PMDS kompozitų su Ag nanodalelėmis dielektrinė spektroskopija

DIELECTRIC PROPERTIES OF POLYDIMETHYLSILOXANE COMPOSITES FILLED WITH AG NANOPARTICLES OF DIFFERENT SIZES

Edita Palaimiene[1], Sebastien Schaefer[2], Jan Macutkevic[1], Juras Banys[1], Vanessa Fierro[2], Alain Celzard[2]
[1] Institute of Applied Electrodynamics and Telecommunications, Vilnius University,
LT-10257 Vilnius, Lithuania
[2]French National Centre for Scientific Research, Institute Jean Lamour, Université de Lorraine,
F-88000 Epinal, France
edita.palaimiene@ff.vu.lt

Polydimethylsiloxane (PDMS) is the most widely used silicon-based organic polymer. The multiple valuable features of PDMS, such as flexibility, thermal stability, and biocompatibility, make it an excellent matrix material for composites [1]. PDMS composites widely used as bioactive materials [2], elastic strain sensors, flexible sensors and electromagnetic coatings [3] flexible batteries, and electronics [4]. It has been shown that, by changing the size of the conductive fillers in the PDMS matrix from micro to nano, the concentration threshold necessary for the onset of conductivity is lowered [1]. To exploit the potential of application of Ag nanoparticles (AgNPs) in flexible electronics and biomaterials, it is important to develop flexible polymeric materials, particularly PDMS-based, loaded with AgNPs because of their relatively low cost, their narrow dispersion in the refraction index, their practically endless possibilities of structure modification and their good processability [5].

The aim of present work is to investigate the dielectric properties of polydimethylsiloxane nanocomposites filled with Ag nanoparticles (AgNPs) of different sizes. The measurements were carried out over a very broad range of frequencies (20 Hz- 40 GHz).

The concentration dependences of both dielectric permittivity and electrical conductivity for different sizes of AgNPs at 129 Hz (which is close to our low frequency limit) and room temperature are presented in Figure 1.

The values of electrical conductivity and dielectric permittivity were selected at 129 Hz frequency, since at lower frequencies the concentration dependence is more pronounced. For concentrations not higher than 15 vol%, the values of dielectric permittivity and electrical conductivity are rather low (about 10 and 1 nS/m, respectively) and are independent of the AgNPs size. An abrupt increase in dielectric permittivity and electrical conductivity occurs near a volume concentration of NPs of 20%, regardless of the particle size, indicating the onset of electrical percolation. The dielectric permittivity and the electrical conductivity are size dependent only close to the percolation threshold, while at lower concentrations it is almost size independent, similarly as in composites with onion-like inclusions. In contrast above the percolation threshold (for AgNPs concentration 30 vol%) electrical properties of composites are almost size-independent.

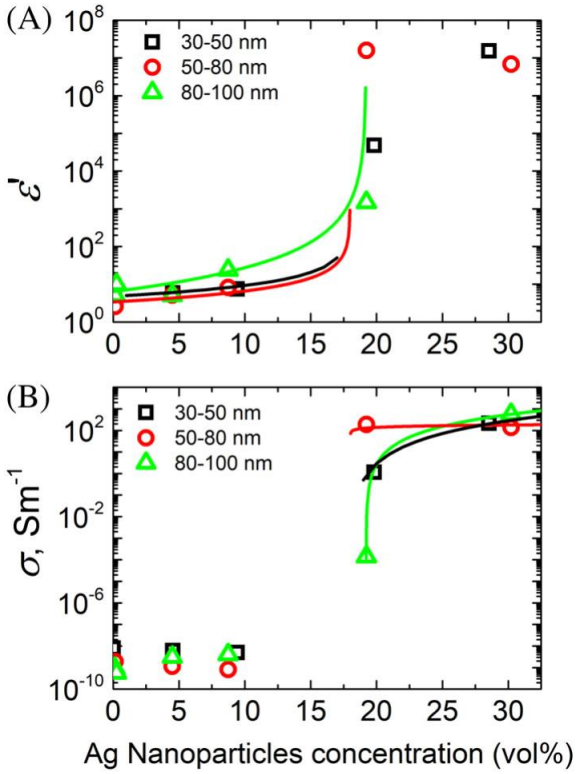

FIGURE 1. Dielectric permittivity, A, and electrical conductivity, B, of silver-loaded polydimethylsiloxane (Ag/PDMS) composites vs Ag concentration and for different particle sizes, at frequency 129 Hz and room temperature.

Keywords: dielectric, composites, percolation.

References

[1] X. Niu, S. Peng, L. Liu, W. Wen, P. Sheng, Adv. Mater.**19**, 2682 (2007).
[2] T. Kokubo, H. M. Kim, M. Kawashita, Biomaterials **24**, 2161 (2003).
[3] J. R. Huang, X. X. Yang, J. T. Liu, S. C. Her, J. Q. Guo, J. F. Gu, L. H. Guan, Nanotechnology **31**, 335504 (2020).
[4] I. You, M. Kong, U. Jeong, Acc. Chem. Res.**52**, 63 (2019).
[5] Y. Chen, Y. Araki, J. Doyle, A. Strevens, O. Ito, W. J. Blau, Chem. Mater **17**, 1661 (2005).