

Accepted Manuscript

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PII: S1742-7061(17)30430-0

DOI: <http://dx.doi.org/10.1016/j.actbio.2017.07.002>

Reference: ACTBIO 4969

To appear in: *Acta Biomaterialia*

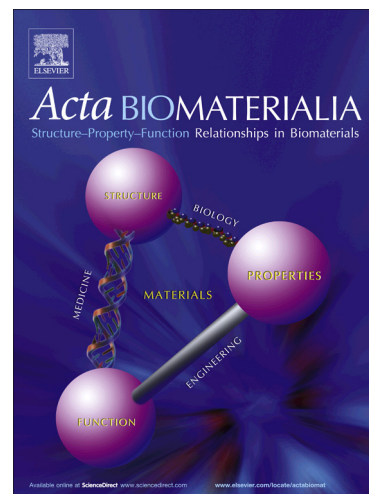
Received Date: 12 April 2017

Revised Date: 27 June 2017

Accepted Date: 2 July 2017

Please cite this article as: Patel, U., Moss, R.M., Hossain, K.M.Z, Kennedy, A.R., Barney, E.R., Ahmed, I., Hannon, A.C., Structural and physico-chemical analysis of calcium/ strontium substituted, near-invert phosphate based glasses for biomedical applications, *Acta Biomaterialia* (2017), doi: <http://dx.doi.org/10.1016/j.actbio.2017.07.002>

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Structural and physico-chemical analysis of calcium/ strontium substituted, near-invert phosphate based glasses for biomedical applications

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Revised for Acta Biomaterialia

Keywords: Biomedical glass; Glass structure; Neutron diffraction; Solid state NMR; Phosphate glass; Strontium; Dissolution rate

Abstract

Neutron diffraction, ²³Na and ³¹P NMR and FTIR spectroscopy have been used to investigate the structural effects of substituting CaO with SrO in a 40P₂O₅·(16-x)CaO·20Na₂O·24MgO·xSrO glass, where x is 0, 4, 8, 12 and 16 mol%. The ³¹P solid-state NMR results showed similar amounts of Q¹ and Q² units for all of the multicomponent glasses investigated, showing that the substitution of Sr for Ca has no effect on the phosphate network. The M-O coordinations (M= Mg, Ca, Sr, Na) were determined for binary alkali and alkaline earth metaphosphates using neutron diffraction and broad asymmetric distributions of bond length were observed, with coordination numbers that were smaller and bond lengths that were shorter than in corresponding crystals. The Mg-O coordination number was determined most reliably as 5.0(2). The neutron diffraction results for the multicomponent glasses are consistent with a structural model in which the coordination of Ca, Sr and Na is the same as in the binary metaphosphate glass, whereas there is a definite shift of Mg-O bonds to longer distance. There is also a small but consistent increase in the Mg-O coordination number and the width of the distribution of Mg-O bond lengths, as Sr substitutes for Ca. Functional properties, including glass transition temperatures, thermal processing windows, dissolution rates and ion release profiles were also investigated. Dissolution studies showed a decrease in dissolution rate with initial addition of 4 mol% SrO, but further addition of SrO showed little change. The ion release profiles followed a similar trend to the dissolution rates observed. The limited changes in structure and dissolution rates observed for substitution of Ca with Sr in these fixed 40 mol% P₂O₅ glasses were attributed to their similarities in terms of ionic size and charge.

1. Introduction

Phosphate based glasses containing ions characteristically native to bone (Ca²⁺, Na²⁺, Mg²⁺, PO₄³⁻) have been widely investigated due to their fully resorbable properties, controlled dissolution rates, and biocompatible nature [1-5]. The ability to control these properties makes phosphate glasses extremely well suited for delivery of therapeutic ions. Their use in both hard and soft tissue repair has been extensively studied [1,6,7] and the benefits of adding these ions into bioactive materials have been summarised by Mouriño *et al.* [8] and Hoppe *et al.* [9].

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