Fall 2019

Design and Mechanical Characterization of 3D Printed Gradient Porosity Poly(propylene fumarate) Scaffolds

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Abstract

Worldwide incidence of bone disorders and conditions, an already prevalent problem, is expected to double by 2020 from the rate in 2013 due to factors such as higher life expectancies and lower levels of physical activity. Every year in the United States, over half a million patients receive bone defect repairs, with costs greater than $2.5 billion.[1] Current repairs are typically done with bone grafts, which are often costly and can result in added complications in the donor surgical site. Tissue engineering, a growing field that seeks to assist and enhance tissue defect repairs through the use of synthetic materials, has been increasingly studied to assist this application as more materials are developed that display the required levels of biological compatibility. One such material is poly(propylene fumarate), or PPF, an unsaturated polyester that has previously been identified as an appropriate resorbable material.[2] PPF degrades into non-toxic byproducts in the time it takes for bone tissue regeneration, has similar mechanical properties to bone tissue, and is photocrosslinkable, making it able to be 3D printed via stereolithography techniques. This allows for patient-custom parts to be manufactured from PPF for each surgery. In order to optimize PPF structures for this application, they should be as similar to bone tissue as possible. One way to achieve this is to consider that bone tissue is porous, and has a natural porosity gradient throughout. This project aims to optimize PPF structures for bone tissue repair applications by designing, manufacturing, and mechanically characterizing scaffolds with gradients in porosity. This report covers the design and manufacturing process of gradient porosity PPF scaffolds, including material selection, computer aided design of the gyroid structure of the scaffold, and the finding of adequate manufacturing parameters, as well as the final comparisons of various designs.

Project is part of work with co-op company 21MedTech. Full report is proprietary and not available on IdeaExchange. If more details on this project are desired, please contact 21MedTech.

References:

1. Amini, A.R., Laurencin, C.T, Nukavarapu,S.P (2013). “Bone Tissue Engineering: Recent Advancements and Challenges”. *Critical Reviews in Biomedical Engineering*, 40(5), 363-408. DOI: 10.1615/CritRevBiomedEng.v40.i5.10
2. Walker, J.M., Bodamer, E., Kleinfehn, A. et al. (2017). “Design and mechanical characterization of solid and highly porous 3D printed poly(propylene fumarate) scaffolds”. *Progress in Additive Manufacturing*, 2(1-2),99-108. DOI: 0.1007/s40964-017-0021-3