Surface Curvature Enhances the Electrotunability of Ionic Liquid Lubrication

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Abstract

Ionic liquids (ILs) are a promising class of lubricants that allow dynamic control of lubrication at electrified interfaces. In the real world, surfaces inevitably exhibit some degree of roughness, which can influence lubrication. In this work, we deposited single-layer graphene onto 20 nm silica nanoparticle films to investigate the effect of surface curvature and electrostatic potential on both the lubricious behavior and interfacial layering structure of 1-ethyl-3-methyl imidazolium bis(trifluoromethylsulfonyl)imide on graphene. Normal force and friction force measurements were conducted by atomic force microscopy using a sharp silicon tip. Our results reveal that the friction coefficient at the lubricated tip–graphene contacts significantly depends on surface curvature. Two friction coefficients are measured on graphene peaks and valleys with a higher coefficient measured at lower loads (pressures), whereas only one friction coefficient is measured on smooth graphene. Moreover, the electrotunability of the friction coefficient at low loads is observed to be significantly enhanced in peaks and valleys compared with smooth graphene. This is associated with the promoted overscreening of surface charge on convex interfaces and the steric hindrance at concave interfaces, which leads to more layers of ions (electrostatically) bound to the surface, i.e., thicker boundary films (electrical double layers). This work opens new avenues to control IL lubrication on the nanoscale by combining topographic features and an electric field.

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