WAVE-LIKE BEADS ON NANOFIBERS BY BLOWN BUBBLE SPINNING

by

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This paper observed wave-like beads with average size of 40 nm on the surface of nanofibers obtained by the blown bubble spinning. Theoretical analysis demonstrates that some perturbed waves are produced on the surface of the moving jets before solidification. The resultant fibers have many potential applications in water/air filtration.

Key words: *blown bubble spinning, nanofibers, wave, beads*

Introduction

Over the past decade, great attention has been paid to the fabrication and applications of nanoscale materials due to their unique properties, such as large surface-area-to-volume ratio, high porosity and superior mechanical properties [1]. Recently, solution blowing spinning [2-5] has been viewed as a new method for mass production of nanofibers because a die assembly containing a serial of orifices can be easily used without electric field interference and harm resulting from popular electrospinning and other methods using high static electricity [6-12]. So blowing technique is significant to make polymer solution streams blown to ultrathin jets by high speed gas flow, and the jets are solidified to nanofibers [13].

Bubble owns an interesting property that the surface tension of a polymer bubble depends geometrically upon its size and the pressure difference [14]. Based on that, fiber fabrication process could be achieved by overcoming the tiny surface tension of bubbles with all kinds of forces. In this paper, a method called blown bubble spinning was employed to produce nanofibers and many wave-like beads were found on the surface of nanofibers.

Experimental

Preparation of nylon6/66 spinning solutions

Nylon6/66($C_{18}H_{37}N_3O_5$, Mw375kDa) was purchased from Sigma, USA. The spinning solutions were respectively prepared by dissolving nylon6/66 at the concentration of 12% in formic acid (88% v/v, Sinopharm Chemical Reagent Co., Ltd, China) under slight stirring for 4 hours.

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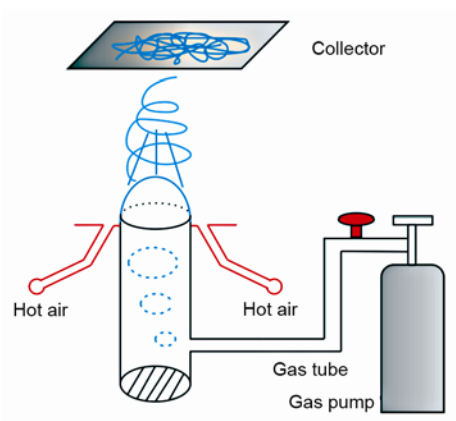

Figure 1. The schematic of the experimental set-up

The process of blown bubble spinning

The experimental set-up of the blown bubble spinning was shown in fig. 1. Compressed gas is released inside the spinning solution to generate one bubble at the orifice; at the same time, the blowing hot air pulls the droplets of the bubble upwards rapidly and continuously, then superfine fibers are obtained on the above collector. The diameter of orifice was 5 mm and the die-to-collector distance was 20 cm. Temperature and airflow ratio were 200 °C and 500 L/min, respectively.

Characterization

Scanning electron microscopy

The morphology of nanofibers was observed using an SEM (Hitachi S-4800, Japan) at 20 °C, 60 RH. Samples were mounted on a copper plate and sputter-coated with gold layer 20-30 nm thick prior to imaging. The diameters of the fibers were measured from randomly collected SEM images using the Image J software and expressed as mean±standard deviation (SD).

Results

Fiber morphology

The morphology of the results was shown in fig. 2. Different from the non-woven mats composed of random nanofibers by electrospinning [15], nanofibrous bundles were obtained. The average diameter of nanofibers was 185.59 ± 45.25 nm (fig. 2, left). Interestingly, many wave-like beads on the nanofibers were discovered in fig. 2 (right), their average size was as small as 40.38 ± 8.75 nm in diameter. In addition, different wave frequencies were observed on different fiber surfaces. Before solidification, a wave might be produced on the surface of the jet due to some a perturbed force, this is similar to waves in the sea surface.

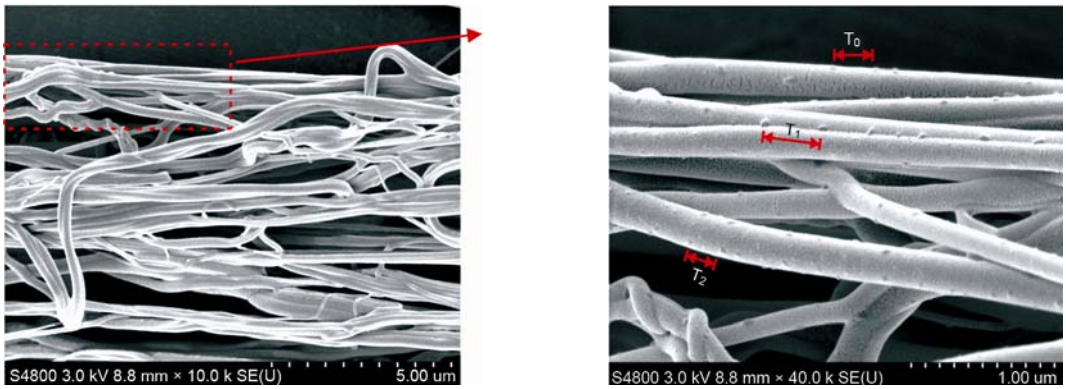

Figure 2. SEM images of the blown bubble-spun nanofibrous bundles (left) and inner nanofibers with periodic wave-like beads (right)

Conclusions

Ultrafine bundles composed of nanofibers were successfully fabricated by blown bubble spinning. Many wave-like beads were found growing on the surface of nanofibers with certain period and their size was so small that they could be applied in the filtration and adsorption areas.

Acknowledgments

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