Liquid Contact Line on a Soft Gel in Dip-Coating Geometry

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Wetting on soft surfaces (of elastic modulus G smaller than 100 kPa) has been investigated for decades, and still presently it is attracting a great attention. In order to provide a clear overview how the three phase contact line behaves on highly deformable surfaces, active investigations are carried out on various types of materials such as gels, elastomer and thin polymer films. According to the primitive model proposed by de Gennes and Shanahan, the "elasto-capillary deformation" plays an important role. The liquid surface tension γ pulls up the substrate, forming a surface ridge of typical spatial extent γ/G [1,2].

We investigated the behavior of a liquid contact line receding on a hydrophobic soft gel surface (SBS-paraffin) [3]. To realize a well-defined geometry with an accurate control of velocity, a dip-coating setup was implemented. A gel plate was dipped into a water bath; successively it was withdrawn from water at a constant velocity.

As the elastic modulus of the gel is small enough, a significant deformation takes place near the contact-line, which in turn influences the wetting behavior. Depending on the translation velocity, the contact line exhibits different regimes of motions. Continuous motions are observed at high and low velocities; meanwhile two types of stick-slip motions, periodic and erratic, appear at intermediate velocities. We conjecture that the observed transitions could be explained in terms of the competition between different frequencies, i.e., the frequency f of the strain field variation induced by the contact line motion and the frequency $f_{\text{cross}} = 1/\tau$ related to the material relaxation. Finally, we propose a qualitative modeling which predicts the existing range of the stick-slip regimes. Therein, we consider the continuous spectrum associated with the surface deformation that ranges from the meniscus size to the elasto-capillary length: $1/l_{\text{cap}} < 1/l < 1/l_e$.

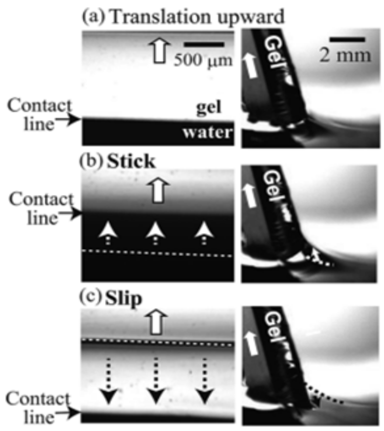

Fig.1 Sequential pictures of the liquid contact line receding on a SBS-paraffin gel surface (v = 0.015 mm/s). Contact line exhibits stick-slip behavior.

References

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