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Carbon Nanotubes and its Application in Nanotechnology

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ABSTRACT

Carbon nanotubes often refer to single-wall carbon nanotubes (SWCNTs) with diameters in the range of a nanometer. Single-wall carbon nanotubes are one of the allotropes of carbon, intermediate between fullerene cages and flat graphene. Carbon nanotubes also often refer to multi-wall carbon nanotubes (MWCNTs), consisting of nested single-wall carbon nanotubes, weakly bound together by van der Waals interactions in a tree ring-like structure. If not identical, these tubes are very similar to long straight and parallel carbon layers, cylindrically arranged around a hollow tube. Multi-wall carbon nanotubes are also sometimes used to refer to double and triple wall carbon nanotubes. Carbon nanotubes can also refer to tubes with an undetermined carbon wall structure and diameters less than 100 nanometers. While nanotubes of other compositions exist, most research has been focused on the carbon ones. The length of a carbon nanotube produced by common production methods is typically much larger than its diameter. Thus, for many purposes, end effects are neglected and the length of carbon nanotubes is assumed infinite. Carbon nanotubes can exhibit remarkable unique properties. These include electrical conductivity, while others are semiconductors. They also have exceptional tensile strength and thermal conductivity, because of their nanostructure and strength of the bonds between carbon atoms. In addition, they can be chemically modified. Thus, due to their variable, unique properties, carbon nanotubes have found applications in many realms such as electronics, optics, composite materials nanotechnology, and other applications of materials science. In addition, carbon nanotubes can be integrated into other molecules to form novel structures with unique properties, different from the individual reactants. These unique products have also found application in many realms of nanotechnology.

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Introduction

Carbon nanotubes (CNTs) are tubes made of carbon with diameters typically measured in nanometers. Carbon nanotubes can be single-wall (SWCNTs) or multi-wall carbon nanotubes (MWCNTs). Single-wall carbon nanotubes (SWCNTs) are nano tubes with diameters in the range of a nanometer. They have a single well. They were discovered independently in 1993 by Iijima and Ichihashi and Bethune *et al* in carbon arc chambers, similar to those used to produce fullerenes. Single-wall carbon nanotubes are one of the allotropes of carbon, intermediate between fullerene cages and flat grapheme Multi-wall carbon nanotubes (MWCNTs) are nanotubes consisting of nested single-wall carbon nanotubes weakly bound together by van der Waals interactions in a tree ring-like structure [1,2]. These tubes are very similar to Oberlin, Endo and Koyama's long straight and parallel carbon layers cylindrically arranged around a hollow tube [3,4]. Multi-wall carbon nanotubes are also sometimes used to refer to double- and triple-wall carbon nanotubes. They have more than one well. Carbon nanotubes can also refer to tubes with an undetermined carbon-wall structure and diameters less than 100 nanometers as discovered in 1952 by Radushkevich and Lukyanovich in 1952 [5].

Synthesis and Purification of Carbon Nanotubes

There are several methods that have been used to synthesise carbon nanotubes. These involve gas phase processes. Three procedures are being used to produce CNTs. These include chemical vapour deposition (CVD) method, the laser-ablation technique, the carbon arc- discharge technique [6-12].

Table: These Methods of Preparation Are Summarized

Method	Arc discharge	Laser ablation	CVD
Yield rate		➢ 75%	➢ 75%
SWNT or MWNT		Both	Both
Advantage	Simple, inexpensive, high-quality nanotubes	Relatively high purity, room-temperature synthesis	Simple, low temperature, high purity, large scale production, aligned growth possible
Disadvantage	High temperature, purification required, tangled nanotubes	Method limited to the labscale, crude product purification required	Synthesised CNT's are usually MWNTs, defects

Nanotube Purification
Depending on the technique of carbon nano-tube synthesis, there are many different methods and procedure used for its purification. The following steps are involved in the purification.

Deletion of large graphite particles and aggregations with filtration, dissolution in appropriate solvents to eliminate catalyst particles and fullerenes, and microfiltrations and chromatography to size separation and remove the amorphous carbon clusters [13]. Purification of MWNTs, resulting from arc-discharge techniques can be achieved using oxidation techniques, which separate MWNTs from polyhedral graphite-like particles [14]. The main disadvantages of this method are the low purity, high destroying rate of starting materials (95%). In addition, the resulting nanotubes formed can react further, due to the existence of dangling bonds [15]. SWNTs can be purified by boiling them in nitric acid or hydrofluoric acid aqueous solutions and then removing amorphous carbon and metal particles [16,17]. Recently, the separation of semi conducting and metallic SWNTs by using size exclusion chromatography (SEC) of DNA dispersed carbon nanotubes (DNA-SWNT) has been reported [18]. Fluorination and bromination processes, as well as acid treatments of MWNT and SWNT material, with the aim of purification, cutting and suspending the materials uniformly in certain organic solvents has been noted [19].

Application of Carbon Nanotubes
Carbon nanotubes have found applications in many realms. They are used in medicine, nanotechnology, manufacturing, construction, electronics etc. These include high strength composites [20,21]. They also have exceptional tensile strength [22]. Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus. This strength results from the covalent sp^2 bonds formed between the individual carbon atoms. In 2000, a multiwalled carbon nanotube was tested to have a tensile strength of 63 gigapascals (9,100,000 psi) actuators energy storage and energy conversion devices, nanoprobes and sensors, hydrogen storage media electronic devices [23-27]. Carbon nanotubes can exhibit remarkable electrical conductivity, while others are semiconductors [28-29].

Band structures computed using tight binding approximation for (6,0) CNT (zigzag, metallic), (10,2) CNT (semiconducting) and (10,10) CNT (armchair, metallic).Unlike graphene, which is a two-dimensional semimetal, carbon nanotubes are either metallic or semiconducting along the tubular axis. For a given (n,m) nanotube, if $n = m$, the nanotube is metallic; if $n - m$ is a multiple of 3 and $n \neq m$, then the nanotube is quasi-metallic with a very small band gap, otherwise the nanotube is a moderate semiconductor. Also, they act as and catalysis and thermal conductivity [30-32]. This is because of their nanostructure and strength of the bonds between carbon atoms. In addition, they can be chemically modified. These properties are expected to be valuable in many areas of technology, such as electronics, optics, composite materials (replacing or complementing carbon fibers), nanotechnology, and other applications of materials science [33,34].

Carbon nanotubes have useful optoelectronic properties. These include absorption, photoluminescence (fluorescence), and Raman spectroscopy properties. Spectroscopic methods offer the possibility of quick and non-destructive characterization of relatively large amounts of carbon nanotubes. There is a strong demand for such characterization from the industrial point of view: numerous parameters of nanotube synthesis can be changed, intentionally or unintentionally, to alter the nanotube quality [35,36].

All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction", but good insulators lateral to the tube axis. An individual SWNT has a room-temperature thermal conductivity along its axis of about 3500 $W{\bullet}m^{-1}{\bullet}K^{-1}$; [70] compare this to copper, a metal well known for its good thermal conductivity, which transmits 385 $W{\bullet}m^{-1}{\bullet}K^{-1}$. An individual SWNT has a room-temperature thermal conductivity lateral to its axis (in the radial direction) of about 1.52 $W{\bullet}m^{-1}{\bullet}K^{-1}$ [37,38]. Carbon Nanotubes can also find applications in Pharmacy and Medicine

The main applications of CNTs in pharmacy and medicine include drug, biomolecule, gene delivery to cells or organs, tissue regeneration, and biosensor diagnostics and analysis. These include: cancer therapy, infection therapy, gene therapy, tissue regeneration, neurodegenerative diseases, antioxidants, biosensors vechicle for diagnosis. Also, for enantio separation of chiral drugs. Extraction of drugs and biochemicals. Before carbon nanotubes can be used in the Pharmaceutical industry, there are three barriers that must be overcome. These are functionalization, pharmacology and toxicity of CNTs. Carbon nanotubes suffer from the lack of solubility in aqueous media. This problem can be overcome via functionalization of the carbon nanotubes with hydrophilic groups. This would improve water solubility and biocompatibility of CNT Another barrier with carbon nanotube is its biodistribution and pharmacokinetics of its nanoparticles, which are affected by many physicochemical characteristics such as shape, size, chemical composition, aggregation, solubility surface and functionalization. Water soluble CNTs are biocompatible with the body fluids and don't impose toxic side effects or mortality [39].

In artificial implants nanomaterials show promise in regenerative medicine, because of their attractive chemical and physical properties [40]. Attachment of nanotubes with proteins and amino acids has been promising. Another area of carbon nanotube application is Tissue engineering. The aim of tissue engineering is to substitute damaged or diseased tissue with biologic alternates that can repair and preserve normal and original functions [41]. In cancer cell identification, Nanodevices are being created that have a potential to develop cancer treatment, detection and diagnosis. Nanostructures are so small (less than 100nm) that the body will excrete them too quickly inorder for them to be efficient in imaging or detection and so can enter cells and their organelles to interact with DNA, RNA and proteins [42-45]. In drug and gene delivery by CNTs, CNTs have the unique properties, such as ultrahigh surface area, which make them promising potential for delivery of drugs, peptides and nuclei acids. There are many barriers with conventional administration of chemotherapeutics agents. These include lack of selectivity, systemic toxicity, poor distribution amongst cells, limited solubility, inability of drugs to cross cellular barriers and lack of clinical procedures for overcoming multidrug resistant (MDR) cancer.

For drug delivery, the general process using CNTs can be briefly resumed as follows. Drug is fixed on the surface or the inside of functionalized CNTs. The conjugate obtained is then introduced into the animal body by classic ways (oral, injection) or directly to the target site through the use of a magnetic conjugate, for example, guided by an external magnet to the target organ, such as lymphatic nodes. The cell ingests the drug CNT capsule and finally the nanotube spills its contents into the cell and thus the drug is delivered [46].

Conclusion
Single wall carbon nanotubes and double wall nanotubes are two forms of carbon nanotubes. The synthesis and purification of carbon nanotubes have been looked at. Carbon nanotubes have found applications in many realms. These include: cancer therapy, infection therapy, gene therapy, tissue regeneration, neurodegenerative diseases, antioxidants, biosensors vechicle for diagnosis, artificial implants. Carbon nanotubes can be modified or functionalized to allow for their ease of functionalization. This improves their water solubility so that they can penetrate tissues easily. These properties have made it possible to use carnon nanotubes in medicine. They have the potential of finding wide application in medicine. The encapsulation of other materials in the carbon nanotubes, will add another dimension for the application of carbon nanotubes in medicine.

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