Surface functionalisation of sol-gel-based bioactive glass scaffolds for drug delivery

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INTRODUCTION

Bioactive glasses are widely used in bone tissue engineering (BTE) since they can develop strong bonds with bone through the formation of a hydroxyapatite (HA) layer[1]. Within these materials, sol-gel-based bioactive glasses (SGBGs) are attractive due to their enhanced bioactivity and resorbability and their capacity of being functionalised with a large variety of moieties[2-3].

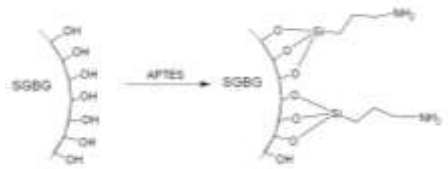
Surface functionalisation is an interesting approach to load drugs into the material and allow their release in a controlled manner[3].

The aim of this study is the development of new SGBGs for 3D porous scaffolds and functionalisation of their surface by two different methods[4-5] in order to enhance the drug delivery capability.

EXPERIMENTAL METHODS

Bioactive glass scaffolds with composition (in mol%) $60SiO_2$ $30CaO$ $5Na_2O$ $5P_2O_5$ were prepared by the sol gel method and the foam replica technique. Scaffolds were characterised by scanning electron microscopy (SEM) and µ-CT, in order to evaluate the macrostructure and porosity and by transmission electron microscopy (TEM) and N_2 adsorption porosimetry using the Brunauer-Emmett-Teller (BET) approach for mesoporosity characterisation. Bioactivity was revealed by Fourier transform infrared spectroscopy (FTIR) characterisation of the scaffolds after SFB immersion.

After heat treatment at 700°C, the scaffolds surface was functionalised by post-condensation of aminosilane, following the reaction shown below:



A second step was considered to avoid steric interference by adding a spacer and allowing an optimal loading of the model drug.

Both systems were loaded with a model drug, and the drug release capabilities were studied in two different media by UV-Vis spectroscopy.

RESULTS AND DISCUSSION

Scaffolds exhibited the required macropore size (~500µm) as well as high and interconnected porosity, of up to 90% as shown in Fig.1 (a-c). TEM (Fig.1 d) revealed the mesoporosity, confirmed by BET analysis (pore size: ~4nm; S_{BET}=150m^2/g). Both porosities are features required by scaffolds for BTE and drug delivery applications[1-2].

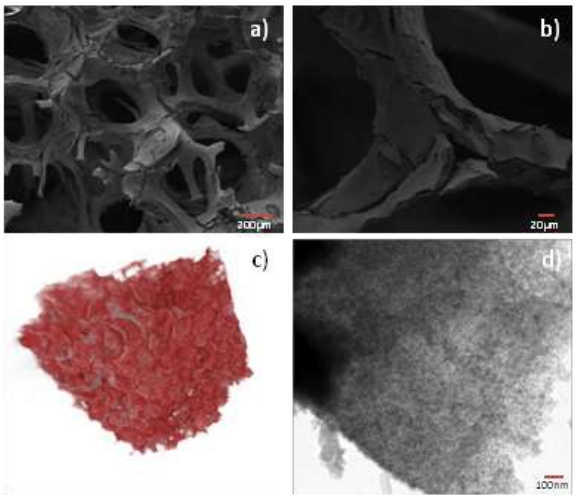


Figure 1. Images of scaffold a,b)SEM micrographs, c) µ-CT reconstruction, d)TEM micrograph

Amino-functionalisation of the surface was confirmed by zeta potential measurements, ninhydrine test as well as by element mapping in SEM.

The different drug release profiles showed that by surface functionalisation it was possible to achieve a reduced initial burst release of the drug in the tested media and a long-term sustained release.

CONCLUSION

According to SEM and µ-CT reconstructions, 3D porous scaffolds were successfully prepared, exhibiting macro- and mesoporosity. Furthermore, amino-functionalised surface allowed the system to exhibit a sustain release of the model drug compared to non-functionalised scaffolds.

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ACKNOWLEDGMENTS

The authors would like to thank ITN FP-7 project "GlaCERCo" for providing financial support; P. Rosner for the help provided in TEM; Prof. E. Verné and Dr. Sonia Fiorilli for the assistance in the material characterisation; Dr. A. Inayat for BET analysis.