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BUBBFIL SPINNING FOR FABRICATION OF PVA NANOFIBERS

by

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Short paper
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Bubbfil spinning is used to fabricate PVA nanofibers. Multiple polymer bubbles are formed on the spinneret, and an external force is added to burst the bubbles immediately. The ejected jets are accelerated to a high velocity, and fiber diameter is tenable by adjusting the spinning parameters.

Key words: *nanofibers, bubble-electrospinning, bubbfil spinning*

Introduction

Bubbfil spinning[1, 2] is to use polymer or melts bubbles or membranes for fabrication of nanofibers [3], nanoparticles [3], nanoscale crimped fibers [4], nanoporous fibers [5], using electrostatic force, blowing air or mechanical force or their combination to overcome the surface tension of bubbles, Bubbfil spinning mainly include the bubble-electrospinning [3], blown bubble spinning [6, 7] and membrane spinning [8, 9]. A history of the development of Bubbfil spinning process was summarized in [1]. Bubbfil spinning technology is now industrially used for mass-production of nanofibers due to its extremely high throughout. In this paper the technology is used to fabricate PVA nanofibers.

Bubbfil spinning

According to Laplace-Chen equation for bubble electrospinning [10], the surface tension of a spherical bubble under electrostatic field can be expressed as:

$$\sigma = \frac{1}{4} r(\Delta P + 2\varepsilon E) \tag{1}$$

where σ is the surface tension, r – the radius of the bubble, ΔP – the pressure difference, E – the electric field intensity, and ε – the electric charge per area. Equation (1) reveals that smaller bubbles are extremely useful for nanofiber fabrication and that only a small external force is needed to overcome the surface tension of a bubble. The applied electric field is the acting force in the bubble electrospinning, on the other side of the coin, it increases the surface tension of the bub-

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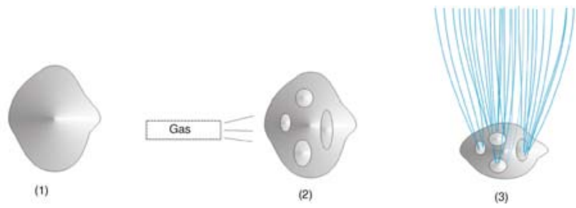

Figure 1. Spinning process of bubbles
(1) forming of a bubble, (2) blowing air is used to break the bubble, (3) multiple debris is ejected

ble. This paper shows that it is possible to control the bubble size as small as possible with almost same size.

In our experiment, the nozzle size was about 0.078 mm × 0.078 mm in a circular spinneret with diameter of about 2 cm. Polymer bubbles from PVA solution with 6 wt% concentration are produced on the spinneret with almost same sizes, fig. 1. Before two bubbles are interacted with each other, the external force makes each bubble to burst immediately [11], and the fragments are ejected into the receiver to form nanofibers.

According to mass conversation of the ejected jet:

$$Q = \frac{1}{4}\pi \mathrm{d}^2 pu \tag{2}$$

where d is the jet diameter, ρ – the density, u – the velocity of the jet, and Q is a constant for each jet. The fiber diameter is tenable by adjusting the velocity of the jet. Equation (2) predicts a smaller nanofiber for a higher velocity of the jet. In this paper, a blowing air with a very high velocity was used to accelerate the jets; the technology is similar to the blown bubble spinning [12].

Experiment

Polyvinyl alcohol (PVA) particles were bought from Sinopharm Chemical Reagent Co. Ltd., and purified water was obtained from Nantong Bubbfil Nanotechnology Company Limited. The spun solution was prepared by dissolving PVA particles into purified water solvent. The spinning process was performed on the Bubble-electrospinning Equipment (Nantong Bubbfil Nanotechnology Ltd.). The morphology of the bubble-electrospun nanofibres has been observed by field emission-scanning electronic microscopy (S-4800, Hitachi Ltd., Japan). Figure 2 presents SEM illustrations showing overall orientation and almost uniform size of nanofibers.

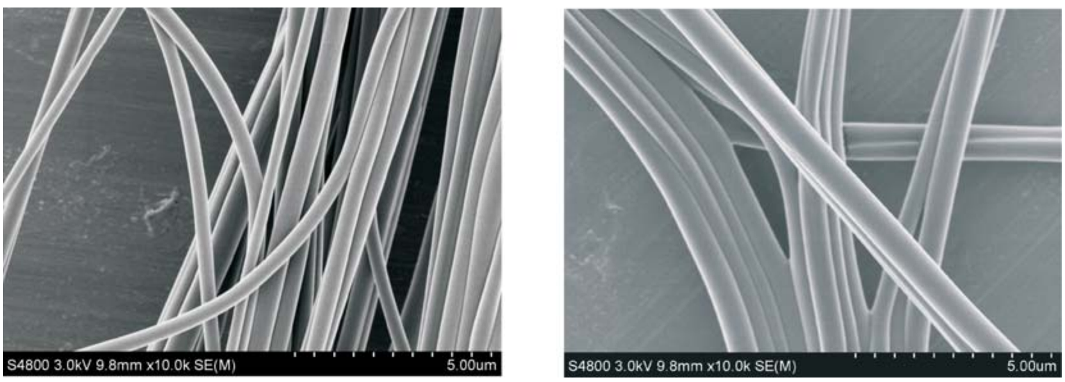

Figure 2. PVA nanofibers obtained by Bubbfil spinning

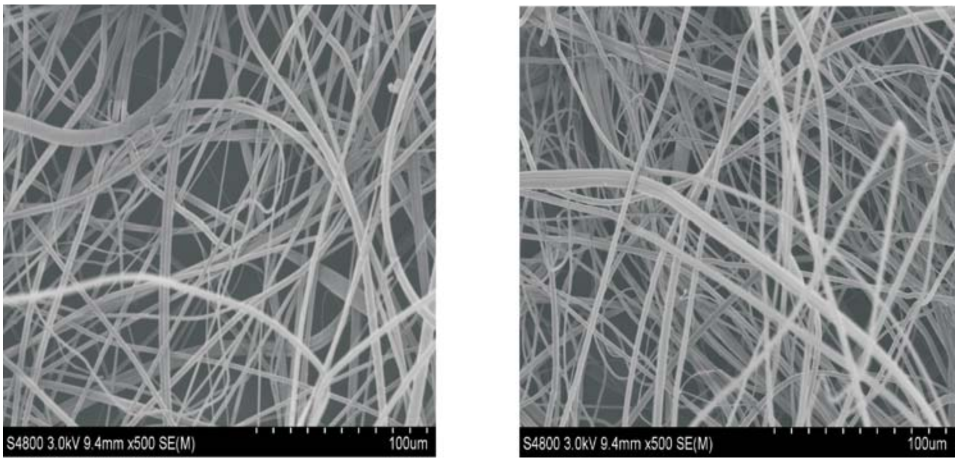

Figure 3. PVA nanofibers obtained by needless electrospinning

For comparison, the same solution is used in needless electrospinning with 22 kV voltage and without any blowing air; other conditions are same as for the Bubbfil spinning process. Figure 3 presents the SEM illustrations showing that fibers' orientation and uniform are deteriorated greatly, and fiber size is larger than those by Bubbfil spinning. Li *et al*. [13] gave a detailed explanation of the difference between the Bubbfil spinning and electrospinning.

Conclusions

Bubbfil spinning pretends to be the best candidate for mass-production of nanofibers. The jet velocity is key factor in fabrication of nanofibers, higher velocity of the jet results in smaller fibers. The obtained nanofibers are used for air filters with extremely high efficiency and low resistance [14].

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