POLYMER COMPOSITES FOR ELECTROMAGNETIC AND ELECTROSTATIC SHIELDING

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The article describes electromagnetic shielding capabilities of carbon nanotube polymer and multiwalled carbon nanotube nanocomposites obtained by spray – drying technique. The used method guarantees uniformly dispersed carbon nanotubes (CNTs), what resulting in forming the continuous network of CNTs inside the polymer matrix. The technique also allows working with solution that is the basis of homogeneous composite material preparation, as the agglomeration of the filler destroys the material desired electromagnetic shielding properties. In manufactured nanocomposites network of conductive filler is playing the role of the electromagnetic radiation shield and thus it is so important to develop the highly effective preparation method leads to uniform dispersion of the filler. Another important feature of the examined nanocomposites is electrostatic shielding capability based also on good uniform carbon nanotubes dispersion what makes the outcome material suitable for protecting fragile electronic devices. The filler particles used in the described process are multiwalled carbon nanotubes coming from LSCVD synthesis in our own laboratory. In this article we are introducing both the method and results for the first of filler and polymer as the basis for the future work we want to finally present.

Keywords:
electromagnetic shielding,
electrically conductive composites,
carbon nanotubes,
polymer composites,
electronic devices

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I Introduction

Electronic devices are widely used today in every field of human activity like industry, health care, or transportation. Thus it is highly probable that fragile by its nature electronics can often work in difficult conditions, also in the presence of variable magnetic fields caused for example by currents flowing in the electrical installation. That is the reason of the need of developing materials that used for housing of the electronic devices could eliminate the electromagnetic and possibly also electrostatic interference. Another important feature is the need of easy shaping and low energy cost of fabricating both the materials and housings. Also eliminating or minimizing amount of toxic waste polluting the environment is very important. Most of polymers used in industrial applications are petroleum based and thus are hardly degradable in natural environment (it can take hundreds of years) so it causes pollution or significantly rising the cost of the product concerning utilization of millions tons of wastes. The material that can meet requirements of electromagnetic shielding and static electricity protection is a polymer composite with carbon nanotubes as a filler and a biodegradable polymer matrix. The choice of carbon nanotubes (CNTs) as the filler is dictated by their great electrical and mechanical properties as well as high thermal and chemical stability [1][2]. These properties makes CNTs one of the best fillers in polymer composites [3][4]. In this publication, polylactide (PLA) has been used as the polymer matrix. It is a biocompatible polymer obtained from renewable sources[5], [6]. In addition, parts made of this polymer are fully biodegradable, and thus do not pollute the natural environment, unlike petroleum-derived polymers commonly used in electrical engineering. A major disadvantage of CNTs as a filling material is the difficulty in obtaining homogeneous dispersions in polymer matrices. Good, uniform dispersion of CNTs in the polymer matrix is a key parameter for the composite performance. In this paper we present method of preparation of nanocomposites with good dispersion of CNTs. It consist in “freezing” of a good dispersion of CNTs in the polymer solution obtained using ultrasound bath. The described method also allows other filler particles and polymer usage as long as the solution can be made.

II Methods And Results

The multiwalled carbon nanotubes, used as a filer in described composites, was synthesized using liquid source chemical vapor deposition (LSCVD) synthesis technique in own laboratory[7]. Carbon nanotubes grow in form of a carpet, perpendicularly to carpets base. Obtained material is characterized by high purity and uniform dimensions. The mentioned properties are synthesis process parameters (temperature, carrying gas and catalyst solution vapours flow) dependable. The method allows easy change of synthesis parameters in order to obtain material of desirable parameters.

Polylactide was provided by Cargill-Dow. It contains 95.9% of L-lactide and 4.1% D-lactide. Reagent grade trichloromethane (CHCl3) was used as solvent for polylactide, as the spray drying technique was used for creating the composite layers. Prior polylactide dissolving, CNT were dispersed in trichloromethane (CHCl3) using ultrasonic bath (90 min) in order to disintegrate nanotube bundles coming from the synthesis. Composite fabrication technique was described in details in authors' publication[8]. To examine of homogeneity of dispersion of the filler particles in fabricated composites scanning electron microscope Jeol JSM 5500 apparatus was used, what shows the below micrograph. Fig. 1 presents the composite obtained by spray – drying technique applied directly on Si wafer surface. What is visible on the SEM micrograph, there is no CNT agglomerates or bundles. What is also important, no charging effects can be seen, what confirms electric conductivity of the composites as the charge is effectively removed from the surface.

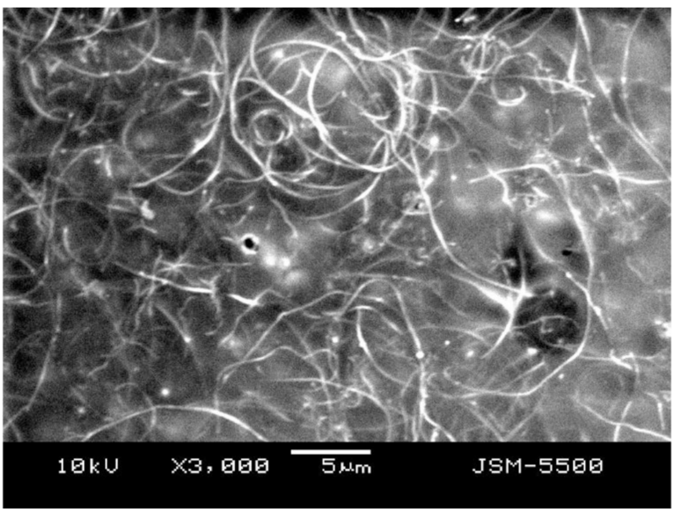

Figure 1: SEM micrograph of composite foil on Si wafer surface, applied after dispersion in CHCl3 (90 min, CNTs weight content is 2%)

All described in the article efforts' goal was creating the material comprising both electrostatic and electromagnetic shielding capabilities. Another important aspect of our research was developing method of fabrication that allows application of the protective composite layer on virtually any surface and is simple and cheap enough to be industry – friendly. The results of electric conductivity measurements in function of the CNTs content are presented on Fig. 2.

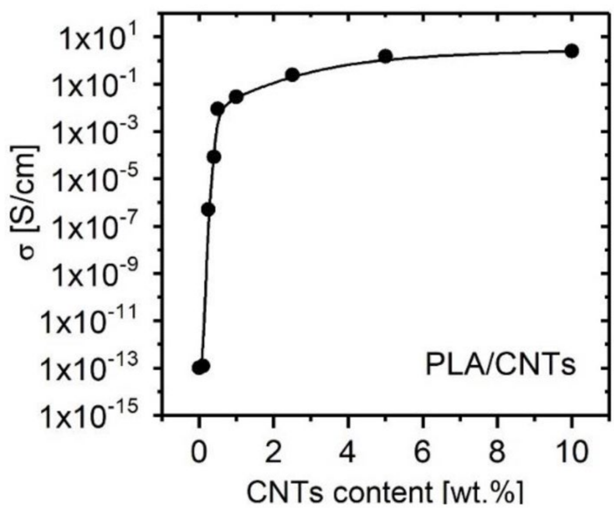

Figure 2: Electric conductivity CNTs content dependence plot; the CNTs content range is 0 to 10% by weight [8]

It is worth of mentioning, that percolation threshold is lower than 0,2% weight percent content and for effective electric charges conducting 0,25% is sufficient[7]. The next material examination analysis step was checking the electromagnetic shielding capabilities. As the experiments are still in progress, an exemplary result for a composite with a weight content of 2% is presented (Fig. 3).

One can observe damping in range from 50 to around 430 MHz and for this specimen magnitude lies in range of 10dB. What is important, dumping was achieved for layer thinner than 0.2 mm.

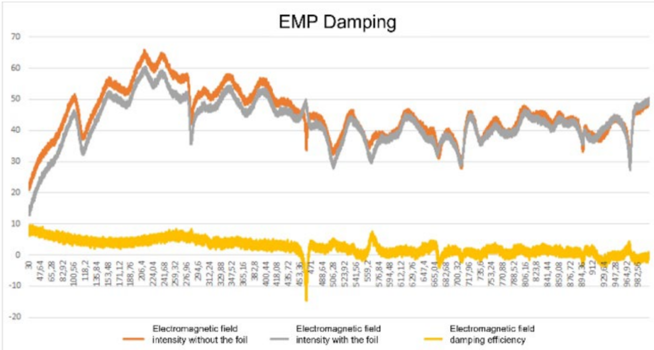

Figure 3. Shielding properties plot of 2% by weight composite foil in comparison to neat polymer

The parameters of presented polymer composites indicates that this material can be used in both electronics and electrotechnics field. Material comprises low manufacturing cost and multiple application possibilities. What is worth of mentioning, the material is also environmental friendly due to polylactide properties, as it is biodegradable. Using spray – drying applying technique making entire process industry friendly and gives possibility of use other polymers and fillers according to the needs. The authors are planning to improve material electromagnetic shielding capabilities and use different fillers and polymers to increase the range of application.

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