Investigation of nanocomposites based on epoxy resin

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Abstract: The article is devoted to the study of nanocomposites based on epoxy resin and multiwalled carbon nanotubes. Research has shown that the most optimal results were obtained using nanopaste obtained using a dissolver and ultrasound. Studying samples using atomic force microscopy (AFM)

Keywords: carbon multilayer nanotubes, polymer matrix, epoxy resin, atomic force microscopy, physico-mechanical properties.

1. Introduction:

The goal of this study is to improve the strength properties of epoxy resin by adding carbon multilayer nanotubes (CNT) to the DEALTOM composition (Fig. 1), which function as structure-forming agents to organize the polymer matrix's structure. This objective is accomplished by the addition of carbon multilayer nanotubes (CNT) by DEALTOM to epoxy resin ED-20.

2. Literature Review:

At the moment, a new generation of composite materials is produced for a variety of uses using carbon nanotubes (CNTs) (Tomishko M. M., 2008, p. 41). When nanotubes are incorporated into matrices of different materials, new structural, rheological, and physico-chemical properties of composites emerge. These unique mechanical, electrical, and thermal properties of nanostructures underpin their wide range of applications. Metal and polymer materials are frequently employed as matrices.

Reinforcing polymer polymers is one use for carbon nanotubes.

The areas in which the use of CNT mixes is permitted are primarily developing because during the synthesis process, mixtures of nanotubes with various characteristics are created, the separation of which is a challenging work (Dyachkov P.N., 2006)

3. Material and Methods:

Epoxy resin ED-20 was utilized for the investigation, and its composition's component ratios were as follows (Table 1).

An MI 40U testing apparatus was used to measure the strength of the samples.

Atomic force microscopy (AFM) studies of samples were performed in contact mode using a SOLVER PRO probe microscope. Height modes were used to produce surface topography images. 1, 10, and 20 μm^2 are the image sizes. There are two-dimensional (2d) and three-dimensional (3d) image formats available. Using the Image Analysis 3.5.0 data processing application, the statistical parameters arithmetic mean surface roughness (Ra) and measurement error of this parameter (MSE) were computed for each sample based on AFM pictures of the surface. Nine distinct surface areas were measured, including the frame

Table 1. Compositions of nanocomposites

Sample	The composition of the sample
№1	ED20 + PEPPA
№2	ED 20 + PEPA+ 0.01% CNT+ D
№3	ED 20 + PEPA+ 0.005% CNT+ D
№4	ED 20 + PEPA+ 0.001% CNT+ D
№5	ED 20 + PEPA+ 0.01% CNT + D+US
№6	ED 20 + PEPA+ 0.005% CNT + D+US
№7	ED 20 + PEPA+ 0.001% CNT + D+US

By creating concentrations (pastes) of nanoparticles in the liquid phase that are well-suited to the modifying material, the suggested method differs from the traditional technique. An further salient observation is the stability of nanoparticles in their final form following processing as a result of certain additions.

Epoxy resin ED-20 was the medium of choice for making pastes.

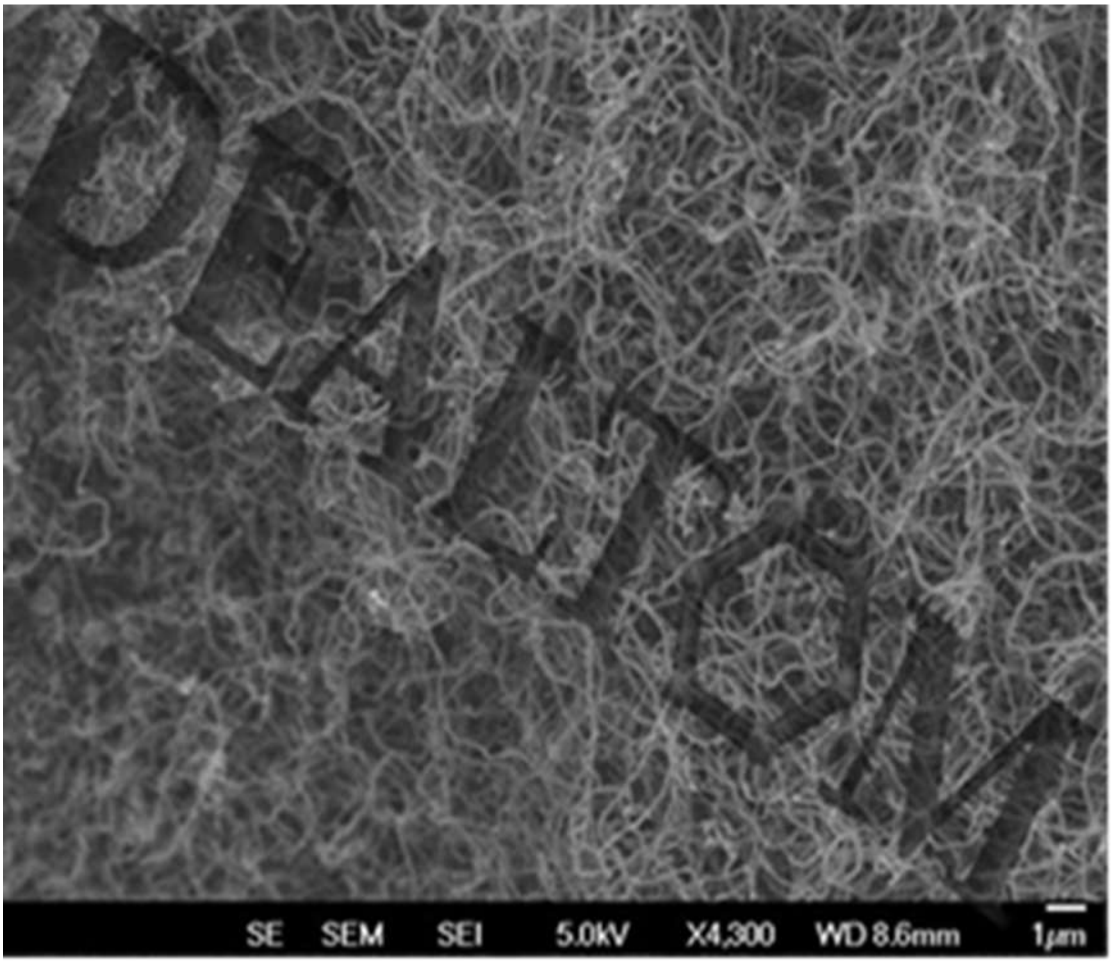

Figure 1. Multi-walled carbon nanotubes DEALTOM. SEM method.

4. Results and Discussion:

Compositions were produced for experimental verification of the intended composition. Subsequently, a dissolver was used to combine the carbon nanotubes with the epoxy resin, spinning at 800 rpm for an hour. Samples and coatings were made in large quantities.

Different nanotube concentrations were chosen. There are several ways to incorporate CMNTs into epoxy resin.

1. Dissolver-based homogenization (D).

2. Homogenization with an ultrasonic unit (US) and a dissolver.

A comparative study of the polymer matrix's distribution, mixing, and manufacturability was conducted. The compositions were cured for seven days at ambient temperature and then for three hours at 70–100°C in a heating cabinet..

D+US was homogenized using a dissolver, and then the UZTA-0.63/22-OM ultrasonic technical device was employed. 60% power for six minutes of exposure. After completion, the paste was combined with ED-20 resin.

Table 2. Physico-mechanical properties of modified CNT and unmodified ED-20-2 resin depending on the homogenization method

№ Sample	Tensile strength, σpp, MPa	Elongation at break, εpp, %
№1	26	3.5
№2	24	2,7
№3	29	2,5
№4	28	2,6
№5	31	2,1
№6	35	2,7
№7	30	1.9

Relative elongation also increases, which is uncommon for polymer composite materials, along with a rise in tensile strength.

Table 3 Arithmetic mean surface roughness of the samples under study (Ra) and measurement error (RMS), calculated from AFM data Ra, nm

Sample	**Ra, nm**	Standard deviation, nm
№1	24,8	6,3
№2	94,8	44,6
№3	48,1	43,5
№4	15,6	5,2
№5	61,1	29,5
№6	18,5	9,8
№7	13,9	3,5

When employing a dissolver for homogenization and when combining a dissolver and ultrasonic with a CNT concentration of 0.005% and 0.001%, the lowest average surface roughness was achieved at a CNT concentration of 0.005%.

Research has indicated that the best outcomes were achieved using nanopastes made by combining ultrasonic, dissolver, and homogenization. A concentration of 0.005% is ideal for carbon nanotubes.

5. References:

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