

PREPARATION OF COMPOSITE NANOFIBERS CONTAINING SOLID PARTICLES

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Abstract

The aim of this work is the preparation of the composite nanofibrous material with the solid particles. This method may utilize AC power for the spinning of polymer solutions. In our patent, CZ 302901, we showed a method of forming a functional nanofiber layer. With addition of a special device for the enrichment of the process with direct addition of the solid particles, the resultant final structure is consisting of solid particles which are held in between nanofibers. The solid particles have an active surface, and thanks to this method of the production, that surface is almost entirely accessible. Thanks to all of the parameters mentioned above, the final material is very suitable for applications in the filtration industry. The main goal in the future is to assemble a line for continuous production of nanocomposite materials.

Keywords:

Nanofibers, nanocomposite, solid particles

1. INTRODUCTION

Electrospinning of the nanofibrous materials is a technique for the preparation of the submicron fibers. The uses of these fibers are many. Our department of Nonwovens and Nanofibrous materials is developing different variants of the electrospinning. The standard way for nanofiber production uses a direct current (DC) high-power source. This technique led to the creation of NANOSPIDER™ and further technologies based on same principle. Based on our research, we found that it is possible to use an alternating current (AC) power source (Patent CZ 304137 A new way of for production of polymeric nanofibers by spinning a solution or melt of polymer in AC electric field and creation of nanofibrous yarn based on the same principle [1]). This technology shows a significantly higher producibility of spinning. It is possible to use it for the production of the composite nanofibrous material with solid particles according to the patent CZ 302901 A method of forming a functional nanofiber layer and the device for implementing the process [2].

2. EXPERIMENTAL

2.1 Method of production nanocomposite material

The main nature of patent CZ 302901 is the combination of the electrospinning and the addition of solid particles. This process creates a material composed of a solid part which is held by the nanofibrous net. Almost the entire surface of solid particle is accessible. Such a material is suitable for filtering applications and works as a barrier material. Inspiration was drawn from [3] and [4].

The ratio of dosage between the nanofibers and solid particles is difficult to tune. The same goes for the distribution of 10 µm particles. Small particles like these are clustering in agglomerates. Such structures are lowering the active surface of the particles, which is negative for behavior of final product. There are two possibilities to negate this effect. The first one uses a device for the generation of an ultrasound which is applied on the particles on their way to the nanofibrous layer. The other one uses a mechanical device for the better distribution of particles. A promising method is based on the use of AC electrospinning combined

with mechanical distribution of solid particles. The productiveness of such a device is higher than with a similar device based on DC electrospinning.

2.2 Preparation of the nanocomposite material

The preparation of the material with the crushed active charcoal for filtration applications requires a special way of dispersing the solid particles. We use a closed chamber with a supply of crushed charcoal. Inside this chamber a mechanical mixing device which stirs the particles by a wind generated ventilator keeps them in suspension. When exiting chamber, particles are sprayed through the injector in the required amount to the spinning head, where the nanofibers are mixed with charcoal. The fibers are deposited using a vacuum on the strap. This creates a layer of composite material on a supporting material **Fig.1**.

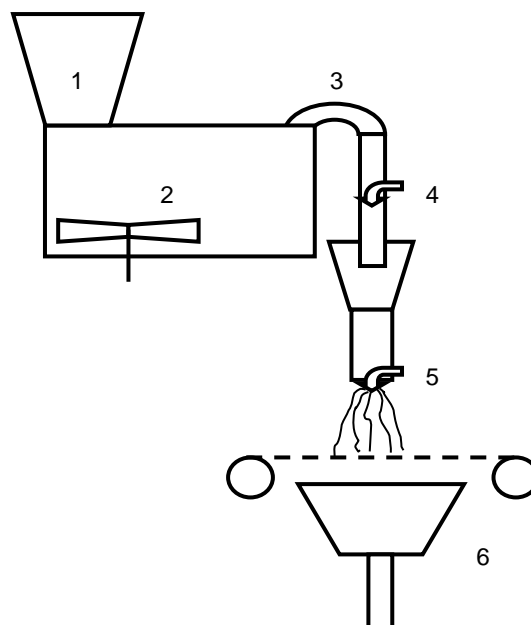


Fig. 1 Schematic diagram of equipment for production of nanocomposite materials. 1 - particles magazine, 2 - vortex chamber, 3 – tube, 4 – injector, 5 – AC electrospinning head, 6 – exhausted conveyor

3. RESULTS

An SEM analysis of gathered material has been performed. The particles of grinded activated carbon exhibit a uniform filling of the material. The particles are held in place by a fine web of nanofibers. The composite material is placed on a supporting textile layer of spunbond nonwoven **Fig.2**.

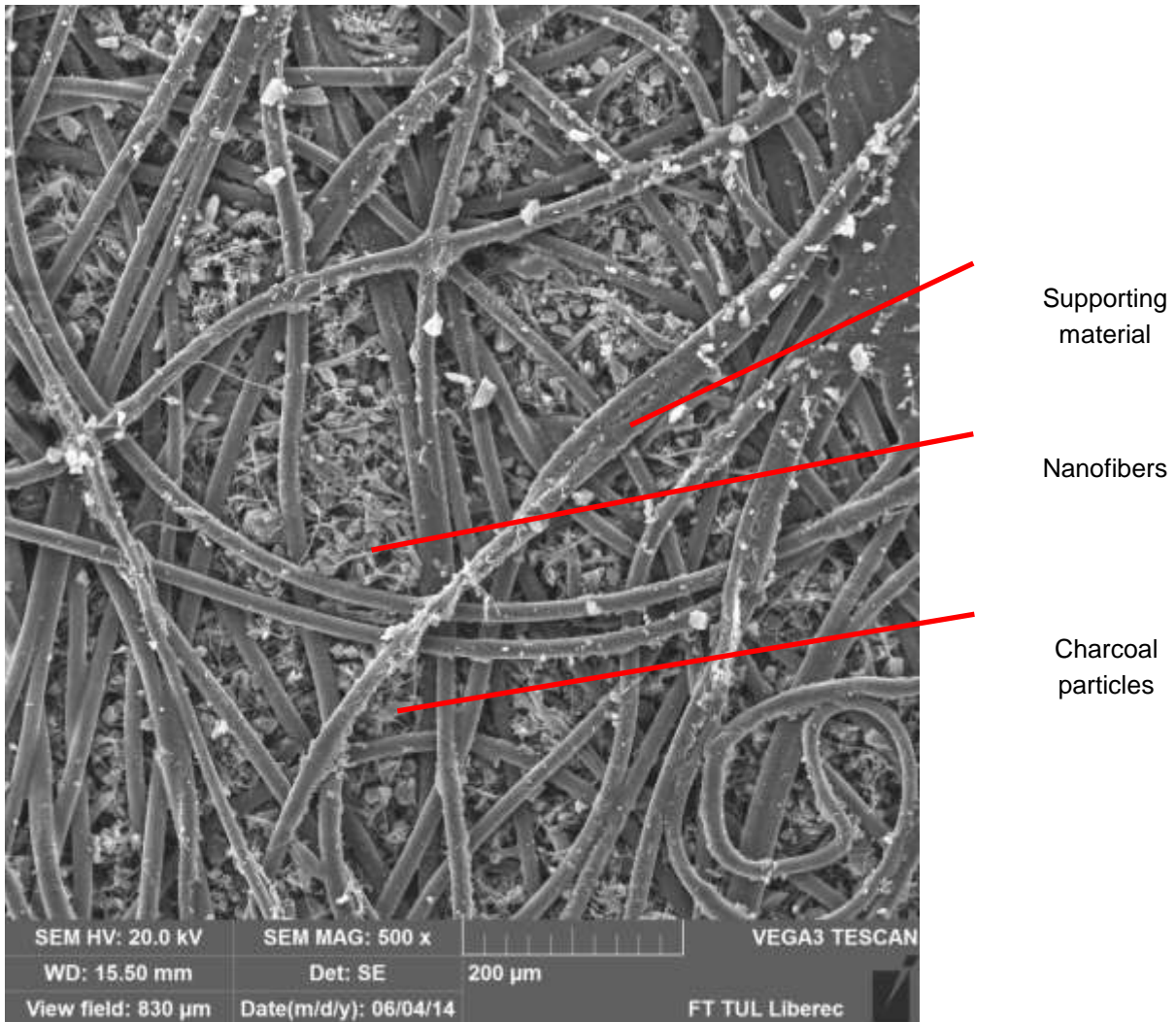


Fig. 2 SEM photographs of composite material

4. CONCLUSION

The combination of AC electrospinning with solid particles creates an interesting filtration and barrier material. We are working intensively to develop a machine for continuous production of the composite material.

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LITERATURE

- [1] CZ 304137 Pokorny a kol.: Způsob výroby polymerních nanovláken zvlákňováním roztoku nebo taveniny polymeru v elektrickém poli a lineární útvar z polymerních nanovláken vytvořený tímto způsobem
- [2] CZ 302901 Pokorny a kol.: Způsob vytváření funkční nanovláčkové vrstvy a zařízení k provádění způsobu
- [3] US 2011/0018174 A1, Baca et al.: Electrospinning Process and Apparatus for Aligned Fiber Production
- [4] US 2003/0226750 A1, Fenn J.B.: Electrospray Dispersion in an Alternating Current Mode