Local Scale Correlations between Adhesion Hysteresis and Friction

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Adhesion hysteresis is the difference between the work necessary for separating two surfaces and that gained on bringing them back together. At local scales neither static methods like force-distance curves nor most of dynamic measurements (with vibrating cantilever) cannot be implemented to probe adhesion hysteresis at the nanometer lengths and to date there are only a few reported studies. One is based on sub-nanometer NC AFM [1], while the other applies ultrasonic force microscopy (UFM) [2] and is used here. It is interesting to study not only adhesion hysteresis, but also its correlation with friction forces. This relationship sets the ultimate resolution for local-scale friction, because adhesion hysteresis measurements are constrained only by the initial area of the tip-sample contact and do not require any lateral displacements as in typical friction experiments. The present work extends the relationship between adhesion hysteresis and friction towards molecular scales. These relationships are investigated theoretically and experimentally. We derive the analytical relations assuming an adhesive, elastic, and wearless tip-sample contact, whereas most of the previously studied cases underlined the anelastic sources of interrelations between friction and adhesion hysteresis. We correct the model for nanoscale roughness and validate it through the adhesion hysteresis and friction measurements on a wide range of samples varying in their elastic and adhesive properties. The close match between theory and experiment is observed, especially when the nanoscale roughness is taken into account.

[1] P. M. Hoffmann et al., Phys. Rev. Lett. 87, 265502 (2001).
[2] R. Szoszkiewicz et al., submitted to Phys. Rev. Lett. (2004)