171

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DEVELOPMENT AND OPTIMISATION OF A NOVEL 3D FIBER-BASED MESH FOR POP REPAIR AND REGENERATION

Hypothesis / aims of study

Monofilament polypropylene meshes are the most frequently used devices for the repair of pelvic organ prolapse (POP). However, given the serious complications associated with their use, such as mesh erosion and shrinkage, pain, dyspareunia and infection, they are currently under the investigation of US Food and Drug Administration, which have also released multiple warnings [1]. To overcome the still open challenges in POP repair, natural polymers have been proposed in the recent literature. However, the clinical application of this class of polymers is also limited because of their rapid degradation rate [2]. Hence, the aim of this study was i) the optimisation of a needleless electrospinning technology toward ii) the development of a novel 3D mesh, based on the combination of a natural and a synthetic polymer, with appropriate mechanical strength, controlled degradation rate and customable antibacterial properties, for the repair of human pelvic floor.

Study design, materials and methods

A needleless Nanospider™ (Elmarco, Czech Republic) electrospinning technology was used to process blends of chitosan (CS) and poly(ε-caprolactone) (PCL) (see Table 1), which were prepared by using a solvent mixture consisting of formic and acetic acid (volume ratio 70:30). After an initial optimisation process of the electrospinning parameters (i.e. voltage, speed of the electrode and collector distance), three-dimensional fibre-based meshes were produced. Fibre morphology of the electrospun CS/PCL scaffolds was examined by scanning electron microscope (SEM). Furthermore, the surface analysis of the blended materials was evaluated by FTIR. Additionally, fibroblasts viability and metabolic activity were assessed using a Live-dead and an MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay at different time points.

Results

For the first time CS/PCL electrospun scaffolds were processed by using a needleless Nanospider™. According to the SEM analysis, the composition with the lowest amount of CS led to uniform and bead-free nanofibres (see Fig.1), with no significant variations in diameter. Additionally, FTIR spectra (see Fig.2) of the combined CS/PCL mesh confirmed the presence of both polymers, and hence their homogenous distribution. Finally, preliminary cellular tests demonstrated efficient cell attachment and proliferation; moreover, in light of the MTT findings fibroblasts resulted also metabolically active.

Interpretation of results

To obtain fine nanofiber-based structure from beaded to non-beaded, an optimisation process either of the electrospinning parameters and of the polymer concentration was necessary. In good agreement with the literature [3] reporting about the conventional electrospinning technique, also with the needless electrospinning, by lowering the concentration of CS is possible to obtain bead-free structures.

Concluding message

Taken together the results of this preliminary work are of interest for pelvic floor repair, since they demonstrated the possibility to successfully scale-up the technology and produce novel surgical meshes as potential treatments for POP.

Table 1: Composition of the polymer solutions.

Formulation	CS (wt%)	PCL (wt%)	Viscosity (mPa·s)
lCS	0.5	10	2580
mCS	0.8	8	3104
hCS	1.2	6	2850

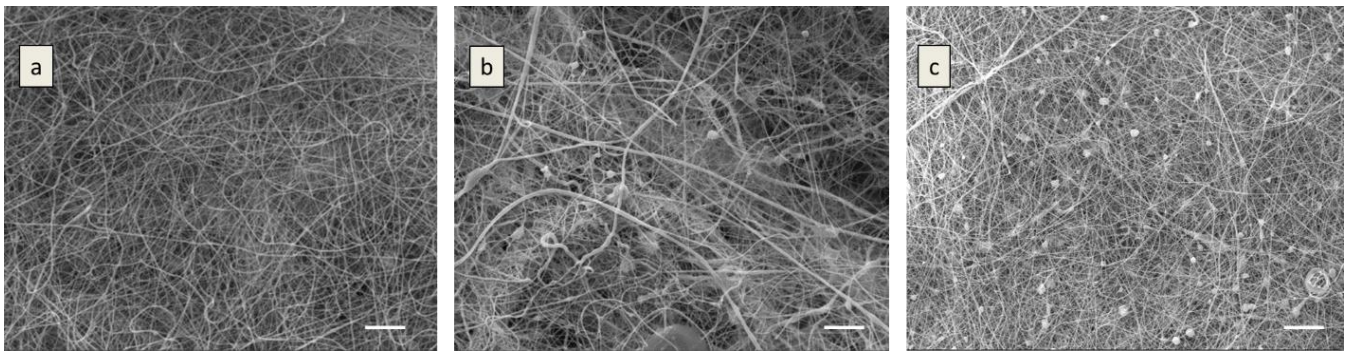

Figure 1: SEM images of a) lCS, b) mCS and c) hCS –derived electrospun scaffolds (scale bar 20 µm).

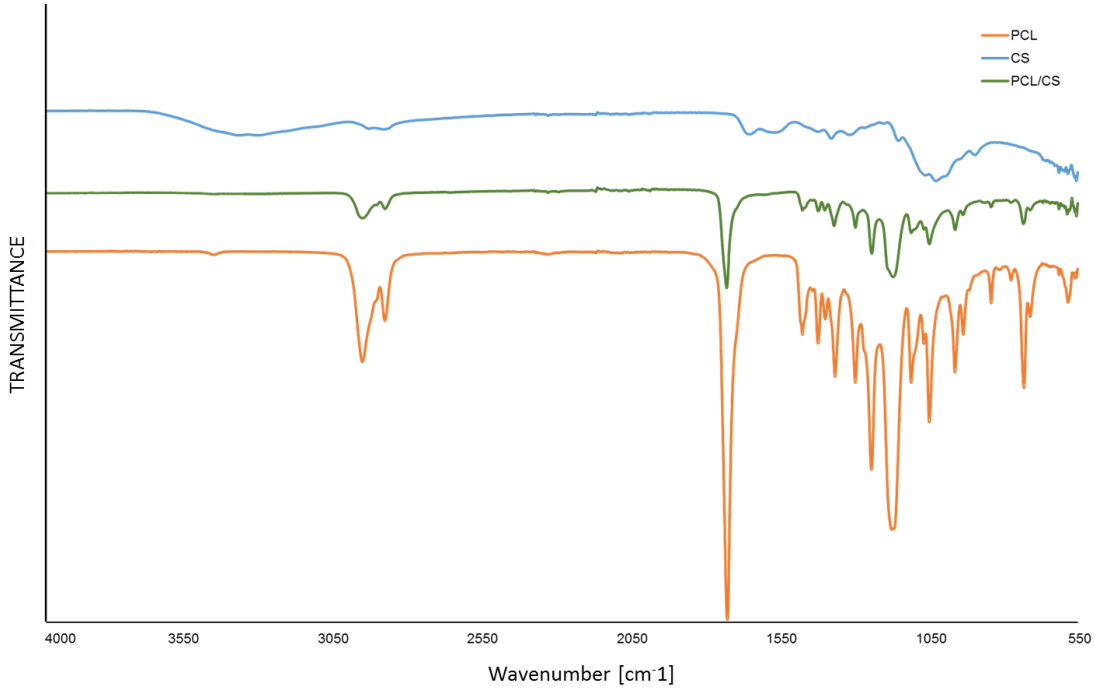

Figure 2: FTIR analysis of PCL (orange line), CS (blue line) and PCL/CS (green line) nanofibers.

References

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Disclosures

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