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Testing of carbon nanotubes and their influence on the physical and mechanical characteristics of polyester resin

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Abstract. Carbon nanotubes have been studied by scanning electron microscopy. Measurement modes - accelerating voltage 10 kV, current in microscopy mode 10'[9] A. The sample was applied to a metal mesh.
Spectroscopic data indicate that this sample consists of carbon (peak at 280 eV). There are no other intense peaks in the spectrum; no impurities were detected by this method. Determination of physical and mechanical characteristics was carried out on a testing machine model N5K-S.

Intorduction

The analysis of the state of the problem has shown that the creation of new types of polymer construction materials using classical methods of filling polymer matrices with traditional dispersed fillers has largely exhausted itself in terms of achieving a new level of performance properties. New breakthrough solutions can be achieved only with the use of the basic principles of nanotechnology, that is, the transition to an ultradispersed state of the amplifying components [1].

In recent years, intensive research has been carried out in Russia and abroad in the field of creating nano structured polymer composites [2]. The structuring of oligomers and polymers with nanodispersed or nanostructured microparticles (nanomodifiers) of artificial or natural origin is one of the ways to obtain new generation polymer materials. Structural control at the nanoscale makes it possible to significantly reduce the defectiveness of the structure and, consequently, to increase the complex of strength and barrier characteristics of both matrix polymers and composites based on them [3]. For the modification of polymers, it is possible to use both natural nanoproducts (montmorillonite, vermiculite, nanosilica) and artificial nanoproducts - fullerenes, carbon nanotubes (CNTs), astralenes, nanodiamonds. CNTs have a large surface area and unique mechanical properties [4-6]. Polyolefins, polyesters, epoxy resins are usually used as a polymer matrix [7].

Research technique

Investigated carbon multilayer nanotubes (CNT) "Taunit" manufactured by "Nanotechcenter" (Tambov). According to the passport data, the outer diameter of the tubes ranged from 15 to 40 nm, the inner diameter varied from 3 to 8 nm, and the length from 2 pm or more. Initial CNTs (Tambov) were studied by scanning electron microscopy. Measurement modes - accelerating voltage 10 kV, current in microscopy mode 10'[9] A. The sample was applied to a metal mesh.

Dispersion of MWCNTs in a polyester resin was carried out using an IL 100-6 / 4 ultrasonic unit, frequency 22 kHz. MWCNTs were added to the polyester resin in various concentrations, the mixture was sonicated until the solid phase was uniformly distributed in the resin. A mixture in which there was no separation of MWCNTs and resin for a long time was taken as a stable dispersed system. Tests of physical and mechanical characteristics were carried out on a testing machine model N5K-S.

Results and its discussion

Investigated carbon multilayer nano tubes (CNT) "Taunit" manufactured by "Nanotechcenter" (Tambov). According to the passport data, the outer diameter of the tubes ranged from 15 to 40 nm, the inner diameter varied from 3 to 8 nm, and the length from 2 pm or more. Initial CNTs (Tambov) were studied by scanning electron microscopy.

Initially, it was necessary to test the CNT for compliance with the passport data. This operation is recognized as necessary by most researchers, since often the declared characteristics of nanostructures do not correspond to reality.

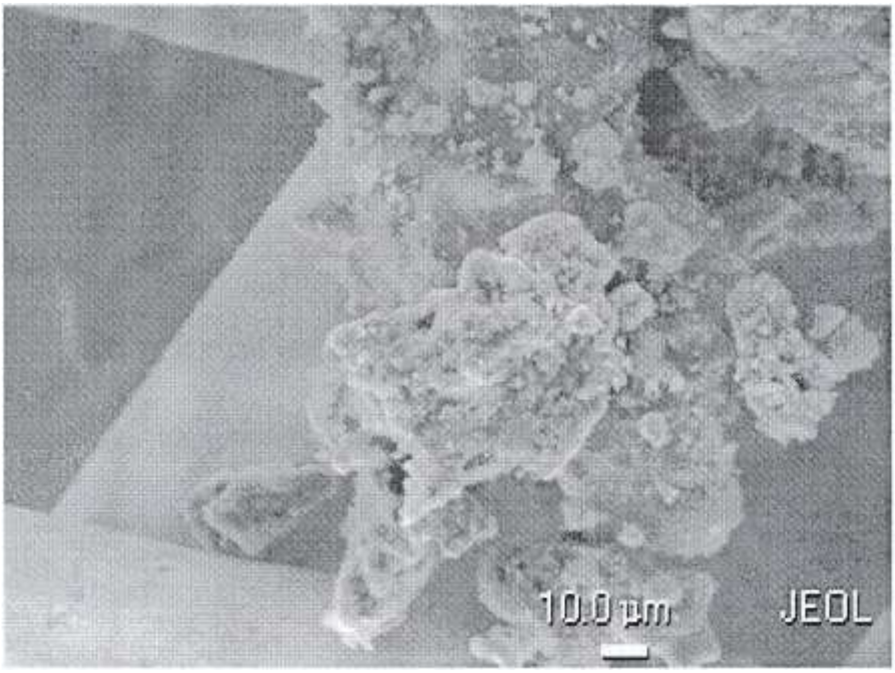

Fig. 1. Image of nanotubes in scanning microscopy mode. Magnification $1 * 10^{3}$

The figures show images of nanotubes with different magnifications (the images show a scale bar in pm). The minimum magnification is 370, the maximum is $1 * 10^{4}$.

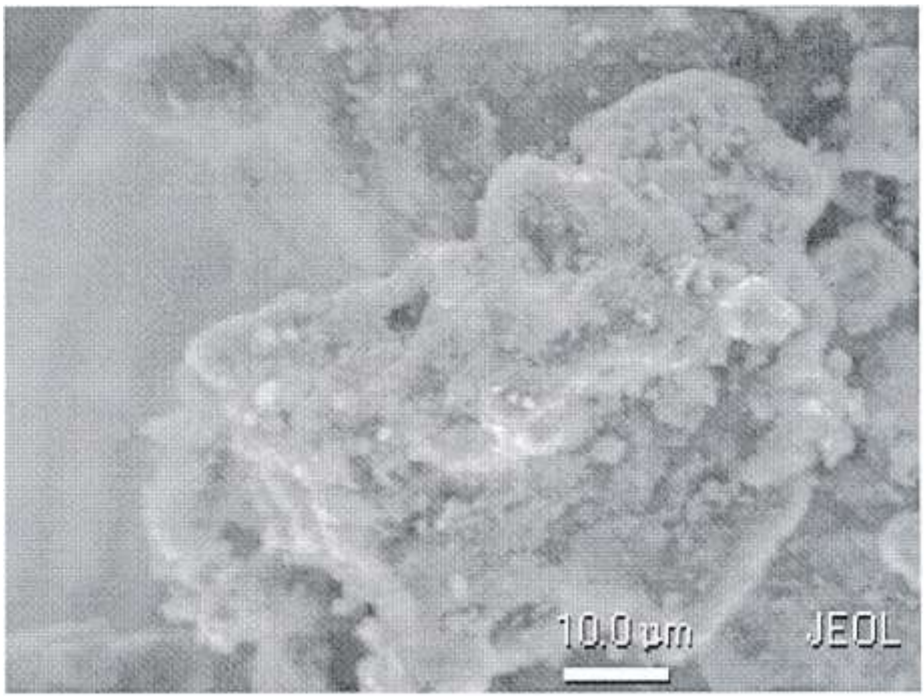

Fig. 2. Image of nanotubes in scanning microscopy mode. Magnification $2 * 10^{3}$

Fig. 3. Image of nanotubes in scanning microscopy mode. Magnification 2.5 * 10^3

It can be seen that the sample has a loose structure resembling cotton wool - intertwined fibers.

Fig. 4. Image of nanotubes in scanning microscopy mode. Magnification 5 * 10^3

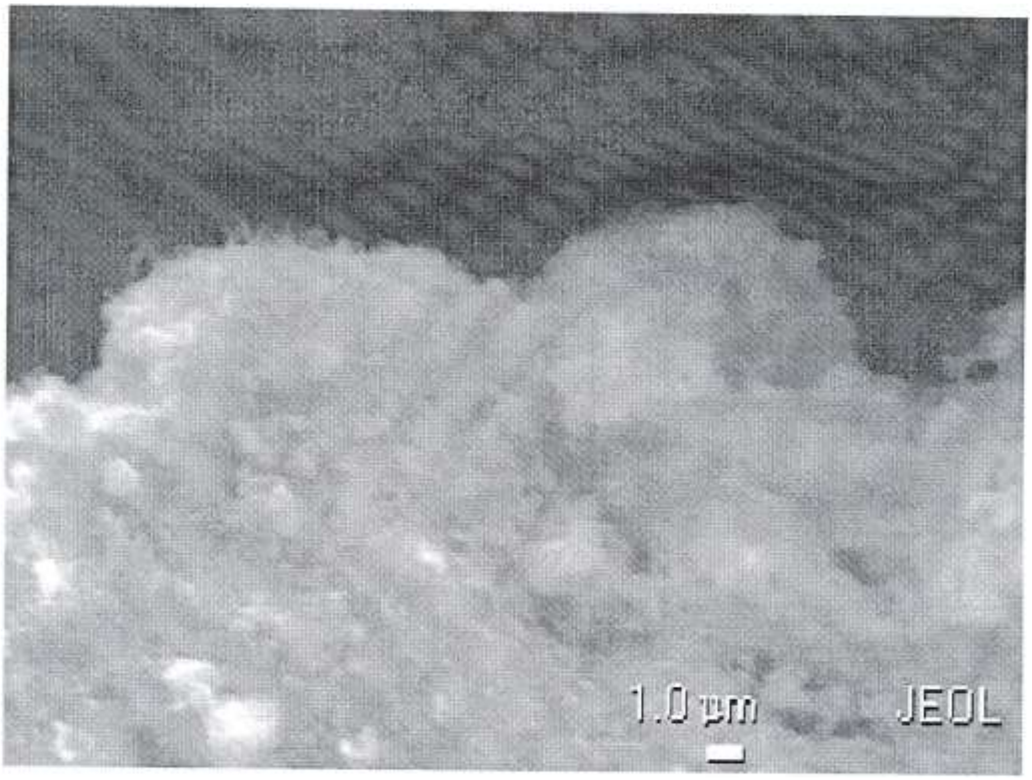

Fig. 5. Image of nanotubes in scanning microscopy mode. Magnification $5 * 10^3$

At the edge of the hills, thin bundles of filaments are visible - apparently nanotubes. The diameter of these beams is, on average, about 70 nm. According to the passport for CNTs, their outer diameter is 15-40 nm. That is, judging by the photo, the size orders are the same. Indeed, this is not carbon black, but a material structured in the nanometer range.

When nanotubes are used as additives in polymer matrices, the particle size is essential.

When dispersing CNds into a polymer matrix, one of the main conditions is the stability of the dispersed system [8]. The degree of dispersion of nanostructures can be increased using vigorous stirring, ultrasonic treatment, chemical and physical modification of the surface of carbon nanoparticles, or a combination of the above methods. One of the effective methods of homogenization is ultrasonic dispersion, in which the MCNT array is crushed into short fragments.

The time of dispersion of MWCNTs in resins to obtain a stable system during ultrasonic treatment depends on the percentage of MWCNTs in the resin and the viscosity of the medium. In more viscous media, a more stable dispersed medium is formed. When using polyester resin as a medium, the time of ultrasonic treatment of the mixture is 0.5-1.0 hours.

Table 1. Physical and mechanical characteristics of polyester resin "Kamfest-01" with MWCNT

PE-MWCNT, [wt%]	0	0,01	0,03	0,05	0,07	0,09
Tensilestrength, [MPa]	45,2	56,95	58,76	55,14	53,78	49,72
Bendingstress, [MPa]	70,78	90,59	89,18	85,64	80,68	77,15

With a further increase in the concentration of PE-MWCNTs, they begin to play the role of a filler and the polymer is a two-phase system consisting of a “solid phase” (near MWCNT particles) and a “soft phase”, which is not affected by MWCNTs.

The introduction of nanotubes into the composite matrix significantly improves the mechanical properties of polymeric materials. In particular, the tensile and bending tensile strength is increased. The resulting composites based on polyester resin and MWCNTs were tested for tensile strength and bending stress. The test results are shown in Table 1.

As the concentration of MCNTs in the polymer composite increases, the tensile strength at break increases and reaches a maximum value at a concentration of 0.03%. A further increase in concentration leads to a decrease in the ultimate strength. For the same composites, the bending stress is maximum at a concentration of 0.01%.

Conclusions

It is certain that the diameter of nanotubes is, on average, about 70 nm. According to the passport for CNTs, their outer diameter is 15-40 nm. That is, judging by the photo, the size orders are the same. Indeed, this is not carbon black, but a material structured in the nanometer range.

New polymer composites with improved characteristics were obtained on the basis of polyester resin "Kamfest-01" of multiwalled carbon nanotubes. The mechanical properties of composites depend on the concentration of nanotubes in the polymer matrix. The tensile strength at break for composites based on polyester resin modified with carbon nanotubes increases 1.3 times compared to polymer without tubes. The bending stress of composites increases by a factor of 1.28.

References

[1] V.V. Karbushev Rheological and mechanical properties of polymers filled with nanosized particles of detonation synthesis diamonds, diss. Cand. chem. sciences. - M .: TIHS RAN, 2010, - p. 24.

[2] Kulichikhin V.G. New approaches to the processing of nanocomposites based on polymer matrices // International forum on nanotechnology "Rusnanotech 08". 2008. Vol.l. M.: "RUSNANO", p. 392-393.

[3] OgrelL.Yu., Strokova VV, Li Yaho, Jan Baode Control of the structure formation of oligomers and polymer composites by inorganic modifiers // Proceedings of the third Voskresensk readings "polymers in construction" . Kazan: KazGASU. 2009. p. 73-76.

[4] Simonyan V.V., Johnson J.K. Hydrogen storage in carbon nanotubes and graphitic nanofibers // Journal of alloys and compounds. 2002. V. 330. P. 659-665.

[5] Gavalas V.G., Andrews R., Bhattacharyya D., Bachas L.G. Carbon nanotube sol - gel composite materials //Nano letters. 2002. V. 1. No. 12. p. 719-721.

[6] Girifalco L.A., Hodak M., Lee R.S. Carbon nanotubes, buckyballs, ropes, and a universal graphitic potential // Physical review B. 2000. V. 62. No. 19. P. 13104-13110.

[7] Badamshina E.R., Gafurova M.P., Estrin Ya.I. Modification of carbon nanotubes and synthesis of polymer composites with their participation // Uspekhikhimii. 2010. T. 79. No. 11. p. 1027-1064.

[8] Aleksashina E.V., Mishchenko S.V., Sotskaya N.V. et al. // Condensed media and interphase boundaries. 2009. T. 11. No. 2. p. 101-105.