Oxidation plasma treatment of fluorocarbon ultrathin films for cardiovascular applications

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Cardiovascular devices, such as stents, peacemakers and heart valves, are generally made by metallic materials which provide appropriate mechanical and structural properties. Nevertheless, when a metal surface is implanted into the body several undesired effects can occur, such as thrombosis, inflammation and corrosion.

Coating the metallic surfaces with fluorocarbon (CF_x) films by Plasma Enhanced Chemical Vapour Deposition (PE-CVD) has been demonstrated to be a promising approach to improve the corrosion behaviour and the biological response of the host [1].

Nevertheless, the modification of some key surface properties of CF_x coatings could further improve the blood compatibility of those coatings. For example, it has been shown that the presence of carboxyl groups and a moderate surface wettability could promote the appropriate proteins adhesion, improving the hemocompatibility and promoting the surface endothelialisation [2, 3].

The objective of this work is to develop an oxidation process of CF_x coatings, based on a methanol plasma treatment, in order to tune the surface energy of CF_x films without affecting the excellent properties of the unmodified CF_x coatings, such as the integrity (i.e. impermeability/corrosion resistance) and the mechanical properties (elasticity and adhesion to the substrate).

316L stainless steel (SS) substrates were electropolished and coated with CF_x coatings by PECVD, as previously reported [1]. CF_x coatings were then modified by methanol plasma treatments, carried out in the same reactor. The chemical composition of the surfaces was analysed by X-ray Photoelectron Spectroscopy (XPS); the surface energy was evaluated by static water contact angle measurements; the morphology and the roughness were studied by Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM), the elastic properties were evaluated by Contact Resonance-AFM and Torsional Harmonix-AFM while the adhesion of the films to the substrates by Small Punch tests. A preliminary evaluation of the hemocompatibility of the surfaces was performed by kinetic clotting time tests.

Tunable oxidation of the surface of CF_x coatings was successfully obtained by methanol plasma treatment, thus producing an increase of surface wettability, without affecting morphology, roughness and mechanical properties of the coatings. Blood test results showed an increased hemocompatibility of the oxidized samples, indicating the possibility of modulating the blood contact behaviour of fluorocarbon surfaces through the modulation of their surface energies.

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