MODELING, FABRICATION AND CHARACTERIZATION OF 3D PLLA SCAFFOLDS PLOTTED WITH COMMERCIAL PRINTER

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Introduction

Biomedical application is one of the main areas of 3D printing usage specifically in creating scaffolds for medical implants [1-2]. Scaffolds made of PLLA can easily mimic the structure, shape, pore size and topography of natural tissue. The use of a three dimensional CAD model in RP allows the recreation of complex 3D architecture, mechanical properties and composition of the materials in contact with cells [3-6]. Supported on the computed tomography (CT) scans RP enables the exact reproduction of natural tissues [7]. The main purpose of this work was to fabricate scaffolds using commercial 3D printer. Different scaffold topography and geometry was created using 3D modelling software.

Materials and Methods

The fabrication process begins in the 3D surface modeller (Rhino3D v5) where scaffold prototype model was obtained. Afterwards 3D model was transferred to 3D FDM printer as -.STL file. The prototype had lattice form made of five layers (FIG. 1a) created by bars with 1 mm rectangular cross-section and 1 mm spacings. Each layer was rotated at 90º with respect to previous one. The dimensions of the scaffold were length 21 mm (11 bars in layer 2, 4), width 9 mm (5 bars in layers 1, 3, 5), height 5 mm.

Poly L-lactic acid (PLLA, 3D4Makers) with a diameter of 1.75 mm, molecular weight 60000-80000 Da, and viscosity of 300000 CP was used as filament for 3D printer (Zortrax M200, Poland). A PLLA filament was fused and guided by an extrusion nozzle to form 3D scaffolds. Printer nozzle temperature was 210°C and the height of printed layer was set to 0.09 mm. The material left the extruder in a liquid form and solidifies upon contact with the fabrication platform (temp. range: 20-60°C). The previously formed layer was the substrate for the next layer.

The samples were evaluated with Stereomicroscope (SN from OPTA-TECH company, equipped with CMOS 3 camera and OptaViewIS software) and with scanning electron microscope (Nova NanoSEM 200, FEI) equipped with EDS analysis. Tensile strength Rm was determined in a static tensile test on Hegewald und Peschke testing machine (Inspekt Table Blue 5kN).

Results and Discussion

Using FDM - additive fabrication process (FIG. 1b - clearly seen each deposited layer of material) it was possible to fabricate the PLLA scaffolds with commercial 3D printer. The selected pattern was simple but provided easy modelling and rather high number of inner and outer surfaces that constitutes places where the cells can grow (FIG. 1c,d). Microstructure and mechanical properties of obtained scaffold were evaluated. The properties of the lattice microstructure of designed scaffold were compared with relevant one for solid cuboid (TABLE 1). Future experiments will be also undertaken to evaluate formation of apatite in Simulated Body Fluid (SBF).

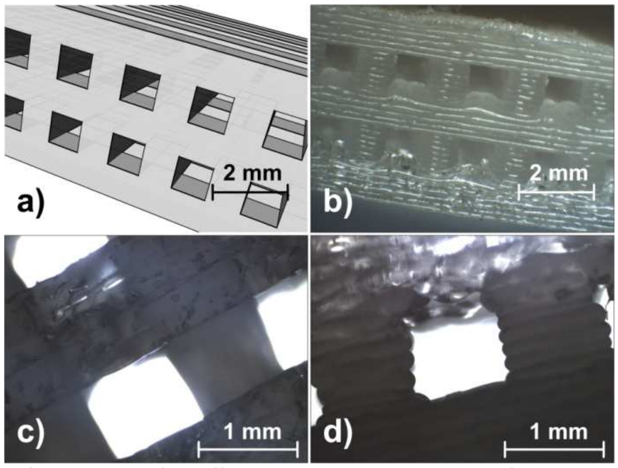

FIG. 1. View of scaffold a) 3D model, b) side (SN, zoom 8x), c) top (MB 200, 40x), d) side (MB 200, 40x).

TABLE 1. The comparison of scaffold properties for lattice microstructure and solid cuboid.

Microstructure	Volume [mm^3]	Porosity [%]	Total Area [mm^2]
Lattice structure	513	45.7	1686
Reference cuboid	945	0	678

Conclusions

Three-dimensional (3D) printers can create complex structures based on digital models. Our preliminary research show the potential of using the commercial printers for plotting PLLA scaffolds with designed geometry and thus influence the scaffold mechanical properties.

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