Electrospun Polycaprolactone Nanofibrous Scaffolds to use for Tissue Engineering

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Statement of Purpose: Polycaprolactone (PCL), a bioresorbable polymer, was electrospun into nanofibers in the form of nonwoven scaffold structures for tissue engineering. The objective of the study was to determine the optimal spinning conditions for preparing scaffolds for the culture of hepatocytes [1]. Such tissue engineered structures will be valuable in the repair and replacement of diseased liver tissue. The electrospinning trials used a parallel plate setup and employed the use of a solution of a mixture of chloroform and methanol [2]. In order to find the optimal spinning conditions for PCL, several different solution conditions were examined during electrospinning trials that were run with varying polymer concentration, solvent ratios, flow rates and voltage potentials. A 1:1 chloroform:methanol solvent mix was found to be the optimal solvent ratio for the solution. Scanning electron microscopy was used to determine the fiber morphology, nanofiber diameter and pore size distribution.

Methods: Polycaprolactone (Mw 65,000) with a melting point of 60°C, density of 1.145, the solvents, chloroform and methanol were all purchased from Sigma Aldrich. All solutions were prepared in varying solvent ratios at room temperature. A 5% by weight PCL concentration was used for all trials of electrospinning. For each concentration, 5 solvent ratios were used (chloroform to methanol, 1:1, 2:1, 3:1, 4:1, and 5:1). Each solution was then tested at 6 different flow rates to determine the optimal spinning conditions (0.10, 0.15, 0.20, 0.25, 0.30, 0.35 mL/min). At each flow rate, the status of the solution was visually evaluated by increasing the voltage potential from 15kV to 50kV by increments of 2.5. The electrospinning trials employed the use of a parallel plate setup, having the bottom plate attached to the power potential and serve as a collection plate for the nanofibers spun. The top plate is grounded.

Results / Discussion: Each solution is characterized by having three states dripping, stable, and whipping [3,4]. From this study, an additional state was found. Only a few solutions were found to have a stable region in only a few flow rates. Instead of reaching a stable region, the solution would whip in a dripping fashion, which we have described as "spraying." Initially, these solutions have found that the 1:1 chloroform : methanol solvent mix has the "best" electrospinning conditions. "Best" has been defined as a solution that shows the lowest whipping values, as seen in Figure 1. Here, it can be seen that a trend does exist amongst the solutions tested. The flow rates of 0.2mL/min and 0.25mL/min have been consistently the best, from preliminary data and throughout this study. At this flow rate, samples have been collected for a duration of 3 minutes and analyzed with scanning electron microscopy. From this analysis, the nanofibers have been found to have an average diameter of about 180nm. These fibers can be seen in Figure 2.

Figure 1: The lowest "whipping" values of 5% PCL solutions

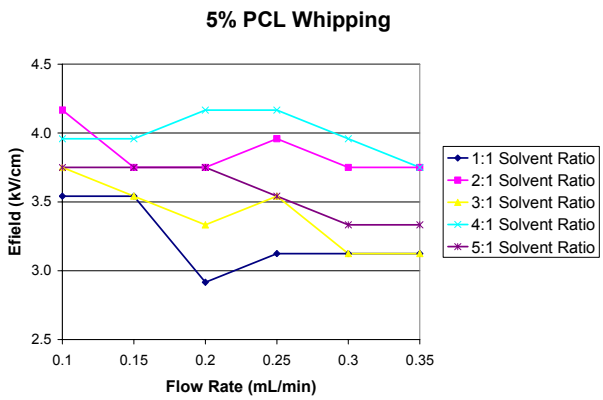
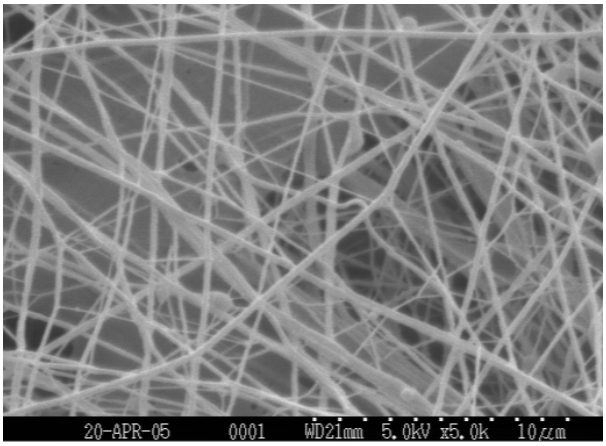


Figure 2: Electrospun nanofibers collected for a duration of 3 minutes



Conclusions: At the moment, the "best" solution is 5% PCL by weight and shows optimal spinning conditions. Because there appears to be a trend within the flow rates, more investigation is needed as well as more concentrations, specifically 10%, 12.5%, and 15%, more flow rates, different molecular weights, and different capillary sizes. The setup itself can also be altered to include different size plates, differing the distance between the two plates, and exposure of capillary. Concurrently, tests are being done to establish the biocompatibility of these PCL nanofibers with hepatocyte cultures. The nanofibers are under investigation to characterize morphology and other physical and mechanical properties. The next phase of the experiment includes collection on nonwoven poly(glycolic) acid or poly(urethane) meshes and culturing hepatocytes.

References:

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