ELECTROSPUN NANOFIBERS AS POTENTIAL REINFORCEMENTS FOR COMPOSITES

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A nanofiber is an elongated and threadlike structure with a diameter in the nanometer range. At this scale several amazing characteristics such as very large surface area to volume ratio (this ratio for a nanofiber can be as large as 10^3 times of that of a microfiber), flexibility in surface functionalities, and superior mechanical performance (e.g. stiffness and tensile strength) compared with any other known form of the material. These outstanding properties make the polymer nanofibers to be optimal candidates for many important applications like filtration, protective clothing and biomedical applications [1].

A large number of synthetic and fabrication methods have already been demonstrated for generating nanostructures in the form of fibers [2]. Among these methods, electrospinning is a simple and low-cost method of producing continuos polymeric, ceramic and composite nanofibers [3-5]. Also, electrospinning is able to fabricate various nanofibre assemblies *in situ*. This gives electrospinning an important edge over other larger-scale nanofibre production methods.

Basically in an electrospinning setup a high voltage is applied to a metallic capillary, like a syringe needle, which is attached to a reservoir containing a polymeric solution. Figure 1 shows a schematic illustration of a typical electrospinning setup. Above a critical electrical field the electrostatic force will overcome the surface tension of the solution and a thin jet is ejected from the tip of the capillary. This charged jet will undergo stretching and whipping as a result of the interactions of the external electric field, the viscosity and surface tension of the polymeric solution and many other parameters [6]. This instability causes the fibers to be collected randomly in the form of nonwoven mats. Figure 2 shows a typical SEM image of the nonwoven mat of nanofibers.

In our lab transparency windows were produced using cellulose based nanofibers. These nanofiber mats were used as the liquid crystal alignment layer in these composite electro-optical devices. An increase in transparency and a marked decrease on the operating voltage of these devices was observed as a consequence of the improved interaction of the liquid crystal with the nanofibers.

In the past years a great effort has been made in order to produce highly ordered structures by electrospinning [7]. Different approaches for making parallel electrospun fibers involve either the modification of the collectors or the manipulation of the electric field [2]. These ordered structures can be used for example in the fabrication of electronic and photonic devices [8,9], fiber-reinforced polymer composites[10] and in tissue engineering[11,12].

Up to date, polymer composites reinforced with electrospun nanofibers have been developed mainly for providing some outstanding physical (e.g. optical and electrical) and chemical properties while keeping their appropriate mechanical performance and less work has been done

on the development of electrospun polymer nanofiber reinforced composites. First of all, not sufficient quantity of uniaxial and continuous nanofibers has been obtained and could be used as reinforcements. The non-woven or randomly arranged nanofiber mats generally cannot result in a significant improvement in the mechanical properties of the composites with their reinforcement. Another reason may be that polymers yielding these fibers are generally considered as less suitable for structural enhancement. Although carbon nanofibers are principally achievable from post-processing of electrospun precursor polymer nanofibers such as polyacrylonitrile (PAN) nanofibers [13], these fibers seem to have not been obtained in large quantity of continuous single yarns yet. Thus, extensive work both from the standpoint of nanofiber composite science (fabrication, characterization, modeling and simulation) and from industrial base (applications) viewpoint is necessary in the future.

References:

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Figures:

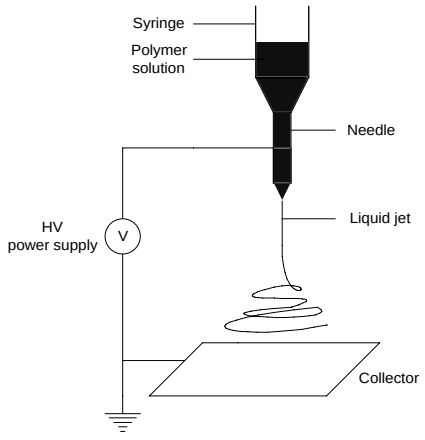

Figure 1 – Schematic illustration of a typical electrospinning setup.

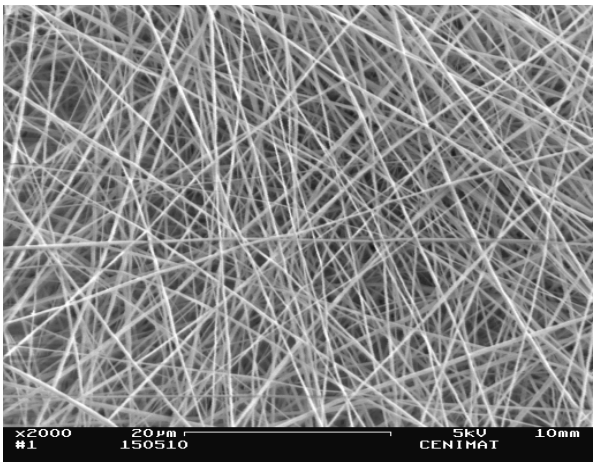

Figure 2 – Typical SEM image of the nonwoven mat of cellulose acetate nanofibers.