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Carbon Nanotubes Properties and Applications

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Abstract: The carbon nanotube (CNT) is one of the most important nanotechnology developments. Over the past two decades many researchers around the world have researched CNTs closely because of their huge potential in various fields. CNTs are graphene rolled by hybridization with SP2. The key aspects of CNTs are their lightweight, smaller size with a high aspect ratio, strong tensile strength and good conductive properties, making them useful as fillers in various materials such as polymers, metallic surfaces and ceramics. CNTs haveapplications in the fields of nanotechnology, medicine, transistors, actuators, sensors, membranes and capacitors. There are different techniques that can be used to synthesize CNTs. These include the method of arc-discharge, the chemical vaporizing deposition (CVD), the method of laser ablation and the method of sol gel. CNTs can be multi-walled, double-walled and single-walled. CNTs have distinct mechanical, electrical, and optical properties which have all been studied extensively. The focus of this analysis is on CNTs synthesis, functionalization, properties, and applications. Often described in a condensed way is the toxic effect of CNTs.

Keywords: Carbon Nanotube, Functionalization, Synthesis, Toxic Effect of CNTS.

INTRODUCTION

Carbon contains different structures of the sp2hybridisation. Graphite is a well-known example of this, but now carbon may shape closed and open cages with a honeycomb arrangement alongside graphite.In the class of carbon nanomaterial, graphene is defined as 2D single layer graphite. Graphene is stronger than diamond, because it produces sp2 hybridization that is stronger than diamond sp3 hybridization[1]. Carbon nanotubes are among the most exciting research areas within recent decades. Carbon nanotubes consist of carbon, and it is a tube shaped material. It has too low diameter and is measured by nanoscale. Graphenes that form carbon nanotubes are rolled up into cylinder[2]. The word "nano" comes from the Greek, meaning dwarf (small); medical research at nano level (atomic level) is known as nanotechnology, which has become a well-known field in the last three decades with the aid of special scientific instruments. CNTs, also known as buckytubes, are cylindrical carbon molecules with unique characteristics that make them highly useful for a wide variety[3]. These include applications related to nanoelectronics, optics and materials. Buckyballs are spherical fullerenes (Fig. 1), while CNTs are cylindrical, with at least one end usually capped with a buckyball-structured hemisphere. The name CNT derives from the size, since a nanotube's diameter is on the order of a few nanometers. The researchers concluded that the substance produced consisted of long filamentous or needle-like carbon crystals with a diameter of approximately 50 nm. The existence of nanotubes went almost unnoticed at that time because of a lack of attention to the field of nanotechnology, like a variety of other fields before and after[4].

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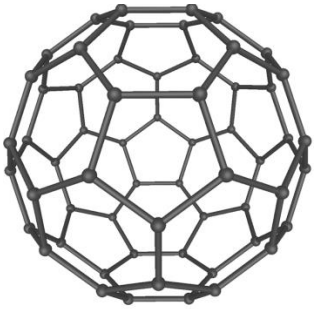

Fig. 1: Fullerene

CLASSIFICATIONS OF CARBON NANOTUBES

CNTs can be classified into two types, based on the number of tubes in the CNTs. Those are listed below[5]:-

1) Single Walled Carbon Nanotubes (SWNT):

They have a one cylindrical wall (Fig. 2). These are only 1-2 nm in diameter, but the length can be a thousand times longer. SWNT is rendered by wrapping a single-atom-thick graphene sheet in a cylinder.Pair of parameters (n, m) represents the way the graphene sheet is wrappedwhere n and m denote the number of unit vectors in the honeycomb crystal graphene lattice in two directions if m=0, they are named zigzag nanotubes, if n = m they are named nanotubes armchairs. They are otherwise called chiral. The diameter is calculable as-

$$d = \frac{a}{\pi}\sqrt{(n^2 + nm + m^2)} = 78.3\sqrt{((n+m)^2 - nm)}$$

Where a = 0.246nm.

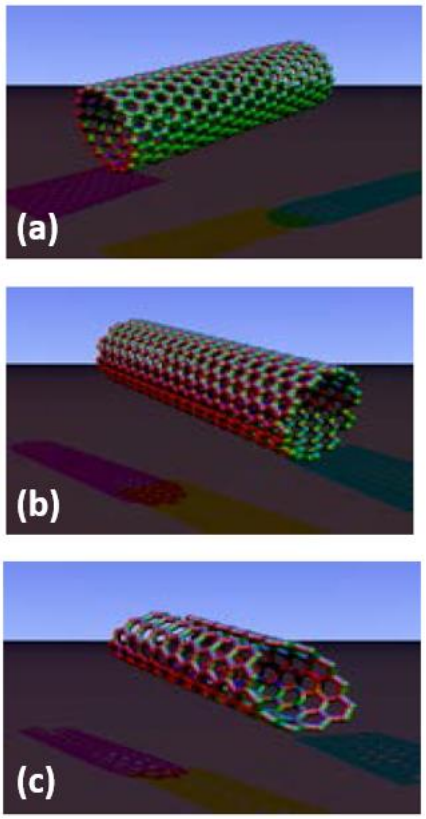

Fig. 2: (a) Zigzag Nanotubes, (b) Armchair Nanotubes, (c) Chiral

Properties of SWNT:

1. They are highly bendable and harder than MWNT.

2. These can be twisted, flattened, bent in two small circles or bent around sharp bends without breaking.

3. These have specific mechanical and electronic properties that can be used in various applications such as displace field pollutants, nanosensors, logic components, etc.

2) Multi walled Carbon Nanotubes (MWNT):

MWNTs consist of several rolled layers of graphene (concentric tubes) (Fig. 3). The outer and inner layer diameters range between 2-25 nm

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and 1-3 nm, respectively. The length is from 1-100 meters[6]. Double-walled nanotubes (DWNTs) are a special class of nanotubes since their shape and characteristics are similar to those of SWNTs but their chemical sensitivity is greatly improved. They consist of precisely two isolated nanotubes, which are 0.35-0.40 nm apart. They may act like metal.

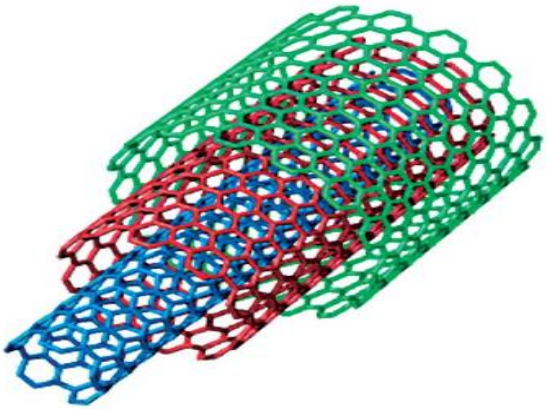

Fig. 3: Multi Walled Carbon Nanotubes

Properties of DWNTs

1. They have each wall's optical and Raman scattering features.

2. These are of four types-metallic-metallic, metallic-semiconducting, semiconducting-metallic and semiconducting-semiconducting-based on the electronic type values of the inner and outer walls.

3. Under intensive chemical, mechanical, and thermal treatments, they have increased lifespan, current densities for field emission, and high stability along with durability.

METHOD OF PREPARATION CARBON NANOTUBES

Plasma based synthesis method (arc discharge method):

Plasma based method or arc discharge method can be used for best quality of nanotubes. It involves two graphite electrodes in the presence of helium, and those two graphite electrodes pass through a current of 50 amperes. This causes graphite vaporization; some of it condenses on the reaction vessel and some of it condenses on the cathode. If users want single walled carbon nanotubes then Co, they can add Ni metals in the anode[7].

Laser Method:

In 1996 Laser was used to generate 70 per cent purity carbon nanotubes. Currently this method is used for carbon nanotubes growth. This process consists of graphite rods and includes a mixture of 50:50 Co and Ni catalysts at 12000C and argon flows through it for sample preparation. In this process metal catalyzes the growth of single-walled carbon nanotubes and also the formation of many side products. By cooling up vaporized species, nanotubes can be built[8].

Chemical vapor deposition:

There are two major problems in the above methods, i.e. controlled synthesis and large-scale production. Chemical vapor deposition process was used in the manufacture of carbon nanotubes in 1996, which is used to produce large quantities of nanotubes. In this phase chamber reaction involves a mixture of nitrogen ethylene and acetylene. During this reaction chamber temperature was 700-9000C and one atmospheric pressure. This approach is used at lower temperatures, and we get the carbon nanotubes well-arranged[9].

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APPLICATIONS OF CARBON NANOTUBES

Nanotechnology applications in different fields have distinctly different demands and are therefore met with different challenges that require different approaches.

The applications are derived from[10]-

1. Nanotubes have peculiar physical properties.

2. The surface area is huge

3. The small size offering extra adjustment possibilities and flexibility to accommodate several functionalities.

4. High Definition TV Phosphors.

5. Used for generation of tissue.

Table 1 shows the discussion on the Synthesis of Carbon Nanotubes:

Table 1: A Summary of the Synthesis of Carbon Nanotubes

Method	Arc discharge method	Laser method	Chemical vaporization method
Process	it involves two graphite electrode in presence of helium and a current of 50 ampere is passed through two graphite electrodes	this process consist of graphite rods and it contain 50:50 catalyst mixture of Co and Ni at 1200^{0}C and argon is flowing through it	in this process reaction chamber contain mixture of nitrogen, ethylene and acetylene. during this temperature of reaction chamber was 700-900^{0}C and one atmospheric pressure.
Conditions	Low pressure inert gas(helium)	Argon gas at 1200^{0}C.	700-900^{0}C temp at one atmospheric pressure
Yield	32-91%	Up to 70%	Up to 100%
SWCNT	Short tubes with diameter .6-1.4nm	Long tubes with diameter 1-2nm	Long tubes with diameter .6-4nm
MWCNT	Short tubes with diameter 1-3nm	they are very expensive and not prepared but can be synthesized	Long tubes with diameter 10-240nm
CARBON SOURCE	graphite	graphite	hydrocarbon
Cost	high	high	low

CONCLUSION

This review paper is focused on the Carbon Nanotubes properties and applications. The purpose of this paper is not only to highlight its unique properties but also its harmful effects that can occur when using very toxic metals.In this study author notice that the best methods for producing carbon nanotubes are chemical vapor deposition because it gives high purity carbon nanotubes. Scientists who are keenly interested in carbon nanotubes and are likely to make more progress in the future.

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