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Properties of strontium-containing BG 58S produced by alkali-mediated sol-gel process

I.R. Oliveira [a,*], A.M. Barbosa [a], K.W. Santos [a], M.C. Lança [b], M.M.R.A. Lima [b], T. Vieira [c], J. C. Silva [c], J.P. Borges [b,**]

[a] Institute for Research and Development - University of Vale do Paraíba - UNIVAP, Av. Shishima Hifumi, 2911, Urbanova, São José dos Campos, São Paulo, 12244-000, Brazil

[b] CENIMAT|i3N, Department of Materials Science, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516, Caparica, Portugal

[c] Tissue Engineering Laboratory, NOVA School of Science and Technology, NOVA University Lisbon, 2829-516, Caparica, Portugal

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ABSTRACT

Among many bioglass (BG) compositions, gel-BG 58S has been indicated in the literature for applications as bone graft due to its promising use to repair bone defects. However, its physical and biological properties also depend of choice of precursors. The use of phosphoric acid as a source of P_2O_5 changes the thermal behavior of BG and in the presence of HNO_3 increases the rate of hydrolysis and reduces the size of sol particles, thus influencing the surface area and in turn rate of apatite formation of bioactive glasses. In addition, the addition of concentrated NH_4OH decreases the gelation time and new bioactive materials have been produced using Ca/Sr substitution in BG compositions. Thus, the aim of this work was to prepare BG 58S by the sol-gel technique at room temperature using phosphoric acid (PA) as the phosphorus precursor compared with conventional precursor triethylphosphate (TEP) and to evaluate the effect of the adding NH4OH (1 or 2 M) as gelation catalyst in order to select the better route to Sr incorporate. The products were characterized using XRD, FTIR and confocal Raman spectroscopy. The composition prepared with 1M NH4OH (PA-1M) presented more evidence of NBO bonds, and the absence of crystallinity. Thus, BG 58S-5 wt% Sr was prepared using the alkali-mediated sol-gel process (PA-1M) and characterized as the techniques mentioned in addition to bioactivity and cytotoxicity assays. Both compositions showed the development of a layer of apatite when treated in a simulated body fluid (SBF). Strontium composition showed higher cell viability and more evidence of calcium phosphate formation while calcium carbonate is mainly identified in strontium-free composition.

1. Introduction

Bioactive glasses (BGs), considered the third generation of biomaterials, are one of the best biomaterials for renovation and bone repair and they were introduced by Hench's team in the late 1960s [1–4]. BG can induce a precise biological response *in vivo* test at the interface with a substantial chemical bond in many tissues, mainly bone and soft tissues [1,3,4]. Using sol–gel processing to prepare these biomaterials started in the 1980s when bioactive ternary gel-glasses of the SiO_2–CaO–P_2O_5 system were produced and presented *in vitro* bioactivity, even for compositions that have approximately 90 mol% SiO2 [1, 4]. The sol-gel method uses a low temperature preparation, generally room temperature, and the gel-BGs prepared by this technology have higher purity and homogeneity, a porous structure with a large specific surface area, which undoubtedly increases the production of the apatite layer and, therefore, the biological activity promotes a strong bond to cartilage and bones and does not form a fibrous layer [1,2,5–7]. In addition, BG also provide antibacterial properties maintaining the implanted site free from contamination during bone tissue regeneration, making them ideal for dental and orthopedic applications [4,7–9] and its application has ever-increasingly been applied [4].

Among many compositions of the ternary SiO2–CaO–P2O5 system, the gel-BG 58S (58 SiO_2, 33 CaO, 9 P_2O_5, wt% or 60 SiO_2, 36 CaO, 4 P_2O_5, mol%) is indicated in the literature for applications as bone graft due to its properties [10–13]. This composition presents a large specific surface area promoting apatite formation on its surface in *in vitro*

* Corresponding author.
** Corresponding author.
E-mail addresses: ivoneregina.oliveira@gmail.com, ivonero@univap.br (I.R. Oliveira), jpb@fct.unl.pt (J.P. Borges).

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