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Synthesis, testing and characterization of porous biocompatible porous bioactive glasses for clinical use

Erasmus, Erika Pombili-Ipawa

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ABSTRACT

The quest for the processing of glass scaffolds that remains amorphous upon sintering while maintaining a fast dissolution and conversion to hydroxyapatite rate is growing. Therefore; glasses within the borosilicate borophosphate and phosphate family were sintered into 3 dimensional (3D) porous scaffolds using 60 and 70 vol. % $NH_4(HCO_3)$ as a foaming agent. In this work the sintering ability of (borosilicate S53B50), borophosphate (P40B10) and phosphate (Sr) bioactive glasses was investigated. The glass powders were crushed and sintered in air at a heating rate of 10°C/min for 2 hours at sintering temperatures between 480°C-600°C. The density of the samples was found to decrease when the temperature was increased up to 580°C. To process highly porous scaffolds with porosity required for scaffold applicable to tissue engineering, the powders were further mixed with 60 vol. % and 70 vol. % of NH_4 (HCO_3) foaming agent. Meanwhile, the density of the samples sintered with NH_4 (HCO_3) was found to decrease with an increase in NH_4 (HCO_3) content. This indicates an increase in porosity of the samples. The glass compositions reached an open porosity of more than 60% at the addition of 70 vol. % NH_4 (HCO_3). The *in vitro* properties of the scaffolds investigated in SBF showed that Upon immersion; the pH of the solution containing the borosilicate scaffolds increased due to the typical non-congruent dissolution of theses glass family leading to large Na+/H+ exchange and large alkaline and alkaline earth release. Borophosphate as well as phosphate scaffolds induced a decrease in pH upon dissolution attributed to the congruent dissolution of those materials and therefore; the large release of phosphorus within the media. The as prepared scaffolds showed a compressive strength of 1.29 ± 0.21, 1.56 ± 0.63, 3.63 ± 0.69 MPa for the samples borosilicate borophosphate and phosphate sintered with 60 vol. % NH_4 (HCO_3), respectively. From SEM/EDS, XRD and ICP-OES analysis a clear precipitation of hydroxyapatite was reported on the borosilicate glass scaffolds. The borophosphate scaffold was found to be stable and to react at a slow rate. The crystallized phosphate glass; however was found to release very large amount of phosphate; compared to the amorphous glass; indicating preferential leaching of the phosphate rich crystal phase. Except for the borophosphate scaffolds; the mechanical properties dropped with increasing immersion time.