EFFECT OF TEMPERATURE ON THE MORPHOLOGY OF BUBBLE-ELECTROSPUN NANOFIBERS

by

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The morphology and microstructures of poly(vinyl alcohol) and poly(vinyl pyrrolidone) nanofibers produced by bubble-electrospinning are investigated experimentally. It is shown that the temperature predominantly affect the average diameters of the formed nanofibers. The smooth surface and controllable diameters of nanofibers are essential for their applications in different temperature environment.

Key words: *bubble-electrospinning, temperature, nanofibers*

Introduction

Nanofibers are an important class of nanomaterials with long lengths and diameters from a few nanometers to micron size which have a high surface to volume ratio [1]. Polymeric nanofibers can be fabricated by a number of techniques such as drawing, template synthesis, phase separation, and self-assembly. Bubble-electrospinning is a novel technology which overcomes the bubble surface tension to produce nanofibers with diameters ranging from 20 nm to several micrometers [2]. In this paper, continuous nanofibers were prepared by bubble-electrospinning of poly(vinyl alcohol) (PVA) and poly(vinyl pyrrolidone) (PVP) solutions at different temperatures between 25 °C and 75 °C, respectively. The effect of temperature on the morphology and microstructures of nanofibers was investigated while keeping other parameters constant.

Results and discussions

The previous report [3] indicated the relationship between the average diameter of nanofibers produced by electrospinning and the solution viscosity can be expressed as:

$$d \propto \eta^{\alpha} \tag{1}$$

where d is the average diameter of nanofibers, η – the solution viscosity, and α – the constant.

The experiments showed that the solution viscosity decreased and the conductivity increased as the temperature raised. Based on eq. (1), the average diameter of nanofibers should decrease. Figure 1 exhibits SEM micrographs of bubble-electrospun PVA nanofibers under different temperatures (from 25 °C to 75 °C). It is clear that the temperature change did not appreciably affect the morphology of the PVA fibers. The smooth fibers were obtained in

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all cases. Additionally, the fiber diameters were found to be 216, 158, 139, 119, 109, and 99 nm at the temperatures of 25 °C, 35 °C, 45 °C, 55 °C, 65 °C and 75 °C, respectively (the bottom in fig. 1). The average diameter of the fibers decreased with the temperature increase, which is consistent with eq. (1).

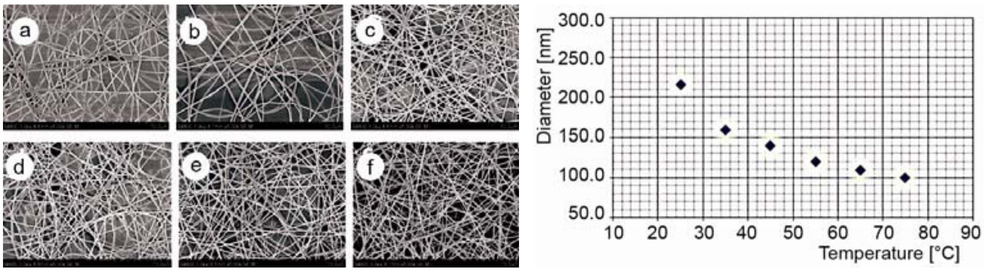

Figure 1. SEM micrographs (top) and the average diameters (bottom) of bubble-electrospun PVA nanofibers at different temperatures

Figure 2 exhibits SEM micrographs of bubble-electrospun PVP nanofibers under different temperatures (from 25 °C to 75 °C). The fibers appeared adhesion at low temperature of 25 °C, fig. 2(a), 35 °C, fig. 2(b), and 45 °C, fig. 2(c), respectively. When the temperature continued to rise, the smooth fibers were obtained, figs. 2(d), (e) and (f). Additionally, the fiber diameters were found to be 2401, 2302, 2192, 1704, 1195 and 970 nm at the temperature of 25 °C, 35 °C, 45 °C, 55 °C, 65 °C, and 75 °C, respectively (the bottom in fig. 2). The average diameter of the fibers also decreased with the temperature increase, which is consistent with the experiment results of PVA.

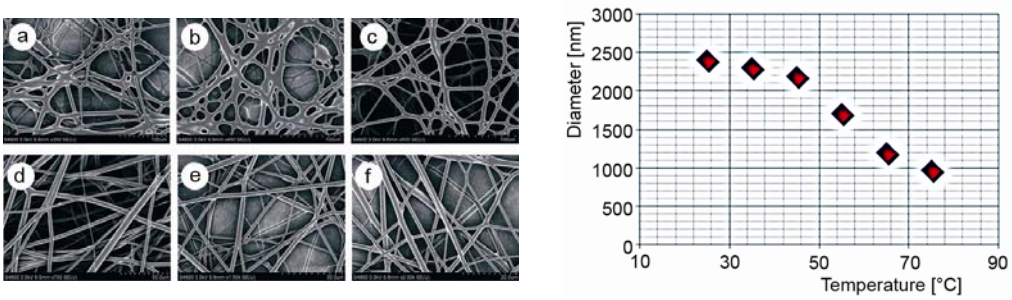

Figure 2. SEM micrographs (top) and the average diameters (bottom) of bubble-electrospun PVP nanofibers at different temperatures

Conclusions

The effect of the temperature on the morphology of bubble-electrospun PVA and PVP nanofibers was studied. At a certain condition, the morphology of nanofibers can be found relatively uniform. In addition, the average diameter of the fibers decreased with the temperature increase. The ability to generate nanofibers with controllable diameters will enhance their applicability significantly.

Acknowledgments

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References

[1] Bagheri, H., *et al*., A Highly Thermal-Resistant Electrospun-Based Polyetherimide Nanofibers Coating for Solid-Phase Microextraction, *Analytical and Bioanalytical Chemistry*, *406* (2014), 8, pp. 2141-2149
[2] He, J. H., *et al*., Apparatus for Preparing Electrospun Nanofibres: a Comparative Review, *Materials Science and Technology*, *26* (2010), 11, pp. 1275-1287
[3] He, J. H., *et al*., Scaling Law in Electrospinning: Relationship between Electric Current and Solution Flow Rate, *Polymer*, *46* (2005), 8, pp. 2799-2807

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