NANOTECHNOLOGY AND ITS APPLICATIONS IN MEDICINE

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ABSTRACT

Nanotechnology is the study of extremely small structures, having size of 0.1 to 100 nm. Nano medicine is a relatively new field of science and technology. Brief explanation of various types of pharmaceutical nano systems is given. Classification of nano materials based on their dimensions is given. An application of Nanotechnology in various fields such as health and medicine, electronics, energy and environment, is discussed in detail. Applications of nano particles in drug delivery, protein and peptide delivery, cancer are explained. Applications of various nano systems in cancer therapy such as carbon nano tube, dendrimers, nano crystal, nano wire, nano shells etc. are given. The advancement in nano technology helps in the treatment of neuro degenerative disorders such as Parkinson’s disease and Alzheimer’s disease.

Keywords: Nano devices; Nano material; Nano medicine; Nano pharmaceutics; Drug delivery

Introduction

Advancement in the field of nanotechnology and its applications to the field of medicines and pharmaceuticals has revolutionized the twentieth century. Nanotechnology [1] is the study of extremely small structures. The prefix “nano” is a Greek word which means “dwarf”. The word “nano” means very small or miniature size.

History of Nanotechnology

The development in the field of nanotechnology started in 1958 and the various stages of development have been summarized in Table 1.

Nano scale and Nanostructures

The nano scale is the place where the properties of most common things are determined just above the scale of an atom. Nano scale objects have at least one dimension (height, length, depth) that measures between 1 and 999 nanometers (1-999 nm) (Figure 1).
The brief explanation of pharmaceutical nano system is as follows: As shown in the schematic diagram (Figure 2), pharmaceutical nanotechnology is divided in two basic types of nano tools viz. nano materials and nano devices. These materials can be sub classified into nano crystalline and nano structured materials. Nano structure consists of nano particles, dendrimers, micelles, drug conjugates, metallic nano particles etc.

Carbon nano tubes: These are small macromolecules that are unique


Importance for biomedical use (Figure 3).

Liposomes: These have been extensively explored and most developed nano carriers for novel and targeted drug delivery due to their small size, these are 50-200 nm in size. When dry phospholipids are hydrated, closed vesicles are formed (Figure 4).

Dendrimers: Dendrimers are hyper branched, tree-like structures. It contains three different regions: core moiety, branching units, and closely packed surface (Figure 5). It has globular structure and encloses internal cavities. Its size is less than 10 nm. These are used for long for their size, shape, and have unique physical properties. Nano tubes have some special advantages over other drug delivery and diagnostic systems (Figure 3) due to their unique physical properties.
Metallic nano particles: Metallic nano particles have used in drug delivery, especially in treatment of cancer and also in biosensors. Amongst various metals, silver and gold nano particles are of prime scale building blocks with control on size, composition etc. It is also important for the production of chemicals. Modern revolution in catalysis is due to the availability of unlimited commercial quantities of zeolites.

Classification of Nano Materials
Nano materials can be classified dimension wise into following categories:

Manufacturing Approaches
The two major approaches to get nano materials are -one is the bottom up and the other is top down approach. Bottom up produce components which are made of single molecules, and covalent forces hold them together that are far stronger than the forces that hold together macro-scale components. Enormous amount of information could be stored in devices build from the bottom up. For example, use of AFM, liquid phase techniques based on inverse micelles, sol-gel processing, and chemical vapor deposition (CVD), laser pyrolysis and molecular self-assembly use bottom up approach for nano scale material manufacturing.

Applications of Nanotechnology
The different fields that find potential applications of nanotechnology are as follows:
   a. Health and Medicine
   b. Electronics
   c. Transportation
   d. Energy and Environment
   e. Space exploration

Nanotechnology in health and medicine
Even today various disease like diabetes, cancer, Parkinson’s disease, Alzheimer’s disease, cardiovascular diseases and multiple sclerosis as well as different kinds of serious inflammatory or infectious diseases (e.g. HIV) constitute a high number of serious and complex illnesses which are posing a major problem for the mankind.
With the help of nanotechnology, damaged tissue can be reproduced or repaired. These so called artificially stimulated cells are used in tissue engineering, which might revolutionize the transplantation of organs or artificial implants.

Their study uses AFM as an experimental platform.

i. Probe molecule to serve as signature of leukemia cells identified.

ii. Current flow due to hybridization will be through CNT electrode to an IC chip.

iii. Prototype biosensors catheter development.

Nanotechnology has made excellent contribution in the field have been successfully used to isolate and group stem cells. Quantum dots have been used for molecular imaging and tracing of stem cells, for delivery of gene or drugs into stem cells, nano materials such as carbon nano tubes, fluorescent CNTs and fluorescent MNPs have been used.

**Nanotechnology, energy and environment**

Nanotechnology will play a critical role in coming 50 years by protecting the environment and providing sufficient energy for a growing world. The advanced techniques of nanotechnology can help storage of energy, its conversion into other forms, ecofriendly manufacturing of materials and by better enhanced renewable energy sources.

**Medical use of Nano Materials**

Nano medicine is a relatively new field of science and technology. By interacting with biological molecules at nano scale, nanotechnology broadens the field of research and application.

Two forms of nano medicine that have already been tested in mice and are awaiting human trials; use of gold nano shells to help diagnose and cure cancer, and the use of liposome as vaccine adjuvants and as vehicles for drug transport.
Drug Delivery

In nanotechnology nano particles are used for site specific drug delivery. In this technique the required drug dose is used and side-effects are lowered significantly as the active agent is deposited in the morbid region only. This highly selective approach can reduce costs and pain to the patients.

The applications of nano particles in drug delivery

Abraxane, is albumin bound paclitaxel, a nano particle used for treatment of breast cancer and non-small- cell lung cancer (NSCLC). Nano particles are used to deliver the drug with enhanced effectiveness for treatment for head and neck cancer, in mice model study, which was carried out at from Rice University and University of Texas MD Anderson Cancer Center..

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Proteins and Peptide Delivery

Protein and peptides are macromolecules and are called biopharmaceuticals. These have been identified for treatment of various diseases and disorders as they exert multiple biological actions in human body. Nano materials like nano particles and dendrimers are called as nano biopharmaceuticals , are used for targeted and/or controlled delivery.

Applications

Nano particles were found useful in delivering the myelin antigens, which induce immune tolerance in a mouse model with relapsing multiple sclerosis.
**Conclusion** Nano materials have increased surface area and nano scale effects, hence used as a promising tool for the advancement of drug and gene delivery, biomedical imaging and diagnostic biosensors. Nano materials have unique physicochemical and biological properties as compared to their larger counterparts.