International Interdisciplinary Virtual Conference on
'Recent Advancements in Computer Science, Management and Information Technology'
International Journal of Scientific Research in Computer Science,
Engineering and Information Technology | ISSN : 2456-3307 (www.ijsrcseit.com)

Carbon Nanotubes in Biomedical Applications

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ABSTRACT

Nanotechnology involves minimization of the size of molecules that are 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. Surface modification methods are very useful to make biocompatibilities of CNT in biological systems and improve propensity to cross cell membranes. Functionalized CNT can be developed as biomedical application.

Keywords: CNT, Nanotechnology, Surface modifications, biomedical application.

I. INTRODUCTION

Nanotechnology: Nanotechnology brings evolutionary changes in everyday's life. It has become a well-known field in the last three decades [1, 2]. Nanotechnology explores many facts about the structures and properties of materials. CNTs (Carbon Nano tubes) are the members of the fullerene family 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. CNTs, also known as sp2 -bonded carbon atoms [4, 5].

Types of CNTs: CNTs can be divided into three categories on the basis of number of tubes present in the CNTs.

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

Multi-walled CNTs: These tubes have an approximate inter-layer distance of 0.34 nm (Figure 1.C) [7].

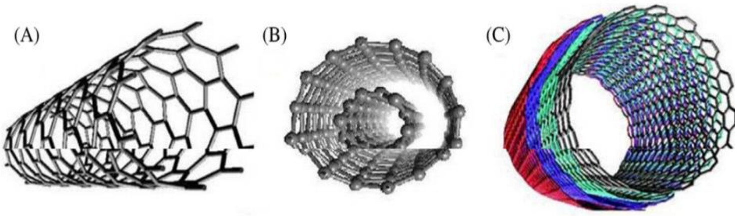

Figure 1. (a) Single-walled CNTs (b) Double walledl- CNTs (c) Multi-walled CNTs

[Source: Beg, S.,.... 2010. 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. Functionalized CNTs are highly suitable for encapsulation of therapeutic molecules for multimodal-targeted delivery [6]. Functionalization is broadly classified into two major categories: noncovalent 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, Drug molecules to CNTs surface have been for therapeutic biomacromolecules,

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]

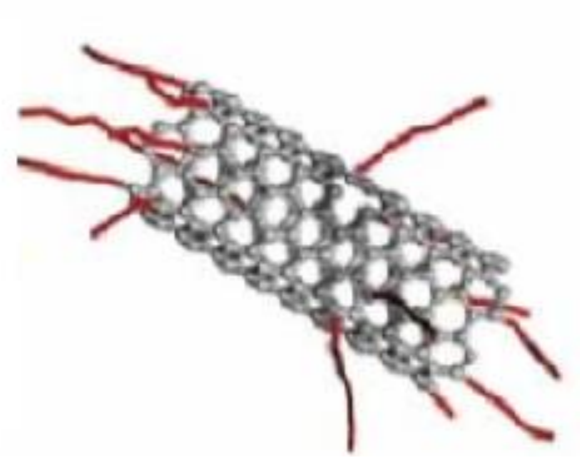

Figure 2.(a) End Defect functionalization

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, SWCNTs are more susceptible toward sidewall functionalization than MWCNTs . CNTs reportedly have extremely high surface areas, large aspect ratios, and remarkably high mechanical strength.

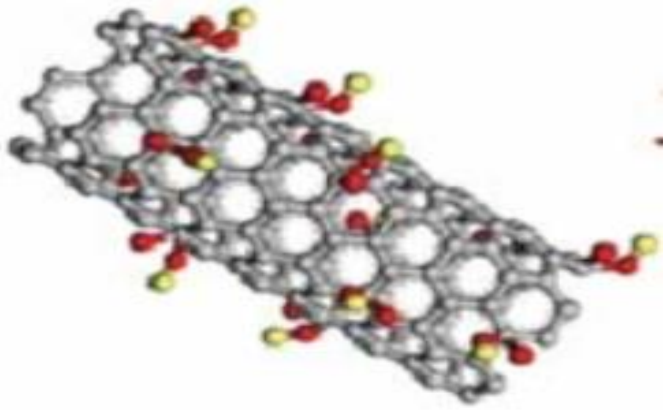

Figure 2(b) side-wall Functionalization

Multifunctional applications of Carbon Nanotubes

Carbon nanotube-nanoreservoirs 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. Functionalized CNTs have been used for the delivery of biomolecules and drugs to the desired sites.

Figure 3. CNT as nanoreservoirs

II. METHOD

Non-covalent method (Physical modification), interaction is achieved without disturbing the system of graphene sheets.[9,10] This could be done by exposing the CNTs to a severe environment like concentrated sulfuric acid 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.

III. RESULTS AND DISCUSSION

Noncovalent SWCNT reactive surface surfactants, polymers and biopolymers can be bonded involving π-π stacking. This extension of pi electrons helps in improving the conductance of material and thereby increases its application in several fields. Use as delivery agents, chemical functionalization is a preferred approach for sensing in nanosensors.

IV. CONCLUSION

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.

V. ACKNOWLEDGEMENT

The Authors are thankful to Sarwar Beg and Jurgen Abraham for understanding functionalization of Carbon Nanotubes as a smart and nanocarriers.

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