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Molecular Level Investigations of Interfacial Friction of Polymer Brush Surfaces

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The development of synthetic polymer lubricants to mimic joint lubrication within the human body will be presented. Unlike most industrial applications involving oils and greases, lubrication of these joints is accomplished in an aqueous environment. Fundamentally, water is a poor lubricant in most settings due to the weak pressure dependence of its viscosity, yet the contacting surfaces of skeletal joints function with low friction throughout a lifetime. Motivated by the molecular structure of materials making up joint surfaces, interfacial friction between polymer brush surfaces under aqueous environments has been probed with an array of molecularly sensitive surface analytical techniques including atomic force microscopy. The brush surfaces, comprised of poly(L-lysine)-g-poly(ethylene glycol) (PLL-g-PEG), have been generated through the spontaneous adsorption of polymer from solution onto oxide substrates and sodium borosilicate surfaces (AFM tip). The character of the polymer films has been investigated in-situ with the quartz crystal microbalance (QCM) and atomic force microscope (AFM) and ex-situ with ellipsometry and X-ray photoelectron spectroscopy (XPS). The interfacial friction measurements have been carried out on polymer-coated substrates with bare or polymer-coated, microsphere-attached tips in over a range of solution conditions. It was found that the adsorption of polymer on oxides strikingly reduced the interfacial friction, resulting in ultra-low friction under certain conditions. By using a series of PLL-g-PEG polymers differing from each other in PEG side-chain length and grafting ratio, we observed that frictional properties of polymer-coated interfaces strongly depend on the architecture of PLL-g-PEG. Polymer-film formation and the influence of polymer architecture will be reviewed while the role of solvent and manifestation of ultra-low friction will be discussed in detail.