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Carbon Nanotubes- A Nanotechnolgy Based Drug Delivery System and its Recent Trends: A Review

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Abstract : CNTs are allotropes of carbon with a nanostructure which are cylindrical in its shape. There are single walled as well as double walled nanotubes. They have many biological and biomedical applications not because of its small size alone but to their remarkable optical, electric and magnetic properties .They are promising candidates for targeted drug delivery as they can detect and deliver drugs to neoplastic cells. They are a new alternative and efficient tool for transport and translocation of therapeutic molecules as they have easy access to cytoplasm and nucleus without immunogenic response or toxicity. CNT even serve as a very simple, rapid, sensitive and electrical sensor. The known uses of CNTs are briefly reviewed in this article.
Key Words: Carbon nanotubes, drug delivery, cancer, gene therapy, sensor.

Introduction:

Drug particles in nanometer size range have unique characteristics that can lead to enhance performance in a variety of dosage forms. Scientists use nanotechnology to approach classical and novel drug delivery applications. Controlled and targeted delivery are the most enviable requirements expected from a carrier, which involves multi-disciplinary site specific or targeted approach.[1]

Carbon nanotubes (CNT) are allotropes of carbon with cylindrical nano structures.[2] They can be visualized as a sheet of carbon atoms rolled up into a tube with a diameter of around tens of nanometers.They have electrical,optical,thermal, mechanical properties. There are two types of CNTs, single walled CNTs and multiwalled CNTs.The multi walled CNTs are formed by several concentric layers of rolled graphite[3]. It has good adsorption properties which can detect some chemicals and biological agents[1.] It is used to transport drug as well as proteins, DNA, RNA, into cells. They can pass through membranes carrying vaccines and nucleic acid to the target cells. Functionalized CNTs are the advanced technology in the field of nanobiotechnology and nanomedicine .CNTs has been liked by most of the scientists worldwide because of its unique application in all fields including cancer.

The unique capability of CNTs to penetrate cell membranes paves way to make them utilise as carriers to deliver therapeutic agent into cytoplasm as well as to nucleus[4]. Drug delivery by this means improve the physiological and therapeutical effect of the drugs .The larger inner volume of CNT helps in encapsulation of the molecules of drug.CNT can control the release of drugs by releasing the loaded drug along the period of

time. Its semiconductor, thermal, mechanical, electromagnetic and electro acoustic properties make them to easily penetrate the membranes such as cell wall .[5]

Different methods like Arc discharge method, Laser ablation method; Chemical vapours deposition method, Flame synthesis method and Silane solution method are used for the production of CNTs. The biodistribution and pharmacokinetics of nano particles rely to a large extent on their physicochemical characteristics such as size, shape, aggregation, chemical composition, surface functionalisation and solubility [6].

Carbon Nanotubes Based Drug Delivery:

CNTs can serve as carriers for drug delivery and drug targeting of antibiotics, anticancer drugs. CNTs-based carrier system can offer a successful oral alternative administration of the enzyme erythropoietin. It also acts as lubricant or glidants in pharmaceutical industry for manufacture of tablet. [6]

Delivery of drug by suitable carriers can enhance solubility and increase the residence time in blood circulation and can improve their bioavailability. Antioxidants play an important role in cancer therapy as they can combat oxidative stress. Scientific studies are available for the incorporation of antioxidant [4]. Magnetic CNT complexed with magnetite have been reported for lymphatic tumor targeting.

CNTs in Cancer Therapy:

The transporting capabilities of CNTs combined with suitable functionalisation chemistry and their intrinsic optical properties can lead to new classes of novel nanomaterials for drug delivery and cancer therapy.[5] CNTs are used for drug targetting in cancer therapy as it has high retaining capacity to accumulate in the lymph nodes for longer time when compared to other nano carriers.[7] Many scientific studies report the targetted delivery of many anticancer agents like methotrexate, carboplatin, campothecin ,doxorubicin after incorporating into CNTs. Gemcitabine loaded into multiwalled CNTs on subcutaneous injection into mice showed high activity against lymph node metastasis. Magnetic nano particles of cisplatin loaded to Multiwalled CNTs and functionalized with folic acid for cancer chemotherapy as cancer cells over express folic acid receptors[7], If anticancer drugs are loaded in CNTs ,it is released into lymphatic system which will kill the metastatic cancer cells as many cancer metastasize through lymphatic canal.Kam etal reported selective cancer cell killing in vitro by hyperthermia due tothermal conductivity of internalised CNTs into the cell.[8]

CNTs in Gene Therapy:

CNTs are used for manipulating the genes and atoms. It acts as a carrier for gene to treat cancer and genetic disorders. Nanotubes may be complexed with DNA which forms a DNA before it is destroyed by cells. The cell RNA fragments capable of inhibiting the protein needed for the multiplication of virus , is encapsulated within nanotubes and can be used as a nasal sprays or drops for antiviral effect. When,CNTs are used as gene therapy vector, it is able to associate with DNA, RNA or nucleic acid and helps in the intracellular translocation and can reduce immunogenicity compared with viruses . CNTs mediated gene delivery can lead to the production of markers proteins.

CNTs in Alzheimers:

Drug delivery to CNS is a challenging due to the blood brain barrier. CNTs help in treating Alzheimer's disease. Learning and memory capabilities seen in animal model with Alzheimer's disease .[9]

CNTs IN HIV/AIDS Therapy:

siRNA molecules conjugated with CNT are efficiently delivered to human T cells and primary cells. [10]The same study reports that the si RNA sequence used were able to silence the expression of the cell surface receptors CD4 and coreceptors CXCR4 necessary for HIV entry and infection of Tcells. CNTs are thus indicated to use for the treatment of HIV.[3]

CNTs in Vaccine Therapy:

Use of CNTs can improve immune response.Vaccine delivery can be achieved by linking antigen to CNT and by inducing antibody response. [11]

CNTs in Detection:

CNTs are used for detection of chemical and biological agents by casting on suitable sensitized electrodes .[12] CNTs can detect, toxic organophosphorous compounds and alkylating agents containing sulphur, nitrogen. Even toxic proteins and micro organisms can be detected with the help of CNTs.[13-15] Single walled CNTs embedded in Cadmium arachidate amphiphilic matrix were used as micro acoustic sensor for organic vapour detection.[16] CNT have utilized for toluene and xylene .[17]

They can detect biomolecules like DNA (optical DNA sensor), antigen-antibody (immunosensors), cells (cytosensor) and other biomolecules like NADH, glucose, hydrogen peroxide. DNA analysis has so much significance in diagnosis of infectious diseases, genetic mutations, drug discovery, food security and warning against biowarfare agents. Thus, they can act as biosensors.[18]

CNTs act as immunosensors and were used for detection of prostate cancer. Enzymes like GOD, ALP, HRP etc were incorporated into CNTs for enzymatic signal. [3]

Non Medical Application Contents

CNTs have wide non- medical applications in textile industry and for fire protection, production of aircrafts, bridges,loud speakers, sports equipments, to increase the tensile strength and stopping crack propagation in concrete, fire protection.[19-22] It has great use in desalination of water. [23]CNTs are used for the production of pyroelectric infrared detector.[24]

Conclusion:

Carbon nanotubes are emerging as a new class of technological materials with numerous novel and useful properties. Different types of CNT delivery has been explored in various biomedical applications. CNTs and their composite materials are likely to become important biomaterials in the near future due to their superior and unique characteristics over conventional biomaterials. Their electrical, optical, thermal and spectroscopic properties make them unique for the detection of biomolecules such as DNA, antigen-antibody, cells and other biomolecules, thereby leading to great advancement in therapy. CNTs will find numerous applications as biomaterials and have important roles in the development of emerging technologies.

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