CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Aditi Ghalsasi

Project Number

S0609

Project Title

Development of Functionalized PCL-2000 to Create Ideal 3D Printable Polymers

Abstract

Objectives

3D printing promises to produce complex biomedical devices according to computer design using patient-specific anatomical data. However, the application of such techniques in biomedical devices has been slow due to the stringent performance criteria and concerns when new materials, such as biocompatible and printable polycaprolactone (PCL), are in their infancy. PCL is a highly biocompatible aliphatic polyester obtained by the polymerization to the open-loop form of caprolactone. Despite the several attractive qualities of PCL to produce medical devices, PCL is highly viscous, melts at high temperatures and loses accuracy as printing speed increases. Our experiment aimed to decrease the natural viscosity of the polymer.

Methods

In this study, monomers with varying carbon branch lengths were added to the backbone of the current PCL molecule using DIC/DPTS mediated coupling; the addition was intended to decrease viscosity and lower the melting temperature of the polymer while preserving advantageous physical properties. Monomers were synthesized in the lab with aliphatic carbon chain lengths of 2, 6, and 10, and polymers were synthesized using a step-polymerization reaction between PCL-2000 and each corresponding monomer.

Results

Gel permeation chromatography (GPC) and nuclear magnetic radiation (NMR) spectra confirmed new structures and molecular weights for testing. Differential scanning calorimetry (DSC), rheology, tensile, and 3D printing tests showed an increased viscosity and similar melting temperatures in the lab-made polymers as compared to PCL-2000, contrary to the expected result. 3D printed scaffold quality varied among polymers.

Conclusions

The experiment successfully produced lab made PCL polymer, 3 monomers with carbon lengths 2, 6, and 10, and three polymers with varying aliphatic chain lengths via step reaction with monomers. We were unable to decrease the natural viscosity of PCL-2000; instead, results show an increase in viscosity after the addition of side chains. The melting point of PCL decreased, generally improved scaffold quality and ease of printing with modified PCL polymers. These results promise 3D printing possibilities for implants and replaceable parts. Future research includes developing drug developing complexes and fluorescent materials capable of changing 3D printing qualities.

Summary Statement

I created several polymers from a polycaprolactone base that are suitable and sustainable for 3D printing scaffolds and implants.

Help Received

I worked with The University of Akron in Ohio under a qualified mentor. I received guidance from my mentor for reactions and usage of machinery, but conducted the work on my own.