

The Influence of Solvent Type and Polymer Concentration on the Physical Properties of Solid State Polymerized PA66 Nanofiber Yarn

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ABSTRACT: We investigated the effects of two different solvent types and three solution concentrations on the electrospinning of solid state polymerized polyamide 66 (SSP PA66) nanofiber yarns. Nanofiber yarns were electrospun from SSP PA66 solutions in formic acid and formic acid/chloroform (3/1), using two oppositely metallic spinnerets system. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) were employed to characterize the morphology and properties of the nanofibrous yarns. Experimental results show that adding chloroform to formic acid as a binary solvent increases viscosity of polymer solution and the nanofibers diameter significantly. XRD patterns reveal that the presence of chloroform affects the

crystallinity and the mechanical properties of the produced nanofibrous yarns. PA66 nanofiber yarn from 10 wt % formic acid/chloroform (3/1) solution was successfully electrospun with strength and modulus of 120.16 MPa and 1216.27 MPa respectively. It is also shown that the solution concentration has a significant effect on the modulus of the nanofibers yarns. © 2012 Wiley Periodicals, Inc. *J Appl Polym Sci* 126: 1112–1120, 2012

Key words: nanotechnology; nanofibers yarn; solid state polymerized polyamides; mechanical properties; X-ray diffractometry; scanning electron microscopy; solvent type; solution concentration

INTRODUCTION

Recently, electrospinning has attracted huge attention as a technique that is very simple and inexpensive to manufacture submicron fibers and nanofibers.¹ Customary electrospinning equipment consists of four main parts: a metallic spinneret, a high voltage source, a pump and a collector. During the electrospinning process, an electrical potential is being applied to a polymer droplet flowing out from the tip of a needle. Charging the droplet results in the formation of a flow phenomenon known as Taylor Cone. When the electrical forces overcome the surface tension of polymer solution, a charged fluid jet is ejected following a spiral path.² The electrical forces elongate the jet thousands of times and the jet stretches toward the grounded electrode. Electrospun nanofibers are often collected as randomly oriented structures in the form of nonwoven mats which have already had interesting applications in fields of filtration, protective clothing, self-cleaning,

drug delivery, tissue engineering, electronic and photonic devices, etc.^{3–9}

For some polymers, the strength of a single nanofiber may be so weak for conventional physical manipulation due to its small size and low mechanical strength and as a result, it breaks under its own weight.¹⁰ Meanwhile, obtaining continuous aligned nanofibers and high-volume production is very important for many areas such as fiber reinforcement and device manufacture.¹¹

Various structures such as aligned nanofibers, arrayed nanofibers, and uniaxially aligned electrospun nanofibers yarn have been achieved using different mechanical collection devices and manipulating the electric field.¹² Aligned nanofibers in particular can be tailored for use in microelectronics, photonics and in a variety of electrical, optical, mechanical, and biomedical applications.¹³

Up to the end use, a new generation of yarns can be engineered to be used in new fields such as tissue scaffolds and reinforcement materials in composites¹⁴ which have functions different from nanowebs. Collecting nanofibers in arrays and inserting twist in this bundle initiates a new nanofibrous material as nanofiber yarn. Continuous nanoyarns were produced by modifying the electric field in a limited linear density.^{15,16} Some of these techniques

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