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Hemocompatible Carbon Based Biosurfaces for Cardiovascular Implants

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Introduction:
Thrombus formation is one of the common problems observed at cardiovascular implants. Various coatings composed of material/material combinations have been developed to encounter this problem. Carbon biomaterials is one of the early tested materials in this field. More recently Diamond Like Carbon (DLC) has been considered an alternative material in cardiovascular medical devices. Here, we present development of a new type TiO_2-DLC bi-layer coating for reduction of the thrombosis formation.

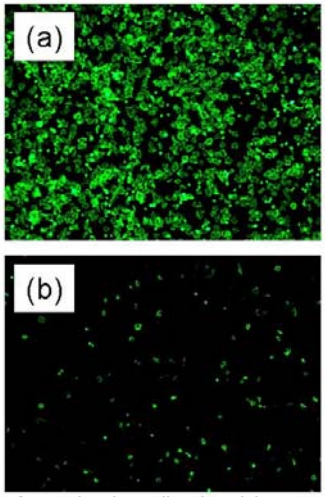

Fig1: Platelet adhesion (a) control and (b) TiO_2-DLC bi-layers

Methods:
A double layer coating was developed using two different types of techniques. The first layer consists of a thin TiO_2 film obtained by sol-gel method and using a dip-coating procedure. Afterwards, Si-DLC films were deposited on TiO_2 coated substrates using radio frequency (RF) plasma enhanced chemical vapor deposition (PECVD) technique. Acetylene (C_2H_2) and tetra-methylsilane ($Si(CH_3)_4$, TMS) were used as the precursor gases.
For biocompatibility analysis, in-vitro monoculture models was established for Human Umbilical Artery Endothelial Cells (HUAEC) and Human Umbilical Artery Smooth Muscle Cells (HUASMC). Cells were seeded on prepared substrates and incubated under standard conditions. After reaching the desired confluence (~80%) each cell type was fixed and stained at different time points respectively after 24h, 72h and 96h in order to visualize morphology and early adhesion behavior. Furthermore, scanning electron microscopy (SEM) was used for a detailed observation of the cytoskeletal behavior and orientation over the different surfaces. In addition platelet adhesion testing was performed to investigate the morphology, quantity and aggregation of the adherent platelets using fresh blood drawn from a healthy adult volunteer.

Results:
While used cell types; HUAEC and HUASMC exhibit similar behaviours to those observed on control substrates, platelet activation is reduced TiO_2-DLC bi-layers (Fig.1). In comparison to control substrates, no fibrin networks or platelet aggregation was observed on TiO_2-DLC bi-layers.

Conclusions:
We have shown that TiO_2-DLC bi-layer is an effective surface modification method for reducing thrombosis. Such coating systems may play unique roles in next generation cardiovascular implants. On the other hand, detailed surface analysis (e.g. XPS) and cytotoxicity will be carried out to explore the mechanism of the platelet interaction with the surface.