PREPARATION AND CHARACTERIZATION OF GLASS-CERAMIC MATERIALS MODIFIED WITH IRON OXIDE WITH ADDITION OF SrO AND ZnO

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Introduction

Magnetic materials represent advanced solutions suitable for a wide range of biomedical applications, according to their different magnetic responses to an applied external magnetic field [1]. Bioactive glasses are known to be osteoinductive materials as their ionic dissolution products stimulate the cell genes toward a path of regeneration and self-repair [2]. Biocompatible magnetic glasses have attracted the attention for possible use in the advanced treatment of bone cancer as a complementary approach to chemotherapy, which is known to carry many side effects to patients. Fe_3O_4-containing melt-derived glass-ceramics were found highly promising for the treatment of osseous tumors by hyperthermia [3, 4]. Glass modification with ZnO and SrO can bring two benefits. On one hand, Zn and Sr ions released from glass structure are known to support osteoblast function and bone regeneration [5]. On the other hand, the presence of these both oxides can lead to the formation of magnetic phases after glass crystallisation, i.a. zinc ferrite and strontium ferrite [6,7].

Materials and Methods

The chemical composition of the bioglass applied in the experiment was SiO_2 – CaO – P_2O_5 – Na_2O with Fe_2O_3 modifiers and with ZnO and SrO addition. Glass-ceramic materials were produced by melting, followed by a process of directed crystallization. Four types of samples with various amounts of iron oxide and additions of zinc oxide and strontium was obtained.

The produced materials were analyzed from thermal (thermogravimetry, differential thermal analysis and differential thermal calorimetry) and microstructural (X-ray diffraction) viewpoints. SEM and EDS were applied to present the results of the study.

Results and Discussion

Differential thermal calorimetry (DSC) were performed to determine the thermal parameters of the sample: the glass temperature (Tg) and the crystallization temperature (Tc). The Tthermogravimetry (TG) analysis was performed for selected materials before and after the controlled crystallization.

For phase and structural analysis, X-ray diffraction for samples before and after the crystallization process was execute. The investigation on glass samples before the directed crystallization process confirmed their amorphous structure. The obtained results indicate that in the materials a ferritic phase with a hexagonal structure and structure with inverted spinel present.

Scanning electron microscopy (SEM) and EDS techniques were performed on the glasses before and after soaking in SBF solution. The samples were removed from this solution, washed with distilled water and dried at room temperature. SEM and EDS measurements indicated the presence of apatite layer formed on the surface of the prepared glass ceramics after immersion in SBF within 7 to 21 days. The investigation of the results clarified that the addition of iron oxide causes the formation of apatite on the surfaces of the samples in the simulated body fluid.

Conclusions

Using the method of melting and directed crystallization of bioglass modified with iron oxides with the addition of zinc oxide and strontium oxide, is possible to obtain glass-ceramic materials containing zinc and strontium ferrite. X-ray diffraction confirmed presence of crystallite phase from ferric. SEM analyze confirmed the bioactive properties of the materials obtained.

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