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BIOACTIVE GLASS CRYSTALLINE MATERIALS OBTAINED BY SOL-GEL METHOD

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Abstract: *The article is devoted to the establishment of the method of obtaining glasses of a given chemical composition in the system SiO_2 - P_2O_5 - CaO - Na_2O, which involves the use of sol-gel method. The method involves the use of the following raw materials: ethyl silicate $(C_2H_5O)_4Si$ as a source of gelation, phosphoric acid H_3PO_4 and soluble salts of $Ca(NO_3)_2$ and $NaNO_3$. The synthesis of the material takes place with constant stirring during gelation and subsequent calcination at a temperature of at least 600°C. This technology involves reducing energy consumption for production and improving the basic characteristics of the glassy material. The glasses obtained by this technology can be used in the production of bioactive glass crystalline materials.*

Keywords: *Sol-gel method, Ethyl silicate, Bioactive glass, Calcination, Glass crystalline materials*

INTRODUCTION

Today there is a growing need for bioactive materials that can participate not only in prosthetics, but also in bone regeneration (Kharytonov, D. Yu., 2014).

Of greatest practical interest are glass-ceramic materials based on calcium phosphate (hydroxyl apatite), which belong to the group of natural bone metabolites and, thus, have high biocompatibility (Modyna, T.N., Volvach, Yu. Yu., & Kascheev, B. V., 2015). They do not cause adverse allergic, immunological reactions, have no carcinogenic, mutagenic effects and integrate well with bone tissue.

When creating most bioglasses, the composition is used,% (Putlyaev, V. I., 2004): 24.5 – Na_2O, 24.5 – CaO, 45.0 – SiO_2, 6.0 - P_2O_5. By changing the composition, it is possible to vary the bioactivity of such materials in a wide range. Slow cooling of the melt of these oxides in accordance with certain temperature conditions makes it possible to partially crystallize the glass and obtain mixed glass-crystalline materials - biomaterials that have higher mechanical properties compared to glass.

However, glass-ceramic materials obtained not by traditional melting of raw materials, but by the sol-gel method, may have greater biological activity (Hench L., & Djons D., 2007). They have a porous structure in the nanometric range, which significantly increases their activity, and many silanol groups on the surface act as zones of formation of active centers of crystallization of hydroxylapatite.

Currently, sol-gel technology is one of the most relevant and promising methods for the production of composite materials, including nanosystems. An important advantage of the sol-gel method is the ability to obtain materials with different properties by changing a number of parameters at different stages of the process due to the uniform (at the molecular level) distribution of components in the initial solution. By changing the initial components, it is possible to obtain

fine-grained and coarse-grained materials with the inclusion of ultra-thin metals, complex in composition (Semchenko, G.D., 1997).

EXPOSITION

The aim of this work was to investigate the possibility of obtaining a homogeneous glassy material based on the polyoxide system $SiO_2 – P_2O_5 – CaO – Na_2O$. The following materials were selected for the study: ethyl silicate $(C_2H_5O)_4Si$ as a source of gelation, phosphoric acid H_3PO_4 and soluble salts of $Ca(NO_3)_2$, $NaNO_3$ (Table 1).

Table 1 - Raw materials for the synthesis of bioglass

Component name	Melting point, °C	Decomposition temperature, °C	Solubility in water, g/100 ml
H_3PO_4	42.4	158	548
$Ca(NO_3)_2$	561.0	561>	121
$NaNO_3$	306.8	380	92
SiO_2 (ETC – 40)	1728.0	–	–

The metered amount of ethyl silicate was mixed in an electric stirrer (800 rpm) with water for the hydrolysis process, and orthophosphoric acid acted as a catalyst. The resulting system in the mixing process due to the exothermic reaction was heated to 50 – 55 °C, which contributed to a more active process. Saturated aqueous salt solutions were then introduced into the system and stirred until a homogeneous sol was obtained. During the day, the latter were transferred to the gel, which was subjected to natural drying to a humidity of 2 – 3%. Next, the resulting mixtures were subjected to heat treatment at 600 °C in order to decompose and remove nitrogen oxides, resulting in the compositions remained only pure oxides (table. 2).

Table 2 - Chemical composition of the test composite material, wt.%

The name of the oxide	Theoretical	As a result of synthesis
Na_2O	24.5	22.7
CaO	24.5	25.4
SiO_2	45.0	47.1
P_2O_5	6.0	4.8
Amount	100	100

Chemical analysis revealed that the obtained composition practically corresponds to the given chemical composition of bioglass, and as a result of X-ray phase analysis the amorphous vitreous structure of the obtained material was confirmed.

CONCLUSION

Thus, the possibility of obtaining a vitreous material in the system SiO_2 - P_2O_5 - CaO - Na_2O using the sol - gel method. This eliminates the need for high-temperature preparated of glass at high temperatures, which opens up a wide range of energy savings in this area. In addition, due to the averaging of components at the molecular level, greater homogeneity of the material and therefore higher its activity when used as a regenerating material for the human body.

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