

Kinetics of evaporation of sessile droplets of water-based surfactant solutions: experiments and computer simulations

Hezekiah Agogo^{1*}, Sergey Semenov²,

¹ – Instituto Pluridisciplinar, Universidad Complutense, Madrid, 28040, Spain

² – Department of Chemical Engineering, Loughborough University, LE11 3TU, UK

* – hoagogo@quim.ucm.es

Experiments on evaporation of sessile droplets of water-based solutions of superspreader surfactant SILWET L77 were performed for different ambient temperatures, relative humidity's and surfactant concentrations. Drops of surfactant solutions were deposited unto Teflon-covered surface of a silicon wafer. The evaporation process was recorded with a video camera. Contact line radius, contact angle and volume of a droplet were measured from the side-view image of a droplet.

The experiments were carried out over a wide range of concentrations i.e. below and above critical aggregate concentration. It was observed that evaporation of a sessile droplet occurs in four stages, (a) spreading, increase in droplet contact radius while contact angle reduces and the droplet volume is constant i.e. evaporation is negligible, (b) first stage of evaporation with constant droplet radius, (c) second stage of evaporation with constant contact angle, and (d) final stage of evaporation with simultaneous reduction of contact angle and droplet radius. It was also observed that increasing the concentration of surfactant lead to an increase in the spreading of the sessile droplets until the critical wetting concentration was reached, at higher concentrations there was no observable influence of surfactant concentration on spreading. A theoretical model for evaporation was developed to describe the first and second stages of evaporation. The model predicts universal curves for the time dependence of contact angle (first evaporation stage) and for droplet base radius (second evaporation stage). The prediction of the model agrees reasonably well with the experimental results of pure fluid droplets unto hydrophobic surfaces.

In the case of surfactant solutions it was observed that for surfactant concentrations above the critical aggregation concentration (CAC), i.e. when the surface tension of the solution does not depend on surfactant concentration, then evaporation proceeds in accordance with above described two regimes of evaporation (b) and (c) and the agreement with theoretical predictions is good. However for concentrations below CAC, stage (c) for constant contact angle was not observed. Instead, the contact angle decreased continuously as evaporation proceeds, which can be explained by the dependence of surface tension on the concentration.

Acknowledgements:

MULTIFLOW EU project FP7-ITN-2008-214919.