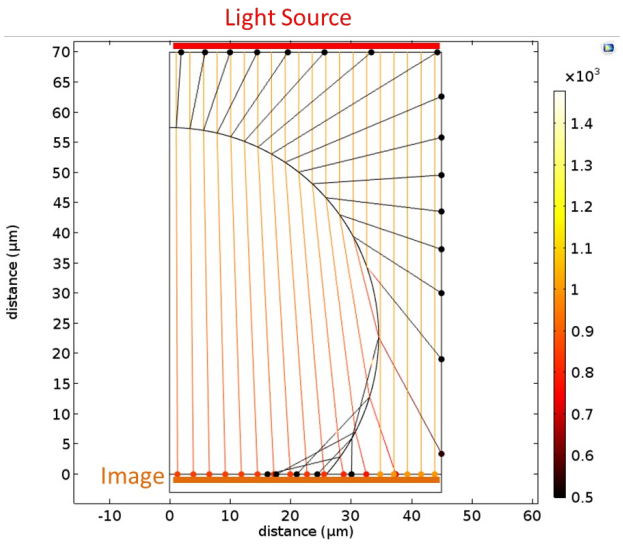

Figure 1: 2D axisymmetric model of sessile droplet deposited on the glass substrate. Lines represent ray trajectories. Colour legend: Intensity of the light (W/m2).