Adsorption and lubricating properties of poly(L-lysine)-graft-poly(ethylene glycol) (PLL-g-PEG) on human hair surfaces

We have characterized the adsorption and lubricating properties of the polycation-PEG graft copolymer poly(L-lysine)-graft-poly(ethylene glycol) (PLL-g-PEG) on human-hair surfaces by means of X-ray photoelectron spectroscopy (XPS), Fluorescence microscopy, and atomic force microscopy (AFM). XPS measurements indicated that PLL-g-PEG copolymers spontaneously adsorbed onto the surface of bleached-hair samples (a good model of a weathered, damaged hair surface for Cosmetic care applications) from an aqueous solution. Further treatment with cationic surfactants present in common shampoo formulations removed the adsorbed PLL-g-PEG from the hair samples. Fluorescence microscopy showed that the adsorption of PLL-g-PEG onto the hair samples from an aqueous polymer solution occurred inhomogeneously. Nanotribological studies with AFM (friction vs load plots) revealed that the relationship between load and friction was approximately linear for all hair samples, while the slopes of the plots varied considerably along the hair sample surface. Under ambient, "dry" conditions, the Frictional properties of the bleached, bleached + PLL-g-PEG-treated, and bleached + PLL-g-PEG-treated and subsequently surfactant-treated hair samples did not reveal a clear difference. In distilled water, however, the bleached + PLL-g-PEG-treated hair samples showed statistically lower frictional properties than simply bleached or bleached + PLL-g-PEG-treated and subsequently surfactant-treated hair samples. Overall, the three Instrumental techniques have consistently shown that the adsorption of PLL-g-PEG onto the hair sample surface occurs unevenly, which can be ascribed to the intrinsically heterogeneous properties of the human-hair surface. A control experiment, involving an injection of concentrated PLL-g-PEG solution into a liquid cell where an AFM tip was already scanning over, a specific area (line scan mode), revealed an immediate and apparent reduction in the frictional force. Despite the inhomogeneity of the hair surface, the adsorption of the polymer seems to be extremely effective in promoting lubrication of the fiber. This suggests that the adsorbed graft copolymers act as a boundary lubricant on the hair surface. The presence of a more organized, brushlike layer of polymers contrasts with the usual random adsorption of chains that is believed to be present in the case of linear polyelectrolytes that are nowadays applied for shampoos and conditioners in the cosmetic or textile industries.

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