Effect of Nozzle Shapes on the Formation of Taylor Cone and the Oscillation of Fibers During Electrospinning Process

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ABSTRACT

The purpose of this work was to investigate the effect of nozzle shapes on the formation of Taylor cone and the oscillation of fibers during the preparation of polyacrylonitrile nanofibers via an electrospinning process. Electrospun polyacrylonitrile fibers were obtained, using high-voltage DC power supply rated 20 kV at a distance between nozzle and target (or substrate) of 15 cm. The experimental results showed that the nozzle in sawtooth shape gave higher length of Taylor cone than that in flat shape having angle of 180o and in standard nozzle. At high flow rate of polymer solution, it was found that the standard nozzle generated the splitting of Taylor cone. However, this phenomenon had not occurred in the case of other nozzles. In addition, we also found that the use of nozzle in flat shape provided the lowest oscillation of fibers.

Key words: Electrospinning, Taylor cone, Electric field, Electrospun polyacrylonitrile

INTRODUCTION

Polymeric material processing is an area which is receiving increasing attention as progress is made towards tailoring the morphology and porosity of constructs for a variety of applications, including filters, membranes, biomimetic materials and composites (Zheng et al., 2003; Jing et al., 2005; Robinette and Palmese, 2005; Tan et al., 2005). Towards this end, electrospinning represents an attractive approach to the fabrication of fibrous materials for these applications. Electrostatic fiber spinning, or "electrospinning", is a technology for fabricating fibers with nanoscale diameters, one to two orders of magnitude smaller than fibers produced by conventional extrusion techniques, through the action of electrostatic forces. The fibers are derived by charging a liquid from the electrode. The charged liquid is attracted to the electrode of opposite polarity, forming a so-called Taylor cone at the tip of nozzle and, eventually, a fiber jet as the electric field strength exceeds the surface tension of the solution (David, 2000; Cory et al., 2004; Eugene et al., 2005; Seong et al., 2005; Veli et al., 2005).

The properties of the nanofibers produced depend on many process parameters including the properties of polymer precursor, the solvent, the magnitude of the applied voltage, and the distance and geometrical relationship between the nozzle and the collector (Myung et al., 2004; Won et al., 2004; Bumsu et al., 2005). However, most of earlier investigations on polymeric nanofibers have been focused on the viscosity of polymer solution, the type of solvent, the field strength and the working distance of the system (the nozzle tip-to-target distance). The shape of nozzle requires a special attention leading to a homogeneous spinning and a control of deposition area. Therefore, the present work is devoted to investigate the influence of nozzle shapes on the formation of Taylor cone and the oscillation of fibers