THE STUDY OF THE DIFFERENT PERCENTAGE PERFORMANCE OF NANOPARTICLES ON THE PROPERTIES OF EPOXY RESIN

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Abstract: The paper deals with the production and testing of samples of nanocomposite materials based on epoxy resins and measuring their temperature dependences of the dissipation factor, relative permittivity and internal resistivity. The sample microstructure and material composition was studied with a scanning electron microscope.

Keywords: composite, nanoparticulate, nanofiller, epoxy resin, oxides, REM

1. INTRODUCTION

One of the most dynamically growing groups of new materials are currently polymers and composite materials. To improve the properties of composite materials significantly, nanofillers are added to the matrix in order to achieve the best physical and chemical properties. This paper deals with the study of impact of different percentage filling of nanoparticles on the electrical properties of epoxy resin, which has very good mechanical and electrical properties. It was experimentally proved that the use of nanoparticles with a higher permittivity create composites whose permittivity is lower than the permittivity of the base polymer and nanoparticles [1], [2], [3].

2. PREPARATION OF SAMPLES

The basis of the mixture for preparation samples is an epoxy resin CY228, hardener HY918, softener DY045 and accelerator DY062. Production of the sample starts with the correct weighing of individual sub-components of the mixture. Following heating of the mixture (to ensure a sufficiently low viscosity), mixing of the individual sub-components among themselves and vacuum (to remove air bubbles). Then the mixture is poured into a special decomposable mould and again vacuuming. The mixture inserts into the sterilizer after vacuuming in the mould where it is predicated in two phases [2], [4].

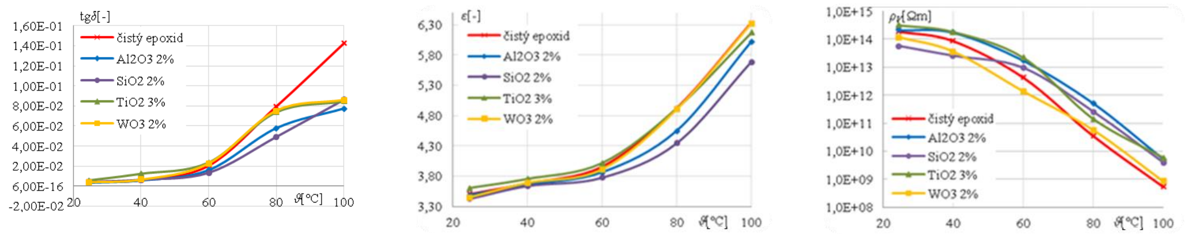
Production of samples with nanoparticles is more complicated compared to production of a pure epoxy samples and also more time-consuming. After addition nanoparticles to the mixture of epoxide, aggregation occurs and the formation of lumps, which bind to themselves molecules of air. It is expected that the formation of lumps should be minimised due to the influence of microwaves. Nanoparticles should be equally distributed in epoxide volume for this case. Unfortunately, this assumption was not proven by our results mentioned bellow.

Nanoparticles of alumina (Al_2O_3), sulfur dioxide (SiO_2), titanium dioxide (TiO_2) and tungsten oxide (WO_3) from Sigma Aldrich Company were used as a filler. The guaranteed size of the nanoparticles was 5-100 nm.

3. EXPERIMENT

Four sets of samples for each filler with 0.25, 0.5, 1, 2 (3 - TiO_2) weight percent were made for our experiment. The values of the dissipation factor tgδ, permittivity ε_r and resistivity ρ_v were determined by measuring. Measurement was carried out for decreasing temperature due to deprivation of possible residual moisture of the samples [2], [4].

The graphs below display wave forms of electrical quantities for each single sample with 2% of the filler which were found the greatest improvement in the electrical properties due to pure epoxy.



(A) **(B)** **(C)**

Figure 1: **A** Comparison of temperature dependences of dissipation factor of pure epoxy and specimens with 2% filler content, **B** Comparison of temperature dependences of permittivity of pure epoxy and specimens with 2% filler content, **C** Comparison of temperature dependences of resistivity of pure epoxy and specimens with 2% filler content.

Owing to the above description, we are able to prepare samples with better electrical properties. Unfortunately, despite the advanced procedure of samples production, aggregation of nanoparticles is still visible in Figures 2 and 3. Figures 2 and 3 show randomly chosen samples observed using a detector of secondary electrons in a scanning electron microscope [5] REM Jeol JSM 6700F at a magnification of 10.000x and 50.000x.

4. RESULTS

The main problem is the inhomogeneity of distribution of nanoparticles in the sample manifested by the formation of lumps, documented by figures 2 and 3. It can be assumed that the optimization of the manufacturing process will be achieved to increase the quality of the samples and particularly their final properties of the described measured electrical parameters.

The samples containing SiO_2 exhibit an influence of the nanoparticles in the entire temperature range. At 100 °C a decrease in the dissipation factor by an order of magnitude occurs. The samples with TiO_2 show an influence on the dissipation factor up to the temperature of 80°C.

The lowest permittivity was encountered in the samples with the 2% filling of Al_2O_3 and SiO_2, in the case of TiO_2 it was 1% (see Fig. 1A).

In the samples containing Al_2O_3 a SiO_2 the impact of the nanoparticles on the intrinsic resistivity is evident in the full temperature range (Fig. 1B). The highest intrinsic resistivity is in the sample with the 0,5% content of SiO_2, apart from the sample with 0,5% of Al_2O_3which has a lower resistivity than pure epoxide.

The most pronounced improvement in the electrical properties of the resulting nanocomposite was achieved by adding Al_2O_3 and SiO_2. The influence of TiO_2 was less obvious, and adding the nanoparticles of WO_3 caused no change in any of the measured parameters.

ACKNOWLEDGEMENT

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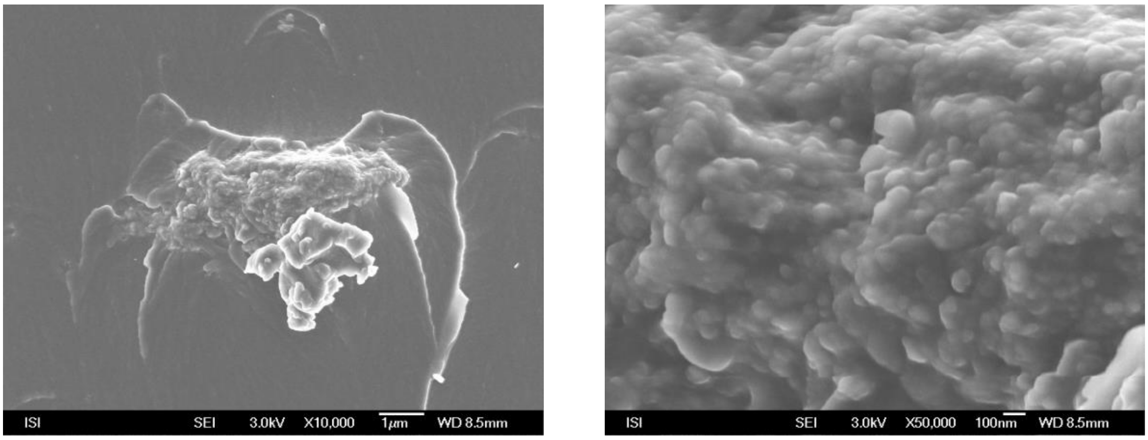

Figure 2: Microstructure of the surface of the epoxy resin with 1 weight percent of filler Al_2O_3 nanoparticles, REM Jeol JSM 6700F

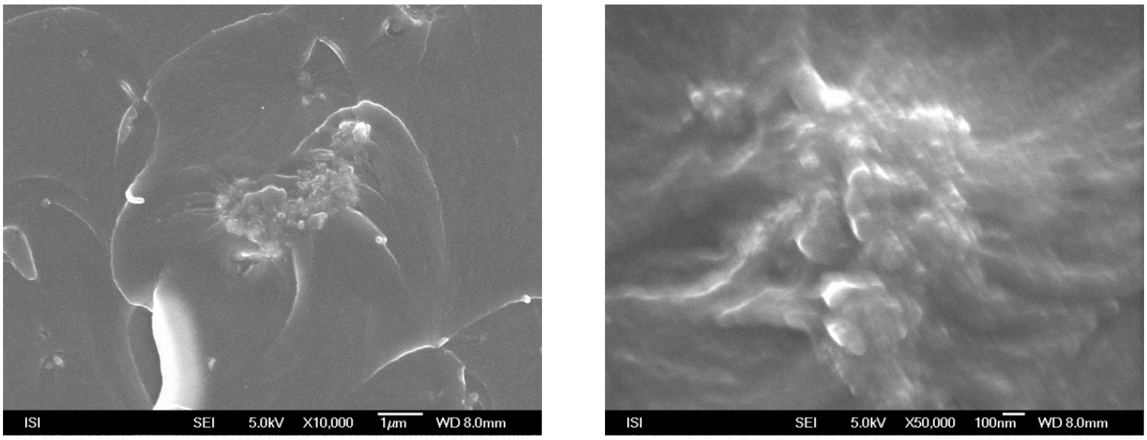

Figure 3: Microstructure of the surface of the epoxy resin with 1 weight percent of filler SiO_2 nanoparticles, REM Jeol JSM 6700F

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