BIORESORBABLE POLYESTERS AND HYDROXYAPATITE BASED COMPOSITES AS MATERIALS FOR 3D PRINTING OF BONE TISSUE ENGINEERING SCAFFOLDS*

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Despite the downward trend regarding disability prevalence over the last decade statistics of the musculoskeletal system diseases remain at the same high level [1]. Surgical treatment of polytrauma and congenital diseases accompanied by massive bone tissue lose is still one of the most challenging issues for modern orthopedics and traumatology. Consolidation of bone fragments during the treatment of such diseases even with the use of external fixation devices is often accompanied by complications leading to the increase in the time of osteosynthesis and, in some cases, to the additional surgical intervention. There is continuous research for new treatment methods in modern orthopedics, aimed at reducing the time of osteosynthesis.

The designing of new biodegradable polymer composites is one of the most promising areas of modern orthopedics and regenerative surgery. At present, a number of methods have been proposed for designing and processing biodegradable polymer composites via various 3D printing technologies, however, the homogeneity of filler distribution together with mechanical properties of scaffolds made of such composites are far from those required for clinical use [2,3]. In this study, the new method for producing highly filled (up to 60 wt.%) biodegradable composite material based on polylactic acid (PLLA) and polycaprolactone (PCL) solution in organic solvent and hydroxyapatite (HAp) powder by mixing in low-speed ball mill was proposed. Composites were extruded on the horizontal single-screw extruder to obtain filaments for Fused Deposition Modeling (FDM) 3D printing of porous scaffolds. The study of scaffolds morphology showed homogeneous distribution of HAp in the PLLA and PCL matrix and decrease in the scaffolds deformation after additional annealing as the weight fraction of HAp was increasing from 0 to 60 wt.%. Furthermore, XRD results showed that the weight fraction of HAp not only affects the macro deformation of scaffolds but also affects the crystallization process of the polymer matrix. According to the results of Raman spectroscopy, the absence of residual organic solvents in the composite materials was shown. The thermal stability and crystallization kinetics of the polymer matrix was evaluated after each step of the heat treatment using the methods of TGA and DSC. The change in the molecular weight distribution of the polymer matrix was evaluated by GPC. As a result of this study, optimal parameters of highly filled PLLA/HAp and PCL/HAp filament extrusion and 3D printing were proposed which ensure high printing accuracy, the thermal stability of the polymer matrix and its molecular structure. It was shown that porous PLLA/HAp and PCL/HAp composite scaffolds 3D-printed in this study can be potentially employed for bone tissue engineering due to its adjustable physical and mechanical properties.

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