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Effect of Methyl Cellulose on Apatite Formation of a Sol–Gel Derived Bioactive Glass/Titania Nanostructure Composite

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Abstract. In order to widen the application range of bioactive glass (BG), we prepared a bioactive glass as a composite matrix, strengthened by titania nanoparticles. The prepared composites had different amounts of both bioactive glass (49S) and titania in the weight percents of 1:3, 1:1 and 3:1, respectively. Bioactive glass sols (49S) in the system (SiO_2–CaO–P_2O_5) were prepared following the sol–gel technique, then a solution of 2 wt% methylcellulose was added and stirred at room temperature. Precalcinated TiO_2 nanopowder was dispersed in the sol and the prepared mixture was fired at 600 °C. The inhomogeneity problem in preparation of composite powder was overcome by using methylcellulose (MC) as a dispersant. The nanostructure composites were characterized using X-ray diffraction (XRD) and Fourier transforms infrared spectroscopy (FT-IR). The microstructure of the surfaces of the different composites was examined by scanning electron microanalysis (SEM) to verify the apatite formation. The results led us to the conclusion that the addition of MC reinforces the composites and increases the formation of an apatite layer in the presence of BG and titania content.

Introduction

Since the discovery of ‘‘Bioglass’’ by Hench, (e.g. glasses, sintered HA, glass–ceramics, composites) many bioactive materials have been synthesized and developed for medical applications [1]. However, bioglass implants present critical drawbacks in their low mechanical properties and this causes great limitations to their use for load bearing sites. For this reason, bioglass parts often coupled with tougher material, providing thus their excellent surface properties without a great loss in the bioactivity of the bioglass [2]. Titanium dioxide is known as a bioactive material that is able to sequestrate hydroxyapatite on its surface [3]. The production of composite between bioactive glass and TiO_2 has proven to be suitable solutions for improving the mechanical properties of bioactive glasses [4]. However, if an aggregated TiO_2 nanopowder was introduced into a bioactive glass matrix to produce a composite, it could not serve to strengthen the bioactive glass matrix to some extent. Therefore, we report a novel method to preparation of biocomposites containing bioactive glass (49S) and titania by sol-gel process using methyl cellulose (MC) as organic dispersant and investigate the effect of introducing of MC on apatite formation ability.

The nanostructured bioactive glass-titania composite was prepared by addition of 70 g/l of TiO_2 nanopowder (anatase nanopowder, Aldrich) to a prepared bioactive 49S glass sol (SiO_2:CaO:P_2O_5 = 50:46:4, mole ratio) containing 2 wt. % MC. Then, the prepared gel was calcined for 2 h at 600 °C to stabilize the 49S/Titania composites. Synthesized powder samples were immersed in SBF solutions. The solution was stirred for 7 days and then dried at room temperature.

XRD patterns of bioactive glass and 49S-titania composite powders are shown an amorphous powder of bioactive glass and an anatase phase in calcined 49S-titania powder at 600 °C (Fig. 1). The SEM images of 49S/titania powders obtained with no, and with MC clearly indicate the influence of MC on the powder morphology. In the sample with MC, the growth of nanoparticles seems more inhibited. Figs. 2(c) and d show the surface of the biocomposite samples after soaking in SBF solution. The SEM images indicate the presence of abundant spherical shapes with their accumulation on each other to form a bone-like apatite layer for both composites especially composite with MC. This result is due to composite with MC contains high porosity which leads to increase of active sites resulting in high nucleation of apatite.

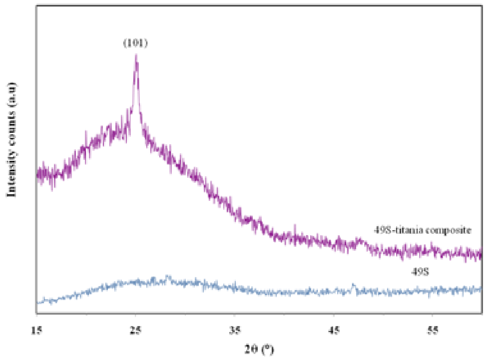

Fig. XRD for 49S and 49S-Titania composite after calcinations at 600°C.

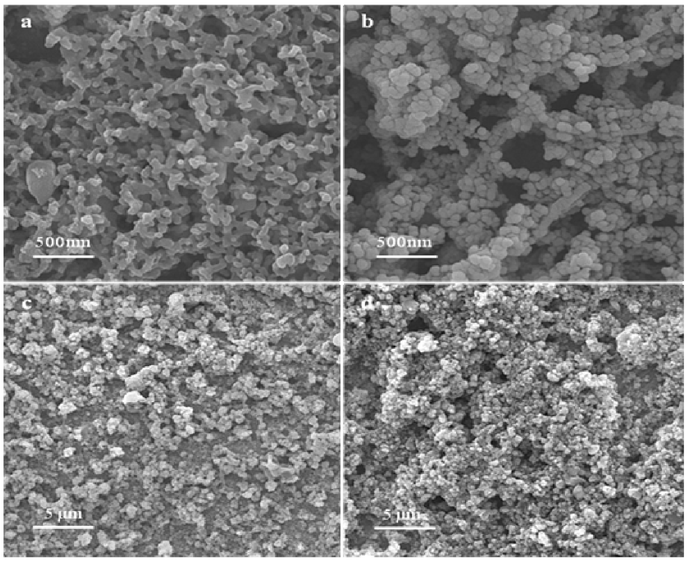

Fig. 2 SEM for 49S-titania powder (a) no MC, (b) with MC, (c) no MC after 7 days in SBF and (d) with MC after 7 days in SBF.

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