Conformal Coating of Yarns and Wires With Electrospun Nanofibers

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Metal wires and fibrous yarns are often coated with functional polymeric layers aimed at adding certain finishing properties such as abrasion resistance, electrical insulation, or enhanced lubrication. This manuscript demonstrates that by modifying some aspects of typical electrospinning setup, a novel method for nanocoating of textile yarns and copper wires with conformal layers of electrospun nanofibers can be devised. The benefits of the presented experimental setup were evaluated by twisting and wrapping of electrospun nylon nanofibers on the surface of conventionally spun nylon yarns as well as by coating polylactic acid nanofibers on the surface of copper wires. The coating density was found to be influenced by the applied voltage and the take up velocity of the yarn while the alignment of the nanofibers was found to be influenced only by the yarn take up velocity. The presented setup may open a new avenue to provide conformal finishing characteristics to yarns and fibers. POLYM. ENG. SCI., 00:000–000, 2012. © 2012 Society of Plastics Engineers

INTRODUCTION

Many coating techniques such as drop coating, melt coating, chemical vapor deposition, and dip coating have been extensively used [1–5] to produce functional coatings on metal wires and fibrous yarns. These coatings can add certain properties such as mechanical stability, abrasion resistance, chemical resistance, smoothness, as well as color or design effects. In recent years, electrodynamic coating, mainly electrospraying, has been developed to obtain uniform nanoparticle coatings on substrates such as metals and silicon [6–9]. Similar in mechanism to electrospraying, electrospinning offers a flexible technique capable of enabling coating of nanofibers onto textile fabrics and other different substrates, including steel, silicon, computer chips, and glass slides implant stents [10, 11]. In this article, a novel method is reported for conformal coating on textile yarns and metal wires using electrospun nanofibers.

In a typical electrospinning setup, a reservoir is used to contain a polymeric solution. The solution is transferred from the reservoir to a spinneret which is generally a blunt tip needle commonly using a syringe pump [12–16]. A pendant drop of the polymer solution is allowed to form at the needle tip. A high voltage bias is then applied to the solution such that at a critical voltage the electrostatic repulsive forces within the solution will cause a fine jet of solution to erupt from the tip of the pendent drop. The distance between the collector and needle can be adjusted depending on many factors including the ability of the solvent to evaporate although it usually varies between 10 and 20 cm. Although the initial portion of the electrospun jet is stable, this jet soon enters into a bending instability region where further stretching, bending, spiraling, evaporation of the jet, and looping paths with growing amplitude cause the formation of a nonwoven mesh on the collector [17–27]. Unlike conventional fiber spinning techniques, electrospun nanofibers are often collected in the form of nonwoven webs which has somewhat limited their applications [28–32].

While most collectors are usually in the form of smooth and flat surface solids, some researchers have reported success of using some variations in order to obtain unique nanofibrous architectures. Indeed fabrication of nanostructured yarns using nonconventional collectors is a topic of considerable research interest because of potential applications in electronic textiles [33], ballistic protection fabrics [34, 35], and tissue engineering including artificial muscles [14, 36–38]. For example, in biomedical engineering applications, scaffold's porosity is a critical feature as it controls free migration of cells. The pore sizes required by different cells may vary and must be at least equal to the size of a cell, i.e., about 10 μm. However, in many cases pore sizes of several 100 μm are

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