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Dynamics of Droplet Motility on Hydrophobic Polymer Brush Surfaces Facilitated by Vapor Interaction

Polymer brushes swell completely in good solvents and partially in good vapours. The spreading of volatile liquids on brush layers is governed by subtle combination of hydrodynamic flow, vapour transport and swelling kinetics.
We studied the wetting dynamics of alkanes on oleophilic polymer brush layers of poly-lauryl methacrylate (PLMA), synthesised via surface initiated activators regenerated by electron transfer atom transfer radical polymerization (SI-ARGET-ATRP).

A rich phenomenology is observed including the formation of a wide halo, characterised by a gradient in the degree of swelling of the brush layer in front of the slowly advancing contact line [1]. Local evaporation and condensation conspire to stabilise the inhomogeneous non-equilibrium stationary swelling profiles.

Significantly, when a vapour concentration gradient is imposed above an alkane droplet, macroscopic motion can be induced without exerting external forces.
We obtain both spatial and time dependent swelling profiles in the halo region as well as droplet contact angles from interferometric measurements. We find that the advancing contact angle is lower than the receding contact angle, contrary to typical moving droplets.

We believe that the vapour concentration imposes in a gradient in local swelling near the contact line, corresponding to a gradient in the equilibrium contact angle. As a result, the droplet experiences a pulling force in the direction of the lower contact angle, causing it to move. Additionally, the contact angle appears to exhibit notable viscous drag along the contact line. Utilizing the acquired contact angles, the total horizontal component force is calculated and related to the droplet motion.

[1] Ö. Kap et al. 'Nonequilibrium configurations of swelling polymer brush layers induced by spreading drops of weakly volatile oil'. In: The Journal of Chemical Physics 158.17 (2023), p. 174903. issn: 0021-9606. doi: 10.1063/5.0146779.

Primary author: REUVEKAMP, Sander (University of Twente, SPC group)

Co-Autoren: MUGELE, Frieder (University of Twente); DE BEER, Sissi (University of Twente)

Vortragende(r): REUVEKAMP, Sander (University of Twente, SPC group)