PRODUCTION OF COMPOSITE NANOMATERIALS USING THE 4SPIN® TECHNOLOGY

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INTRODUCTION

Electrospinning is a relatively simple, universal and effective fabrication technique for the production of nanofibers with diameters ranging from 50 nm to several micrometers using polymer solutions or melts. Typically, electrospinning devices allow the production of nanofibrous nanomaterials from only one material. However, further improvements to the electrospinning device set up allow nanofibrous layers to be produced using different types of polymers, enhancing their materials properties.

MATERIALS AND METHODS

- All nanomaterials were electrospun using the new types of emitters of the 4SPIN® technology.
- Composite nanomaterials were prepared using the following six polymers:
  - polyethylene oxide (PEO)
  - hyaluronic acid/polyethylene oxide blends (HA/PEO)
  - polyvinyl alcohol (PVA)
  - polyacrylonitrile (PAN)
  - polycaprolactone (PCL)
  - polyurethane (PU)

- Composite nanostructures were prepared using the Electrospinning® Electrospinning technology. Depending on the concentration of the polymer solution used.
- Nanofibres were deposited on a rotating drum collector. The jets must be behind one another on the plane perpendicular to the axis of rotation of the drum collector.
- The homogeneity of polymer distribution in a nanofibrous layer is verified by measuring the absorption spectra of its individual components. Two PVA solutions were prepared with the addition of the Brilliant Blue dye (absorbance 570 nm) to one solution and Erythrosin (absorbance 530 nm) to the other.
- Chemical composition of the resulting materials was noninvasively determined with confocal Raman spectroscopy. Confocal Raman arrangements enable the detection of inelastically scattered radiation from a selected area on the surface of the sample. Spectral differences can indicate spatial distribution of the individual components of composite nanofibrous layers.

A new desktop laboratory apparatus has been developed for the 4SPIN® device. Thanks to the implemented methods and the new types of emitters of the 4SPIN® device, which can be used for simultaneous electrospinning of two or three different types of polymers onto the same collector. The simplest method is to use a needle jet emitter. It forms a high gradient electrostatic field around the drop of the polymer solution thus leading to the highest spinning ability. Another approach is needleless electrospinning capable of scaling up the nanofibrous material production. To obtain homogeneously mixed nanofibrous layers, nanofibres can be directly collected on a rotating drum. A needleless advanced type of the 4SPIN® emitter is a coaxial single needle jet. By using the coaxial electrospinning method, it is possible to produce hollow fibres and even core materials that will not form fibres via electrospinning.

EMITTERS

- Composite double jet E6
- Composite triple jet E7
- Composite needless rod E8
- Composite multi needless jet E9
- Coaxial single jet E10

RESULTS

- Homogeneity

Absorption spectra obtained from nanofibrous layers prepared separately from PVA with Brilliant Blue (BB), PVA with Erythrosin (Er) and their composite material fabricated on the drum collector (A, B, C).

Raman spectroscopy

Raman spectra of PCL and PEO representing the main differences between the polymers.

CONCLUSIONS

Composite nanomaterials composed of two or three different types of polymers were investigated. Various morphologies were also achieved in the resulting materials. The homogeneity and distribution of individual components were analysed with a spectrophotometer and examined using Raman spectroscopy.

REFERENCES

3) Pokorny, M., et al., Cz 304 097 (2012)