Electrospun medical grade polyurethane nanofibers containing MWCNTs for future tendon and ligament regeneration

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Advanced technologies (e.g., melt blowing, phase separation, self-assembly, template synthesis and electrospinning technique) are well-suited for the fabrication of nanofibers. However, associated technology and infrastructure cost limits their viability in biomedical applications. The nanofibers are popularly produced via electrospinning, while changing the parameters (e.g., applied voltage, needle size, tip-to-collector distance and humidity) which allows controlling the final fiber morphology and overall yield. Electrospinning technique has been attracting a tremendous attention due to a resultant web-like matrix that mimics the topology of the extracellular matrix (ECM) present in the human body. Therefore, these matrices can be used as scaffolds in tissue-engineering and regeneration applications. The multi-walled-carbon-nanotubes (MWCNTs) are considered to be unique materials due to their excellent mechanical, electrical and thermal conductivity along with the high chemical stability [1]. With this impression, cell-free and cell-laden fibers are reviewed, revealing an introduction of carbon nanotubes can remarkably influence the mechanical properties of nanofibers.

In this work, we demonstrate the preparation of nanofibers incorporated with MWCNTs. The obtained nanofibers were characterized by various techniques to determine the interactions between the polymer matrix and the MWCNTs. Finally, the goal is to obtain excellent mechanical properties and absolute biocompatibility. The three nanofiber combinations (i.e., randomly-obtained, semi-aligned and completely aligned nanofibers) were prepared while spinning completely dispersed polymeric solution containing MWCNTs by using simple electrospinning procedure [2]. Three different rotation speeds of the collector drum were adjusted to produce randomly-obtained, semi-aligned and completely aligned nanofibrous morphologies. To obtain these different morphologies, the rotation speeds of the collector were set at 798, 3240 and 5740 rpm, respectively.

To study cell cytotoxicity of the obtained nanofibers, fibroblasts were cultured from a frozen ampoule and were allowed to propagate into a 25 cm² culture flask in DMEM, supplemented with 10% newborn calf serum and 1% Antibiotic-Antimycotic 100x in a humidified incubator with 5% CO₂ environment at

37°C temperature. After 24h of incubation of initial cell seeding, the media was taken out and 80μl of fresh media was added into the wells. At this point, the samples punched out and nanofibers were added to the 96 well microplates and 80 μL of fresh media was added to each experimental well in order to have a final volume of 160 μL. Finally, the microplates were incubated at 37 °C with 5% of CO₂ for a period of (3, 5 and 7 days), during the incubation time exhausted media was replenished at the 3 day mark.

Figure 1: The results for advanced mechanical properties due to introduction of MWCNTs and complete alignment. The inset figure represents pattern of cell attachment on nanofibers incorporated with MWCNTs

The results from cell culture studies indicated non-toxic behavior of the prepared nanofiber mats and had a significant attachment of cells towards nanofibers. The incorporation of MWCNTs into polymeric nanofibers led to an improvement in tensile stress from 11.40±0.9 to 51.25±5.5 MPa. Furthermore, complete alignment of the nanofibers resulted in an enhancement on tensile stress to 72.78±5.5 MPa (Figure 1). Displaying these attributes of high mechanical properties and non-toxic nature of nanofibers are recommended for an ideal candidate for future tendon and ligament grafts.

References

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