Forces at a Moving Contact Line

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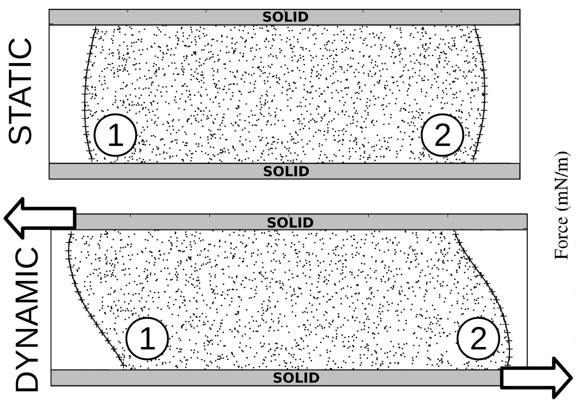
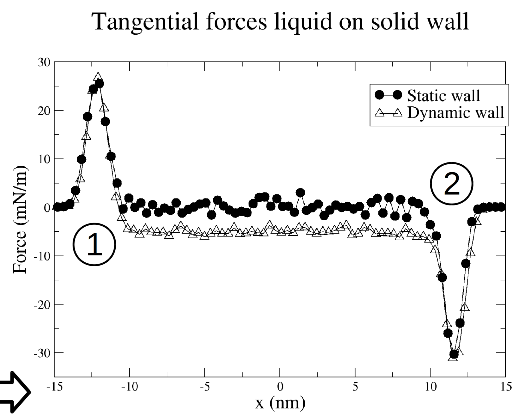
Abstract

Our understanding of liquid coating processes is based on hydrodynamics and derives its support from experience, experiments and modeling. A key factor in this understanding is the way in which the liquid dynamically wets or can be forced to wet the solid surface. However, although hydrodynamics offers a self-consistent model of dynamic wetting and the dynamic contact angle, there remains considerable debate about the best way to rationalize a contact line that moves with the standard no-slip boundary condition. The molecular-kinetic theory of dynamic wetting (MKT), which has also proved successful in accounting for dynamic wetting behavior, avoids this problem, but lacks an obvious link to the hydrodynamics. One of the key results of the MKT is that it predicts the existence of a localized frictional force at the contact line that opposes dynamic wetting and is the principle reason why the dynamic contact angle is velocity dependent. The friction increases with contact-line velocity and therefore requires an increasing out-of-balance surface tension force to overcome it. Here, we present the results of large-scale molecular dynamics simulations of Couette flow with free interfaces that demonstrate the existence of this force and its locus at the molecular scale. We will show how the magnitude of the force scales with velocity, contact angle and solid-liquid interactions. We will also suggest how the flow fields associated with contact line friction might be integrated with conventional hydrodynamics and models of slip.





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