Ministry of Education and Science of Ukraine
Sumy State University
IEEE Nanotechnology Council & IEEE Magnetics Society
International Union for Pure & Applied Physics

2021 IEEE 11th International Conference "Nanomaterials: Applications & Properties" (NAP-2021)

NANOmaterials: Applications & Properties-2021

ABSTRACTS

Institute of Electrical and Electronics Engineers
2021

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Percolation Effects in the Nanocomposites with Conducting Polymer Fillers

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The study of percolation phenomena in filled polymer systems is an important task, because the description of the properties of the systems near the critical point open the perspectives for the creation of nanomaterials with predicted functional characteristics [1, 2]. In this work, the electrical properties of polymer-polymer composites based on dielectric polymer matrices – polymethyl methacrylate (PMMA), styromal (ST-MA), polyvinyl alcohol (PVA), polyacrylic (PAA) and polymethacrylic (PMAA) acids, as well as ED-20 epoxy matrices and electrically conductive polymer fillers - polyortotoluidine, polyorthoanisidine and polyaniline were investigated. Conducting polymers are "synthetic nanometals" [1] with a particle diameter of 10-20 nm and unique electronic properties, the ability to absorb radioactive rays, which allow them to be used in many fields.

It is shown that the concentration dependence of the specific electrical conductivity on the content of fillers has a percolation character (Fig. 1) with a low "percolation threshold", which depends on the nature of the polymer matrix and conducting polymer (Table 1).

The main equation of percolation theory (Kirkpatrick model) reflects the dependence of electrical conductivity σ on the bulk content of the filler φ:

$$\sigma = \sigma_0(\varphi - \varphi_c)^{\tau} \qquad (1)$$

φ is the volume fraction of filler, φ_c is the percolation threshold, the lowest content of filler at which a continuous cluster of conductivity is formed, $\varphi > \varphi_c$; τ is the critical conductivity index after percolation threshold [2, 3].

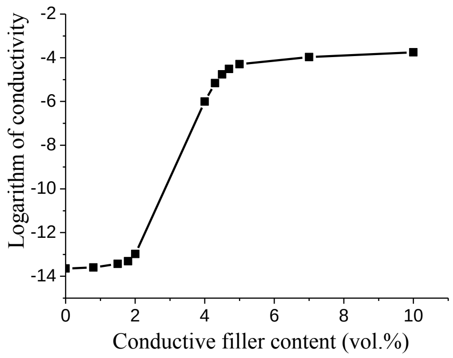

Fig. 1. Tipical dependence of conductivity logariphm on the content of conductive filler for PVA-polyaniline composites. The percolation threshold φ_c =2,3 vol. % .

Increasing the filler content leads to a sharp transition from the non-conductive state to the conductive state (there is a phase transition insulator-conductor).

TABLE I. PERCOLATION PARAMETERS OF POLYMER COMPOSITES WITH CONDUCTING POLYMER FILLERS

Polymer matrix	Conducting polymer filler	Percolation threshold, φ, vol.%	Critical index of conductivity, t
PVA	Polyaniline	2,1	1,75
PVA	Polytoluidine	2,8	1,58
PVA	Polyanisidine	1,7	1,88
PMMA	Polyaniline	2,0	1,43
PAA	Polytoluidine	2,3	1,38
PMAA	Polytoluidine	3−4	1,48
St-MA	Polytoluidine	10	2,53
St-MA	Polyaniline	8,4	2,67
St-MA	Polyanisidine	8,0	2,56
ED-20	Polyaniline	2,5 − 5	-

In this case, all the filler particles are completely delocalized throughout the polymer matrix and become conductive, and the formed composite has the maximum conductivity. It was found that composites based on the investigated polymer matrices are characterized by low values of the percolation threshold, which are typical for composites with an electrically conductive polymer phase [1]. The calculated values of critical index of conductivity are in the range of 1.4 – 2.6 that is characteristic for a three-dimensional system [3]. This constant mainly depends on the topological dimension of the system and does not depend on the structure of the particles that form clusters and their interaction.

REFERENCES

[1] O. I. Aksimentyeva, O. I. Konopelnyk, G. V. Martyniuk, "Synthesis and Physical–Chemical Properties of Composites of Conjugated Polyaminearenes with Dielectric Polymeric Matrixes," In: Computational and Experimental Analysis of Functional Materials Toronto, New Jersey: Apple Academic Press, 2017, pp. 331−370.

[2] A. Herega, "Some Applications of the Percolation Theory: Review of the Century Beginning," *J. Mater. Sci. Eng. A*, vol. 5, no. 11-12, pp. 409-414, 2015.

[3] E. A. Lysenkov, V. V. Klepko. "Analysis of Percolation Behavior of Electrical Conductivity of the Systems Based on Polyethers and Carbon Nanotubes," *J. Nano- Electron. Phys.*, vol. 8, no. 1, ID 01017, 2016.