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Atomic force microscopy measurements of topography and friction on dotriacontane films absorbed on a SiO2 surface

We report comprehensive atomic force microscopy (AFM) measurements of the nanoscale topography and lateral friction on the surface of thin films of an intermediate-length normal alkane, dotriacontane, at room temperature. The aim of these studies is twofold: (i) to study the film structure by a direct imaging technique and compare it with that inferred from previous x-ray scattering results on the same films; and (ii) to determine the lateral frictional force exerted on the tip of the microscope cantilever and correlate this with the topography. As a prototypical system, we chose dotriacontane (n-C32H66) films adsorbed from a heptane (n-C7H16) solution onto SiO2-coated Si(100) single-crystal substrates whose structure we had previously characterized. Our topographic and frictional images simultaneously recorded in the contact mode reveal a multilayer structure of the dotriacontane films. Nearest the SiO2 surface, we observe one or two layers of molecules that are oriented with their long axis parallel to the interface. Above this "parallel film," solid layers adsorb in which the molecules are oriented perpendicular to the surface. Regardless of the concentration of the initial dotriacontane-heptane solution, all of the perpendicular layers are incomplete with higher layers having progressively smaller area. The thickness of a perpendicular layer that we measure with AFM agrees with that inferred from previous x-ray specular reflectivity measurements. We also observe bulk dotriacontane particles and, in contrast to our previous measurements, are able to determine their location relative to the parallel and perpendicular layers. The particles have a terrace structure on top that indicates their molecules are oriented nearly perpendicular to the SiO2 surface. We find that the lateral friction is sensitive to the molecular orientation in the underlying crystalline film and can be used effectively with topographic measurements to resolve uncertainties in the film structure.