Effect of hemocompatibility on the surface properties of Si incorporated diamond like carbon films.

Si 함유 DLC 필름의 표면 특성에 따른 혈액적합성에 대한 효과

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1. Introduction

Biomaterials of good quality are highly desirable for better biomedical treatments. The main problem with a medical device in cardiovascular application lies in its thrombogenicity, cytotoxity and stability during long term use. In this respect, diamond like carbon (DLC) has emerged as a promising material for cardiovascular application due to its superior tribological, inert and hemocompatible properties. The medical implants in cardiovascular applications are also subjected to various compressive and tensile forces which sometimes lead to delamination and spallation of the coatings. To get rid of this problem, it is necessary to dope the surfaces of biomaterials with certain elements or use an interlayer which improves its adhesive properties, corrosive resistance and hemocompatibility. Several attempts have been done to improve the hemocompatibility of DLC coatings by doping it with suitable elements like N, F and P and modify its surface. In this report, we have investigated the effect of hemocompatibility on the surface properties of Si incorporated DLC films for effective coating on endovascular nitinol stents. The surface modification were done by treating the Si incorporated DLC films with plasma of various gases like O_2, CF_4, N_2 and H_2. A Si interlayer has been used to ensure better adhesion of the films. The resultant films were subjected to *in vitro* hemocompatibility tests.

2. Experimental

Si incorporated diamond like carbon (DLC) films were synthesized on Si and nitinol substrates using capacitively coupled rf plasma assisted chemical vapor deposition (PACVD) technique. Benzene (C_6H_6) and silane (SiH_4) were used as the precursor gases. All the depositions were carried out at a bias voltage of - 400 V and at a system pressure of 1.33 Pascal. The substrates were initially cleaned with argon ions for 15 mins. at a bias voltage of - 400 V and pressure of 0.49 Pascal. An interlayer of Si of thickness nearly 5 nm was deposited on the substrates to ensure better adhesion of the Si-DLC films. The resultant Si incorporated DLC films were treated with plasma of various gases like O_2, CF_4, N_2 and $H_2$for 10 minutes at a bias voltage of - 400 V and 1.33 Pascal chamber pressure. The wettability of the films was determined by measuring the contact angle with two liquids water and formamide. XPS studies were done by Physical Electronics PHI 5800 ESA system. The plasma protein adsorption tests were done by treating the samples with albumin and fibrinogen solution and measuring the absorbances through ELISA analysis. The films were also exposed to platelet poor plasma (PPP) andplatelet rich plasma (PRP) of fresh human blood for activated partial thromboplastin time (aPTT) and platelet adhesion experiments.The adhesion and activation of platelets were visualized through FESEM.

3. Results and discussion

The plasma treated Si-DLC films showed a wide range of water contact angles starting from 13.4^0 to 88.4^0. The polar and dispersive components of the surface energies revealed a higher polar component for the O_2 plasma treated films and a higher dispersive component for the H_2 plasma treated ones. The XPS studies denotes the presence of C-C, F-F, C-N, Si-O and Si-C bondings in case of Si-DLC and CF_4, N_2, O_2 and H_2 treated Si-DLC respectively. The plasma protein adsorption tests showed a higher albumin adsorption for O_2, N_2 and CF_4 plasma treated films and minimum fibrinogen adsorption in case of H_2 plasma treated Si-DLC films. A higher aPTT was noted in case of O_2plasma treated Si-DLC films. The O_2 plasma treated Si-DLC films also minimized platelet adhesion and activation compared to other samples. The low blood-biomaterial interfacial tension seemed to explain the improved hemocompatibility of the O_2 plasma treated Si-DLC films. The oxygen and CF_4 plasma treated Si-DLC films can serve as effective coating on endovascular SMART nitinol stents.