

# Carbon Nanotubes in Colon Cancer Therapy: A Review



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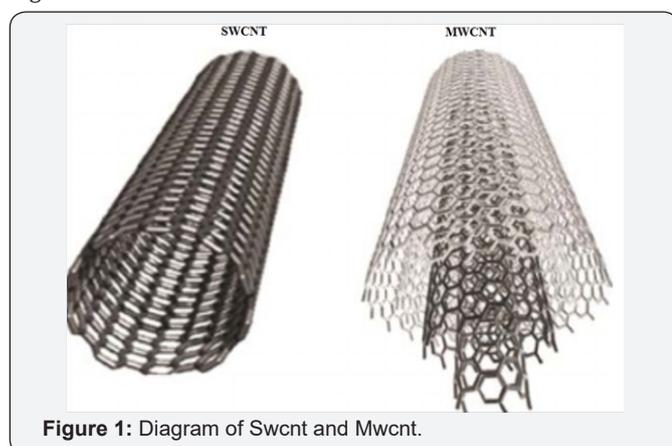
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## Abstract

Carbon nano tubes (CNTs) are allotropes of carbon with cylindrical shape and of nano size range. It comprises of graphene sheets rolled up into a seamless cylinder that can be either open ended or capped, with a high aspect ratio with diameters up to 1nm or a length of several micrometers. Due to its unique structural, mechanical and electrical properties it has varied applications in medical, biomedical field, nano technology, tissue engineering, etc. The use of CNTs especially for cancer treatment and diagnosis is on the rise. This article highlights about its various application and its role especially in cancer treatment.

## Introduction

Carbon nano-tubes (CNTs) are allotropes of carbon with a cylindrical shaped nanostructure [1]. They are made up of cylindrical carbon molecules possessing remarkable properties, which are exploited in the field of electronics, nanotechnology, optics, materials science and technology. Their unique properties include its exceptional mechanical geometrical and electrical properties, thermal conductivity, stiffness, strength [2,3]. CNTs are categorized based on their structure as single-walled nanotubes (SWNTs) comprising of a single graphite sheet wrapped into a cylindrical tube and multi-walled nanotubes (MWNTs) consisting of an array of such nanotubes concentrically nested together resembling the rings of a tree trunk as shown in Figure 1.



## Applications

CNTs are one of the promising nanomaterials having wide application in the field of biomedicine. It is used in the cancer treatment and diagnosis. They have been studied for intracellular delivery of peptides, proteins, drugs, fluorescence contrast agents for MRI. They are also used in vaccine development [4]. Functionalized CNTs are used as novel drug delivery systems. (The site specific drug delivery is attributed to its unique chemical, biological and physical properties, hollow monolithic structure, nano-needle shape, ability to obtain the desired functional groups on its external layers, etc). They act as nano carriers for genes, drugs and proteins. Bulk nanotubes (mass of unorganized fragments of nanotubes) are used as composite fibres in polymers. Due to the improved mechanical, electrical and thermal properties exhibited by them, they find application in different arenas. *In-vitro* CNTs nano injector system using atomic force microscope probes tips [5]. In the field of bone tissue engineering, carbon nanotubes are used as scaffolds. Its applicability for micro fabrication techniques is currently being researched upon [6,7]. It also has its role in electronic devices, sensors, nano composite materials [8].

## CNTs in the field of cancer treatment

CNTs have started emerging as a novel biotechnological tool for the diagnosis and treatment of cancer. This is based on their property of minimum toxicity and higher biocompatibility. Lately, CNTs are being coupled to diverse quantum dots (QDs) which

helps in the localization of cancer cells due to their nano size range and ability to penetrate individual cancer cells [9]. CNTs also help to obtain high-resolution imaging obtained from their narrow emission bands compared to that of organic dyes. And finally the cancer cells are attacked via site specific drug release or thermal treatment method (conversion of optical energy in to thermal energy). Thus the conjugation of QDs to CNTs helps in the simultaneous diagnosis and treatment of cancer. CNTs also release considerable vibrational energy after exposure to near-infrared radiation which produces localized heating within a tissue and thus used as phototherapy in the treatment of cancer. Immuno-sensors help in the detection of cancer biomarkers which are an amplification strategy for SWCNT [10]. Thus CNTs help not only in cancer cell imaging, but also thermal ablation, site specific drug delivery directly to a particulate cell or tissue, etc. It also acts as nano-carriers for anticancer drugs or molecules. Magnetic nano particles or nano carriers with folic acid functionalized MWNTs containing anti-cancer drugs such as cisplatin and gemcitabine were used to treat lymph node cancers. Due to their non-spherical nature they exerted prolonged action and thus could selectively inhibit the tumour. PVA functionalized MWNTs were effective against skin and breast cancers [11-13]. Biotin-functionalized SWNTs conjugated with the anticancer drugs were also used in certain cancers [14]. Incorporation of artemisinin and its derivatives to the modified CNTs especially MWCNTs without altering the drug property enhanced their anticancer activity. It was exhibited via vitro evaluations on K562 cancer cell lines and in the tumor-bearing murine model. But the side effects caused due to its prolonged usage still remains to be studied [15-17]. The high surface area of CNTs allows easy conjugation or adsorption with a therapeutic molecule. Thus functionalized or surface engineered CNTs are used to bind to desired target tissue to acquire a desired therapeutic action.

### CNTs in colon cancer

Colon cancer is the second leading cancer responsible for the death of nearly one million people yearly. MC38 murine colon carcinoma cell line was used to study the anti-tumour activity in an in vitro model. Water-soluble paclitaxel (PAX) loaded carbon nanotubes and its different cellular interactions were studied using poly (2-(dimethylamino) ethyl methacrylate-co-methacrylic acid). It indicated effective anti-cancer action against colon cancer cells. Embryonic stem cells (ESC) as cellular agents (it can stimulate the biological systems to destroy cancer cells) in combination with MWCNTs showed anticancer activity against MC38 cancer cells [18-20].

### Potential applications of CNTs

CNTs have numerous potential applications such as in the field of nanotechnology engineering. As building blocks to help in the fabrication of 3-D macroscopic all-carbon devices such as scaffolds which have applicability in fabrication of the next generation of energy storage, field emission transistors, super capacitors, high-performance catalysis, biomedical devices,

implants, photovoltaic's [21]. In the making of electrically conducting yarn suitable for energy and electrochemical water treatment purpose and as a replacement of the winding material [22].

### Conclusion

CNTs play a vital role in cancer treatment and diagnosis. It is used in various types of cancer. Studies have been carried out to regarding the same although not much work is reported based on colon cancer. More detailed research is needed for the same and further research is needed to reveal any hidden side effects or disadvantages posed by these CNTs.

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