

# Non-destructive Characterization of the Morphology of a Polymer Co-Extruded Scaffold Using Optical Coherence Tomography

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## Introduction

It is generally understood that a complex interaction of many variables controls the success of cell infiltration, proliferation, and differentiation within a tissue scaffold. One parameter that has a large influence on the development of functioning tissue is the microstructure of the scaffold itself. Here, we utilize optical coherence tomography (OCT)<sup>1,2</sup> to non-destructively characterize the microstructure of a co-extruded blend. OCT provides us with a volumetric image of the pore size, size distribution, and connectivity. This information is available in a limited degree only using traditional destructive characterization. Another advantage of using OCT is that time dependent properties such as cell proliferation and scaffold degradation can be monitored in vitro on the same scaffold. This work will present OCT microstructure characterization of a poly( $\epsilon$ -caprolactone) and poly(ethylene oxide) co-extruded blend.

## Experimental

### Materials and Methods

Poly( $\epsilon$ -caprolactone) (PCL) is blended with poly(ethylene oxide) (PEO) in a twin-screw extruder to form a two-phase material with micron-sized domains. The characteristic pore size is controlled by annealing and can reach in excess of 100  $\mu\text{m}$ . Selective dissolution of the PEO with water results in a porous material.

### Instrumentation

With OCT, reflections from heterogeneities within the sample are mapped as a function of thickness for any one position using a wide bandwidth laser and a fiber optic based Michelson interferometer. Quantitative information about the location and size of a feature within the material is obtained. Details about this technique are provided in previous work.<sup>2</sup> In this configuration, the scaffold is the fixed arm of the interferometer. Volume information is generated by translating the sample on two motorized stages. OCT can practically image biomaterials having a thickness of up to 0.5 cm with a spatial resolution of 5-15  $\mu\text{m}$ . The group refractive index of the scaffold in index matching fluid was measured to be  $1.425 \pm 0.005$  at 1.314  $\mu\text{m}$ . Axial (thickness) dimensions measured in air were corrected by dividing the axial distance by the group refractive index to obtain the actual axial dimension.

## Results

An OCT cross-sectional image of the scaffold with the remaining PCL is presented. This particular scaffold was blended 50 % (by volume) PCL and 50 % PEO and

annealed for 60 min at 80  $^{\circ}\text{C}$ . The dark gray and black features represent the remaining PCL. The pores are shown by the light gray regions. Although the contrast degrades as one probes deeper into the scaffold, the morphology can be clearly resolved at an appreciable depth,  $\sim 700 \mu\text{m}$ . This morphology agrees well with corresponding scanning electron micrograph images<sup>3</sup>. A volumetric representation shows that the pores are interconnected and can provide a path for migration of the cells to the interior of the scaffold.

## Conclusions

We have shown that OCT has high potential for the characterization of tissue scaffolds because it can provide high sensitivity measurements of the interior of a scaffold. These measurements are on a size scale important to the field of tissue engineering, 5  $\mu\text{m}$  to hundreds of microns. Using OCT, candidate scaffolds can be rapidly screened for pore size and connectivity. Scaffold degradation can be monitored in vitro. Previous work exists that shows OCT has the sensitivity to detect cells<sup>4</sup>, and we believe it is possible to monitor cell proliferation with cells types that are resolvable with our instrumentation.

## References

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