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PAN monofilament in nanoscale: a novel approach

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Abstract: A novel electrospinning setup was employed for producing aligned polyacrylonitrile (PAN) monofilament in nanoscale. Unlike conventional method, the PAN monofilaments is collected using a rotating drum with various linear speed from bulk of nanofibers. it originates from two syringe infusion pumps contain 14wt% PAN/DMF solution which passes through two separate high voltage electric field. Various collecting drum speed were examined to clarify its effect on degree of alignment, internal structure and mechanical properties. Image process technique used to illustrate the best degree of alignment for nano-monofilament collected at take up velocity of 59.5 m/min. The amount of Crystallization Index (C.I) and orientation parameter calculated respectively from FTIR spectra and Raman spectra also supports the results demonstrated by image processing techniques. The ultimate strength and elastic modulus of nano-monofilament bundles increase with increase of take up velocity. They approach respectively to a maximum of 73.7 MPa and 4.2 GPa at take up velocity of 59.5 m/min. Results acquired by differential scanning calorimetry (DSC) show no significant effect on glass transition temperature with increasing take up velocity. However, minimum value of evolved heat caused by chemical reaction was obtained at surface speed of 59.5 m/min.

Introduction

The emergence of various applications for nanofibers is stimulated from their outstanding properties such as very small diameters, huge surface area per mass ratio and high porosity along with small pore size. Moreover, the high degree of orientation and flexibility beside superior mechanical properties are extremely important for diverse applications [1, 2, 3]. Electrospinning is a sophisticated technique that relies on electrostatic forces to produce fibers in the nano to micron range from polymer solutions. In a typical process, an electrical potential is applied between droplet of a polymer solution held at the end of a capillary tube and a grounded target. When the applied electric field overcomes the surface tension of the droplet, a charged jet of polymer solution is ejected. The jet extends through spiraling loops, as the loops increase in diameter the jet grows longer and thinner until it solidifies or collects on the target [3]. Due to initial instability of the jet, fibers are often collected as randomly oriented structures in the form of nonwoven mats, where the stationary target is used as a collector. These nanofibers are acceptable only for some applications such as filters, wound dressings, tissue scaffolds and drug delivery [4]. Aligned nanofibers are another form of collected nanofibers that can be obtained by using rotating collector or parallel plates [1, 2]. Recent studies have shown that aligned nanofibers have better molecular orientation and as a result