Introduction to carbon Nanotube

Carbon Nanotubes
Discovery

Smalley discovered Fullerene, one of carbon allotropes(a cluster of 60 carbon atoms : C60) for the first time in 1985.
Dr. Iijima, a researcher of this new material, of the NEC laboratories in Japan, in 1991 discovered thin and long straw-shaped carbon nanotubes during a TEM analysis of carbon clusters synthesized by the arc-discharge method.

Introduction to carbon Nanotube

1. Carbon nanotubes are tubular forms of carbon that can be envisaged as graphene sheets rolled into cylindrical form.
2. These nanotubes have diameters of few nanometers and their lengths are up to several micrometers.
3. Each nanotube is made up of a hexagonal network of covalently bonded carbon atoms.
4. Carbon nanotubes are of two types: single-walled and multi-walled.
5. A single-walled carbon nanotube (SWNT) consists of a single graphene cylinder whereas a multi-walled carbon nanotube (MWNT) comprises of several concentric graphene cylinders.

Types of carbon Nanotube

Depending on the way of rolling of graphene sheets (as shown in Fig),single- walled nanotubes of different types, viz. armchair, zig-zag and chiral could be produced.

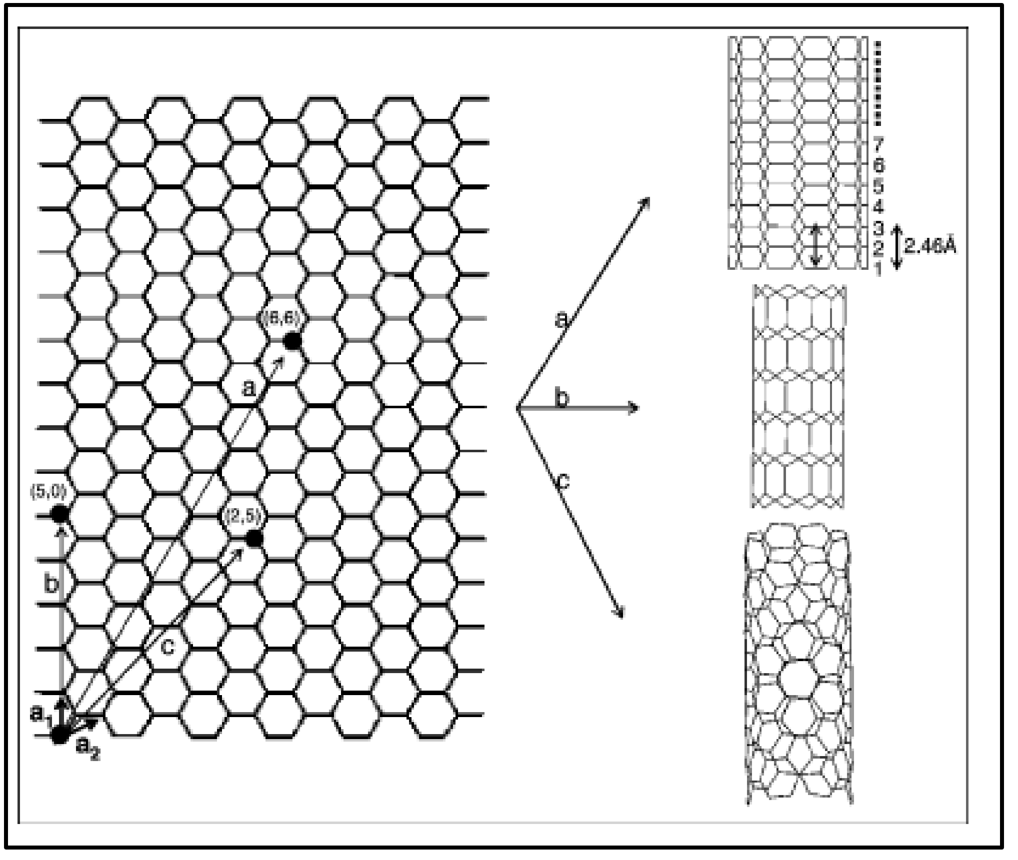
They can be represented using the method given by Hamada.

For example, to realize an (*n*, *m*) nanotube, one has to move *n* times **a**1 from the selected origin and then *m* times **a**2.

On rolling the graphite sheet these points coincide to form the (*n*, *m*) nanotube.

Thus armchair, zig-zag and chiral nanotubes can be represented as (*n*, *n*), (*n*, 0) and (*n*, *m*) respectively

Types of carbon Nanotube



Rolling of a graphite layer to form single-walled carbonnanotubes of (a) armchair, (b) zig-zag and (c) chiral type. The numbering in the case of the armchair nanotube shows the numbering of the layers running perpendicular to the tube axis as described in the text.

Properties of carbon Nanotube

Special properties of carbon nanotubes

Electronic, molecular and structural properties of carbon nanotubes are determined to a large extent by their nearly one dimensional structure.

The most important properties of CNTs and their molecular background are stated below.

Chemical reactivity.

The chemical reactivity of a CNT is, compared with a graphene sheet, enhanced as a direct result of the curvature of the CNT surface.

Carbon nanotube reactivity is directly related to the pi-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.

Though, direct investigation of chemical modifications on nanotube behaviour is difficult as the crude nanotube samples are still not pure enough.

Properties of carbon Nanotube

Optical activity

Theoretical studies have revealed that the optical activity of chiral nanotubes disappears if the nanotubes become larger.
Therefore, it is expected that other physical properties are influenced by these parameters too.
Use of the optical activity might result in optical devices in which CNTs play an important role.

Mechanical strength

Carbon nanotubes have a very large Young modulus in their axial direction.
The nanotube as a whole is very flexible because of the great length. Therefore, these compounds are potentially suitable for applications in composite materials that need anisotropic properties.
Table gives the comparison of Young's modulus, tensile strength and density of carbon nanotubes with some other materials

Synthesis of carbon Nanotube

Synthesis of CNT

There are three commonly used means by which to synthesize carbon nanotubes.

- The first of these methods is **laser ablation**.

  A high power laser is rastered across a carbon target. In the plasma plume that is generated by the laser, provided that appropriate conditions exist, SWNTs form and are collected downstream from the plasma plume on a "cold finger".

- The **Arc-discharge method** synthesizes nanotubes by using a fairly low voltage power supply to strike an electrical arc between two carbon electrodes.

  The carbon anode can be enriched with particles of a transition metal in order to aid synthesis. Nanotubes form in the arc and collect on the anode, along with a host of other carbon byproducts.

  The nanotubes that are synthesized by this means are typically very ropy and multi-walled.

Synthesis of carbon Nanotube

Chemical vapor deposition

- **(CVD)** is the means of synthesis that is of interest for this study. CVD synthesis is achieved by taking a carbon species in the gas phase and using an energy source, such as a plasma or a resistively heated coil, to impart energy to a gaseous carbon molecule.
- Commonly used gaseous carbon sources include methane, carbon monoxide, and acetylene.
- The energy source is used to "crack" the molecule into a reactive radical species.
- These reactive species then diffuse down to the substrate, which is heated and coated in a catalyst (usually a first row transition metal such as Ni, Fe, or, Co) where it will bond.
- The result is that carbon nanotubes will form if the proper parameters are maintained.
- CVD allows the experimenter to avoid the process of separating nanotubes from the carbonaceous particulate that often accompanies the other two methods of synthesis.
- Excellent alignment as well as positional control on the nanometer scale, can be achieved by the use of CVD.
- Control over the diameter, as well as the growth rate of the nanotube can also be maintained. The appropriate metal catalyst can preferentially grow single rather than multi-walled nanotubes.