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Characterization and synthesis of Carbon Nanotubes

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A B S T R A C T

Large-scale production of carbon nanotubes (CNTs), a type of nanomaterial with numerous applications, is undertaken. Studies on animals have demonstrated that exposure to CNTs, particularly a particular kind of multi-walled carbon nanotube. CNTs are utilized as nanocarriers for antitumor drugs, including antibiotics, camptothecin, carboplatin, cisplatin, paclitaxel, Pt (II),and Platinum (IV), and genes, including inclusion body polymer, small busy-bodied ribonucleic acid, oligonucleotides, and RNA/DNA aptamers. This is achieved through acceptable functionalization. A variety of techniques, including chemical vapor deposition, laser ablation, and arc discharge, are used to produce CNTs. CNTs have special mechanical, thermal, electrical, and optical properties that make them useful in a variety of applications. They find use in biomedical applications, drug delivery systems, sensors, implants, tissue engineering, and anticancer therapy. Outstanding advancements have led to a dramatic shift in CNT biosensor modifications. An overview of recent advancements in CNT biosensors is presented in this article, along with a thorough analysis of several strategies for enhancing CNT performance through novel designs.

Keywords: Carbon nanotube, Cyoxicity action, Biosenssors, Malignant Mesothelioma, Cellular assimilation Nanotechnology of drug delivery.

Introduction:

The term of carbon nanotube describe as important bio-material in the nanotechnology. In 1991 carbon nanotube ascertain by Iijima and Ichihashi. Most of carbon nanotubes is refered as CNTs. According to desired properties of CNTs has a wide range of application in pharmaceutical such as a novel drug delivery system,biosensors,,biomedical,some other referances as fabrication technique,but our focus is addition in new approch in pharmaceutical chemistry.Whether they are made of organic or inorganic materials, new nanomaterials often have been examined as closly relation to drugs. CNTs are variations in carbon. Their structure is tubular form, composed of graphite. CNTs have different unique qualities that make them beneficial for nanotechnology research and development of drugs. They have a nanoscale size round and few millimeters long. It has extensive assortment of electronic, structural, thermal, and other characteristics. These attributes differ based on the type of nanotube determined by its length, chirality, diameter,tensile strength,rigidity. Their distinct surface region, rigidity, tensile power.When it comes to producing next-generation composite materials, carbon nanotubes (CNTs) are regarded as one of the best materials because of their high surface area, high aspect ratio, and remarkable material qualities like mechanical strength and thermal and electrical conductivity[1].Despite the aforementioned due to their chemical structure, which restricts their appealing qualities, they have a tendency to clump together and resulting in improved interactions between matrix materials and polymer matrices and the fictionalized CNTs.

There is now more momentum to expand the use of carbon nanotubes are intended in recent advancements techniques for functionalizing them. Organic functional groups are produced through chemical functionalization.The characteristics of nanotubes and expanding the range of uses for them. Various research initiatives committed as a covalent and non-covalent for different application. Operationalized CNTs have produced high-quality nanocomposites with success, showing a wide range of application in optoelectronics, catalysis, and as biological and chemical sensors. Modified CNTs have been used as a unique and adaptable drug delivery mechanism as well as for bone tissue engineering. The synthesis, characteristics, and uses of carbon nanotubes are briefly covered in this review article. This involves the requirement for CNTs to become functional.Techniques and varieties of functionalization, characteristics offunctionalized carbon nanotubes, and their usesin particular with regard to medicine delivery systems, water purification, and the material and biological science

All of the carbon in carbon nanotubes (CNTs) is described as roll-up, tubular covering, single- layer graphene, and developed as of hexagonal round carbon atoms in the benzene category. CNTs have a one-dimensional structure and a distance end to end ratio of 1000.Their is distinct types of carbon nanotubes are possible in addition to the two basic structures. Armchair carbonnanotubes, zigzag carbon nanotubes, and chiral carbon nanotubes are these three varieties of CNTs. Depending on how the graphite is "rolled up" during the creation process, different types of carbon nanotubes are produced. The radius of the closing cylinder and the rolling axis's selection in relation to the grapheme sheet's hexagonal network of certain carbon atom. The tensile strength of carbon nanotubes is greater than that of Kevlar and steel. The sp2 bonds that hold each individual carbon atom together are give them their strength. This bond is more powerful than the diamond's sp^3 bond. Individual nanotubes can form bonds with one another under high pressure, exchanging

some sp^2 bonds for sp^3 bonds. Long nanotube wires could be produced as a result of this. In addition to being strong, carbon nanotubes are elastic. Ananotube can bend when you press on its tip without causing any damage to it; when the force is released, the nanotube returns to its original shape[2].

The elasticity of a nanotube has a limit, and it can permanently change into the shape of a nanotube when subjected to extremely high forces. Defects in a nanotube's structure can reduce the nanotube's strength. Atomic vacancies or a rearrangement of the carbon bonds cause defects. A small portion of a nanotube may weaken due to structural flaws, which subsequently lowers the nanotube's overall tensile strength. the tensile strength of a nanotubeis determined by the strength of the weakest segment within the tube.

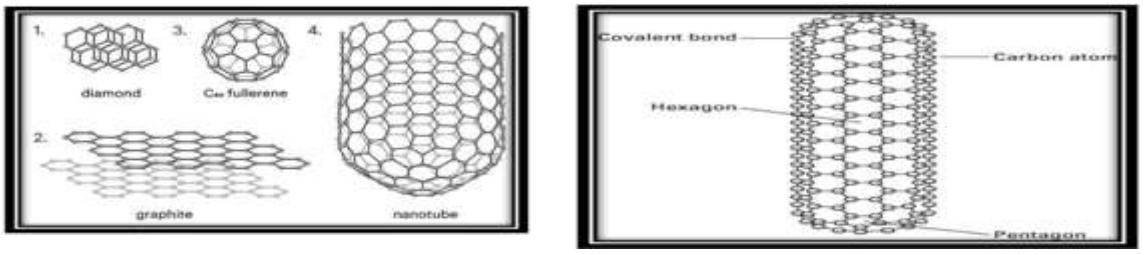


Fig 1: Structural elucidation of carbon nanotube

Classification CNT:

Carbon nanotube is a nanostructure which composed with a allotropes of carbon atom. Depending on their structure of nanotubes they are classified in two types followed by SWCNTs and MWCNTs. SWCNTs stand for Single walled carbon nanotubes and MWCNTs stand for Multiple walled carbon nanotubes[3].

Single walled carbon nanotubes:

The formation of single-walled carbon nanotubes can take three different forms: Armchair, Chiral, and Zigzag. These forms are determined by the manner in which the graphene is wrapped into a cylinder. To visualize one of these forms, roll a piece of paper from one corner; for another, roll the paper from the edge. The structure of a single-walled nanotube is represented by a pair of indices (n,m) known as the chiral vector; this vector is defined in the picture below. The structural design has a direct effect on the nanotube's electrical properties. When $n - m$ is a multiple of 3, then the nanotube is described as "metallic" (highly conducting), otherwise the nanotube is a semiconductor. The Armchair design is always metallic while other designs can make the nanotube a semiconductor.SWCNTs have a 1-2 nm of circuit. The SWCNTs blend needed a specific stimulus in order to form nanotubes. The mass unification of SWCNTs is problematic because they needed the proper reform overextension and uncommon air condition. It has to be synthesized with a catalyst. SWCNTs lack a complex structure and are not well purified. It twists easily.

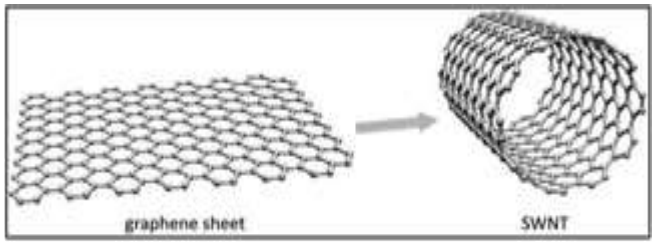


Fig 2: Single walled Carbon nanotubes.

Multiple walled carbon nanotubes:

There are two multi-walled nanotube structural models. A carbon nanotube with an inner nanotube (whose diameter is smaller than its outer) is enclosed by an outer nanotube in the Russian Doll model. A single graphene sheet is repeatedly rolled around itself in the Parchment model, giving the appearance of a rolled-up scroll of paper.The feature of multi-walled carbon nanotubes are comparable to those of single-walled carbon nanotubes, but the outer walls of multi-walled carbon nanotubes can shield the inner carbon nanotubes from external materials through chemical interactions. In comparison to single-walled nanotubes, multi-wallednanotubes exhibit a greater tensile strength.The width of MWCNTs' graphene multilayers variesfrom 2 to 50 nm, depending on how many graphene cylinders are present. The distance between these graphene cylinders is 0.34 nm. MWCNTs are more virtue-filled than SWCNTs and can be delivered by the mass union without the need for additional encouragement[3].

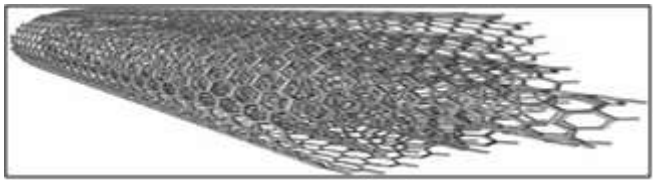


Fig 3: Multiple walled carbon nanotubes.

Cellular assimilation of CNTs

The unique properties of CNTs make it possible for a wide variety of cells to readily absorb them. For instance, CNTs' needle-like form makes it possible for them to effectively pass through cell membranes, which, depending on the intended medical application, may or may not be advantageous. Because of this, CNTs have the potential to be used in a wide range of biomedical applications, most notably in the delivery of drugs and genes.There are still a lot of unanswered questions regarding the mechanisms of cellular uptake and the cellular pathways that are triggered when CNTs are used in drug or gene delivery systems, despite the abundance of studies conducted on the subject.18 Naturally, internalization of CNTs and their cargo must be thoroughly examined since it affects not only how CNTs are absorbed by cells but also their quantity and ability to transport a medication[5].

There is no one mechanism for the cellular uptake of carbon nanotubes (CNTs), as will be explained in the following section, and multiple pathways have been identified based on the characteristics of the CNTs. CNTs cellular internationalization can happen by diffusing across the lipid bilayer of the cellular membrane via a needle mechanism or passive pathway. CNTs are able to get through these obstacles thanks to their high respect ratio and needle-like structure.Endocytosis is another pathway for CNT internalization and can be classified into five types:44 caveolin-mediated endocytosis, clathrin/caveolae independent, phagocytosis, pinocytosis (primarily micropinocytosis), and receptor-mediated endocytosis.An endocytic pathway called phagocytosis allows cells to take up large particles, about 1 μm in size[5].

In particular, a number of methods have been put forth to explain how CNTs internalize, including:

i. Direct penetration through the cell membrane.

ii. Passive uptake and endocytosis mechanisms.

iii. Active uptake.

Table no1: Representation of cell mechanism for CNTs

Sr.no	**Types of carbon Nanotube**	**Cell Type**	**Mechanism**
1.	SWCNTs	Macrophage cell	Phagocytosis
2.	SWCNTs	Murine macrophages cells	Micropinocytosis
3.	MWCNTs	TTI Cell	Micropinocytosis
4.	CNTs	Cancer cell	Clathrin- mediated endocytosis
5.	MWCNTs	Plant cell	Passive diffusion

Method for synthesis of CNTs:

There is various approaches to create CNTs in lab quantities with varying morphologies and structures, several methods have been devised. Chemical vapor deposition (CVD), laser ablation,and arc discharge are the three processes most frequently used to create CNT. Three essential components are needed for the creation of nanotubes: a carbon source, a catalyst, and enough energy.

Chemical Vapour deposition:

The process used to produce CTNs on a large scale is called chemical vapor deposition, or CVD. Using this technique, the carbon precursor and CNT decompose on the catalyst particle surface.Using metallic nanoparticles as catalysts, the CVD method breaks down a gaseous or volatile carbon compound. The nanoparticles also act as sites where carbon nanotube growth can start.CVD has been demonstrated to be the more effective way to produce carbon nanotubes on a large scale.To synthesize CNTs is essentially a two-step procedure. Initially, physical vapor deposition, sputtering, dip coating, etc. are used to prepare the catalyst. After that, the substrate is heated to 500–1000°C in a gaseous environment that is rich in carbon[9].

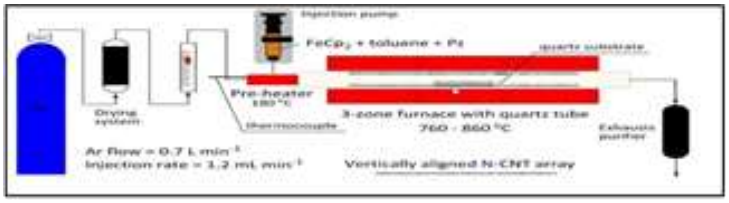


Fig4:Chemical Vapour deposition.

laser ablation:

In this process, carbon vapor is released from graphite by applying laser pulses to a target thatis heated to 1200°C. The carbon is moved by inert gases, such as helium, toward the reactor's colder surfaces, where it eventually condenses into nanotubes. Collecting nanotubes occurred on colder surfaces. This method produces high-quality SWCNTs with controlled diameter at a cost that is higher, at 70% yield. The reaction temperature (RT) can be used to examine this.The following method's yield of CTNs is completely temperature dependent. The growth temperature, type of gases, laser, catalyst composition, and gas pressure can all be changed to alter the average diameter and size distribution of nanotubes.

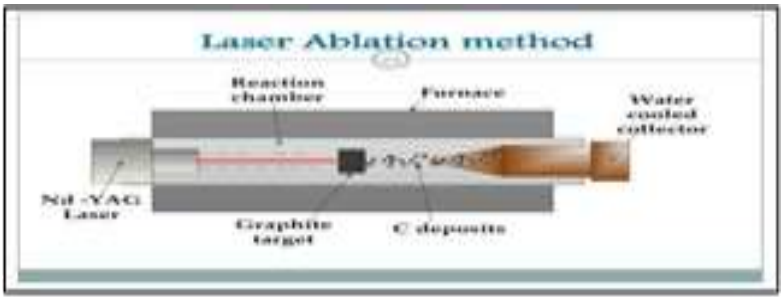


Fig5: laser ablation

Arc discharge:

The arc evaporation production method, which involves 50 amps of current flowing between two distinct graphite electrodes with helium environments, is thought to be the best methodfor producing CNTs of the highest quality.This is the most straightforward and widely used method for producing nanotubes. The arc discharge method, which mostly relies on the atmospheric conditions, produces nanotubes at high temperatures. circumstances andcatalyst.As a result, other substances will condense on the cathode electrode and graphite will vaporize and condense on the wall of the chemical reaction pan. This material builds up on a cathode called carbon nanotubes (CNTs). SWCNTs produced by adding more metal to the anode electrode along with copper (Co), nickel (Ni), and other elements[14].

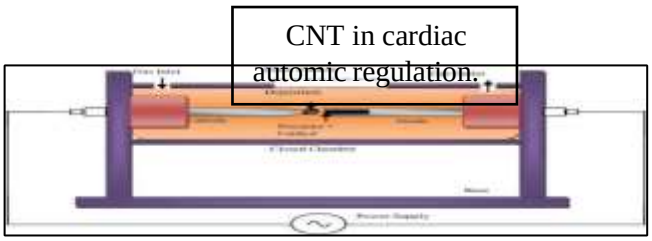


Fig6: Arc discharge

Properties of CNTs:

i. High thermal physical phenomenon.

ii. argentiferous or semi-metallic behavior &

iii. High area.

iv. Tensile Strength.

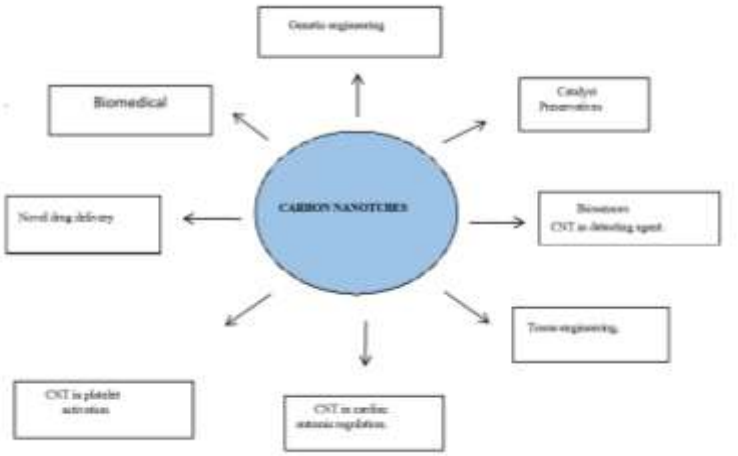
v. Ordered structure with a high ratio.

vi. Ultralight weight.

vii. High mechanical strength.

viii. High electrical physical phenomenon.

Application:



Role of CNT:

i. Drug Delivery.

ii. Cancer.

iii. Biosensor.

iv. Human safety

i. Drug Delivery:

Nanotube technology is currently being utilized in the rapidly expanding field of drug delivery. Dendrimers, polymers, and liposomes are some of the drug delivery systems now in use, but carbon nanotubes offer the chance to work with efficient structures that have strong drug loading capacities and good cell penetration attributes. Medication delivery systems are typically created to enhance a medication molecule's physiological and therapeutic properties. Both high and low drug molecules can be encapsulated in carbon nanotubes (CNTs) due to theirhuge inner volume. Additionally, it enables the encapsulation of both lipophillic and hydrophilic medications. In the case of multi-drug therapy, more than one medication may also be put into CNTs[10].Carbon nanotubes can be manufactured with or without end caps due to their tube structure, which means that an end cap would make the interior, where the medicine is stored, more accessible.Ligands and diagnostic materials can also be synthesized and conjugated to thesurface of CNTs to target the medications to a particular site of action. When the loaded pharmaceuticals are released over a predetermined amount of time, the CNTs can function as acontrolled release system[13].

ii. Cancer: (Mallignant Mesothelioma)

In order to successfully treat cancer and provide medical assistance, CNT–polymer hybrid nanomaterials are now being employed to deliver biologically active therapeutic molecules intothe tumor site. Six The main focus of nanomedicine in oncology is the development of safer and more affordable methods for prompt diagnosis and prudent drug administration in cancer therapy.Malignant pleural mesothelioma (MPM) is the term for malignant mesothelioma (MM),an aggressive neoplasm with a poor prognosis that primarily affects the mesothelial lining cells of the pleura. First discovered in 1956 in South Africa's Cape Province, the link between MPM and asbestos exposure was later verified by numerous epidemiological studies.Another benefit is the distribution of many therapeutic agents for improved therapeutic efficacy in conjunction with medical care. The specific binding of medicine to the targeted cancer cells, concurrent mental imaging of tumors via novel imaging techniques, accumulated drug circulation times, controlled drug unharness mechanics, and higher dose planning for compliance of improved patients are frequently the opposite crucial edges of nanomedicines[16].

Cytotoxic medications like doxorubicin and prodrugs like cisplatin and paclitaxel can be transported across the cellular membrane by CNTs acting as biological carriers. Drugs may be delivered to (specific) cancer cells via CNTs, maybe producing better effects than medications without a carrier. It is possible to lower systemic toxicity and raise therapeutic molecule concentrations in tumors through targeted medication administration. Furthermore, by adjusting the pH, it is possible to control the release of medications from carbon nanotubes (CNTs), thereby enhancing their therapeutic efficacy[17].

Without endangering receptor-free normal cells, selective internalization of SWNTs within cells tagged with folate receptor tumor markers, and NIR-triggered cell death allowed for the targeted elimination of cancer cells. Therefore, when appropriate functionalization chemistry and intrinsic optical features are combined with carbon nanotubes' carrying capabilities, new classes of innovative nanomaterials for cancer therapy and drug delivery can be created.

iii. Biosensor:

The basic idea behind electrochemical biosensors is that a biological event is converted into an electrochemical signal by use of a two or three electrode electrochemical cell (reference, working, and counter electrode). The superiority of CNT-based electrochemical biosensors in biological applications can be attributed to their high sensitivity, low production cost, rapid response, ease of use, and prospective portability.Together with high biological qualities, an ideal biosensor should also have good physical and chemical properties. Because CNTs are easily able to pass through biological membranes, they can be used in vivo with little intrusiveness and are also being used in photoacoustics. There are several ways to disperse and functionalize CNTs to make them biocompatible.

The density of surface functional groups decreases with increasing CNT toxicity, and increases with decreasing CNT toxicity.Because of their incredibly low detection limit, carbon nanotubes (CNTs) are frequently used as working electrodes for sensing devices [24–26]. Enzyme adsorption benefits from CNTs' hollow shape. As a result, CNTs are always utilized in amperometric CNT-based biosensors to functionalize with enzymes to create enzyme-CNT electrodes or to alter the electrode surface. To aid in the electrooxidation of nicotinamide adenine dinucleotide-based biosensors, Eguılaz et al., for instance, demonstrated that covalently functionalized SWCNT with polytyrosine electrode has an efficiency to create surfaceQuinone groups[18].

iv. Human safetey:

The growing use of carbon nanotubes (CNTs) and the accompanying worries about their possible toxicological and environmental effects draw attention to the unmet need for a consistent, science-based method to evaluate the risks and exposures associated with them from a life-cycle perspective and to give policymakers accurate information on these risks. This endeavor is complicated by problems with CNT taxonomy, measurement standardization, and knowledge gaps about toxicity and environmental impact[19].

Conclusion:

This review focuses on the use of CNTs for drug and gene delivery, which is one of the most significant biomedical uses for them. This review is an update on our earlier work on drug delivery and covers a wide range of research studies.The development of MPM and lung damage associated with CNT exposure have not been thoroughly studied. The development of malignancy by CNTs is more intricate than MPM related to asbestos.As a result of their distinct physicochemical properties, CNTs are more varied.The creation of biosensors based on carbon nanotubes possess a wide range of characteristics that call for collaboration between engineers and materials scientists to fabricate novel devices like biosensors.eThe scientific community hasbecome interested in CNTs because of their special qualities and extensive applications across many fields of study and technology. However, they also have certain drawbacks that make them less suitable as materials for the suggested uses. Because the functionalized CNTs offer the potential for additional chemical derivatization, they are more vrsatile and can be used in a wider range of fields, including materials science, biomedical science, and water purification. Functionalized carbon nanotubes have been extensively researched and employed as effective adsorbents to remove harmful contaminants

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