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A Brief Review on Carbon Nanotube Composites their Properties and their Applications

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Abstract

Carbon Nanotube Composites plays a vital role in or day to day life. Its explicit strength and outstanding mechanical properties makes it even more important to human society welfare. Research has been going on a large scale to know more about the compound and enhance its properties as required by us. This paper throws light on the existing Carbon nanotubes Composites and its mechanical properties. It also enlightens the Application of Carbon Nanotube Composites.

Keywords- CNT; Composites; Mechanical properties of CNT; Applications of CNT

1. INTRODUCTION

Carbon is unique among the elements in its ability to assume a wide variety of different structures and forms. It is now a little more than twenty years since nanotubes were discovered. Carbon nanotubes have unique physical and chemical properties that chemists are trying to better understand through laboratory research. One of the physical properties of carbon nanotubes is that it's possible to make them only a single atomic layer thick. This means that they can be about 1/50,000th the thickness of a human hair.One of the interesting physical properties about carbon nanotubes is that when you have two of them which have slightly different physical structures and they are joined together, the junction between them can function as an electronic device. This electronic behavior depends upon the structure of the two tubes. Currently scientists are trying to make carbon nanotubes in large amounts with a high degree of purity, so that the physical structures are all the same. If they have similar physical and chemical properties then it becomes easier to predict their behavior which would ultimately make them more useful for possible nanosensors. These nanosensors could behave like semiconducting materials in microelectronic circuits, or detect small changes in electric current, or register chemical reactivity, or changes in air pressure or temperature. Since carbon nanotube science is relatively new, scientists from the fields of chemistry, physics and the material sciences are just beginning to unlock its mysteries and hypothesize about its potential applications.

2. NANOTUBE GEOMETRY

There are three unique geometries of carbon nanotubes. The three different geometries are also referred to as flavors. The three flavors are armchair, zig-zag, and chiral [e.g. zig-zag (n, 0); armchair (n, n); and chiral (n, m)]. These flavors can be classified by how the carbon sheet is wrapped into a tube.

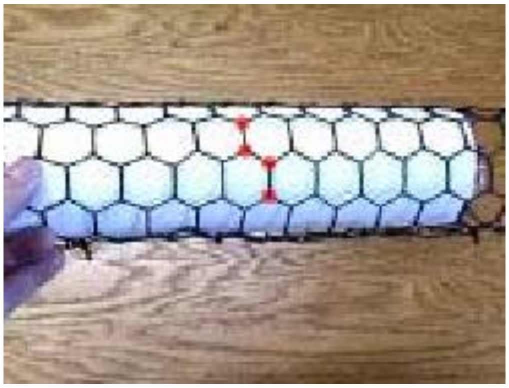

Fig.2.1 Armchair arrangement of carbon atoms

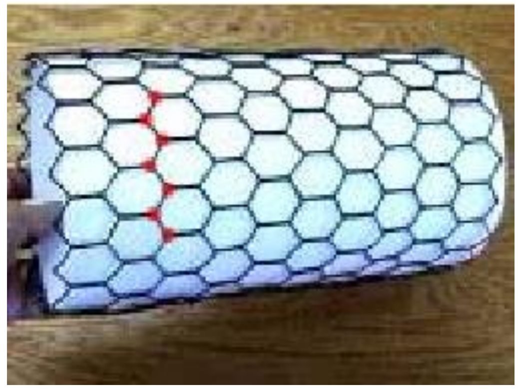

Fig.2.2Zig-zag arrangement of carbon atoms

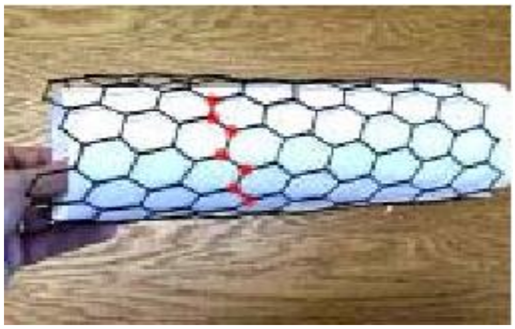

Fig.2.3Chiral arrangement of carbon atoms

2.1 SINGLE-WALL NANOTUBES (SWNT)

Most Single-Walled Nanotubes (SWNT) have a diameter of close to 1 nanometer, with a tube length that can be many millions of times longer. The structure of a SWNT can be conceptualized by wrapping a one-atom-thick layer of graphite called graphene into a seamless cylinder. The way the graphene sheet is wrapped is represented by a pair of indices (n,m) called the chiral vector. The integer‘s n and m denote the number of unit vectors along two directions in the honeycomb crystal lattice of graphene. If m = 0, the Nanotubes are called "zigzag‖, which is named for the pattern of hexagons as we move on circumference of the tube. If n = m, the Nanotubes are called "armchair", which describes one of the two confirmers of cyclohexene a hexagon of carbon atoms. Otherwise, they are called "chiral", in which the m value lies between zigzag and armchair structures. The word chiral means handedness and it indicates that the tubes may twist in either direction.

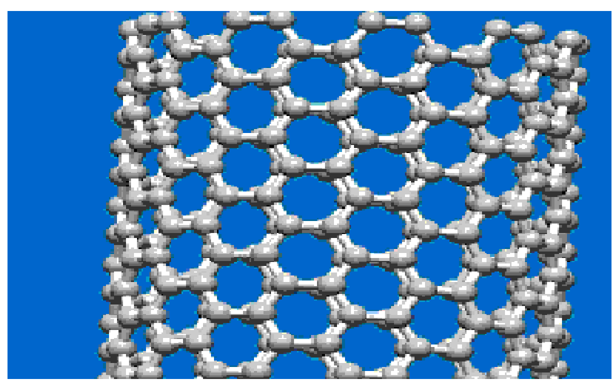

Fig.2.4Single walled Carbon Nanotube

2.2 MWNTS- MULTIPLE WALLED CARBON NANOTUBES

There are two models which can be used to describe the structures of multi-walled nanotubes. In the Russian Doll model, sheets of graphite are arranged in concentric cylinders, e.g. a single walled nanotube (SWNT) within a larger single-walled nanotube. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of parchment or a rolled newspaper. The interlayer distance in multi-walled nanotubes is close to the distance between graphene layers in graphite, approximately 3.3 Å (330 pm). The special place of double-walled carbon nanotubes (DWNT) must be emphasized here because their morphology and properties are similar to SWNT but their resistance to chemicals is significantly improved. This is especially important when Functionalization is required (this means grafting of chemical functions at the surface of the nanotubes) to add new properties to the CNT. In the case of SWNT, covalent Functionalization will break some C=C double bonds, leaving "holes" in the structure on the nanotube and thus modifying both its mechanical and electrical properties. In the case of DWNT, only the outer wall is modified. DWNT synthesis on the gram-scale was first proposed in 2003 by the CCVD technique, from the selective reduction of oxide solutions in methane and hydrogen.

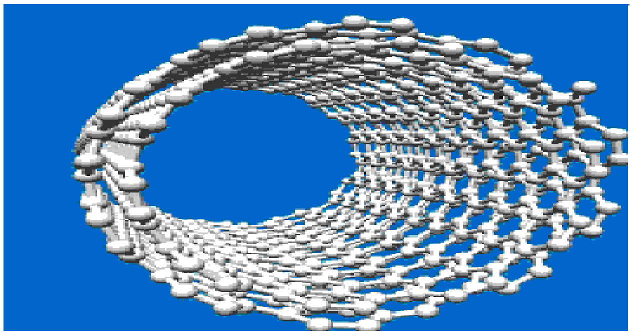

Fig.2.5 Double-wall Nanotubes (DWNT)

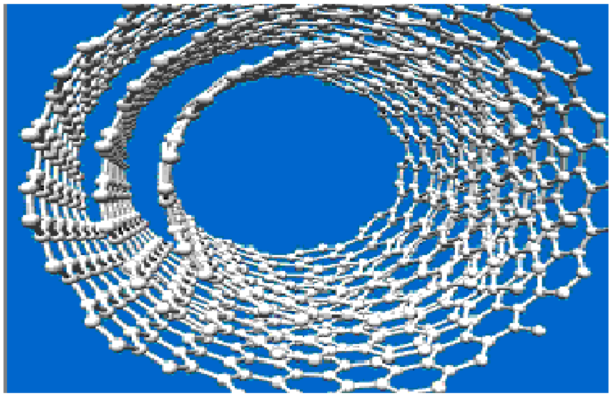

Fig.2.6 Multiwalled Nanotubes

Table2.1-Comparison between SWNT and MWNT

Sr. No.	SWNT	MWNT
1	Single layer of grapheme	Multiple layer of grapheme
2	Catalyst is required for synthesis	Can be produced without catalyst
3	Bulk synthesis is difficult as it requires proper control over growth and atmospheric condition	Bulk synthesis is easy
4	Purity is poor	Purity is high
5	A chance of defect is more during functionalization	A chance of defect is less but once occurred it’s difficult to improve
6	Less accumulation in body	More accumulation in body
7	Characterization and evaluation is easy	It has very complex structure
8	It can be easily twisted and are more pliable	It can not be easily twisted

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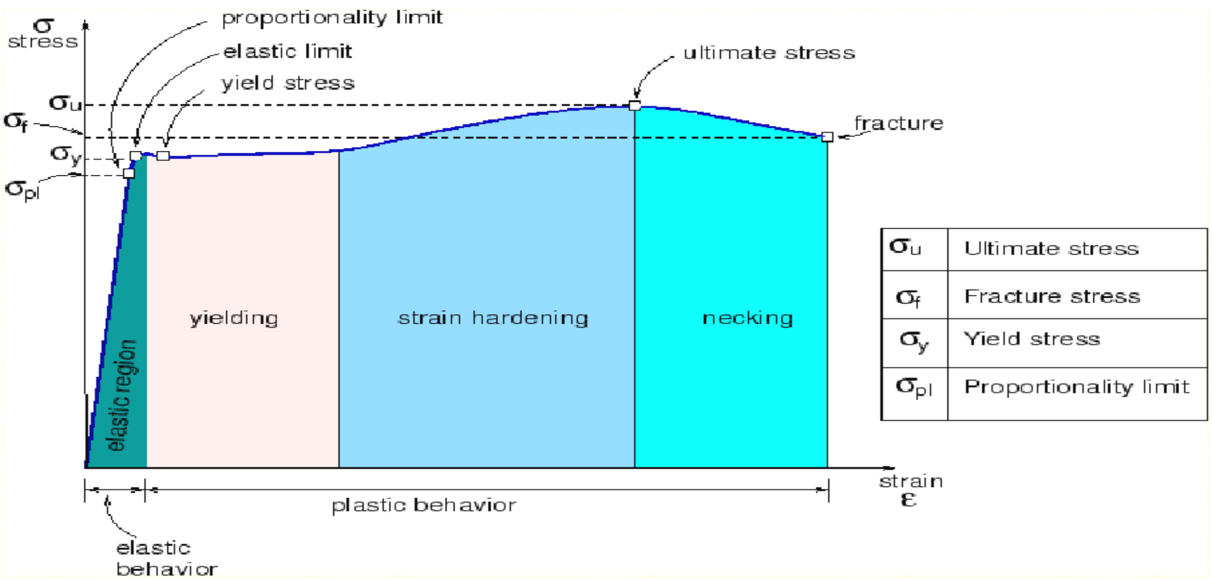
3. PROPERTIES OF NANOTUBES

Carbon nanotubes are long meshed wires of carbon and Longest tubes up to 1mm long and few nanometers thick made.

Property	Carbon Nanotubes	Comparatively
Size	0.6-1.8 nm in diameter	Si wires at least 50nm thick
Strength	45 Billion Pascals	Steel alloys have 2 Billion P.
Resilience	Bent and straightened without damage	Metals fracture when bent and restraightened
Conductivity	Estimated at 109 A/cm2	Cu wires burn at 106 A/cm2
Cost	$2500/gram by BuckyUSA in Houston	Gold is $15/gram

3.1 MECHANICAL PROPERTY

The mechanical properties of carbon nanotubes and their elastic properties and strain-induced transformations are discusses. Only single walled nanotubes are considered as they can be grown with many fewer defects and are thus much stronger. Because nanotubes can be viewed as “rolled-up” graphene sheets, and because graphite is exceptionally strong with respect to in plane deformations, nanotubes possess extraordinary mechanical properties. We focus primarily on two aspects: elastic deformations, where the shape of the nanotube may change but the local atomic coordination does not; and the onset of irreversible behavior, where the atomic structure undergoes irreversible changes. In either case, nanotubes are exceptionally elastic and strong: They can reversibly bend to very high angles, and their tensile strength is unmatched by any known material. The carbon nanotubes are expected to have high stiffness and axial strength as a result of the carbon–carbon sp2 bonding. The practical application of the nanotubes requires the study of the elastic response, the inelastic behavior and buckling, yield strength and fracture as given bellow.



3.2 THERMAL PROPERTIES

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction, "but good insulators laterally to the tube axis. It is predicted that carbon nanotubes will be able to transmit up to 6000 W/mK at room temperature; compare this to copper, a metal well-known for its good thermal conductivity, which transmits 385 W/mK. The temperature stability of carbon nanotubes is estimated to be up to 2800 °C in vacuum and about 750 °C in air. Thermal expansion of CNTs will be largely isotropic, which is different than conventional graphite fibers, which are strongly anisotropic. This may be beneficial for carbon-carbon composites. It is expected that low-defect CNTs will have very low coefficients of thermal expansion.

3.3 CHEMICAL PROPERTIES

The chemical reactivity of a CNT is, compared with a graphene sheet, enhanced as a direct result of the curvature of the CNT surface. This curvature causes the mixing of the π and σ orbital, which leads to hybridization between the orbitals. The degree of hybridization becomes larger as the diameter of a SWNT gets smaller. Hence, carbon nanotube reactivity is directly related to the π-orbital mismatch caused by an increased curvature. Therefore, a distinction must be made between the sidewall and the end caps of a nanotube. For the same reason, a smaller nanotube diameter results in increased reactivity. Covalent chemical modification of either sidewalls or end caps has shown to be possible. For example, the solubility of CNTs in different solvents can be controlled this way. However, covalent attachment of molecular species to fully sp2-bonded carbon atoms on the nanotube sidewalls proves to be difficult. Therefore, nanotubes can be considered as usually chemically inert.

4. APPLICATIONS OF CNTs

Various applications of CNTs are as follows:

1) Carrier for Drug delivery**:** Carbon nanohorns (CNHs) are the spherical aggregates of CNTs with irregular horn like shape. Research studies have proved CNTs and CNHs as a potential carrier for drug delivery system.

2) Functionalised carbon nanotubes are reported for targeting of Amphotericin B to Cells.

3) Cisplatin incorporated oxidized SWNHs have showed slow release of Cisplatin in aqueous environment. The released Cisplatin had been effective in terminating the growth of human lung cancer cells, while the SWNHs alone did not show anticancer activity.

4) Anticancer drug Polyphosphazene platinum given with nanotubes had enhanced permeability, distribution and retention in the brain due to controlled lipophilicity of nanotubes.

5) Antibiotic Doxorubicin given with nanotube is reported for enhanced intracellular penetration.

6) The gelatin CNT mixture (hydro-gel) has been used as potential carrier system for biomedical.

7) CNT-based carrier system can offer a successful oral alternative administration of Erythro-poietin (EPO), which has not been possible so far because of the denaturation of EPO by the gastric environment conditions and enzymes.

8) They can be used as lubricants or glidants in tablet manufacturing due to nano size and sliding nature of graphite layers bound with Vander Waals forces.

9) In Genetic Engineering

10) Biomedical applications etc.

CONCLUSION

This paper describes the review of the structure and mechanical properties of carbon nanotubes. The properties and characteristics of CNTs are still being researched heavily and scientists have barely begun to tap the potential of these structures. Single and multiple walled carbon nanotubes have already proven to serve as safer and more effective alternatives to previous drug delivery. CNTs are an important aspect of human society and hence are the most researched compound in the present era. Its mechanical properties make it superior than any compound present on earth. Hence it is getting a wide range of use in a lot of application and scientific research.

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