

4.3.11. CARBON NANOMATERIALS OF THE “TAUNIT” SERIES – RESEARCH AND APPLICATIONS

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During the last decade intensive researches in the field of carbon nanomaterials were carried out all over the world. As a result of improvement of technologies today carbon nanotubes (CNT) and nanofibers (CNF) are produced in industrial scale in USA, Japan, China, and Europe. Tambov Innovative Center of Mechanical Engineering Ltd. together with NanoTechCenter Ltd., and Tambov Factory “Komsomolets” named by N.S.Artemov Ltd. have developed series of carbon nanomaterials “Taunit” and created technologies of its manufacturing. These technologies are based on the catalytic vapor deposition method with using propane-butane and other hydrocarbons as a source of carbon.

The technological line includes pretreatment of starting components, synthesis of catalysts, pretreatment of hydrocarbons, and synthesis of CNT and CNF in industrial reactor. If needed, carbon nanomaterials obtained are purified from mineral admixtures and chemically functionalized. Today reactor with productivity of 2000 kg carbon nanomaterial per year works. If necessary production of carbon nanomaterials can be scaled in any scope.

Our industrial CNM synthesis reactor was supplied to Sankei Giken Kogyo Co., Ltd. (Japan).

Dependently on technological regimes CNMs of different structure can be obtained. Today following series of carbon nanomaterials is produced:

- CNM “Taunit”, which presents itself carbon nanofibers with cone arrangement of carbon layers, external diameter 30-60 nm, surface area nearly 120 m²/g, bulk density 0.4-0.6 g/cm³.
- CNT “Taunit-M”, presenting itself coaxial carbon nanotubes, external diameter 8–15 nm, surface area nearly 300 m²/g, bulk density 15–30 g/dm³.
- CNT “Taunit-MD”, presenting itself coaxial carbon nanotubes, external diameter 30-60 nm, length more than 10 mcm, surface area nearly 200 m²/g, bulk density 15–30 g/dm³.

As-obtained CNTs Taunit-M and Taunit-MD contain 3–4 wt% of minerals (catalyst). After treatment with acid contents of minerals does not exceed 0.3 wt%.

Along with development technologies of CNMs production we research chemical functionalization of CNM and study fields of its application. Creation of nanocomposite materials containing organic polymers and carbon nanotubes is one of the most promising applications of CNTs today. Introduction of 0.01–1% CNTs results in considerable increase of elasticity modulus, impact toughness, strength, wear resistance, electrical conductivity of polymer materials. There are hundreds of publications and patents in this area. As polymer matrices, polyethylene, polypropylene, polystyrene, rubbers, epoxy- and

phenol-formaldehyde resins, silicones, Teflon, polyamides, and other polymers were studied.

The important condition for obtaining polymer nanocomposites with high mechanical parameters is disaggregation of carbon nanotubes and their uniform distribution in matrix. Different methods of CNTs incorporation in polymers are used. One method is ultrasonic-assisted suspending of nanotubes in organic solvents, mixing with solution of polymer, and evaporation of solvent. Other method consists in direct mixing of nanotubes with liquid oligomers or melted polymers in shear deformation mode. Latex methods are also used.

To achieve good distribution of CNTs in polymer matrix and compatibility with it functionalization of CNTs surface is of valuable importance. For instance, carboxyl, amino-, silicon-organic, and other functional groups can be chemically attached to the surface of CNT. These groups can chemically react with components of polymer matrix and provide good adhesion between matrix and CNTs surface.

It is also promising modifying the CNTs surface with polymer molecules by free-radical initiated polymerization of monomers on the surface of carbon nanotubes. It is also very perspective for different applications modifying of CNT surface with polyaniline, which improve electrochemical parameters of CNTs, as well as adhesion to polymer matrices.

We carry out researches the goal of which is to obtain carbon nanotubes containing on its surface carboxyl, hydrocarbon, and phosphate groups.

For efficient application of CNTs in polymer nanocomposites the quality of starting nanotubes is important. The Taunit-M and Taunit-MD nanotubes developed by us possess very low bulk density, in the range of 15 to 30 g/dm³. This indicates relatively low aggregation of nanotubes. Such materials readily distribute in polymer matrices. Dispersibility of these materials can be improved by pretreatment with ultrasonic in organic solvents.

Using chemical functionalization of CNTs and their dispersing by different methods we obtained concentrated masterbatches of CNTs in epoxy resins, stable concentrated aqueous dispersions of CNTs, which increase strength of concrete. Polyaniline modified CNTs were obtained. Very likely, application of concentrated masterbatches containing CNTs distributed in polymers is the most effective method of preparation CNTs-polymer nanocomposites.

Tambov Innovative Center of Mechanical Engineering Ltd., NanoTechCenter Ltd., and Tambov Factory "Komsomolets" named by N.S.Artemov Ltd. have possibilities for production of different carbon nanomaterials, their modified forms and polymer masterbatches. The manufacturing can be scaled in any needed extent. We are ready for cooperation with all interested organizations.