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Synthesis and study of the properties doped Bioglass 60S composites for bone tissue engineering applications

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Introduction / Objectives / Aims

The 60S sol-gel glass characterized by osteoconductive properties that depend on the surface structure of the material. The specific surface area of sol-gel glasses (up to 200 m^2/g) is much higher than other bioactive ceramics and creates the prerequisites for the adsorption of the necessary organic and inorganic substances on their surface.

As a result of the hydrolysis of bioactive glass, changing the pH level and active ion-exchange processes leads to an increase in the concentration of Si^{4+}, Ca^{2+}, HPO_4^{2-} ions in the biological environment, which can affect on the viability and activity of cell cultures.

For La^{3+}, Y^{3+} the spectrum of therapeutic activities includes apoptosis of cancer cells, decreased rate resorption of bone and bioceramics, selective immunomodulatory activity.

In addition, as a result of doping La^{3+} and Y^{3+} changes in the specific surface area, due to a decrease in the size of primary crystals, and the formation of active sorption centers on the surface is predicted

Metods

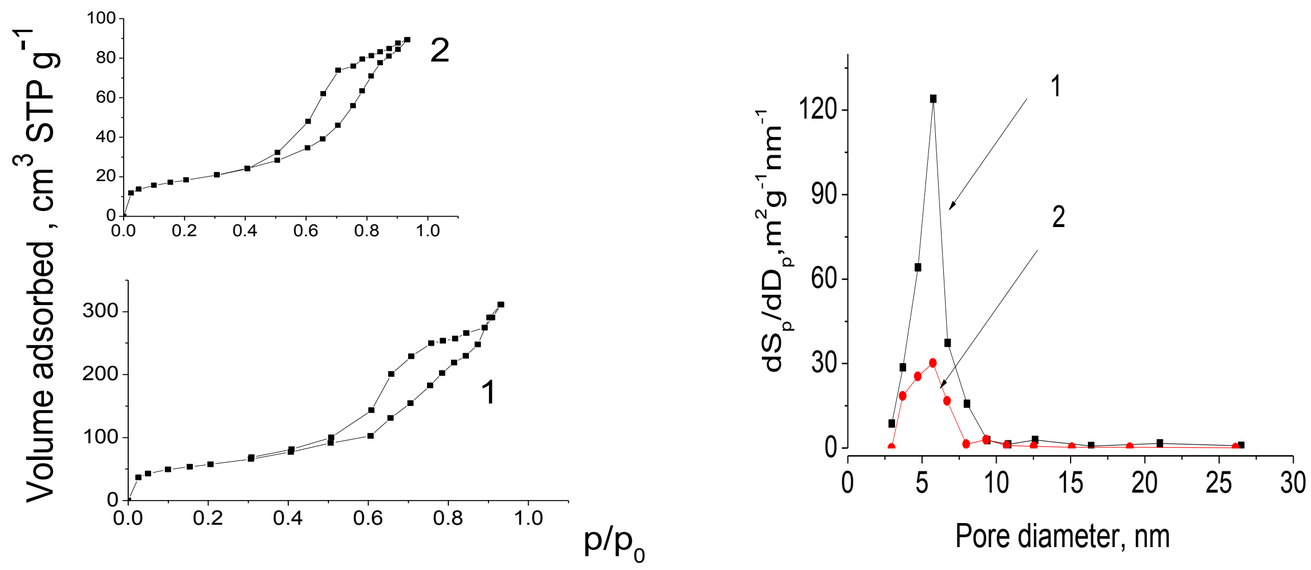
- The dissolution processes in the model biological environment - SBF solution (*Kokubo's model*) are investigated.
- SSA determined by the method of nitrogen thermal desorption using KELVIN 1042 Sorptometer.
- The processes of biodegradation of 60S glass were studied in a dynamic mode. Atomic absorption (for Ca^{2+}, Mg^{2+}) was used to study the change in the ionic composition of model physiological fluids (AAS C115 M1).
- Samples before and after the biodegradation process were examined by IR spectroscopy, pH change was monitored by potentiometric method.

Synthesis of sol-gel glass 60S

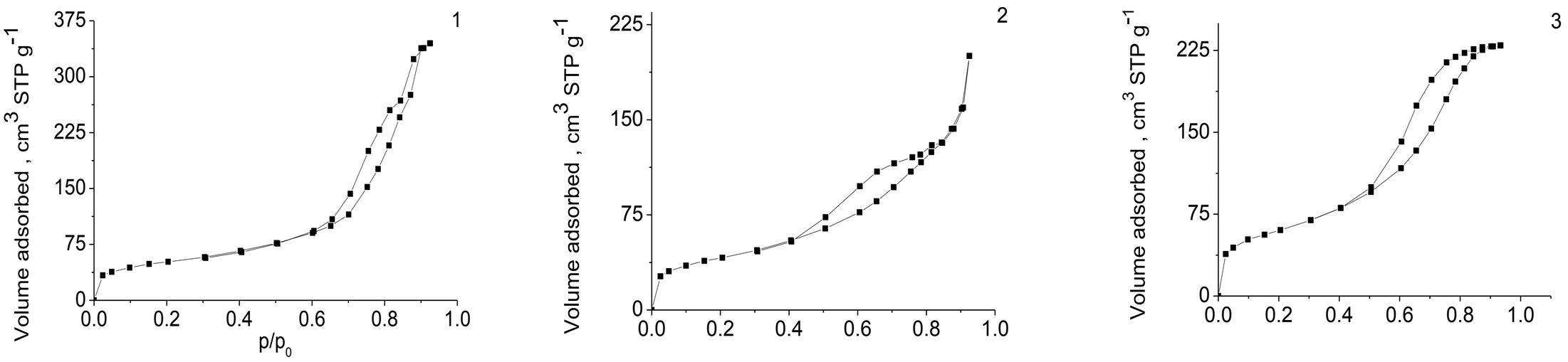
- 60S glass has a composition (mol%) of 60% SiO_2, 36% CaO, 4% P_2O_5.
- The synthesis was carried out by sol-gel method using: tetraethyl orthosilicate (TEOS) $(C_2H_5O)_4Si$, triethyl phosphate (TEP) $(C_2H_5O)_3PO$, ethanol C_2H_5OH, calcium nitrate tetrahydrate $(Ca(NO_3)_2 .4H_2O)$, 59 % solution of nitric acid (HNO_3). Mass ratios of precursors for the synthesis of 60S glass were: $(C_2H_5O)_4Si$,: $(C_2H_5O)_3PO$: $(Ca(NO_3)_2 \cdot 4H_2O)$: H_2O : C_2H_5OH = 8,59 : 1: 5,85 : 9 : 3.
- The sol-gel synthesis method produced samples of 60S glass (4% P_2O_5, 35% CaO and 60% SiO_2) and doped with La (4%), Y (4%) and La 2% +Y 2%.

Low-temperature nitrogen adsorption-desorption isotherms pore distribution

Investigated the value of SSA - important characteristic that is regulated by the synthesis conditions and depends on the alloying components and affects the adsorption/ desorption processes involving the glass surface. Samples of BG 60S doped 4% La are characterized by an increase in the value of total pore volume to 533 cm^3 g^{-1} and the formation of a microporous structure with values of micropore volume 2.42 mm^3 g^{-1} and micropore area 6.86 m^2 g^{-1}. Addition of 4% Y or 2% La+2% Y does not lead to the formation of micropores.



N_2 ad/desorption isotherms (a) and pore distribution (b) of the samples: 1 – BG 60S (synthesis temperature - 700°C), 2 - BG 60S (synthesis temperature - 1000°C)



N_2 ad/desorption isotherms of the BGs 60S samples doped : 1 – 4% La; 2 – 4% Y; 3 – 2% La +2% Y