BLOWN BUBBLE-SPINNING FOR FABRICATION OF SUPERFINE FIBERS

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Short paper
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A novel method called the blown bubble-spinning is designed to produce superfine fibers. In this method, a blowing air is used as an acting force. A silk fibroin solution is used to fabricate superfine fibers.

Key words: *bubble-spinning, superfine fibers, regenerated silk fiber*

Introduction

It is well-known that polymer bubbles can be used for fabrication of nanofibers using a high electronic force [1-6]. In this paper, we show that the polymer bubbles can also produce superfine fibers using a blowing air.

Blown bubble-spinning technique

The most interesting property of a polymer bubble is that its surface tension depends geometrically upon its size. According to the Young-Laplace equation [1], the surface tension of a spherical bubble can be expressed as:

$$\sigma = \frac{1}{4} r \Delta P \tag{1}$$

where σ is the surface tension, r – the radius of the bubble, and ΔP – the pressure difference.

In the bubble electrospinning [1-6], the electronic force is used to overcome the surface tension of the bubble to proceed the spinning process. Hereby we show that we can also use blowing air to pull the bubble upwards to produce superfine fibers, the process is very much similar to that in the bubble electrospinning, and we name the new method as the blown bubble spinning.

Experimental

Figure 1 shows the experimental set-up of the blown bubble-spinning. A single bubble or multiplier bubbles is produced on the top of the tube, and the blowing hot air pulls the bubbles upwards, and superfine fibers are obtained on the above receiver.

Materials. Raw silk was degummed three times with 0.5% (w/w) Na_2CO_3 solution at 100 °C for 30 min and then washed with distilled water. Degummed silk fibroin (SF) was

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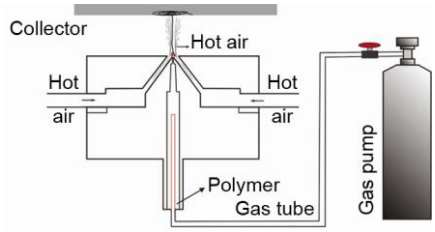

Figure 1. The experimental set-up of the blown bubble-spinning

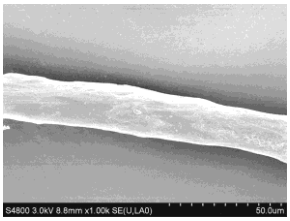

Figure 2. Scanning electron micrograph of the regenerated silk fiber fabricated by the blown bubble-spinning

dissolved in 9.3 mol/L LiBr solution. After dialysis in cellulose tubular membrane (molecular weight cutoff = 8000 ~ 14000, Sigma, USA) against distilled water for 3 days and filtration, air-dried membrane was prepared in the ABS plastic disc at room temperature. The 8 wt. % SF solution was acquired by dissolving SF membrane in 98% formic acid.

Characterization. The morphology of electrospun fibers were observed with scanning electron microscopy (SEM, S-4800, Hitachi, Tokyo, Japan) at 20 °C and 60% relative humidity, and is illustrated in fig. 2. The average diameter of obtained fibers in the experiment is 19.91 ± 0.84 μm.

Discussion and conclusions

By a simple theoretical analysis, we can conclude that the fiber size depends mainly on the bubble size, velocity of the blowing air, and temperature. A complete theoretical study and experimental verification will be carried out later. This paper gives a preliminary report that the technology works and it gives significant potential to fabricate superfine fibers.

Acknowledgments

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References

[1] He, J.-H., Effect of Temperature on Surface Tension of a Bubble and Hierarchical Ruptured Bubbles for Nanofiber Fabrication, *Thermal Science*, *16* (2012), 1, pp. 325-328
[2] He, J.-H., *et al*., BioMimic Fabrication of Electrospun Nanofibres with High-Throughput, *Chaos Soliton. Fract.*, *37* (2008), 3, pp. 643-651
[3] Liu,Y., *et al.*, The Principle of Bubble Electrospinning and its Experimental Verification, *J. Polym. Eng.*, *28* (2008), 1-2, pp. 55-65
[4] He, J.-H., Liu,Y., Xu, L., Apparatus for Preparing Electrospun Nanofibers: a Comparative Review, *Mater. Sci. Tech.*, *26* (2010), 11, pp. 1275-1287
[5] He, J.-H., *et al*., *Elelectrospun Nanofibres and Their Applications*, Smithers Rapra Update, Shawbury, UK, 2008
[6] Yang, R. R., *et al.*, Bubble-Electrospinning for Fabrication of Nanofibres with Diameter of about 20 nm, *Int. J. Nonlin. Sci. Num.*, *11* (2010), S, pp. 163-164

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