NANO AND MICRO STRUCTURED ELECTROSPUN BLEND POLYMERIC SCAFFOLDS FOR CARDIOVASCULAR TE: BIOMECHANICS AND MORPHOLOGY

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Introduction

Polycaprolactone (PCL) and chitosan (CS) are polymers with attractive properties (excellent biocompatibility & degradation, resp. cytocompatibility) [Szentivanyi et al, 2011]. However their mechanical properties as separate homogenous electrospun fibrous membranes are not similar and do not satisfy the needs for cardiovascular (CV) tissue engineering (TE). In the present work we aimed to optimize electrospinning parameters (polymer solution concentrations, flow rate, voltage) to obtain a flexible PCL/CS polymeric membrane, with combined nano- and micro-fibre architecture and appropriate mechanical properties for cardiovascular tissue engineering applications.

Methods

PCL and CS were dissolved in 99Vol.% acetic acid (AAC) with concentrations:185-190 mg/mL and 5-12,5 mg/mL respectively. The solutions were stirred at room temperature for 48 hours to achieve homogenous blends. Electrospinning was performed at a custom made apparatus with flow rates of 0,5, 1 & 1,5 mL/h, at room temperature, 22-23 KV and a tip/collector distance of 28 cm. Morphology of the fibrous membranes (pore size and fibre's diameter) was examined by SEM. Cyclic sinusoidal uniaxial mechanical tests were performed with a BOSE electroforce dynamic tensile testing system, equipped with a 200 N load cell and a high rate/high resolution video extensometer. Rectangular, 25x9 mm strips (15 mm free length) were cut and tested at 0-20% strain, 1 cycle/sec, RT, dry conditions. The applied force and the local principal strain (at a 5x5 mm central region) were monitored and stress/strain data was computed. Mechanical properties, Young's modulus (the elastic modulus at linear portion of stress/strain curve) and the hysteresis were determined and compared.

Results

Preliminary results showed significant changes in PCL electrospun membranes in the presence of CS. SEM observations and measurements showed a micro fibrous (2 μm) structure in PCL and a nano- (250 nm) and micro (2 μm) fibrous arrangement from PCL/CS blend solutions. The pore size ranged 20-40 μm among micro fibres and 10 μm between nanofibres. Young's modulus showed a significant drop from 25 MPa (PCL) to 2-3 MPa in (185+5)% & (190+5) % PCL/CS blends, in 0-20% total cyclic strain. However, it increased to 5-6 MPa with increasing CS concentration (190+12,5)%. Flow rate (0,2 to 1 mL/h) does not seem to affect the mechanical performance. Hysteresis, as a ratio of dissipated/loading energy, ranged 38-50% in all cases.

Discussion

From early results it seems that the concentration of CS plays an important role in structural appearance of electrospun PCL. A combination of nanofibre/microfibre structure with a variety of small/great porous arrangement, suitable for potential cell seeding, was obtained in polymer blends. Elastic modulus of polymer blends, especially in higher CS concentration, was close to properties measured in soft cardiovascular tissues. Although a relatively high hysteresis ratio was measured, it has to be attributed to the dry conditions of testing. More tests shall be performed, together with a more quantitative study of the porosity of nanostructured membranes.

References

Szentivanyi A. *et al.,* Advanced Drug Delivery Reviews 63 (2011) 209–220.