# MULTIDISCIPLINARY RESEARCH

Prof. Rajani Shikhare

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# Carbon Nano tubes in Biomedical Applications

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**Background:**

Nanotechnology involves minimization of the size of molecules which are 1-100nm in size and designed in such a way that it acts at bimolecular level. Nanotechnology-based delivery systems are benefiting the consumers by improving the therapeutic index and reducing the side effects. CNT offers attractive biomedical application towards the targeting efficacy of itself to the nucleus of the cells imaging and therapy. Surface modification methods are very useful to make biocompatibilities of CNT in biological systems and also improve propensity to cross cell membranes. Functionalized CNT can be developed as biomedical application.

**Method:**

There are two methods of functionalization, i.e., covalent functionalization and Non-covalent functionalization. In the non-covalent method (Physical modification), interaction is achieved without disturbing the system of graphene sheets. Whereas in case of covalent functionalization, interaction is achieved by disturbing the graphene system. This could be done by exposing the CNTs to a severe environment like concentrated sulfuric acid ($H_2SO_4$) or nitric acid ($HNO_3$) which causes high instability and breaking of hexagonal structure within the surface architecture which is responsible for the generation of reactive regions on the surface. To these reactive surface surfactants, polymers and biopolymers can be bonded involving $\pi$–$\pi$ stacking. This extension of pi electrons helps in improving the conductance of material and thereby increases its application in several fields.

**Results and Discussion:**

Covalent and noncovalent SWCNT surface modifications enable their use as delivery agents and as Nano sensors: covalent chemical functionalization has been used to add synthetic handles to attach cargo useful for molecular recognition and targeted delivery 7–9. Whereas non-covalent chemical functionalization is a preferred approach for sensing applications.

**Conclusions**:

CNTs have a unique set of electrical, mechanical and thermal properties. Due to the greatest potentials of CNTs, it is clear that novel technologies Nano tube functionalization methods which disperse CNTs well lead to less toxic CNTs.

**Keywords:**

CNT, Nanotechnology, Surface modifications and biomedical application.

**Introduction :**

**Nanotechnology:**

Nanotechnology brings evolutionary changes to everyday life. The word "Nano" is from the Greek, meaning dwarf (small); scientific treatment at the Nano level (atomic level) with the help of special scientific instruments is known as nanotechnology, which has become a well-known field in the last three decades[1-2]. The word "nanotechnology" was coined by Norio Taniguchi in 1974, in Japan. Nanotechnology is a vast field which explores many facts about the structures and properties of materials.

**Carbon nanotubes (CNT) :**

CNTs are the members of the fullerene family, which was discovered by Kroto et al.[3] in 1985. Buckyballs are spherical fullerenes, whereas CNTs are cylindrical, with at least one end typically capped with a hemisphere with the buckyball structure. The name CNT derives from the size, as the diameter of a nanotube is on the order of a few nanometers.[4]. The discovery of nanotubes passed almost unnoticed due to lack of attention to the field of nanotechnology at that time, like a number of other areas before and after[5].

**Structure of CNTs :** CNTs, also known as tubular fullerenes, are cylindrical graphene sheets of $sp^2$ -bonded carbon atoms.

**Types of CNTs:** CNTs can be divided into three categories on the basis of the number of tubes present in the CNTs. These are described below.. Single-walled CNTs

**Single-walled CNTs (SWCNTs)** are made of a single graphene sheet rolled upon itself with a diameter of 1–2 nm (Fig. A).

The length can vary depending on the preparation methods.

**Double-walled CNTs:** These nanotubes are made of two concentric carbon nanotubes in which the outer tube encloses the inner tube, as shown in (Fig.B.)

**Multi-walled CNTs:** These tubes have an approximate inter-layer distance of 0.34 nm (Fig.C) [7].

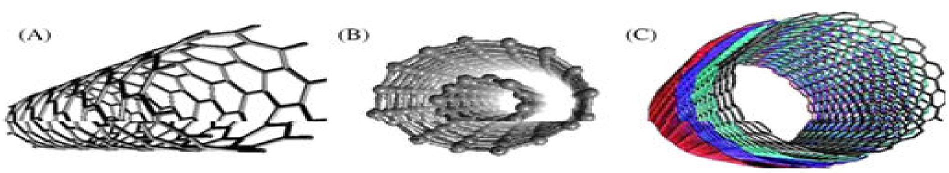


Figure 1. (a) Single-walled CNTs
(b) Double walled l- CNTs (c) Multi-walled CNTs

**Source:**

Modified with permission from Beg, S.,Rizwan, M.,Sheikh, A.M.,Hasnain, M.S.,Anwer, K.,Kohli, K., 2010. Advancement in carbon nanotubes: basics, biomedical applications and toxicity. J. Pharm. Pharmacol. 63, 141-163

**Functionalization of Carbon Nanotubes :**

The process of functionalization imparts high solubility with enhanced biocompatibility to the CNTs. Accordingly, functionalized and accumulated in organs. The process of functionalization imparts high solubility with enhanced biocompatibility to the CNTs. Accordingly, functionalized CNTs are highly suitable for encapsulation of therapeutic molecules for multimodal targeted delivery[6]. Functionalization is broadly classified into two major categories: non covalent functionalization and covalent functionalization. Various approaches for functionalization of CNTs are elaborated below:

**Covalent Functionalization :**

Covalent functionalization creates a more secure conjunction of functional groups, surfactants, polymers, drugs, or other biomacromolecules[7]. In order to achieve such types of functionalization, CNTs are subjected to treatment with chemical and high temperature reflux conditions. Complete control over such chemo- or region-selective additions, however, is somewhat tricky to achieve, as it involves particular groups,. Moreover, such reactions often require extreme conditions for covalent bonding. Furthermore, characterization of such functionalized nanotubes to determine the precise functionalization location and mode of addition are also very difficult. In drug delivery perspectives, the direct covalent functionalization of drug molecules to CNTs surface have been less reported in literature. However, for therapeutic biomacro molecules, such as proteins, peptides, DNA, and siRNA, covalent functionalization has been widely practiced (Chen et al., 2011a).

**End-defect functionalization :**

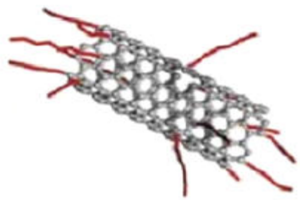

Figure: 2.(a) End Defect Functionalization

This is a special type of covalent functionalization, where oxidation of native pristine CNTs is carried out using strong acids, such as $H_2SO_4$ or $HNO_3$. This causes reduction in the length of CNTs, followed by ring opening at both the ends. Furthermore, it generates carboxylic groups at the "end," on the surface of tips, after the ring opening due to 1,3-dipolar cycloaddition reaction. Consequently, the process is also called carboxyl functionalization, which is used for increasing the dispersibility of CNTs in aqueous solutions[8].

**Side-wall functionalization :**

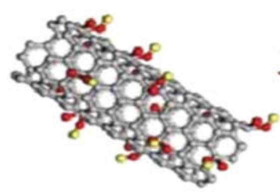

Figure: 2(b) side-wall Functionalization

Such functionalization is primarily used for the dispersion of CNTs in aqueous solutions, which can be assisted by covalent binding of surfactants, proteins, and peptides on the surface of CNTs. Furthermore, sidewall functionalization can also be achieved by directly reacting CNTs with organic species such as nitrenes, carbenes, and other radicals to generate respective functional moieties. In this regard, SWCTs are more susceptible toward sidewall functionalization than MWCNTs. CNTs reportedly have extremely high surface areas, large aspect ratios, and remarkably high mechanical strength.

**Multifunctional applications of Carbon Nanotubes :**

Carbon nanotube-nano reservoirs

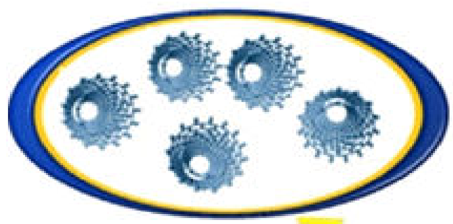

Figure 3. CNT as nanoservoirs

CNTs have been recently used as nanocarriers for controlled drug delivery of therapeutic molecules, due to their electric property and hollow tubular structure. Likewise, selective functionalization of CNTs with polymers having electrical conductivity provides controlled drug delivery upon electrical stimulation. The f-CNTs also have beneficial aspects of delivering several hydrophobic biomolecules (e.g., proteins, peptides, nucleic acids, enzymes) to enhance their bioavailability.[3]. Functionalized CNTs have been used for the delivery of biomolecules and drugs to the desired sites.

**Conclusions:**

With the remarkable development of nanotechnology-based approaches in healthcare sector, CNTs always regarded as a new and interesting type of materials, have a unique set of electrical, mechanical and thermal properties.,it is clear that novel technologies Nanotube functionalization methods lead to less toxic CNTs especially for wide-ranging applications to biomedical and engineering.

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