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Combined wet-spinning and electrospinning: novel and facile method to fabricate micro-nano scale conducting fibres

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Abstract

One of the main challenges in tissue engineering is to design and fabricate an appropriate 3D extra cellular matrix (ECM) with capability to tune the in vivo environment in conjugation with additional requirements for cells enhancement. The composition, topology and artichectures of ECM are critical to achieve the desirable functionality of tissue or organ to be regenerated [1].

Keywords

spinning, electrospinning, novel, facile, method, fabricate, micro, nano, scale, conducting, combined, fibres, wet

Disciplines

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INTRODUCTION

One of the main challenges in tissue engineering is to design and fabricate an appropriate 3D extra cellular matrix (ECM) with capability to tune the *in vivo* environment in conjugation with additional requirements for cells enhancement. The composition, topology and artichectures of ECM are critical to achieve the desirable functionality of tissue or organ to be regenerated [1].

ECM fabricated from conducting polymer can offer intriguing platforms for tissue regeneration due to their capability to enhance cellular growth via electrical stimuli as well as controlling the release of biological molecules [2]. Topological design and biocompatibility of the conducting ECM are critical factors in order to have appropriate *in vivo* environment for cells, their attachment to ECM and ability to transfer the electrical signals to the cells. Recent increasing attention for utilising conducting polymers in regenerative medicine have turn them into highly demanding materials to fabricate into complex 3D structures by scalable methods such as wet-spinning. In addition, electro-spinning is a well-established, versatile technique to produce ultra-fine fibres in different artichectures including random oriented mats, aligned, twisted and untwisted yarns with high surface area to volume ratio. Since the dimension of nanofibres is a few orders of magnitude smaller than cells, cells posses promising interaction against the nanofibers [1].

In this study, we introduce a novel and facile method to integrate wet-spinning and electro-spinning to fabricate continues multifunctional fibres. In this method Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT: PSS) is being injected into a chitosan coagulation bath to form a hybrid fiber [2] followed by washing process in an ethanol bath. At the same time, PLA-PLGA nanofibers are being electro-spun on the top of the ethanol washing bath. When PEDOT:PSS-Chitosan hybrid fibers taking up from the washing bath, it being covered by electrospun PLA-PLGA nanofibers to form PEDOT:PSS-Chitosan/PLA-PLGA yarn.

APPROACH

Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT: PSS) pellets were obtained from Agfa (Orgacon dryTM, Lot A6 0000 AC) with water content of 9.8m/m% H_2O and used as supplied. High molecular weight Chitosan (CHI) was purchased from Sigma (>75% deacetylation). Poly lactic-co-glycolic acid (PLGA) (75:25) was purchase from Purac (Singapore).

The wet-spinning method was used to fabricate PEDOT:PSS-CHI fibres by injecting PEDOT:PSS with concentration of 25 mg/ml into the 1.0 wt% chitosan solution. The feeding rate of wet-spinning pump was 15 mL/hr using a 5.0 mL syringe with a detachable needle (20 gauge) used as a spinneret. The electro-spinning set up has been modified to receive the wet-spun fibre into ethanol bath while 25 mg/ml PLGA in DMF was electro-spun on top of fibre with feeding ratio of 15 ml/h. Finally, the fibres were collected on spool.

RESULTS AND DISCUSSION

Novel mico-nano dimensional fibres were fabricated using combination of wet and electro spinning. The scanning electron microscopy (SEM) of fibres presented unique, new structure with micro fibres underneath of electro-spun layer. Fig 1 shows the SEM images of fibres with different magnifications.

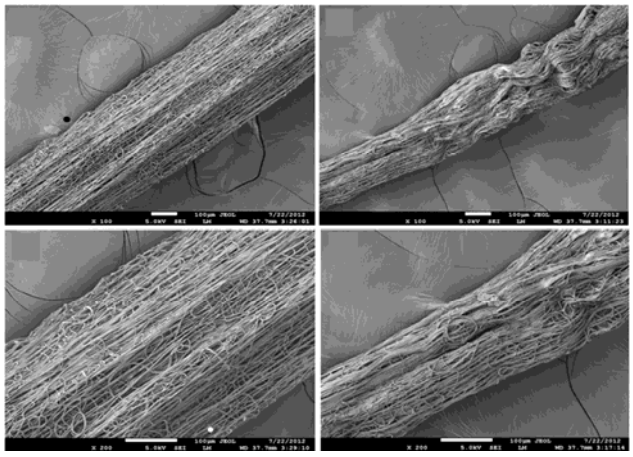

Fig 1. SEM images of fibres with different magnifications.

The size distribution of fibres carried our by SEM demonstrated sub-micron dimension of fibres (Fig. 2) however, the nano dimension of electro-spun layer can be achieved by modifying electro-spinning feeding ratio and polymer concentration.

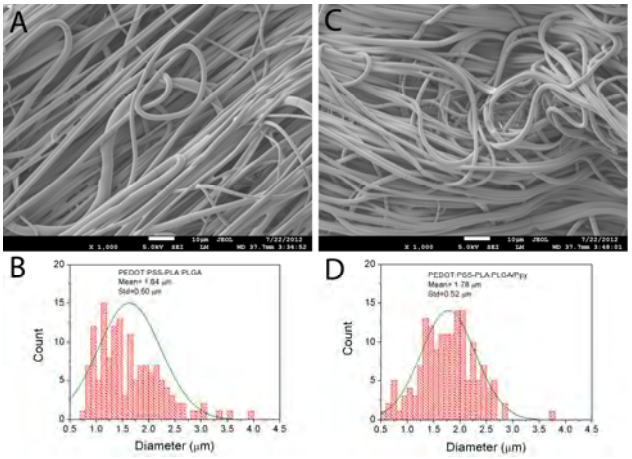

Fig 2. SEM of electro-spun layer with 1000X magnification (A and C). Size distribution of electro-spun layer (B and D).

CONCLUSION

Novel three-dimensional structure was delivered by combination of electro and wet-spinning systems. The morphology of the fibres was characterised using scanning electron microscopy. The presence of sub-micron electro-spun layer open lots of doors in biomedical engineering whilst, the electrochemical property of fibres can facilitate cells development using electrical stimulation.

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