Characterizing the Mechanical Properties of Implantable Biomaterials

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Introduction

Any material that interfaces with living tissue is considered a biomaterial. In order to be effective, biomaterials, especially biomaterials that are implanted into living tissue must be biocompatible. Biocompatibility is routinely characterized by immune and inflammatory responses by the body, but mechanical properties, like strength and elasticity, of the material are equally important to the function of the material within the surrounding tissues. Human tropoelastin is a versatile and novel biomaterial that has broad potential application as an implantable biomaterial. Tropoelastin can be manipulated by blending it with other proteins and varying the crosslinking, bonds formed between fibers, of the scaffold. This study aims to characterize the mechanical properties of a customizable biomaterial.

Methods

- **Materials**
  - Electrospun protein scaffolds
  - Human tropoelastin, pure and blended with collagen, ePTFE, and porcine hernia patch.
- **Tensile Testing**
  - Testing system
  - Servo-motor lever
  - Labview DAQ board used to control and record the force and displacement of lever. Converted into stress and strain.
- **Grips**
  - Upper and lower clips were used to secure test material
  - Connection to lever designed to match material compliance (Figures 2.3)
- **Internal compliance material**
  - Induced internal system compliance
  - Rubber band for compliant materials
  - Chain system for less compliant materials

Results

**100% Tropoelastin vs. 50:50 Tropoelastin Collagen Blend: Dry**

**Hydrated Tropoelastin**

**100% Tropoelastin vs. 50:50 Tropoelastin Collagen Blend: Hydrate**

Discussion

Tropoelastin, as native protein, has the potential to elicit favorable biocompatibility as an implantable material. Therefore, matching its mechanical properties to the application requirements can further enhance its utility as a biomaterial.

Initial testing has shown a marked difference between the dry and hydrated protein scaffolds. The 100% hydrated tropoelastin was able to stretch 350% its initial length (the maximum length allowed by the system) and fully recover. Additionally, differences were seen in the stress-strain curve between the 50:50 tropoelastin collagen blend and the 100% tropoelastin in both the dry and hydrated testing.

In both test conditions the 50:50 tropoelastin collagen blend was stiffer than the 100% tropoelastin which was the most compliant of all the tested materials.

This study sets the foundation to investigate the range of mechanical properties of biomaterials. Using electrospinning, many variables can be adjusted to tune the material’s mechanical properties to specification. Next, the mechanical properties of similar protein scaffolds will be determined to better understand how each variable affects the mechanics. The variables that will be tested are a greater range of blends of tropoelastin with other proteins, namely collagen, crosslinked versus non-crosslinked scaffolds, and the effect of different strain rates on each material. Understanding how this material can be designed to mechanical requirements will allow it to be applied as a customizable biomaterial.

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References


Basic Research