STUDY ON OBTAINING SPECIAL NANOFIBERS

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REZUMAT. Nanofibrele sunt o nouă clasă de materiale cu proprietăţi speciale, de aceea sunt folosite pentru mai multe aplicaţii cum sunt: textile medicale, echipamente militare, filtrare, bariera, şerveţele, îngrijire personală, compozite, articole de îmbrăcăminte, de izolare, in transporturi, ca dispozitive electronice, echipamente de stocare a energiei. De asemenea, descoperirea şi evoluţia rapidă a nanotuburilor de carbon au dus la o înţelegere mai bună a nanotehnologiei, precum şi la zeci de aplicaţii posibile pentru nanomateriale de diferite forme şi mărimi. În prezent, electrofilarea este văzută ca o tehnică specială de fabricare a nanofibrelor de polimer. Mulţi polimeri au fost electrofilaţi în fibre ultrafine în ultimii ani, cea mai mare parte în soluţie de solvent. Există multe aplicaţii bazate pe nanofibre, în special ca material de armare în nanocompozite. În această lucrare, este prezentat un punct de vedere privind cercetările şi descoperirile cu referire la electrofilarea alcoolului polivinilic, inclusiv prelucrarea, structura, caracterizare şi aplicaţii.

Cuvinte cheie: material avansate, nanofibre speciale, nanotuburi de carbon, electrofilare, tehnologie de activare.

ABSTRACT. Nanofibers are a new class of material with special properties, so they are used for several applications such as: medical textiles, military equipments, filtration, barrier, wipes, personal care, composite, garments, insulation, transportation, electronic devices, and energy storage. Also the discovery and rapid evolution of carbon nanotubes have led to a vastly improved understanding of nanotechnology, as well as dozens of possible applications for nanomaterials of different shapes and sizes. Nowadays, electrospinning is seen as a special technique for obtaining polymer nanofibers. Many polymers have been electrospun into ultrafine fibers in recent years, mostly in solvent solution. There are many applications based on nanofibers, especially as reinforcement in nanocomposite. In this paper, is presented a point of view on the researches and developments related to electrospun polymer nanofibers including processing, structure, characterization and applications.

Keywords: advanced materials, special nanofibers, carbon nanotubes, electrospinning, enabling technology.

1. INTRODUCTION

In the textile field, research and innovation can help to integrate and open the infrastructures, both from industry and research institutes and academia, to be guaranteed the success of key enabling technologies (KET). These new technologies are very close to certain scientific disciplines as chemistry, microbiology, genetics, thermodynamics, optics [1]; [2]; [3].

The nature of KET technologies do not only help the general industrial development, but also allows significant savings to be made in relation to existing complementary technologies. The enabling technologies are in different stages of maturity and the European competitiveness differs from one area to another.

One of the categories that belong to the enabling technologies is called *advanced materials*: advanced synthetic polymers, advanced ceramics, new composite materials, advanced biopolymers, advanced metals [4]. The special nanofibers are part of these advanced materials [7].

2. MATERIALS AND METHODS

In the *Faculty of Textiles, Leather and Industrial Management of Iasi*, there is installed an experimental equipment of electrospinning in the "Textile otherwise" Laboratory (Figure 1).

Fig. 1. Electrospinning equipment [6].

Any electrospinning equipment is made up of the pump, in the form of a syringe, containing the

solution of the polymer and a support submission. Between the pump and the polymer deposition holder it is applied a potential difference of the order of kV. In order to produce nanofibres, it is used an original electrospinning device, consisting of a micropump for the solutions (that are obtained by dissolving the polymer in water), a high voltage source and a support to collect the nanofibres. To ensure the needed difference of potential between the needle and the support it is installed a high voltage source.

As support for the submission of nanofibres it is used a platform coated metal collector and aluminum foil to ensure a good contact between the high voltage power and it.

The electrospinning process involves three steps:

− initiating and flow of the jet;

− increase the stability, followed by a stretching or drawing a stream which allows it to move in a curved shape or a spiral;

− jet solidification as nanofibers .

A fibrous layer of nanofibers is obtained by using as polymer polyvinyl alcohol and water (Figure 2).

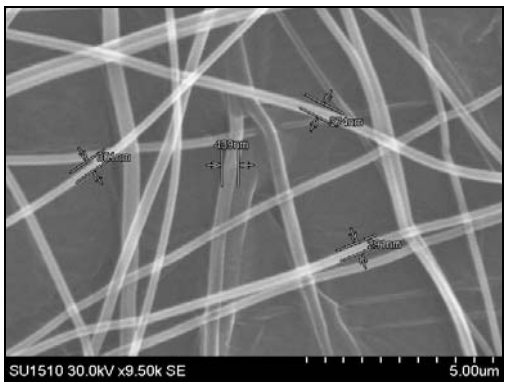

Fig. 2. Layer of nanofibers [6].

The polyvinyl alcohol is a water-soluble synthetic polymer produced by the polymerization of vinyl acetate. It was electrospun with the distilled water solution.

a) To increase the electrical conductivity, it is proposed to introduce the carbon nanotubes or other substances (eg. medical encapsulated/embedded products) in the polymer solution (until now, it has been used the organic acids, as a solvent). The nanotubes used in electrical circuits work as metallic conductors or semiconductors (having the best strength-to-weight ratio of any known material). In the experimental studies, it was found that increasing conductivity favors the formation of thin fibers.

b) Instead of tipped syringes, it is proposed to use a pump with three nozzles with various diameters needles, not linearly arranged. They are set at 120 degrees, so that one of the simultaneously resulting layers can be considered for consolidation.

c) The polymer can be colored;

d) The fibrous layer is released on a flat collector;

e) They can be made the following adjustments:

− the pump allows adjusting the flow rate in the range of 0.6 ml/h at 3 ml/h;

− the collector-ace-distance can vary between 0-30 cm in a powered (10 to 30 kV voltage supply).

3. RESULTS AND DISCUSSIONS

The nanofibers which can be obtained will be continuous, smooth, with a high electrical conductivity due to the presence of carbon nanotubes.

Nanofibers can have multiple applications:

– intelligent clothing: they will measure heartbeat and will transmit data to a mobile phone application;

− high-tech sport costumes;

− advanced military equipment;

– automotive industry;

– chemical industry.

A basic understanding of advanced materials, the techniques and technologies available on the market, the turnkey technologies, all these emerge to knowledge. Research in nanofibres field and all domains involved, including textiles,in terms of disciplines mean transdisciplinary.

In a transdisciplinary research endeavor, scientists contribute their unique expertise but work entirely outside their own discipline.

On one hand, the results obtained from the research on getting this type of nanofibres may allow the completion of new projects, accessing European funds, co-operation between SMEs and university / public-private partnerships.

On the other hand, the collaboration between European or non-European technical / medical / architecture universities can be developed by promoting interdisciplinary projects in the *"EU research program for research and innovation - Horizon 2020"* or obtaining patents.

4. CONCLUSIONS

− Through the process of electrospinning, there can be produced uniform, continuous in length, submicron diameter fibers, using cheap materials and a relatively simple experimental device. In the simplest version of the process, a drop of the polymer solution formed in the tip of a needle is loaded in an electric field of high intensity, which causes its deformation into the form of a fiber. After that, it is

drawn and collected on the electrode which is placed at a distance by the needle tip. If the tip of the needle is fed continuously with the solution, the process can be carried out over long periods of time, producing large quantities of nanofibers as a spider's web.

− The process of electrospinning is influenced by: the process parameters (electrical voltage between the tip of the needle and collector, pump flow, object type collector, the distance between the needle tip and collector), thermostat parameters (temperature, humidity and air speed), polymer solution parameters (concentration, molecular weight, viscosity, surface tension, conductivity / density of pregnancy).

− Carbon nanotubes (CNT) are molecular carbon structures, very small, with a million times smaller in diameter than the tip of a pencil. Carbon nanotubes are tube-shaped material which has many structures, differing in length, thickness, and in the type of helicity and number of layers. Although they are formed from essentially the same graphite sheet, their electrical characteristics differ depending on these variations, acting either as metals or as semiconductors.

− Carbon nanotubes have electrical, mechanical and thermal particular properties: high electrical conductivity, which can be 1000 times higher than copper conductivity, hardness approximately equal to that of diamond, being the hardest material in nature, the mechanical strength of the stretch of it is approximately 14 times higher Kevlar (Kevlar is a polyamide five times stronger than steel). Calculations show that the wire from the several layers nanotubes, with a thickness of one millimeter; it will maintain a weight up to 15 tons. At the same time, in cross-section, it can retain heat as well as brick or concrete.

− The special nanofibers obtained can have multiple fields of use: key enabling technologies, composite materials, textile industry, IT, automotive, construction, etc.

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