HYDROGEL SCAFFOLDS FOR MEDICAL APPLICATIONS OBTAINED BY INDIRECT 3D-PRINTING METHOD

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Introduction

Hydrogels are more and more widely used in biomedical applications, e.g. as dressings and matrices for tissue and organ engineering [1]. Classical direct hydrogel printing is challenging, particularly for fast gelling hydrogels. Indirect 3D printing method involves material casting in 3D printed mold and subsequently dissolving soluble mold material (in organic solvent or water). It results in obtaining a scaffold with a desired shape, being a negative of sacrified mold. The method of provides opportunity to obtain a wide variety of scaffolds without rheology requirement necessary to print by direct extrusion method [2].

Materials and Methods

Indirectly 3D printed hydrogel scaffolds where obtained from 0.5% w/v gellan gum (GG) and 2.5% w/v gelatin (Gel) mixture (both from Sigma Aldrich).

3D models of gyroid shape were algorithmically generated by slicing program (Cura 3, Ultimaker). Gyroid scaffold models were compared with classical lattice models in terms of stress distribution using finite elements method (FEM) in Fusion 360 software (Autodesk).

Gyroid model of the mold (FIG. 1A) was 3D printed from poly(vinyl alcohol) (PVA, Formfutura, Nederland) (FIG. 1B) and polylactide (PLA, Noctua ULTRA-PLA, Poland, as a reference) filament on He3D FDM 3D printer. GG/Gel mixture was molded into PVA (FIG. 1C). PVA was dissolved in water by incubation for 24 h to obtain GG/Gel hydrogel scaffold (FIG. 1D).

Quality of the prints for different infill percentage was examined by optical means (Keyence microscope). Obtained molds were used to produce GG/Gel hydrogel scaffolds. Additionally PVA molds were tested in contact with water to determine maximal gelation timeframe in which mold details are still preserved and can be imprinted into molded hydrogel.

Results and Discussion

It was shown that for the same load gyroid structure was more mechanically stable with lower maximal stress values compared to lattice structure. PVA material was more demanding to print than PLA therefore 4-fold reduction of printing speed was required. Dried PVA showed inferior layer adhesion compared to wet PVA.

It was also shown that any hydrogel with gelation time lower than 2 minutes can be molded in water soluble PVA with minimal detail lost.

Conclusions

The study showed possibility to use indirect 3D printing in PVA molds for fast gelling GG/Gel hydrogels although PVA printing process was more challenging than classical PLA printing.

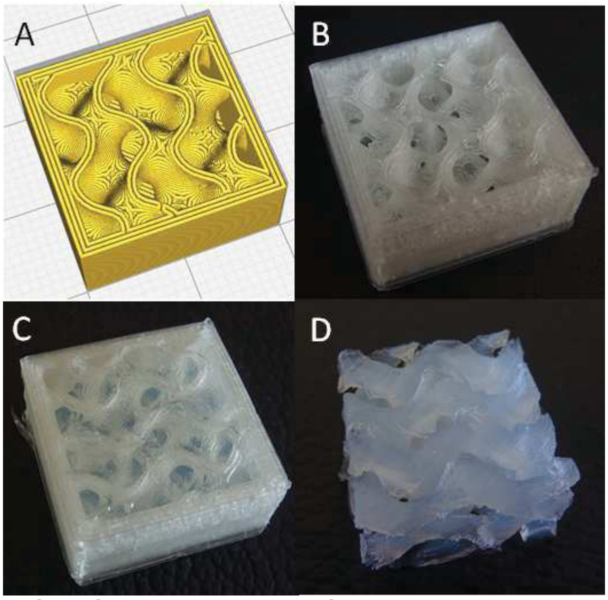

FIG. 1. Gyroid mold model in Cura 3 (A), PVA mold (B), PVA mold after GG/Gel infiltration (C), hydrogel scaffold after PVA removal (D).

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