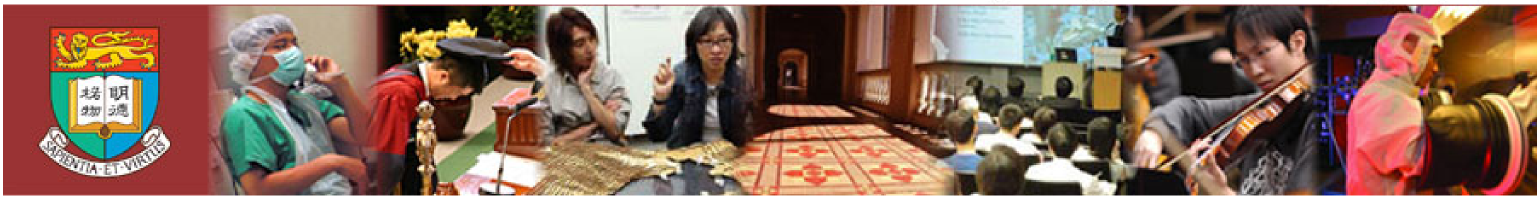

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AN INVESTIGATION INTO NEGATIVE VOLTAGE ELECTROSPINNING OF PLLA AND PLGA FIBROUS TISSUE ENGINEERING SCAFFOLDS

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INTRODUCTION

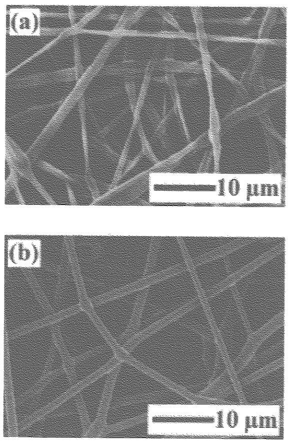
Due to the advantages of fibrous scaffolds that it can produce, electrospinning of ultrafine fibers has been intensively investigated in recent years in the tissue engineering field. So far, high positive voltages (PVs) have been mainly used in electrospinning of polymers for various medical applications. There is virtually no report on negative voltage (NV) electrospinning of tissue engineering scaffolds. There was evidence that PV-electrospun fibers bore positive charges and that these charges could be retained for relatively long times [1]. On the other hand, it is well known that cells respond differently to biomaterial surfaces bearing either positive or negative charges [2]. Therefore, PV- or NV-electrospun scaffolds could have different protein, cell and tissue responses. Furthermore, different polymers have different charge-bearing capabilities. In our preliminary study, we used pseudo-negative voltage for electrospinning fibrous scaffolds and demonstrated the effects of emitting electrode polarity [3]. In the current study, actual NV-electrospinning was used for two commonly used synthetic and biodegradable biopolymers for tissue engineering: poly($_{\text{L}}$-lactic acid) (PLLA) and poly(lactic-*co*-glycolic acid) (PLGA).

METHODS

PLLA was dissolved in a mixture of dichloromethane and dimethylformamide (DMF). PLGA (50:50) was dissolved in a mixture of chloroform and DMF. Polymer solutions were then NV-electrospun using a previously established setup. In NV-electrospinning, the needle was negatively charged, which rendered a polymer jet that may eventually carry negative charges. The NV-electrospinning processing window for each biopolymer (PLLA and PLGA) was established and effects of various parameters (polymer solution concentration, electrospinning voltage, working distance, etc.) on fiber diameter were systematically investigated. Techniques such as SEM, water contact angle measurement, tensile testing and FTIR were used for studying NV-electrospun fibrous scaffolds.

RESULTS AND DISCUSSION

In this study, consideration was given to the electric field strength of the applied voltage. Therefore, when voltage changes from -10kV to -25kV, the voltage is said to increase from -10kV to -25kV. The morphology of the NV-electrospun PLLA and PLGA fibers and corresponding NV-electrospinning parameters are shown in Fig.1. For PLLA, when -10kV was applied, the diameter of most electrospun fibers was 600-700 nm. When the applied voltage was increased to -15kV or -20kV, the fiber diameter distribution shifted slightly to a larger diameter region. The PLLA fiber diameter distribution was narrow (400-1000nm) no matter whether the working distance was 10cm, 15cm or 20cm, although the fiber diameter was slightly decreased with increasing working distance. The polymer solution concentration played an important role in the resultant PLLA fiber diameter and morphology. When the polymer solution concentration was 5%w/v, only beaded PLLA fibers were obtained. Non-beaded PLLA fibers could be electrospun when the polymer solution concentration was 10%w/v.



PLLA concentration = 10%w/v
Solution feeding rate = 2.8ml/h
Needle ID = 0.5mm
Working distance = 10cm
Applied voltage = -10kV

PLGA concentration = 15%w/v
Solution feeding rate = 2.8ml/h
Needle ID = 0.5mm
Working distance = 10cm
Applied voltage = -10kV

Figure 1: NV-electrospun fibers and optimized NV-electrospinning parameters for (a) PLLA, (b) PLGA.

The effects of various parameters on the diameters of NV-electrospun PLGA fibers were similarly investigated. The water contact angles of NV-electrospun PLLA and PLGA fibrous scaffolds were 108.3±10.0° and 120.5±1.0°, respectively, indicating that these fibrous polymer scaffolds were all hydrophobic. Both PLLA and PLGA fibrous scaffolds exhibited similar Young's modulus, ultimate tensile strength and elongation at break. FTIR results showed that both PLLA and PLGA fibrous scaffolds had several common peaks such as the stretching vibration of C=O and C-CH_3.

CONCLUSIONS

Processing windows for NV-electrospinning of PLLA and PLGA were found and it was shown that the processing parameters affected the fiber diameter. The fiber morphology and mechanical properties, wettability and molecular structures of NV-electrospun scaffolds were evaluated. Investigations into NV-electrospinning for forming fibrous tissue engineering scaffolds are of high importance in terms of creating scaffolds of special characteristics and solving technological problems for electrospinning the scaffolds.

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