CONDUCTIVE POLYMER NANOCOMPOSITES FOR MEDICAL APPLICATIONS

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Introduction

Recently, polymer-based electro-conductive materials have been included in practical applications in the domain of medical therapy and diagnostics [1,2]. These materials occur to be indispensable for, among others, bio-sensor design, tissue engineering and regenerative medicine. Different high requirements and standards imposed by medicine very often are hard to be met by intrinsically conductive, conjugated polymers. In contrast, polymer nanocomposites can be much easier tailored to fulfil prerequisites for such applications. A particular place is occupied by carbon nanoforms. When introduced into a polymer matrix, they not only make it conductive, but can impart the desired mechanical properties and affect the surface parameters of the composite. Characteristics of this latter are decisive for the nature of interactions with the tissue and cell environment. To exploit this direction of research, we produced nanocomposites containing multiwall carbon nanotubes (MWCNT) or carbon nanofibres (CNF) dispersed in two different polysiloxane-based matrix. A part of samples contained functionalized derivatives of the above carbon nanoforms. Such a range of materials were thoroughly tested in terms of surface morphology, amount of carbon in the structure and electrical conductivity, and then compared and discussed.

Materials and Methods

MWCNTs were purchased form Nano-Amor, USA. Carbon nanofibers were obtained by fragmentation of ESCNF (electrospun carbon nanofibers) received by carbonization of polyacrylonitrile (PAN) precursor processed by electrospinning. Both types of carbon nanoforms were chemically treated in a mixture of acids (H_2SO_4, HNO_3), what ensured good dispersions in silkosan sol. The nanocomposites were produced using the sol-gel method. The siloxane sol containing dispersed carbon nanoforms was subjected to thermal treatment at 70°C for 7 days and then deposited on different solid substrates. The resulting nanocomposites were tested by mean of X-ray Photoelectron Spectroscopy (XPS), Energy Dispersive X-ray Spectroscopy (EDS), Scanning Electron Microscopy (SEM), contact angle (CA) technique and electrical conductivity (EC) as function of temperature.

Results and Discussion

Polymer nanocomposites containing MWCNT differ significantly in properties from composites with CNF. Both materials featured electrical conductivity, however higher in the case of composites with nanotubes. In samples containing CNF, a much stronger hopping character of the electrical conductivity was observed. CNF are longer and have a larger diameter than nanotubes. It is reasonable to assume that for this reason individual CNFs are more spatially separated. The resulting potential barriers are higher and more difficult to overcome for charge carriers, especially at cryogenic temperatures.
Analyzing the obtained XPS depth profiles, it was found that the carbon nanoforms were dispersed more homogeneously in the polysiloxane matrix containing phenyl groups. In the case of layers containing only methyl groups, there was observed a density gradient in the direction perpendicular to the sample surface.
Each of the nanoadditives has a different impact on the surface properties of the polymer. The topography of samples containing CNFs was much more developed comparing to the smooth and featureless surface of material containing MWCNTs. In contrast, the studied materials had hydrophilic surfaces regardless the type of the nanoadditive. differing only in the ratio of the energy components; dispersion and polarisation.

Conclusions

Polymer nanocomposites with carbon nanoforms have a high potential for medical applications. By choosing the content and the type of the nanoadditive, it is possible to vary significantly the material parameters, important for this domain. The results also proved that carbon nanotubes can be successfully replaced with carbon nanofibers. The biocompatibility of these latter has already been widely recognised, what opens the route to produce nanocomposites fully safe for the patients.

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