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Effect on instability section of PVA electrospinning nanofibers by adding LiCl

Ni Li, Xiao-hong Qin *, En-long Yang, Shan-yuan Wang

College of Textile, DongHua University, 2999 North Renmin Rd., Songjiang District, Shanghai, 201620, China

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Abstract

Polyvinylalcohol (PVA) was used to study the effect of LiCl on the variation of jet diameter with axial coordinate after the onset of whipping instability during electrospinning. Jet diameters at different points were measured by optical microscope. The results indicated that the addition of LiCl significantly accelerated jet thinning and solidification. It was found that average diameter of smooth jets decreased with increasing LiCl concentration. When LiCl concentration was equal or larger than 0.8 wt.%, surface charge became saturated and full charge on jet surface was obtained. The power exponent *b* in the allometric law was found to decrease with increasing LiCl concentration.

Keywords: Nanomaterials; Polymer; Electrospinning; Polyvinylalcohol; LiCl; Allometric

1. Introduction

Electrospinning is an efficient method to produce polymer fibers in nanometers to a few microns diameter range using an electrically driven jet. Due to a high specific area, electrospun fabrics show a wide application [1,2]. The effect of added salts on fiber morphology has been investigated in some contributions [3–6]. Won Keun Son et al. [4,5] reported that the average diameters of electrospun fibers were decreased and their distributions were narrowed by adding salt due to the increased charge density in solution. Chang Kee Lee et al. [6] investigated the influence of added ionic salts on nanofiber uniformity. But the effect of added salts on electrsopun jet, especially the jet after the onset of beading instability, is very limited. The bending instability is not an anomaly, but an essential part of the process that elongated the jet [7,8].

For an evolving solution jet based on the estimated draw rations, three different regions were assigned. Straight segment was named as region I, the segment from the onset of beading instability to the point where jet thinning was inhibited because of solvent evaporation and jet solidification was named as region II and the residual part was named as region III [9]. Because our previous study [10] concluded an allometric law and the relation between the scaling exponent and LiCl concentration for region I, in this work, we explored the effect of different LiCl concentrations on electrospun jet during region II. Moreover, for region II we investigated the relation of surface charge and the power exponent in allometric law with salt concentration, respectively.

2. Experimental

PVA (88,000 g/mol) was obtained from J & K Chemical ®. Distilled water was used as the solvent and LiCl was purchased from Pinjiang Chemical Co.

0.2 wt.% LiCl was added to distilled water and the solution was stirred till LiCl was dissolved completely. Then PVA polymer was added to the solution incrementally until 10 wt.% solution of PVA polymer in distilled water reached, the solution was stirred for three hours under 80 °C to obtain homogenous solution.

0.5, 0.8, 1 wt.% LiCl were added respectively to make PVA polymer solutions, and the same procedure was made as the previous step. The experiments were conducted with other experimental parameters unchanged. The applied voltage is 20 kV,

* Corresponding author. Tel.: +86 21 67792783; fax: +86 21 67792627.
E-mail address: xhqin@dhu.edu.cn (X.-H. Qin).

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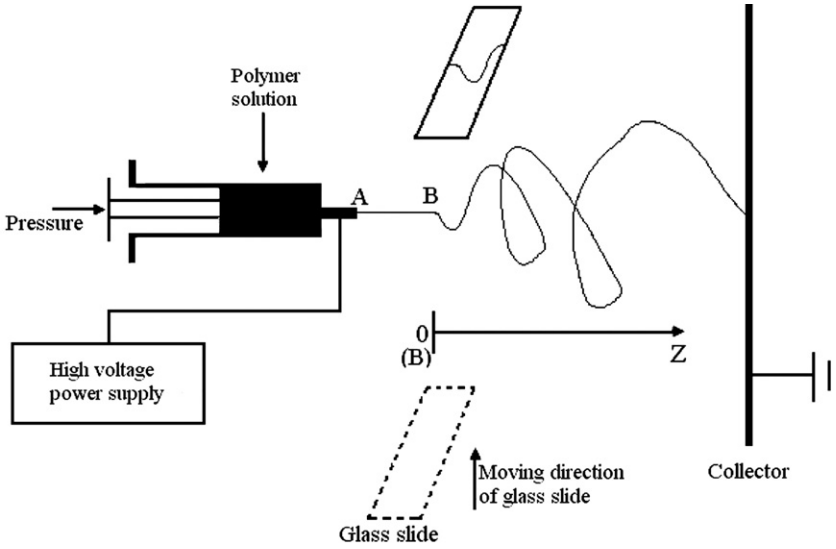

Fig. 1. The schematic diagram of the electrospinning set-up.

the distance between the needle and the collector is 20 cm and the diameter of needle is 1 mm. Fig. 1 shows a schematic diagram of the homemade electrospinning set-up. All experiments were performed at room temperature.

In this study, a glass slide, which was adhered to a long insulating rod, was swept below the onset of the bending instability [11,12]. The jet diameters at different points along axial coordinate were measured by optical microscope (Nikon 50i, Japan), using a computer attached to the microscope. Wide-angle X-ray diffractometer (RTP300, Rigaku Co., Japan) was employed to examine final nanofiber structure.

3. Results and discussion

3.1. The effect of LiCl on jet morphology

The variations of jet diameter D at instability section with axial coordinate Z for five different samples were plotted in Fig. 2. For axial coordinate Z, denote zero as the onset of jet (Fig. 1). When PVA solution without the addition of LiCl was electrospun, jet diameter changed irregularly after the onset of jet and it undulated with axial coordinate (Fig. 2a). In other words, jet was uneven to this case (Fig. 2A). On the other hand, it was obvious that jet diameter decreased regularly with increasing axial coordinate when different LiCl contents

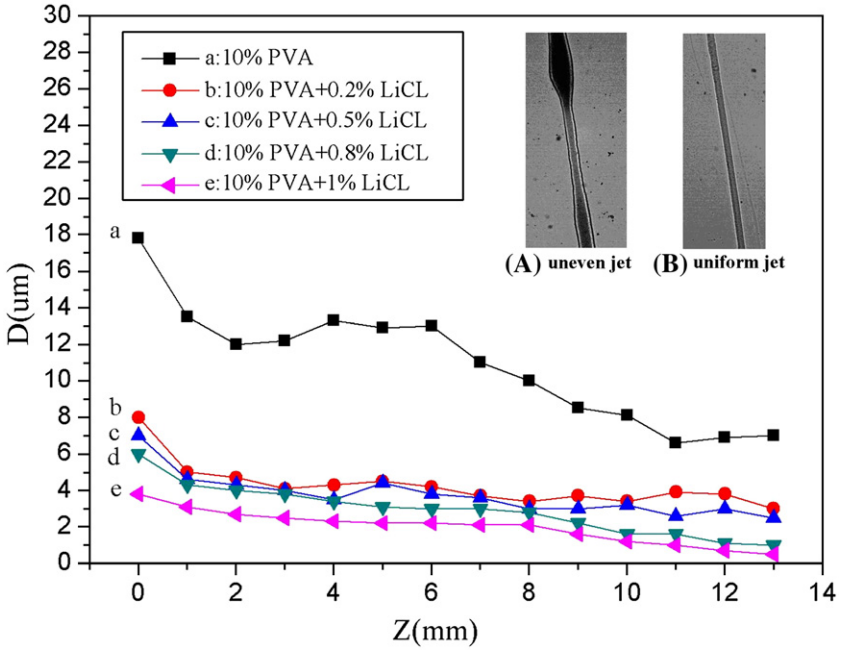

Fig. 2. The variations of jet diameter with axial coordinate. The inset optical photographs of jet morphology for (A) 10 wt.% PVA solution and (B) 10 wt.% PVA solution with added LiCl.