9

Preparation of Cellulose-based Nanofibers Using Electrospinning

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1. Introduction

Eelctrospinning is a straightforward method to prepare fibers with diameters as small as several tens of nanometers (Doshi & Reneker, 1995). In eclectrospinning, a high electrostatic voltage is imposed on a drop of polymer solution held by its surface tension at the end of a capillary. The surface of the liquid is distorted into a conical shape known as the Taylor cone. Once the voltage exceeds a critical value, the electrostatic force overcomes the solution surface tension and a stable liquid jet is ejected from the cone tip. Solvent evaporates as the jet travels through the air, leaving behind ultrafine polymeric fibers collected on an electrically grounded target (Fong et al., 1999, 2002; Shin et al., 2001). Electrospun mats have a larger specific surface area and small pore size compared to commercial non-woven fabrics. They are of interest in a wide variety of applications including semi-permeable membranes, tissue engineering scaffolds and drug delivery systems (Tsai et al., 2002; Gibson et al., 2001; Kenawy et al., 2002; Luu et al., 2003).

Recently, electrospun nanofibers (NFs) based on cellulose and its derivatives have been studied as potential candidates for applications within the field of pharmaceuticals. For instance, several reports deal with the investigation of electrospun fiber mats as delivery vehicles, showing dosage forms with useful and controllable dissolution properties. This interest in cellulose-based NFs is primarily driven by its environmental value as a biomaterial. The cellulose is an abundant and renewable resource found in most parts of the world, which makes it a cheap raw material for various applications (Zeng et al., 2003; Jiang et al., 2004; Verreck et al., 2003; Liu & Hsieh, 2002). However, little research has been done on the use of cellulose and cellulose derivatives as a raw material within electrospinning. The complications involved in electrospinning of cellulose are mainly due to the many difficulties ascribed to the material, one being its reluctance to interact with conventional solvents. Therefore, the choice of solvent systems is very important.

Ethyl-cellulose (EC) is a kind of cellulose ether, and it shows a non-biodegradable and biocompatible polymer. EC is one of the extensively studied encapsulating materials for the controlled release of pharmaceuticals (Prasertmanakit et al., 2009). The film made from EC has quite good permeability, it has been widely used industrial air filter (Park et al., 2007).

Hydroxypropyl methylcellulose (HPMC) is frequently used as the basis for sustained release hydrophilic matrix tablets (Ford, 1999). HPMC backbone is composed of glucose

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The diameter of HPMC NFs was measured (??) a narrow distribution when the electric voltage decreased. It was found that the fibers had an average diameter of 129nm at a voltage of 10keV and an average diameter of 140nm at a voltage of 15keV. Electrospun NFs of HPMC showed similar results to EC NFs

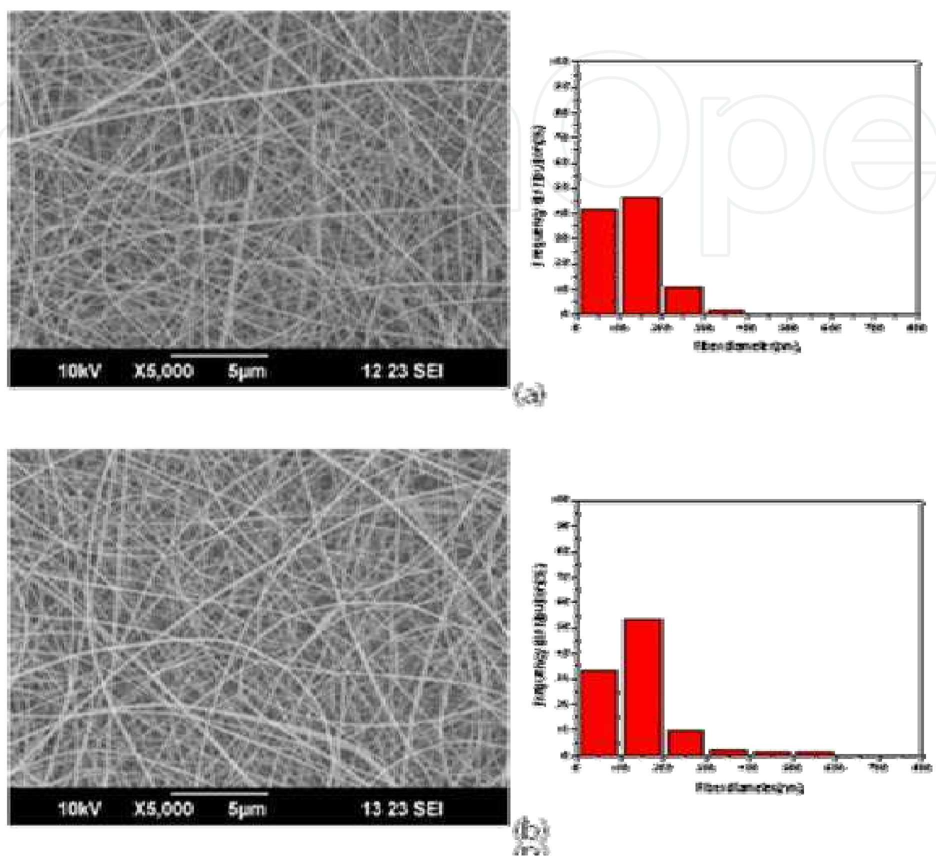

Fig. 7. Effect of electric voltage on HPMC fiber morphology (solution concentration=1.0 wt%, flow rate=0.05 ml/ min). Voltage: (a) 10 keV; (b) 15 keV.

3.4 Effect of the needle tip-target distance

Fig. 8 shows that NFs formed with decreasing tip-target distance of EC. As tip-target distance of NFs was increased, the diameter of NFs. The NFs had non-uniform diameters. It may be assumed that the lower electric strength solvent from evaporating. However, (??we were observed that formation of HPMC NFs regardless of tip-target distance. ??) The most uniform NFs derived with our experimental conditions were afforded at 5cm of tip-target distance. Increasing diameter of NFs at 10cm and decreasing diameter of NFs at 15cm (??).

4. Conclusions

Submicron EC and HPMC fibers have been successfully prepared by electrospinning of polymer solutions. The morphology of the fibers was strongly affected by the parameters such as polymer concentration, tip-target distance, solution flow rate, and applied voltage. At below 6 wt% EC solutions, electrospinning was not enhanced due to the low viscosity. (the concentration of EC solution,) the morphology was changed from beaded fiber

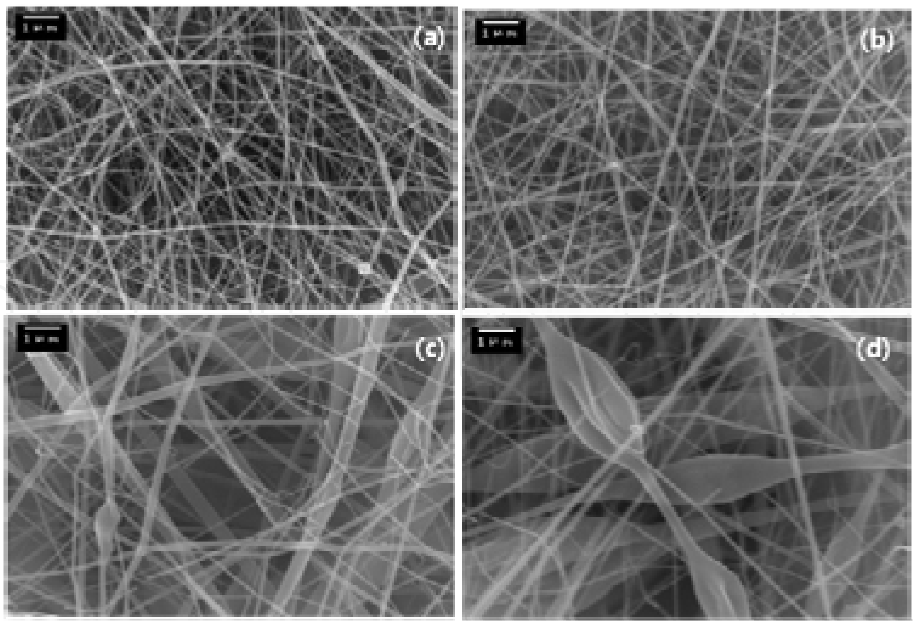

Fig. 8. Effect of needle tip-target distance of EC NFs (solution concentration, 10wt%; electric voltage, 15 keV; flow rate, 0.005 ml/ min). (a) 5 cm, (b) 7 cm, (c) 9 cm, (d) 11 cm.

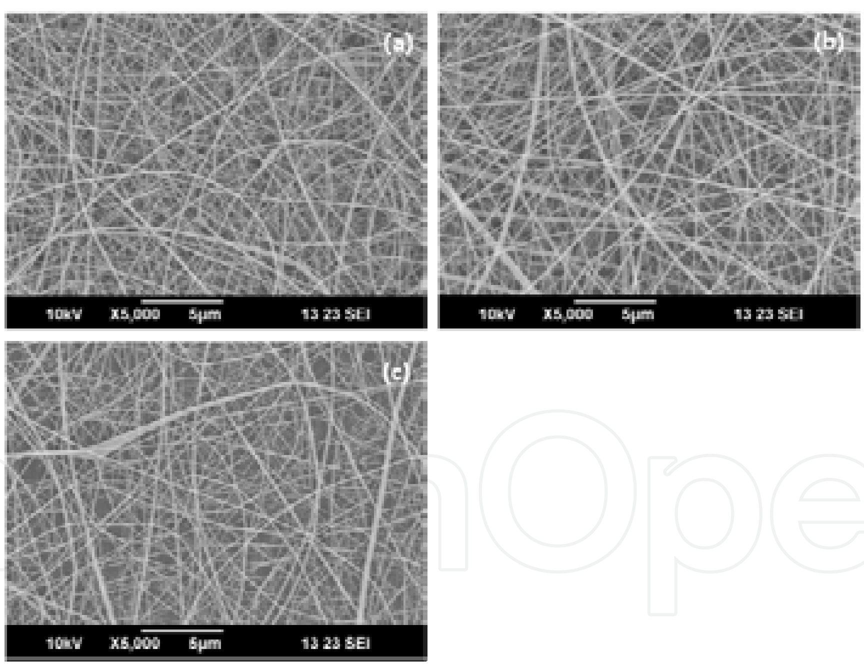

Fig. 9. Effect of needle tip-target distance of HPMC NFs (solution concentration, 1.0wt%; electric voltage, 15 keV; flow rate, 0.05 ml/ min). (a) 5 cm, (b) 10 cm, (c) 15 cm.

to uniform fiber structure and the fiber diameter was also increased. There was an increase in fiber diameter and fiber distribution with increasing solution flow rate, while there was a slightly decrease in average fiber diameter with increasing applied electric field. The HPMC NFs are feasible for use as wound healing and drug delivery systems for biomedical applications.

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“There’s Plenty of Room at the Bottom” this was the title of the lecture Prof. Richard Feynman delivered at California Institute of Technology on December 29, 1959 at the American Physical Society meeting. He considered the possibility to manipulate matter on an atomic scale. Indeed, the design and controllable synthesis of nanomaterials have attracted much attention because of their distinctive geometries and novel physical and chemical properties. For the last two decades nano-scaled materials in the form of nanofibers, nanoparticles, nanotubes, nanoclays, nanorods, nanodisks, nanoribbons, nanowhiskers etc. have been investigated with increased interest due to their enormous advantages, such as large surface area and active surface sites. Among all nanostructures, nanofibers have attracted tremendous interest in nanotechnology and biomedical engineering owing to the ease of controllable production processes, low pore size and superior mechanical properties for a range of applications in diverse areas such as catalysis, sensors, medicine, pharmacy, drug delivery, tissue engineering, filtration, textile, adhesive, aerospace, capacitors, transistors, battery separators, energy storage, fuel cells, information technology, photonic structures and flat panel displays, just to mention a few. Nanofibers are continuous filaments of generally less than about 1000 nm diameters. Nanofibers of a variety of cellulose and non-cellulose based materials can be produced by a variety of techniques such as phase separation, self assembly, drawing, melt fibrillation, template synthesis, electro-spinning, and solution spinning. They reduce the handling problems mostly associated with the nanoparticles. Nanoparticles can agglomerate and form clusters, whereas nanofibers form a mesh that stays intact even after regeneration. The present book is a result of contributions of experts from international scientific community working in different areas and types of nanofibers. The book thoroughly covers latest topics on different varieties of nanofibers. It provides an up-to-date insightful coverage to the synthesis, characterization, functional properties and potential device applications of nanofibers in specialized areas. We hope that this book will prove to be timely and thought provoking and will serve as a valuable reference for researchers working in different areas of nanofibers. Special thanks goes to the authors for their valuable contributions.

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