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הפקולטה להנדסה כימית
ע"ש וולפסון
The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Seminar
Lecture Hall 6, Wolfson Department of Chemical Engineering,
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Dynamic wetting-dewetting during the evaporation of volatile polymer solution and binary mixtures

Mohammad Abo Jabal

Advisor Prof. Ofer Manor

The motion of the three-phase contact line (CL) between a volatile solution, its vapor and a substrate, plays an essential role in the evaporative self-assembly process, and hence in the deposition of soft matter into micro and nano-structures with a wealth of well-defined and functional structures for various applications.

Here we investigate the underlying connection between the state of deposition and the motion regimes of the CL of volatile polymer solutions. In particular, we study the mechanisms, which determine the different motion regimes of the CL e.g. the monotonous slip, and stick-slip motion, and we report and elucidate a new regime, the Oscillatory Wetting-Dewetting (OWD) motion.

In our experiment, we evaporate solutions of Poly-methyl-methacrylate (PMMA) and Poly-dimethyl-siloxane (PDMS) in toluene. The solutions are confined in a well-defined geometry (rectangular micro-chamber), where we align the CL linearly and adjust the system temperature, initial polymer concentration and molecular mass, and precisely determine the rate of evaporation.

We show that the state of polymer deposition and the regimes of CL motion are correlated and governed by a balance between the different mass transport mechanisms in the meniscus. We quantify the balance between polymer diffusion and convection, using a Peclet number, Pe, and the balance between the evaporative and surface energy contributions to mass transport using a Marangoni number, Ma. We demonstrate that the oscillatory wetting-dewetting motion is the consequence of an unstable balance between the rate of solvent evaporation and an outward Marangoni flow. We summarize our results in phase diagrams; one diagram presents the different morphologies of the deposit, while the other diagram visualizes the transitions between the different regimes of CL motion.

We further prove that the Oscillatory Wetting-Dewetting motion is a generic phenomenon. One could observe it during the evaporation of sessile droplets composed of binary mixtures that satisfies outward Marangoni flow. By investigating the evaporation and spreading of binary mixtures of Toluene and Ethanol droplets, using IR camera, we visualize the vortices inside the evaporating droplets. We demonstrate that the contact line motion strongly rely on the position and distribution of the Marangoni vortices inside the droplet, where the last depend on the composition of the mixture. These findings explain a historical dilemma of the non-monotonic spreading behavior of binary mixtures.

Refreshments will be served at 13:15