Calcium phosphate coating on activated carbon fiber cloth for biocompatible applications

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Due to their mechanical properties, i.e. flexural and fatigue strength, high strength to weight ratio, carbon fibers have previously been considered for hard and soft tissue implanting. Due to the strong electrostatic forces within the cloth combined with a microporous structure, the activated carbon cloth has naturally permeable properties which enhance the breathability of the cloth. However, its poor biological activity restricts its extensive use in medical applications and therefore needs to be enhanced[1,2,3]. Thanks to their excellent biocompatibility, bioactivity, and osteoconductivity, calcium phosphate (CaP) ceramics, especially hydroxyapatite (HA), have received much attention in the biomedical materials field and have been clinically applied in orthopaedics and dentistry[3]. So, carbon fiber -reinforced HA composites, combining the highly biocompatible CaP matrix with the properties of carbon fiber, are promising bioceramic materials, which could be particularly useful in the reconstruction of bone defects[3].

For this purpose, several methods have been reported in the past decade to deposit CaP onto implant surfaces, including plasma spray, rf sputtering, pulsed laser-deposition, sol-gel, electrophoretic methods, and electrochemical deposition. Among these, the electrochemical technique is an attractive way to efficiently coat highly irregular materials at ambient temperature and has been already applied on metal substrates or porous carbon composites[1-7]. Additionally, the thickness and the chemical composition of the coatings can be well controlled through adequate conditions of the process[1,2,5,6,].

In the present study, CaP coatings on CT13 activated carbon cloth from MAST Carbon (Fig.1) are performed using two techniques: the sol-gel method and the electrochemical deposition, with or without application of ultrasound.

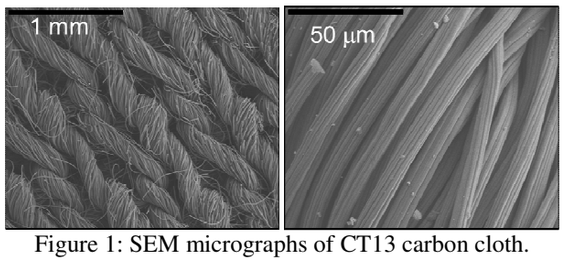

Figure 1: SEM micrographs of CT13 carbon cloth.

In the case of the sol-gel process, the CT13 cloth is dipped in the precursor made of phosphoric acid and calcium nitrate dissolved in ethanol at different molar ratios. Then, the impregnated matrix is treated at temperatures ranging from 300 to 700°C under inert gas. Depending on the experimental conditions, coatings of various thickness and adhesion are obtained (Fig.2).

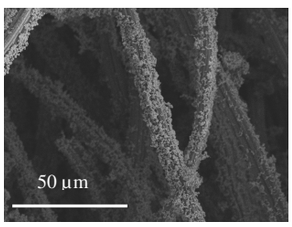

Figure 2: SEM micrographs of a CaP deposit obtained by the sol-gel process.

The electrodeposition of CaP is performed using calcium nitrate and $NH_4H_2PO_4$ maintaining a Ca/P ratio of 1.67. Hg/Hg_2SO_4 was used as reference electrode, and a platinum basket as counter electrode. The polarization of the carbon electrode is conducted using a potentiostat/galvanostat with current densities ranging from 100 to 1000 mA/g and polarization periods ranging from six to twenty-four hours (Fig.3).

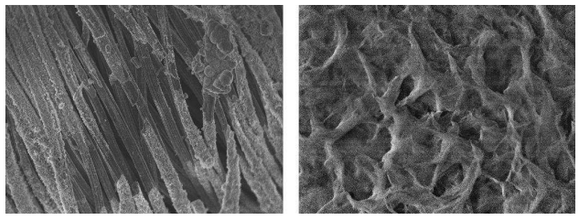

Figure 3: SEM micrographs of a CaP deposit obtained by electrodeposition

Scanning electron microscopy (SEM), FTIR spectroscopy and X-ray diffraction were performed to characterize the texture, the chemical composition and the structure of the deposits.

For the two the processes, the application of ultrasound is crucial to get a uniform and homogenous coating on the carbon fibers. Depending on the experimental conditions, FTIR spectra and XRD patterns show the presence of different CaP phases.

More work is in progress to evaluate the adhesion properties of the coatings and further investigations will be done on the CaP coating effect on osteoblast cell viability in vitro.

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