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# CARBON NANOTUBES IN THE MEDICINE: A COMPREHENSIVE REVIEW

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***ABSTRACT: Carbon nanotubes possess many unusual physical and chemical intrinsic properties and have been intensively studied in recent years for biological and biomedical applications. We summarize the key findings from our and other groups in this area in this thorough analysis and explain that surface functionalization is crucial to the action of carbon nanotubes in biological systems. After surface passivation, ultrasensitive identification of biological species with carbon nanotubes can be performed to prevent the non-specific binding of biomolecules on the surface of the hydrophobic nanotube. A label-free approach to biological detection is provided by electrical nanosensors based on nanotubes. A process of protein microarray with detection sensitivity down to 1 fmol/L opens up surface-enhanced Raman spectroscopy of carbon nanotubes. In vitro and in vivo toxicity studies show that biocompatible, nontoxic, and potentially useful for biomedical applications are highly water soluble and serum stable nanotubes.***

***KEYWORDS: Biological, Carbon, Nanotube, Protein, Surface.***

## INTRODUCTION

Comparable to several biological macromolecules such as enzymes, antibodies, and DNA plasmids, nano materials have sizes ranging from around one nanometer to several hundred nanometers. Different from both the molecular and bulk scales, materials in this size range exhibit interesting physical properties, presenting new opportunities for biomedical research and applications in various areas, including biology and medicine[1]. In developing novel tools and platforms for understanding biological systems and disease diagnosis and treatment, the emerging field of nano biotechnology bridges the physical sciences with the biological sciences through chemical methods[2].

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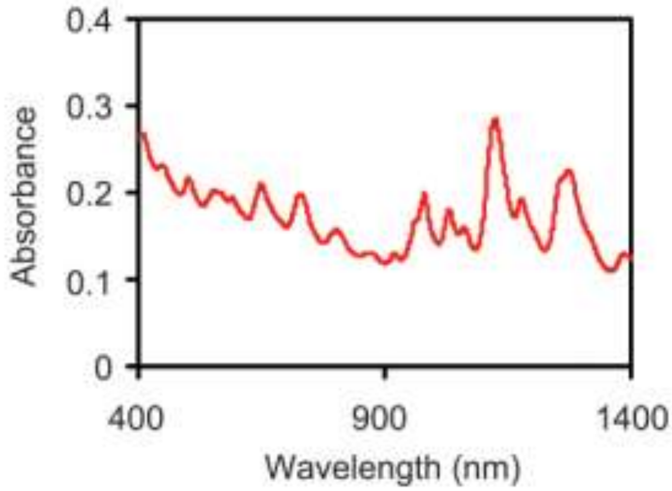


**Figure 1: Illustrates the scheme of the electronic structure of SWNTs.**

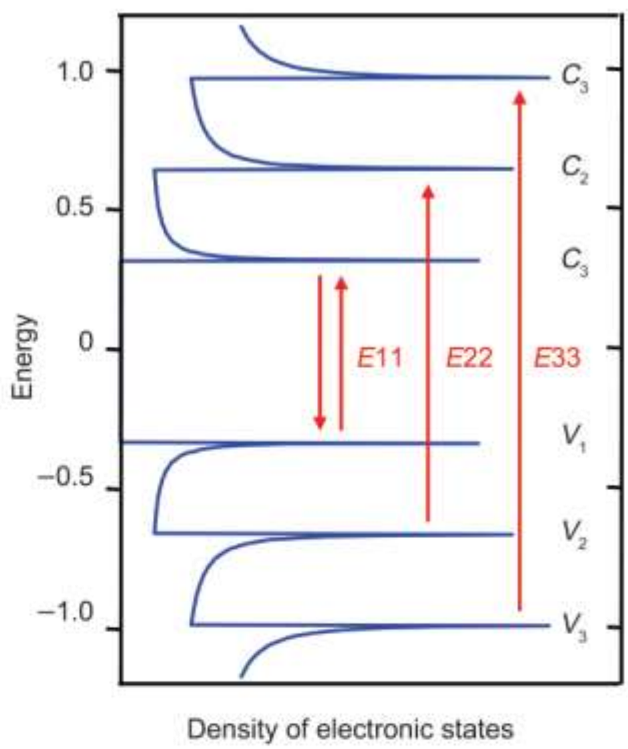


**Figure 2: Depicts the UV-vis-NIR absorption spectrum of an aqueous solution of SWNTs**[3]**.**

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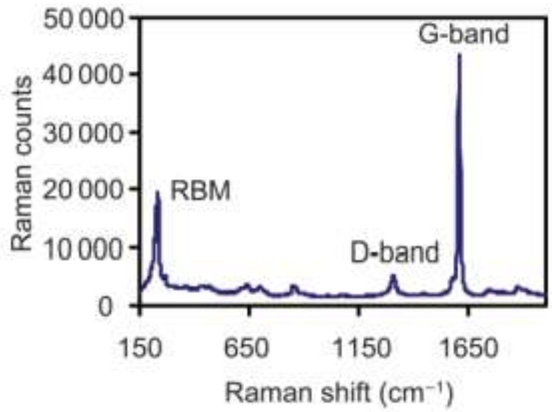


**Figure 3: Depicts the Raman spectrum of SWNTs**[4]**.**

Figure 1 illustrates the scheme of the electronic structure of SWNTs. Figure 2 depicts the UV-vis-NIR absorption spectrum of an aqueous solution of SWNTs. Figure 3 depicts the Raman spectrum of SWNTs. Seamless cylinders of graphene sheets are rolled up by carbon nanotubes (CNTs), exhibiting unprecedented physical, mechanical, and chemical properties that have drawn immense interest in the past decade. CNTs are known as single-walled carbon nanotubes (SWNTs) or multi-walled carbon nanotubes, depending on the number of graphene layers of which a single nanotube is composed (MWNTs)[5]. CNT applications cover many areas and applications, including composite materials, nano electronics, hydrogen storage, and field-effect emitters.

## DISCUSSION

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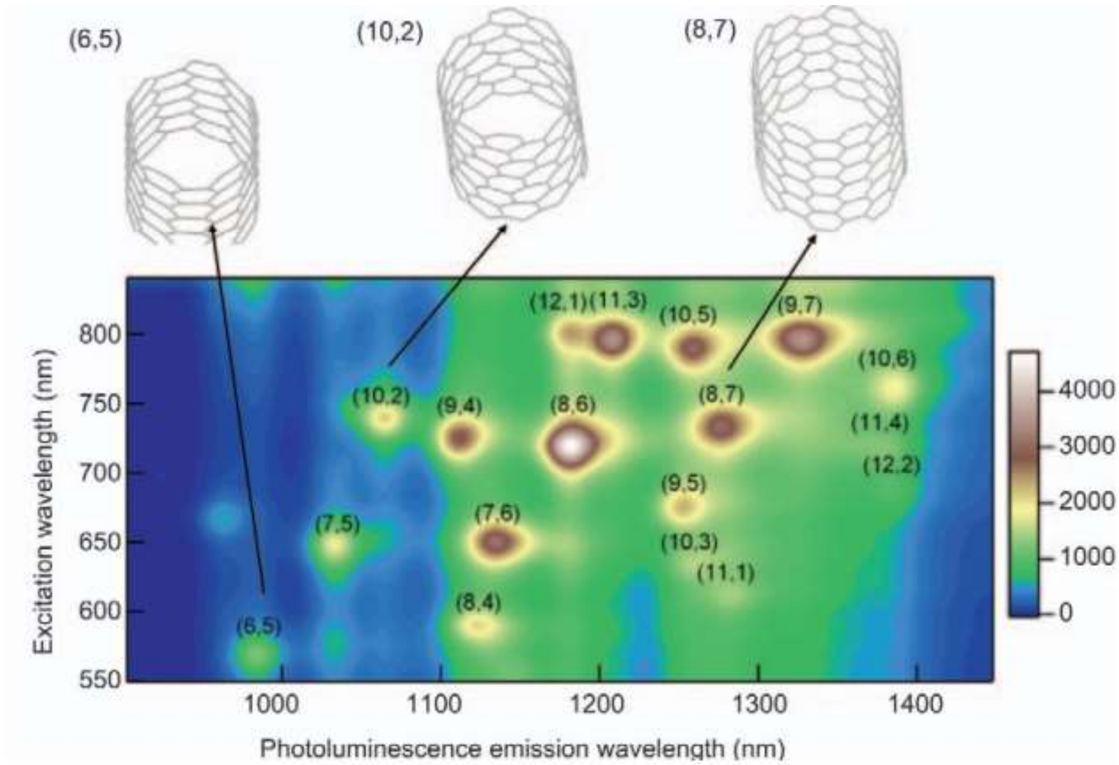


**Figure 4: Illustrates the liquid crystalline.**

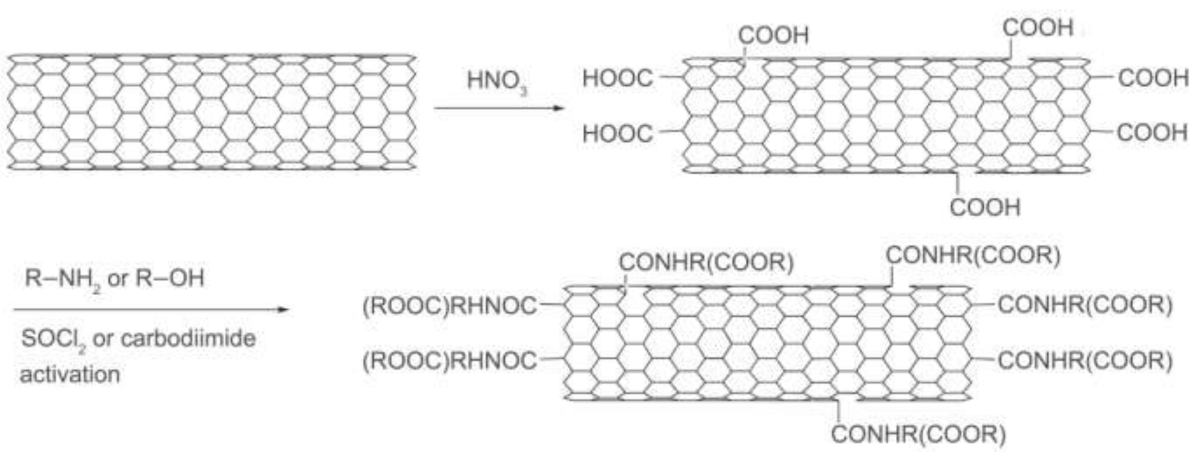


**Figure 5: Illustrates CNTs are oxidized and then conjugated with hydrophilic polymers.**

In comparison to SWNTs, multiple layers of graphene form MWNTs and have much larger diameters (10-100 nm). While MWNTs exhibit less rich and attractive optical properties than SWNTs, because of their larger sizes, their use in biological systems could vary from that of

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SWNTs, which could provide different platforms for various purposes, such as the delivery into cells of large biomolecules like DNA plasmids.

Bio macromolecules, including proteins, DNA, and RNA, seldom cross cell membranes on their own, unlike numerous small drug molecules that are able to diffuse through cells. In order to use these molecules for therapeutic applications, intracellular delivery is thus required[6]. For intracellular transport, proteins may be either conjugated or noncovalently absorbed into nanotubes. The hydrophobic surface of partially functionalized SWNTs (e.g. oxidized SWNTs) makes it possible to bind proteins non-specifically. Figure 4 illustrates the liquid crystalline. Figure 5 illustrates CNTs are oxidized and then conjugated with hydrophilic polymers[7].

## CONCLUSION

We have comprehensively analysed the latest research on the use of carbon nanotubes for biomedical applications in this paper. To functionalize CNTs for biomedical research, various covalent and noncovalent chemicals have been created. Functionalized CNTs have been used for ultrasensitive detection of biological organisms, depending on their electric or optical properties. Surveying the literature, we demonstrate that the toxicity of CNTs in vitro and in vivo is highly dependent on the functionalization of CNTs. In biological solutions, properly functionalized CNTs with biocompatible coatings are stable and non-toxic in vitro to cells and in vivo to mice at the tested doses. Several studies have shown that biological molecules including small drug molecules and bio macromolecules including proteins, plasmid DNA, and si RNA can be shuttled by CNTs through an endocytosis pathway into cells in vitro.

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