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Effect of hydroxyapatite reinforced with 45S5 glass on physical, structural and mechanical properties

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Abstract

This paper presents a study of physical and structural properties of Hydroxyapatite (HA) reinforced with different compositions of 45S5 (SG) bioglasses at different sintering temperatures. Hydroxyapatite reinforced with different compositions of 45S5 bioglasses had been prepared and investigated in terms of density, mechanical strength, and crystalline phases. A decrease in the density of HA was observed after the incorporation of SG, owing to the trapping of air in the SG reinforced HA after sintering process. When compared to the pure HA, different crystalline phases, such as β-tricalcium phosphate, calcium phosphate silicate and sodium calcium phosphate, were detected when different compositions of SG were incorporated into the HA

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Keywords: bioglass; hydroxyapatite; 45S5 glass.

5. Introduction

Hydroxyapatite (HA) with chemical formula $Ca_5(PO_4)_3(OH)$ is a form of calcium phosphate. This material has

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similar structure to the mineral phase of bone[1]. Almost 70% of the amount biological apatite found in the bone by weight. HA has been classified as one of the best biocompatible and bioactive material, therefore it has been used in many biological applications such as bone repair scaffolds. However HA is not suitable used in load bearing applications due to their properties which is brittless, low tensile strength, poor impact resistance and fracture toughness compared to bone. The use of HA in load bearing parts can be explored by providing the strength and toughness of HA. By reinforcement bioglass (BG) into HA perhaps a suitable fabrication techiques to improves the properties. BG are silica based glasses that are able to bind to bone and has the advantages as a promising scaffold material. BG are synthetic amorphous materials with high biocompatibility[2]. Due to this specific property, they can be used as implant materials in the human body in order to replace and/or repair diseased or damaged bone in orthopaedic, cranio-maxillao facial and periodontal surgeries as well as a filling material for human teeth [2]. 45S5 bioglass is a type of bioactive glass that composed: 45% SiO_2, 24.5% CaO, 24.5% Na_2O and 6% P_2O_5

Demirkiran et al., [3] researched on calcium and sodium phosphates and silicates and HA with SG co-sintered bioceramics. They found that by sintering different amounts (1, 2.5, 5, 10, and 25 wt. %) of SG with HA at 1200 ^oC for 4 h yield new crystalline phases. They found that by the addition of small amounts of SG (5 < wt. %) it behaved as a sintering aid and also enhanced the decomposition of HA to ü-tricalcium phosphate (β-TCP). While, with the addition of 25 wt.% SG resulted in the formation of $Ca_5(PO_4)_2SiO_4$ and $Na_3Ca_6(PO_4)_5$ in an amorphous silicate matrix respectively.

Knowles et al., [4] have studied on the effects of sintering on glass reinforced HA. The samples consisted 2% and 4% of glass incorporated into HA and were sintered at a variety of temperatures (1200, 1250, 1300 and 1350 °C). They found that glass is very reactive at high temperatures and so usually glass causing breakdown of some of the HA in order to form a secondary phase which gave an impact on the linear shrinkage. No secondary phase was detected in the samples with 2% bioglass addition. However for 4% bioglass addition, the presence β and α TCP is observed and it also affected the linear shrinkage by increased the volume. They concluded that bioglass act as sintering aid and help eliminated the porosity in linear shrinkage result. Thus, it's also contributed in increased of mechanical properties. In this study, reinforcement of HA with the incorporation of 45S5 glasses within the system, perhaps is a suitable choice for improving its properties. The aim of this research was to gain a better understanding on the effect of SG towards physical and structural properties of HA at different compositions.

Nomenclature

α	alpha
ü	beta

6. Materials and Methods

The sample glass (SG) was prepared by melting and water quenching process. Chemical with weight compositions: 45% SiO_2, 24.5% $CaCO_3$, 24.5% Na_2CO_3 and 6% P_2O_5 were weighed accurately using an electronic balance and thoroughly mixed by ball milling process at 500 rpm for 20 h. Then, the batch was melted in alumina crucible at 1380 °C for about 3 hours soaking time and heating rate 10 °C/minutes. Then, the molten samples were rapidly quenched in water. The obtained frits were dried overnight at room temperature. After the drying process, the glass frits were crushed and ground and sieved at θγ ȝm. The prepared SG[5] and commercial HA powder were ground and sieve at θγ ȝm seperately before mixing process. The mixed powder, then thoroughly mixed by ball milling process at 300 rpm for 20 h. One gram of powder was placed into a steel die and was uniaxial pressed ~5

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