3D Printing of Biopolymer Composites Fabricated from Polylactic Acid & Eggshell-Derived Hydroxyapatite

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Undergraduate Research Program for Honors Students 2020-2021

ABSTRACT

Hydroxyapatite (HAp) is a naturally occurring mineral form of calcium apatite, which is found in 85-90% of human bone. Waste-derived HAp is attracting considerable attention due to its excellent biocompatibility and capacity to enhance the proliferation of osteoblastic cells.

In the present work, HAp was synthesized from waste chicken eggshell and subsequently incorporated as a filler (at different concentrations) into a polymer matrix of polylactic acid (PLA) to fabricate composite filaments for bone deposition modeling (FDM) 3D printing. The filaments were fabricated via extrusion using a solvent-free process. Then, they were placed in an Endure 3.0 FDM 3D-printer to create PLA/HAp composite specimens and scaffolds.

RESULTS

The temperatures of the extruder chamber were varied to fabricate each filament. To reproduce the filaments, these were cut in small pieces and fed to the extruder hopper to fabricate a new filament.

The specimens and scaffolds were fabricated using a fused modeling deposition (FDM) 3D printer from Creality, equipped with a 0.4-mm, 0.4-mm, or 0.4-mm nozzle set at 200°C, while the plate temperature was set at 60°C. The speed chosen for the 3D printer was 30 mm/s with a line pattern.

CONCLUSIONS

HAp was successfully fabricated from waste eggshell via calcination and subsequently, dry ball milling. PLA/HAp filaments having compositions of HAp ≤ 3 wt% were fabricated via a solvent-free preparation method and using a Filafab Extruder 3D. At a composition of 3 wt% of HAp, the filament was so brittle to be placed in the spool.

AFT WORK

➢ Complete the installation and training of the new equipment: biosafety cabinet, cryogenic tank, and the fluorospectrophotometer to proceed with the real culture and the biological characterization of the scaffolds.

➢ Study the effect of the scaffold HAp content on the osteoblast cell’s growth (work in collaboration with Prof. Maria Guarino). This includes:

➢ Study the microstructure of the fabricated scaffolds via Scanning Electron Microscopy (SEM) to understand their mechanical, electrical, and biological performance.

➢ Study the effect of the 3D printing orientation on the materials properties of the fabricated scaffolds.

Recommended:

➢ It is recommended to sieve the hydroxyapatite before its synthesis in order to use only particle size at meso and nano scale. Employing small particles could increase the mechanical stability of the filaments and the 3D-printed scaffolds.

➢ Since the solvent-free method limits the amount of HAp to be used (probably because of its poor dispersion in the PLA), it is also recommended to dissolve the PLA before mixing with the HAp. It is also recommended to use an industrial grade nanopollet to fabricate the pellets as part of the solvent-based mixing method.

➢ The use of more sophisticated FDM 3D-printers could increase the quality of the scaffolds.

➢ It is also recommended to start a post-treatment process for the fabricated scaffolds to improve the mechanical strength of the scaffold.

ACKNOWLEDGMENTS

We would like to thank:

- URI HS SAPIA II program, for providing the required funding.
- Dr. Wilfredo Furtado for allowing us to use the impedance analyzer at his laboratory.
- Prof. Maria Guarino for her contribution in the selection of the biologic equipment.

REFERENCES


