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Ion-assisted plasma polymerization: Surface engineering of biomimetic interfaces

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Titanium-based alloys are promising materials for orthopedic prostheses due to their low toxicity, superb corrosion resistance, and favorable mechanical properties. The sub-optimal biocompatibility of bare metal surfaces, however, often leads to adverse foreign body responses, inflammation, or infection requiring additional medical interventions. The integration of metallic implantable devices with local host tissues can be strongly improved by an ion-assisted plasma polymerized (PP) coating functionalized with biomimetic molecules. The stability of the PP layer in body fluids is indispensable, and the coating must resist failure even when scratched. In this presentation, I talk about a novel approach for the fabrication of chemically and mechanically robust PP coatings on titanium surfaces. A custom-made plasma polymerization system consisting of a radio frequency (RF) electrode and a pulsed voltage source was utilized for PP deposition. The chemical and mechanical stability of the coatings in simulated body fluid (SBF) was examined by incubation of samples in Tyrode's solution at 37 °C for durations of up to 2 months. As evidenced by both X-ray photoelectron spectroscopy (XPS) data and scanning electron microscopy (SEM) observations, the PP coating resisted failure, and no delamination, cracking, or buckling was observed after scratching and subsequent incubation in SBF solution. XPS results revealed that the excellent interface adhesion is linked to the formation of metallic carbide and carbonate bonds, induced by ion implantation, at early stages of film growth. Such atomic interfacial mixing also resulted in the formation of a continuous smooth film near the substrate as suggested by atomic force microscopy (AFM) and time of flight secondary ion mass spectroscopy (ToF-SIMS) data.[1] I present results demonstrating that multifunctional protein layers,[2, 3] peptide molecules,[4] or silver nanoparticles[5] can be covalently immobilized on such radical-rich interfaces for improved osteoblast activity and enhanced antimicrobial properties. I also describe our recent works on utelizing the surface embedded radicals for polymerization and covalent attachment of hydrogel layers,[6] as well as tuning the orientation and density of immobilized molecules on the PP coatings by tuning pH or applying external electric fields during the biomolecule immobilization[7]

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