Atomic-scale friction sensed by a single organic molecule

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The frictional behavior of nano-objects such as organic molecules has also a fundamental interest for understanding their diffusive processes on surfaces or designing molecular nano-machines **[1-2]**. In previous works, we use a tuning fork based AFM operated at low temperature to investigate the mechanical properties of single molecules and developed force-induced manipulations **[3-5]**. Here, we intentionally functionalized the tip apex with a single porphyrin molecule and performed friction experiment (Fig.a). In this configuration, the molecule acts as a spring attached to the apex and dynamically interacts with the surface lattice potential. Scanning the Cu(111) surface at constant height while recording the frequency shift systematically reveals atomic-scale friction patterns (Fig.b). The molecule stiffness as well as the chemical reactivity of specific end-groups give rise to the typical stick-slip behavior (Fig.c). Numerical calculations based on a gas-atom solid interaction potential **[6]** further support the experimental data.

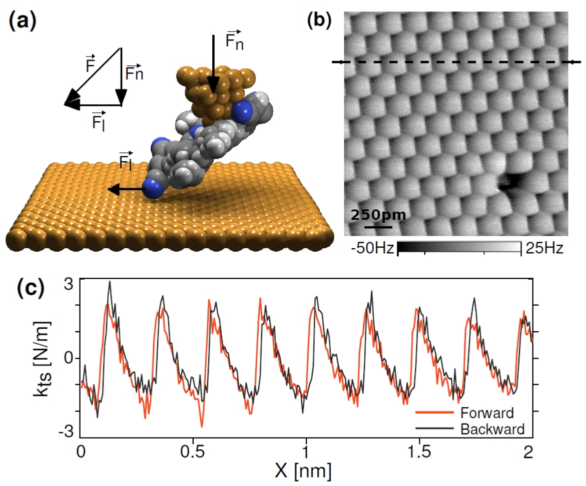

Figure 1: (a) Illustration of the friction experiment : the porphyrin-terminated tip is brought into contact to the Cu(111) while oscillating at it resonance frequency. (b). Constant-height Df(x,y) maps of the surface showing the atomic lattice. (c) Tip-sample stiffness profile k_{ts} along the dashed line of (b) revealing a typical stick-slip pattern. (parameter : fo = 25956 kHz, A0 = 50 pm, scan speed = 1 nm/s.

References

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