EPOXY COMPOSITES LOADED WITH CARBON NANOTUBES AND GRAPHENE

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Addition of carbon based nanoparticles to polymers can improve thermal, mechanical, electrical properties, electromagnetic interference shielding effectiveness (EMI SE) of the composites [1]. The present work has focused on the preparation of epoxy-based composites loaded with various amounts of multiwall carbon nanotubes (MCNTs), graphene nanoparticles (GNPs), MCNTs/GNPs mixtures, and study of their electrical, mechanical properties and EMI SE in the X-band frequency range.

Epoxy resin Biresin CR122 and hardener CH122-5 were provided by SIKA. MCNTs NC7000™ having an average diameter of 9.5 nm and an average length of 1.5 μm were supplied by Nanocyl S.A. (Belgium). Elicarb® graphene epoxy dispersion was produced by Thomas Swan. The electrical conductivity of the epoxy-based composites was measured on cylindrical samples by standard two-point contact method. The EMI shielding efficiency was measured with an Agilent 8722ET transmission/reflection network analyzer at samples with thickness of 1.5 mm in the frequency range from 9 to 11 GHz. A Tinius Olsen H25KT machine equipped with a video extensometer PoE 1 was used for strain measurements.

Optical microscopy studies showed that the MCNTs or GNPs are uniformly distributed in the composites. The conductivity of free epoxy is very low ($< 10^{-9}$ S/m). Addition of the MCNTs to the epoxy matrix leads to an increase in the composite conductivity. The conductivity rises up to 4 S/m with increasing the amount of MCNTs up to 2 wt.%. The percolation threshold for the composites filled with MCNTs is found to be 0.013 wt.%. In comparison with MCNTs, introduction of GNPs into the polymer up to 10 wt.% does not change appreciably the conductivity of the epoxy matrix. EMI shielding efficiency measurements showed that thick film composite samples with split MCNTs absorb electromagnetic waves in the range from 9 to 11 GHz when the MCNTs loading is higher than 0.05 wt.% (Figure 1a). A rise of the MCNTs content in the composite leads to an increase in the shielding efficiency by absorption and reflection (EMI SE). The value of EMI SE grows up to 13 dB when 2 wt.% of MCNTs is loaded in the composite. As compared with MCNTs, GNPs in the epoxy composites cause only slight increase in EMI SE. At the same time, addition of GNPs to the MCNTs/epoxy composites leads to an appreciable improvement of the EMI SE of the composites. Tensile strength of the free epoxy composite is 70÷80 MPa. Its value appreciably decreases with increasing the MCNTs amount (Fig. 1b). Introduction of the graphene nanoparticles up to 5 wt.% does not influence noticeably the tensile strength of the epoxy based composites (Fig. 1b). The mechanical properties of the MCNTs + GNPs composites were similar to that of the MCNTs-loaded composites without GNPs (Fig. 1b).

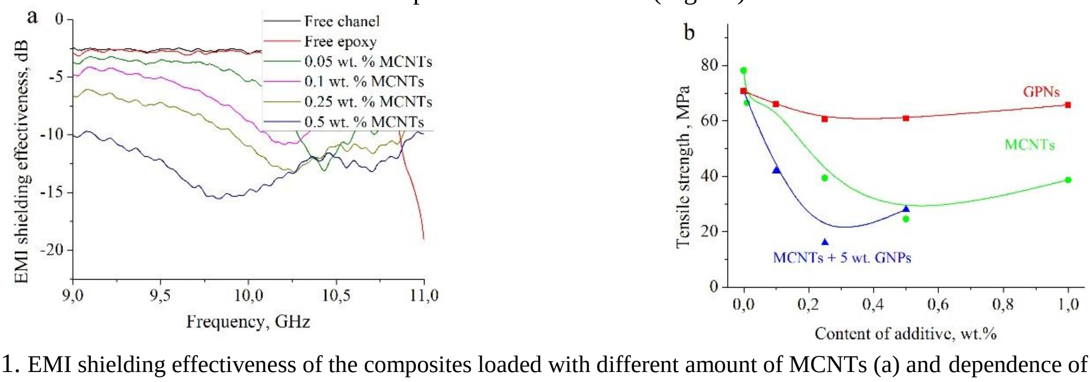

Fig. 1. EMI shielding effectiveness of the composites loaded with different amount of MCNTs (a) and dependence of tensile strength vs. concentration of additives for the epoxy composites filled by different amount of MCNTs, GNPs, MCNTs/GNPs (b)

In conlusion, the conductivity of the prepared composites is determined by the MCNTs concentration. An addition of GNPs to the MCNTs-loaded composites almost does not influence the conductivity of the composites, but improves their EMI shielding effectiveness in X-band frequency range. The MCNTs loading is found to result in the degradation of the mechanical properties of the composites, while addition of GNPs only slightly weakens the tensile strength.

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