Characterization of norbornene-modified cellulose electrospun fibers in different solvent systems for biomedical applications

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Statement of Purpose: Tissue damage due to injuries or disease is a very common and difficult issue to manage. Tissue engineering is a promising approach to repair damaged tissue. Tissue engineering uses a combination of biology and engineering to restore or regenerate compromised tissue through suitable biochemical and biophysical factors. Electrospinning is a common approach to produce scaffolds that mimic the fibrous nature of the extracellular matrix (ECM). Electrospinning applies a high voltage to a polymer solution to create fibrous scaffolds, where fiber morphology is dependent on electrospinning flow rate, plate distance, and voltage [1]. In this study, we aim to electrospin norbornene-modified cellulose acetate (nor-CA) using trifluoroacetic acid (TFA) and dimethylacetamide (DMAc)/acetone solvent systems to evaluate fiber stability and morphology as a function of the solvent system. Scanning electron microscopy (SEM) was used to characterize fiber formation, morphology, and diameter.

Methods: Nor-CA was dissolved in a solution with dithiothreitol and a photoinitiator to enable crosslinking of the scaffold when exposed to UV light. Nor-CA was dissolved in acetone/DMAc (12, 15, and 18% nor-CA) at a 1:1 ratio or TFA (15 and 17% nor-CA). The solution was placed in a 10 mL syringe and expelled onto a grounded collecting plate using a high voltage power source. The needle tip to plate distance was set to 15 cm for acetone/DMAc and 10 cm for TFA. The flow rate was set to 0.7 mL/hr and the voltage was variable depending on the solvent and concentration. Each solution was electrospun for 8 minutes. After electrospinning, the dry fiber mat was collected and imaged using bright field microscopy and SEM. ImageJ was used to determine fiber diameter.

Results: Among the solvents used, acetone/DMAc at a 1:1 ratio and 15% nor-CA successfully produced bead-free aligned nanofibers. In Figure 1b, SEM images show a dense formation of fibers with minimal beading. At 12% nor-CA, there was no indication that fibers formed, instead very small beads were present. At 18% nor-CA, the fiber diameter was larger compared to 15% nor-CA and beads were present. This indicates a trend of growing fiber diameter with increasing nor-CA concentration. TFA showed no signs of fiber formation at 15% nor-CA; however, at 17% nor-CA, there were indications of discontinuous fiber formation. Future work will investigate: 2:1 and 3:1 acetone/DMAc ratio at 12, 15, and 18% nor-CA; TFA at 20% nor-CA; and a 3:1 acetic acid/water ratio at 12, 15, and 18% nor-CA. Additionally, rheology and conductivity will be performed to further understand solution properties.

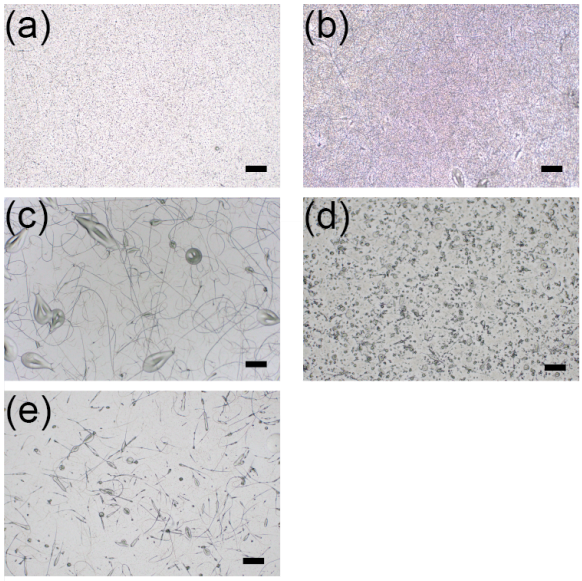

Figure 1: Morphology of nor-CA electrospun fibers using a 1:1 ratio of acetone/DMAc with (a) 12%, (b) 15%, and (c) 18% nor-CA. Morphology of nor-CA electrospun fibers using TFA with (d) 15% and (e) 17% nor-CA. Scale bar = 100 μm.

Conclusion: This work demonstrates that nor-CA is able to form stable nanofibers in at least one solvent system, acetone/DMAc. Future work will vary the solution ratios and nor-CA concentrations to find more ideal conditions to form electrospun fibers.

References: [1] Charpashlo, E., et al. 2021. *Food Hydrocolloids*. *113*, 106–411.