Opinion

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Nanocomposites Made from Carbon Nanotubes

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Opinion

Polymer is a versatile material with numerous distinct qualities such as low density, decent strength, flexibility, and ease of processing. These materials' mechanical characteristics, however, are insufficient for many technical applications. Polymer nanocomposites are a novel type of composite materials that are gaining traction in both research and industry. Because nano fillers are only a few nanometers in size, they provide an extremely wide interfacial area per volume between the nano-element and the polymer matrix. Carbon nanotubes (CNTs) are long cylinders of covalently connected carbon atoms with unusual electrical and mechanical properties. CNTs are classified into two types: Single-Wall Carbon Nanotubes (SWCNTs), which have a basic cylindrical shape, and Multi-Wall Carbon Nanotubes (MWCNTs), which have coaxial cylinders.

CNTs can be made using one of three methods: arc discharge, laser ablation, or chemical vapour deposition (CVD). The majority of these processes occur in a vacuum or with process gases.

The arc discharge

The carbon arc discharge method, which was originally used to make C60 fullerenes, is the most frequent and possibly the simplest approach to produce CNTs. However, graphitic impurities such as carbon soot including amorphous carbon, anions, and fullerens are produced by this approach. By sending an inert gas at a controlled pressure through the reaction vessel, an inert gas environment is formed.

Laser coagulation

Laser ablation employs an intense laser pulse to evaporate a carbon target that also contains trace amounts of metals such as nickel and cobalt and is placed in a 1200°C tube furnace. As the target is ablated, an inert gas is pushed into the chamber, carrying the newly formed nanotubes on a cold finger for collection.

Deposition of chemical vapours

A mixture of hydrocarbon, metal catalyst, and inert gas is introduced into the reaction chamber during this procedure. At temperatures of 700–900°C and air pressure, nanotubes form on the substrate as a result of hydrocarbon breakdown. The diameter of the nanotubes that will be formed is proportional to the size of the metal particles.

Because of the small size of CNTs, determining their physical properties is more difficult than for other fillers. CNT stiffness was first evaluated by measuring the amplitude of thermal vibrations in Transmission Electron Microscopy (TEM) and obtaining average stiffness values of 1.8 and 1.25 TPa. The in-situ tensile tests on individual MWCNTs and ropes of SWCNTs were carried out by performing a stress-strain measurement within a scanning electron microscope using a "Nano stressing stage" (SEM). A proper dispersion of the filler inside the host matrix is critical for a nanocomposite. At the same time, it is critical to stabilise the dispersion to prevent the filler from re-aggregating. These duties are especially difficult in the case of nanofillers due to their extraordinarily large surface area and strong proclivity to create agglomerates.

CNTs are well recognised for forming aggregates during compounding, hence several strategies, such as sonication or mechanical mixing during the manufacture of nanocomposite, have been employed to alleviate this problem. Surface functionalization of CNTs has been accomplished through a variety of ways, including functionalization of defect groups, covalent functionalization of sidewalls, and non-covalent functionalization, such as the production of supramolecular adducts with surfactants or polymers. Covalent functionalization frequently causes tube fragmentation, but non-covalent functionalization causes poor exfoliation. Changes in CNT characteristics result in poor reinforcing and conductivity.

Non-covalent functionalization offers the unique ability to preserve the intrinsic properties of nanotubes, which is critical for their electrical and thermal conductivity. Several investigations have shown that adding a surfactant or wrapping a nanotube with a polymer can result in individualization of the nanotube in an aqueous or organic solvent. CNT/polymer nanocomposites were created in order to use CNTs and their extraordinary capabilities in real-world applications. Currently, polymer composites are the most common application for carbon nanotubes. These nanocomposites are used in a variety of industries, including transportation, automotive, aerospace, defence, sporting goods, energy, and infrastructure. Because of their great durability, high strength, low weight, design and process flexibility, such materials have a wide range of applications. Because of their strong electrical conductivity, CNT/polymer nanocomposites are also employed as Electrostatic Discharge (ESD) and Electromagnetic Interference (EMI) shielding materials.