

Interface Behaviour of Nanostructured Porous Systems Investigated in Simulated Body Fluid Enriched with Proteins

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INTRODUCTION: Nanometer-scale features observed in a variety of biological systems have motivated the development of synthetic, engineered nanoscale systems that could mimic or augment these biological systems [1]. Micro- and mesoporous systems obtained via sol-gel route are common inorganic components of composite scaffolds [2]. Interfaces between synthetic materials and biological systems represent one of the most dynamic and expanding fields in science and technology. The adherence of proteins to the biomaterials surface in order to accomplish their in vitro bioconjugation before to come in direct contact with the alive tissues in the human body is of great interest. This study is focussed on synthesis and characterisation of porous sol-gel derived systems before and after protein functionalisation of their nanostructured surface in simulated body fluids.

METHODS: The investigated alumino-silicate, calcium-silicate and calcium phosphate systems were prepared using the sol-gel method. The heat treatment parameters were chosen according to differential thermal analysis results. The structure of as prepared and heat treated samples was examined by X-ray diffraction. The sample porosity was determined using BET method. Simulated body fluid (SBF) proposed by Kokubo [3] was enriched with bovine serum albumin, collagen or fibrinogen. The samples were immersed for several times, up to 3 weeks, in protein enriched SBF, and kept at 37°C. Before and after immersion in protein-SBF solutions, the samples were analysed by Fourier Transform Infrared (FTIR) and X-ray photoelectron spectroscopy (XPS).

RESULTS & DISCUSSION: X-ray diffraction data indicate the development of nanostructured phases. The size of crystals is up to 40 nm. The porosity of the samples heat treated around 550 °C leads to specific surface area about 70-90 m²/g, that generally decreases for higher treatment temperatures. Both FTIR and XPS results point out the occurrence of a protein layer on sample surface after soaking in simulated body fluids with proteins. The deconvolution of IR absorption bands with components arising from different structures of amide I, allow to quantify the relative amount of each structural component. The β-

sheet/turns ratio was used as a first estimation on the biological reactions taking place at the interface between the synthetic materials and the simulated biological environment [4]. The values obtained on the surface of the investigated samples indicate higher values than for the native proteins, that denotes a good biocompatibility of these materials [5].

XPS results evidences the protein adsorption already after few hours of immersion. Because carbon adsorption usually occurs on all surfaces exposed to the atmosphere, but no N 1s signal was recorded before the immersion of samples in simulated body fluids, N 1s photoelectron peak was used as marker of proteins. The C 1s core level spectra recorded from the samples immersed in protein-SBF solution, beside the low binding energy component, close to 285 eV, corresponding to single bonded carbon, also contain the protein signature given by the components recorded at higher binding energies, close to 287 and 289 eV. On the other hand, the O 1s core level spectra recorded from the interface created between the porous sample and protein-SBF solution have a larger full width at half maximum, because they overlap contributions given by both oxygen atoms from sample surface, OH groups and peptidic oxygens. At the same time, a slight deficiency in electron density around the oxygen atoms was observed after protein functionalisation.

CONCLUSIONS: Sol-gel synthesis correlated with heat treatments lead to controllable nanostructured porous sample. A protein layer is attached in few hours on their surface, denoting a first stage interface created as they are immersed in protein-SBF solutions. The secondary structures of amide I of both serum albumin, collagen and fibrinogen suggest good biocompatibility of the investigated systems.

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