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Recent Advances of Carbon Nanotubes in Science and Technology

Skanda M S, Surendar P M, Revanasiddappa M

Abstract: Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. In addition, owing to their extraordinary thermal conductivity, mechanical, and electrical properties, carbon nanotubes finds several applications as additives to various structural materials. Nanotubes are members of the fullerene structural family. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. These sheets are rolled at specific and discrete ("chiral") angles, and the combination of the rolling angle and radius decides the nanotube properties. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by intermolecular force of attraction between π -stacking sp^2 hybridised species. There are different methods which have been developed to produce nanotubes in sizable quantities, including arc discharge, laser ablation, high-pressure carbon monoxide disproportionation, and chemical vapour deposition (CVD). Most of these processes take place in a vacuum or with high temperature and inert gas atmosphere. CVD growth of CNTs can occur in vacuum or at atmospheric pressure. Large quantities of nanotubes can be synthesized by these methods; advances in catalysis and continuous growth are making CNTs more commercially viable. In particular, the exceptional mechanical properties of carbon nanotubes, combined with their low density, offer scope for the development of different kinds of nanotubes are incorporated in the polymer composite materials. The potential for nanocomposites reinforced with carbon tubes having extraordinary specific stiffness and strength represent tremendous opportunity for application in the 21st century. This case study illustrates concise review of recent advances in carbon nanotubes and their composites.

I. INTRODUCTION:

Carbon Nanotubes are long, thin cylinders of carbon which were discovered in 1991 by Sumio Iijima. These are large macromolecules that are unique for their size, shape, and with remarkable physical properties. They have novel properties that make them potentially useful in a wide variety of applications in nanotechnology, electronics, medicine, optics, energy management, chemical processing and other fields of materials science. Nanotubes are members of the fullerene structural family, which also includes buckyballs. Whereas buckyballs are spherical in shape, a nanotube is cylindrical, with at least one end typically capped with a hemisphere of the buckyball structure. Their name is derived from their size, since the diameter of a nanotube is on the order of a few nanometers (approximately 50,000 times smaller than the width of a human hair), while they can be up to several millimeters in length.

There are two main types of nanotubes: single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). These intriguing structures with astonishing properties have sparked much excitement in recent years and a large amount of research has been dedicated to their understanding and development [1-3]. Currently, the physical properties are still being discovered and disputed. Carbon nanotubes have extraordinary electrical conductivity, heat conductivity, and mechanical properties. They are probably the best electron field-emitter known, largely due to their high length to diameter ratios.

CARBON NANOTUBES – A BOOMING FIELD OF SCIENCE AND TECHNOLOGY

The present day generation being very greedy, want all the things to be in their comfort zone. Considering the fact that achieving 1st, A Nano scale is a tough task but once done, gives you great dividends and thrilling rewards. In recent years, miniaturised products have become increasingly dominant in every aspect of life. The benefits of having smaller components, and hence a device with enhanced capabilities and functionalities, are obvious from the following perspectives: smaller systems tend to move more quickly with ease, than larger systems because of lower inertia of mass, the minute sizes of small devices encounter fewer problems in thermal distortion and vibration, and they consume less power and then cost.

Because of these advantages, miniaturisation of systems and nanoscience has become an active area of research. More broadly, nanotechnology includes many structures and techniques at a size scale below 100 nm, including carbon nanotubes, nanocrystals, quantum dots, nanofibers, nonporous filters, nanowires, Nano particulate metal oxides, Nano pillar, dispersion nanoparticles, nanopin film, polymer nanocomposites, and others [4-6].

CNTs can also act as antennas for radios and other electromagnetic devices. Conductive CNTs are used in brushes for commercial electric motors. They replace traditional carbon black. The nanotubes improve electrical and thermal conductivity because they stretch through the plastic matrix of the brush.

II. STRUCTURE OF CNT'S

Carbon nanotubes are sheets of graphite that have been rolled into a cylindrical tube. A graphene sheet can be in rolled more than one way, producing different types of CNTs, (graphene is an individual graphite layer, Fig. 1).

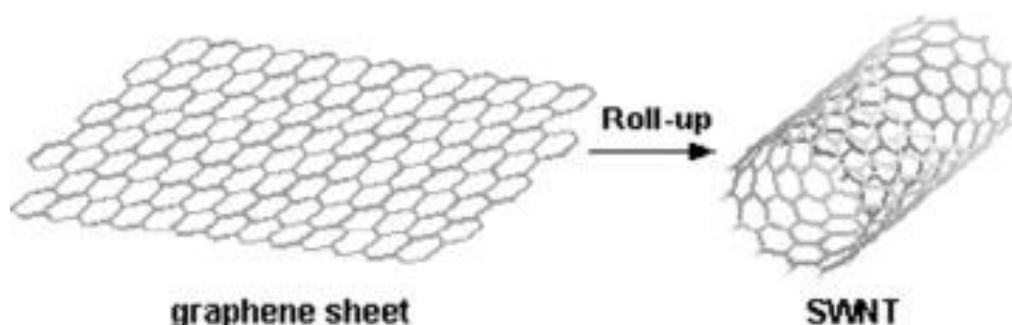


Figure 1 Rolling of a single layer of graphite sheet into SWCNT.

Most important structures are SWCNTs and MWCNTs. A SWCNT is considered as a cylinder with only one wrapped graphene sheet while MWCNTs are similar to a collection of concentric SWCNTs. The length and diameter of these structures differ a lot from those of SWCNTs and, of course, their properties are also very different. The bonding's in CNTs is sp^2 and consist of honeycomb lattices and are seamless structure where each atom is joined to three neighbours, as in graphite.

III. APPLICATIONS AND THE ESSENCE OF USING CARBON NANOTUBES

The special nature of carbon combines with the molecular perfection of single-wall CNTs to endow them with exceptional material properties, such as very high electrical and thermal conductivity, strength, stiffness, and toughness. No other element in the periodic table bonds to itself in an extended network with the strength of the carbon-carbon bond. For example, high-strength steel typically fails at only about 1% of its theoretical breaking strength. CNTs, however, achieve values very close to their theoretical limits because of their molecular perfection of structure. They open an incredible range of applications in materials science, electronics, chemical processing, energy management, and many other fields.

IV. SYNTHESIS OF CNT'S

The way in which CNTs are formed is not exactly known. The growth mechanism is still a subject of study, and more than one mechanism might be operative during the formation of CNTs.

Table 1: Summarises the three most common techniques used in the synthesis of Carbon nanotubes.

Method	Arc discharge method	Chemical vapour deposition	Laser ablation (vaporisation)
Steps involved	Connect two graphite rods to a power supply, place them a few millimeters apart, and the switch is turned on. At 100 amps, carbon vaporises and forms hot plasma	Place the substrate in oven, heat it to 600 °C, and slowly add a carbon bearing gas such as methane. As gas decomposes it frees up carbon atoms, which recombines in the form of CNTs	Blast graphite with intense laser pulses are used rather than electricity to generate carbon gases from which the CNTs are formed under various conditions that produces prodigious amounts of SWCNTs
Typical yield	30–90%	20–100%	Up to 70%
SWCNTs	Short tubes with diameters of 0.6–1.4 nm	Long tubes with diameters ranging from 0.6 to 4 nm	Long bundles of tubes (5–20 microns), with individual diameter from 1 to 2 nm
MWCNTs	Short tubes with inner diameter of 1–3 nm and outer diameter of approximately 10 nm	Long tubes with diameter ranging from 10 to 240 nm	Not of much interest in this technique, as it is too expensive.
Production	Can easily produce SWCNT, MWCNTs. SWCNTs have few structural defects; MWCNTs without catalyst, not too expensive, open air synthesis possible	Easiest to scale up to industrial production; long length, simple process, SWCNT diameter controllable, quite pure	Primarily SWCNTs, with good diameter control and few defects. The reaction product is quite pure
Defects	Tubes tend to be short with random sizes	CNTs are usually MWCNTs and	Costly technique, because it requires

Method	Arc discharge method	Chemical vapour deposition	Laser ablation (vaporisation)
	and directions; often needs a lot of purification	often riddled with defects	expensive lasers and high power requirement, but is improving

V. THE FUTURE OF CARBON NANOTUBES – SUGGESTIONS AND CONCLUSIONS

Nanotechnology is nowadays one of the most important trends in science, perceived as one of the key technologies of the present century and the generations to come. Its applications include the biotechnology and pharmacy fields as well as electronics, scientific tools, industrial manufacturing processes, and introduction of advance materials ... etc.

In this last aspect, nanotechnology includes the production of novel and revolutionary materials of the size of 100 nm or even smaller. Carbon nanotubes may have only recently caught the attention of the world but many advances have been made since their discovery.

They are unique nanostructures which display's the desirable properties of any other known material. The techniques of production have also come a long way but still, more efforts and time is required to make it more efficient and cost effective.

Recently, several studies and researches have highlighted the prospect of using carbon nanotubes as building blocks to fabricate three-dimensional macroscopic (>1mm in all three dimensions) all-carbon devices.

The strength and flexibility of carbon nanotubes makes them a very vital component for its use in controlling other nanoscale structures, which suggests they will have an important role in nanotechnology engineering.

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REFERENCES

- [1] Y.R. Mahajan. (2010, August 10). Carbon nanotubes and the pursuit of body armor [online]. Available: <http://www.nanowerk.com>
- [2] M. Dhinesh Paneer and J. Arun Jacob Packianathan, "Ballistic resistance using carbon nanotubes", Unpublished.
- [3] <http://en.wikipedia.org/www/carbon%nanotube>
- [4] <http://wonderopolis.org/wonder/how-do-bulletproof-vest-work/>
- [5] Chris Scoville, Robin Cole, Jason Hogg, Omar Farooque and Archie Russell, "Carbon Nanotubes".
- [6] <http://www.nanocyl.com/en/CNT-Expertise-Centre/Carbon-Nanotubes>