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DEVELOPMENT AND CHARACTERIZATION OF HIGHLY ORIENTED PAN NANOFIBER

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Abstract - A simple and non-conventional electrospinning technique was employed for producing highly oriented Polyacrylonitrile (PAN) nanofibers. The PAN nanofibers were electrospun from 14 wt% solution of PAN in dimethylformamid (DMF) at 11 kv on a rotating drum with various linear speeds from 22.5 m/min to 67.7 m/min. The influence of take up velocity was investigated on the degree of alignment, internal structure and mechanical properties of collected PAN nanofibers. Using an image processing technique, the best degree of alignment was obtained for those nanofibers collected at a take up velocity of 59.5 m/min. Moreover, Raman spectroscopy was used for measuring molecular orientation of PAN nanofibers. Similarly, a maximum chain orientation parameter of 0.25 was determined for nanofibers collected at a take up velocity of 59.5 m/min.
Keywords: Polyacrylonitrile; Nanofiber; Orientation; Eletrospinning.

INTRODUCTION

With potential applications ranging from protective clothing, tissue engineering and filtration technology to reinforcement of composite nanomaterials, nanofibers offer a remarkable opportunity toward development of multifunctional nanostructural systems (Huang et al., 2003; Ramakrishna et al., 2005; Fennessey et al., 2004; Pan, 2006). The emergence of various applications is inspired by outstanding properties of nanofibers such as huge surface area per mass ratio (Huang et al., 2003) and high porosity along with small pore size (Ramakrishna et al., 2005). Moreover, for diverse applications, highly oriented and flexible nanofiber with superior mechanical properties is extremely demanded. The electrospinning process is a sophisticated technique for producing nanofibers based on applying a high voltage DC electric potential between the end of a capillary tube and a collector. When the applied electric field overcomes the surface tension of the droplet, a charged jet of polymer solution is ejected and nanofibers are collected on the target (Fennessey et al., 2004). Recent studies have shown that aligned nanofibers have better molecular orientation and, as a consequence, improved mechanical properties than randomly oriented nanofibers (Fennessey et al., 2004; Zussman et al., 2005; Gu et al., 2005). Additionally, the aligned nanofibers are better suited for preparing carbon nanofibers from electrospun PAN nanofiber precursors (Jalili et al., 2006). In another attempt (Fennessey et al., 2004) tows of unidirectional and molecularly oriented PAN nanofibers were prepared using a high speed, rotating take up wheel. A maximum orientation factor of 0.23 was determined for nanofibers collected between 8.1 m/s and 9.8 m/s. The aligned tows were twisted into yarns, and the mechanical properties of the yarns were determined as a function of twist angle. Their produced yarn with twist angle of 11° had an initial modulus and ultimate strength of about 5.8 GPa and 163 MPa, respectively (Fennessey et al., 2004). Zussman et al. (2005) have

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