Current Advances in Biosciences- Nanotechnology in Medicine

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Nanotechnology in Medicine

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Abstract

Nanotechnology, a very broad area of research that has great potential in many fields, including health, construction, and electronics, involves manipulating material at the atomic or molecular level to create materials that exhibit astonishing heterogeneity and new properties.In medicine, it is used for the delivery of drugs, gene therapy, diagnosis and the complete transformation of other research, development and medical applications.

Keywords: Nanotechnology, Medicine, Nanoparticles, Cancer

1. Introduction

The concept of Nanotechnology was first introduced in 1959 when physicist Richard Feynman presented a presentation on making things at the atomic and molecular levels [1]. It is the treatment of individual atoms, molecules or compounds into structures to produce materials and devices with special properties. It deals with materials in the size of 0.1-100nm [2]. The ability to manipulate structures at atomic scale allows for the creation of nanomaterials. Nanotechnologies have had a significant impact in almost all industries and areas of society as it offers better built, safer and cleaner. Nanomaterial allows mass-creation of product with enhanced functionality, significantly lower costs, greener and cleaner manufacturing processes, to improve healthcare and reduce the impact of manufacturing on the environment [3].

Nanomedicine uses technologies at nanoscale and Nano-enabled techniques to prevent, diagnose, monitor and treat disease. Nanotechnologies exhibit significant potential in the field of medicine, including in imaging techniques and diagnostic tools, drug delivery systems, tissue-engineered constructs, implants and pharmaceuticals therapeutics [3]. A benefit of using nanoscale for medical technologies is that smaller devices are less invasive and possibly be implanted inside the body, plus biochemical reaction times are much shorter[4]. The Nanomaterials are having interesting optical, magnetic and electrical properties which are having significant effects in the fields of electronic medicine. Nanomedicine's primary fields of use include:

- Delivery of pharmaceuticals
- *In vitro* and *in vivo* diagnostic, including imaging
- Regenerative medicine
- Implanted devices

2.Nanoparticles

Nanoparticles (NPs) are technically defined as particles with dimensions less than 100 nm and unique properties not typically found in bulk samples of the same material [5]. Nanoparticles are gaining importance in various field because of their exceptional features like high surface, volumetric ratio, dissimilarity, submicron size, and improved targeting systems.NPs can have different shapes, sizes, and structures [6].They can be spherical, cylindrical, conical, tubular, hollow core, helical, etc. NPs were found to penetrate deep into tissues and enhance the permeability and retention (EPR) enhancement effect. Additionally, surface properties influence bioavailability and half-life by effectively penetrating epithelial fenestrations [7].

NPs can be homogeneous or composed of multiple layers. In the latter case, the layers would look like this: (a) The surface layer is usually composed of various small molecules, metal ions, surfactants, or polymers. (b) A cladding layer consisting of a chemically different material from the core layer. (c) Nuclear layer representing the central part of the NP [8]. Diagnostic and therapeutic nanoparticles are generally fall into two categories: a) Organic nanoparticle (liposome and micelles) b) Inorganic nanoparticles (Silica, gold, iron oxide, etc).

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3.Types of Nanoparticles

Some common types of nanoparticles are discussed below

- **Micelles**

Micelles spontaneously aggregate and self-assemble into spherical vesicles under aqueous condition with hydrophilic outer monolayer and hydrophobic core. Recently, micelles loaded with metal nanoparticles (MNPs) have been used in several biological applications due to their biocompatibility, pharmacokinetics, adhesion to biological surfaces, targeting, and longevity.The size of micelles ranges from 10-100 nm [9].

- **Liposomes**

Liposome, the old version of lipid nano particle sizes ranging from 30nm to several microns, that consist of lipid bilayer. They can transport hydrophilic or hydrophobic molecules such as proteins, nucleic acids and small molecules.Several liposomal drug formulations have been approved and successfully applied to medical practice [3].

- **Dendrimers**

Dendrimer are nano molecules with regular branching structure. The branches arise from the core in shape of a spherical structure by means of polymerisation. It contains three different regions: core moiety, branching units and closely packed surface. Dendrimers can be employed in place of traditional viral vectors in gene therapy. The number of branching determines the size of dendrimers which can be controlled. It sizes less than 10 nm. Conjugates of dendrimers with saccharides or peptides have been shown to exhibit enhanced antimicrobial and antiviral properties with improved solubility and stability upon absorption of therapeutic drug [10].

- **Quantum dots**

Quantum Dots (QDs) are nanocrystals of size 2-10 nanometers that can be converted into fluorescence when stimulated by light [6]. Semiconductor particles having optical and electronic properties that differ from those of larger particles as a result of quantum mechanics [8]. QDs have been successfully demonstrated due to their unique properties, including outstanding photostability, size-dependent optical properties, high extinction and brightness coefficients etc. Quantum dots provide a versatile tool to support more accurate diagnostics and immunofluorescence assays, multichannel imaging and therapeutic platforms, imaging of cellular and in vivo processes in real time and track single cells and biomolecules [11].

❖ Metallic nanoparticles

Metal nanoparticle are flexible nanostructures due to their ability to control shape, composition, size, structure, assembly, and optical properties [12]. They are generally solid colloidal metal particles of size range 10-1000 nm that incorporates a therapeutic molecule which remains either dispersed in the matrix of polymer carrier, entrapped within a polymer shell, or attached or adsorbed by covalent linkage to the surface of the particles. Metallic nanoparticles have been used as imaging contrast agents, in laser-based treatment, as optical biosensors and drug delivery vehicles.Among the various metals, silver and gold nanoparticles are of prime importance for biomedical use[13].

4. Applications of Nanotechnology in Medicine

Nanotechnology products have been increasingly beneficial in healthcare, resulting in the development of unique nano systems for the diagnosis, imaging, and treatment of a variety of diseases, including cancer, cardiovascular, ophthalmic, and central nervous system ailments [14].One of the most important steps in clinical practice is to diagnose a disease. It is used as sensors, analyte detection, pathogen detection and separation, imaging agent, targeted imaging, delivery vehicles[15].Nano systems provide precise drug delivery to target tissues or organs with controlled release and increased retention time over conventional approaches.Nano-liposomes are one of the best examples of nano systems now being developed for targeted medication delivery in the treatment of various malignancies and cardiovascular illnesses [16].

Cancer is a major disease characterized by aberrant cell growth with the ability to invade or spread to other bodily parts, often known as malignant tumors or malignant neoplasms. There are over 100 different known cancers that affect humans, but most common types are breast cancer, lung cancer, colon cancer, prostate cancer [17]. Nanotechnology is important in the development of cancer treatments and the identification of cancer biomarkers. To target malignant tumors with increased specificity and affinity, NPs can be combined with bio-targeting ligands such as small molecules, peptides, and monoclonal antibodies [18].Nanoparticles bound to antibodies via polyethylene glycol are used in the treatment of breast cancer [19].

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in developed and developing countries. Early diagnosis of coronary artery disease increases the chance of successful treatment and possible cure, giving patients a better prognosis and longer survival. Mass spectrometry is commonly used to identify potential biomarkers for Coronary Artery Diseases, but is limited in sensitivity and specificity due to low biomarker concentrations in human plasma.For these reasons, the combination of nanotechnology with biosensors may constitute a promising solution for diagnosing coronary artery disease in its early stages[20].

Recent advances in nanotechnology have significantly benefited tissue engineering, which is used to repair or regenerate damaged tissues or organs and to design smart drug delivery systems.eg: Titanium based materials have been applied in bone tissue engineering [21].The findings of nanomaterial research have been published based on studies conducted on the following tissues: bone, cartilage, nervous system, skin and heart muscle [22].The materials used include carbon nanotubes (CNTs). Their unique properties have opened up the possibility of the use of CNTs in therapies that focus on repairing damaged tissues, especially those requiring electrical stimulation [23]

Over the past few decades, different nanomedicines have been approved for clinical use from the Food and Drug Administration (FDA). Among the approved nanomedicines, liposomal, polymeric, and micelles were represented and administered using oral, intravenous, and transdermal pathways.Nanodrugs were authorised for a wide range of indications, including cancer[24].Nanotechnologies have also led to extensive discussions on their safety and any health risks associated with their use, although the emerging field of nanotechnology has attracted a great deal of public interest.The use of nanomaterials presents new challenges, notably the identification, evaluation and management of potential health risks[25].

5. Conclusion

Nanotechnology has emerged as a new exciting field in science, with several potential applications for medicine. With a series of innovations and advances in nanomedicine technology, diagnosis and treatment at the micro-level is increasing, and nanotechnology is widely used in medical treatment, diagnosis, and other medical fields.

6. References

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