DESIGNING AND PREPARING BY FDM 3D PRINTING OF POLYMERIC SCAFFOLDS WITH POTENTIAL APPLICATION IN TISSUE ENGINEERING

JAKUB MARCHEWKA*, JADWIGA LASKA

AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, FACULTY OF MATERIALS SCIENCE AND CERAMICS, 30 A. MICKIEWICZA AVE., 30-059 KRAKOW, POLAND
E-MAIL: JMAR@AGH.EDU.PL

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Introduction
The aim of this research is to develop a procedure to prepare the biodegradable polymeric scaffolds using 3D printing by fused deposition modeling (FDM). Mechanical damages of the bone and cartilage tissue within joints are a common result of sport and communication accidents. This type of defects usually causes a pain and limitation of a movement range. The basic problem of the therapeutic procedure is a limited ability of the cartilage tissue to regenerate [1]. One of the most effective methods of supporting of this process is to apply the polymeric scaffolds with shape, dimension, infill and material adequate to the type of the damage. 3D printing by fused deposition modeling is one of the most interesting method of the polymers processing [2,3]. Thermoplastic material in form of a filament is melted and casted layer by layer to produce three dimensional object. The structure of this product could be precisely described by designed computer model.

Materials and Methods
In the presented research an application of low-cost FDM 3D printer and freeware software is evaluated. RepRapPro Tricolour Mendel (RepRapPro, United Kingdom) is a commercially available device designed by open-source project RepRap. Blender, Sli3er and Pronterface are the GNU GPL software used to design the structure of the object and to prepare the print. Poly(L-lactide) (PLLA) and poly(L-lactide-co-trimethylene carbonate) 15/85 (PLLATMC) were purchased from BioMatPol, Poland. The printed polymeric scaffolds were analyzed using Keyence VHX-900F digital microscope.

Results and Discussion
The structure of the scaffolds including shape, dimension and infill was designed using Blender software. Cylinders with 10.0 mm height and 10.0 mm diameter were prepared with three different infill patterns resulting in 60% porosity. The rectilinear patterns with 0.3 mm bar diameter and 0.3 mm layer height include orientation 0°/90° (type A), 0°/60°/120° (type B) and 0°/45°/135°/90° (type C). Designed models were saved as .stl files. The filament with 1.75 mm diameter was prepared using a screw extruder. PLLA/PLLATMC 80:20 blend was selected as a material appropriate for bone tissue regeneration.

The optimization of the printing process was conducted using Sli3er software to get a required quality of the printed structures. The most important parameters include a nozzle temperature (200°C) and the speed of the printing movements (10 mm/s). Prepared .gcode file was uploaded to Pronterface software used for the printer controlling. Microscopic images of the printed polymeric scaffolds are presented in FIG. 1.