Developing Functionalized Biodegradable Membranes Using Natural and Synthetic Polymer Blends

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Introduction

• Biodegradable polymers, such as poly(caprolactone) (PCL), are used in 3D scaffolds to support cells and degrade as new tissue forms¹.
• Physical, mechanical, and biochemical properties of materials must be tailored to mimic native tissue to promote functional regeneration.
• Biodegradable membranes for soft tissue applications, such as skin, cornea, muscle, and blood vessels, may alleviate the need for native donor tissue.
• Here, tunable membrane scaffolds are produced by blending synthetic PCL and a natural polymer chitosan (CHI)².
• Membrane properties can be modified by changing PCL:CHI ratio, specifically influencing optical, mechanical, and degradation behavior.
• Using a strategy developed in the Chow Lab³, membranes can be functionalized with bioactive peptides (i.e., canonical adhesion motif RGDS) by adding peptide-PCL conjugates during membrane formation (Fig. 1)
• This work provides a platform for tuning multi-component tissue engineering constructs that mimic native tissue properties.

Peptide-Functionalized Membranes

• PCL/CHI membranes were prepared with range of PCL:CHI ratios (25:75, 50:50, 75:25) by dissolving PCL and CHI separately in a common solvent formic acid (Fig. 2).
• RGDS(biotin)-PCL conjugate (1 mg/mL or 5 mg/mL) was added to the PCL solution prior to membrane formation to create peptide-functionalized membranes.
• After 24 hours, membranes were washed in phosphate buffered saline (PBS) and 0.5 mM sodium hydroxide to neutralize residual formic acid.
• Membranes were labeled with streptavidin-fluorescein isothiocyanate (FITC) to confirm presence of biotin-tagged RGDS peptide.
• All membranes were imaged using DSLR camera and optical microscopy.
• Fluorescence was quantified by analyzing FITC-labeled membranes using a Tegal microscope plate.
• NIH 3T3 fibroblast cells were seeded at 100,000 cells/membrane to investigate effect of peptide modification on cell adhesion.
• Cell viability was evaluated using a Live/Dead Cell Viability Assay after 24 hours of culture on the membrane.

Cell Adhesion and Viability on Functionalized Membranes

• Membranes with varying PCL:CHI ratios were successfully fabricated.
• Increasing CHI content increased optical transparency and homogeneity as well as mechanical stability (Fig. 3).

Concluding Paragraph

• This study showed membranes can be reproducibly formed with desired optical transparency, structural integrity, and cell adhesion properties using a single-step functionalization strategy with peptide-PCL conjugates.
• Future work involves long-term cell culture studies and mechanical testing and membrane sputtering to verify membranes satisfy clinical use requirements for tissue regeneration applications.
• This platform introduces tunable multi-component tissue engineering constructs that more closely resemble the diverse mechanical and chemical properties of native tissues.

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