Kulchynskyi V.V.

POLYMER FIBERS FABRICATED BY ELECTROSPINNING TECHNIQUE: APPLICATIONS AND PROBLEMS

Department of Biological Physics and Medical Informatics
Bukovinian State Medical University

Electrospinning is a simple, cheap and versatile technique to form fibers from solutions or melts. Force of electric field draws out polymer fibers up to some hundred nanometers in diameter during process of electrospinning from polymer solutions or melts. Moreover, those nanofibers can be made of solutions (melts) of metals, ceramics or composite solutions as well. The electrospinning process is particularly suitable for the production of fibers using large and complex molecules, because it does not require the use of chemical or thermal pre-treatment to obtain solid threads from solution.

The formation of continuous fibers of a broad range of insulating, conducting and semiconducting polymers, or even multi-component compounds, with diameters ranging from a few hundreds nanometers to several hundreds micrometers and length up to kilometres is possible by means of electrospinning. Depending on the electrospinning system and solution formulation used, the resultant fibers can be porous, hollow, aligned, core-shell, and in multilayer coaxial structures. Moreover, various (bio) active molecules can be incorporated into the matrix of electrospun nanofibers. The addition of nanoparticles can further improve the characteristics of electrospun fibers.

Fibers made by electrospinning method are widely applicable due to their adjustable properties. Among fields of their applications, one can find food-packaging, sensors, electronics, energy storage devices, biological tissue engineering and other medical applications. It should be mentioned that list of applications is still updating. However, although this technique possesses its pros, it has limits in each application field as well.

Conducting fibers are mostly applied in sensors due to their clear advantage – an extended surface area. PANI is by far the most employed polymer to develop conducting fibers. Improved quality and morphology of fiberscan be obtained by using polymer blends in the electrospinning process. However, the extent of polymers intermixing and degree of the continuity of the two phases may affect the fibers electrical conductivity due to presence of an insulating matrix.

A key factor in the electrospinning process are the viscoelastic properties of the polymer solution, since a critical amount of chain entanglements is needed for fiber formation. Critical value differs for each system composition. Below this value, the voltage applied cause electrospraying or the formation of beaded fibers due to a capillary wave breakup. On the one hand, the more viscous the system, the less defective the fibers. On the other hand, too high viscosity turns into high cohesiveness of the solution and may cause flow instability. The final quality of the deposited fiber mat can be described by such characteristics as the uniformity of the fibers, the absence of defects, the average diameter and their distribution width. Many processing parameter scan be classified as setup parameters, solution parameters and environmental conditions. Setup parameters are volume feed rate, needle inner diameter, collector type, tip-to-collector distance, applied voltage. Solution parameters are polymer concentration and molecular weight, solvent electrical conductivity and boiling point, solution viscosity, surface tension. Environmental conditions are temperature, pressure and relative humidity. The actual fibers formation and their morphology depend on all these usually highly interrelated parameters. However, solution parameters have a “primary effect” with respect to others that are classified as “secondary parameters”.

Fabrication of considerably complex nanofiber-based 3D scaffolds/tissue constructs with appropriate chemical, mechanical, and biological properties in a spatially controlled manner can be possible in combination of 3D printing and traditional electrospinning techniques.