Study of Nanotechnology & It's Application in Multiple Field

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Abstract: ***Nanotechnology is the exploitation of the unique properties of materials at the Nanoscale. Nanotechnology has gained popularity in several industries, as it offers better built and smarter products. 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. The word "Nanotechnology" consists of two parts. The first one "Nanos" is a Greek word "Nanos", which refers to "dwarf", i.e., everything that is very small. Nanotechnology is a term used to describe the study and utilization of tiny things which can be utilized across all areas of science, like physics, materials science, chemistry, biology, and engineering. Nanoscience studies the main fundamentals of molecules and compounds that do not exceed one hundred Nanometers in size. The base of this technology is built on the capture of the very small atoms of any material, manipulating them and shifting them from their original positions to other locations, then compiling them with atoms of other materials to construct a crystal network to get Nanoscale substances with apparent high-performance features. The application of Nanotechnology in medicine and healthcare is referred to as Nano-medicine, and it has been used to combat some of the most common diseases, including cardiovascular diseases and cancer. The present review provides an overview of the recent advances of Nanotechnology in the aspects of imaging and drug delivery. The focus of this research is on the medical applications of Nanotechnology.***

Keywords: Nanotechnology, Nano-particle, medicine, drug-delivery & Nano-material

1. Introduction

Nanoscience is the study of the unique properties of materials between 1-100 nm, and Nanotechnology is the application of such research to create or modify novel objects. The ability to manipulate structures at the atomic scale allows for the creation of Nanomaterials. Nanomaterials have unique optical, electrical and/or magnetic properties at the Nanoscale, and these can be used in the fields of electronics and medicine, amongst other scenarios. Nanomaterials are unique as they provide a large surface area to volume ratio. Unlike other large-scaled engineered objects and systems, Nanomaterials are governed by the laws of quantum mechanics instead of the classical laws of physics and chemistry. In short, Nanotechnology is the engineering of useful objects and functional systems at the molecular or atomic scale. Nanotechnologies have had a significant impact in almost all industries and areas of society as it offers i) better built, ii) safer and cleaner, iii) longer-lasting and iv) smarter products for medicine, communications, everyday life, agriculture and other industries. The use of Nanomaterials in everyday products can be generally divided into two types. First, Nanomaterials can be merged or added to a pre-existing product and improve the composite objects' overall performance by lending some of its unique properties. Otherwise, Nanomaterials such as Nanocrystals and Nanoparticles can be used directly to create advanced and powerful devices attributed to their distinctive properties. The benefits of Nanomaterials could potentially affect the future of nearly all industrial sectors.

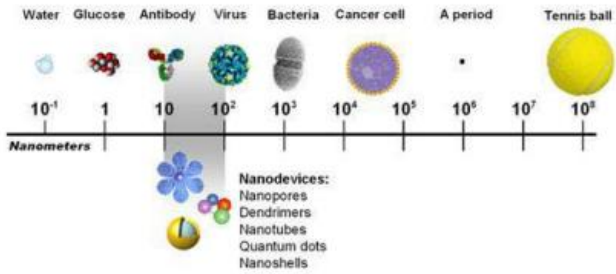

Figure 1: Nanoscale &Nano structures

The root 'Nano' of the word "Nanotechnology" is taken from a Greek word, which refers to 'dwarf or something tiny. It describes one thousand millionth of a meter. In fact, Nanoscience and Nanotechnology are not the same. Nanoscience is defined as the study of structures and molecules on the scales of Nanometers which range from one to one hundred Nanometers. Nanotechnology refers to the technological means, which uses Nanoscience in feasible utilizations like instruments. . For example, one must know that the thickness of only one human hair is sixty thousand Nanometers. The DNA double helix contains a radius of 1 rim as shown in Figure 2 (Gnach, 2015:156l—l584). The Democritus and the Greeks scientists of the fifth century B.C. are considered the pioneers of Nanoscience when they regarded the issue of the continuity of material and therefore indefinitely breakable into very tiny parts, or constructed of tiny particles, which can't be divided nor broken, which are termed in the present time as "atoms".

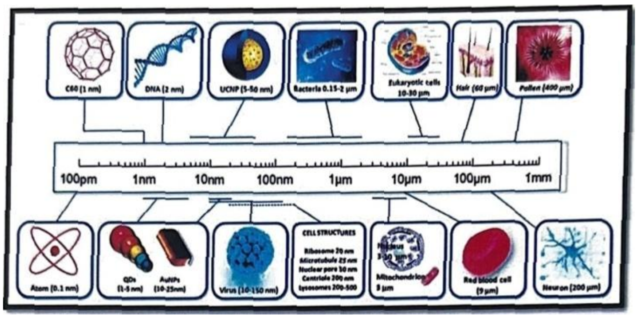

Figure 2: Comparison of sizes of Nanomaterial Reproduced with permission from reference (Gnach, 2015: 1561—1584.

Scientists believe that Nanotechnology will be within the most encouraging and favorable technologies in the twenty first century, due to its capability of making use of the theoretical framework of Nanoscience and transform to beneficial utilizations. This can be achieved by monitoring, measuring, manipulating, compiling, managing and manufacturing material at the Nanometer scale. The National Nanotechnology Initiative (NNI) in the U.S.A defines Nanotechnology as “a science, engineering, and technology conducted at the Nanoscale (1 to 100 rim), where unique phenomena enable novel application’s in a wide range of fields, from chemistry, physics and biology, to medicine, engineering and electronics”. This definition indicates that Nano technology has two states. One of which is a state of scale where Nanotechnology is related to utilizing structures by managing their volume and shape at Nanometer scale. The other state is related to novelty where Nanotechnology must manipulate tiny things by means which make use of certain features in accordance with the Nanoscale. We should indicate the difference between Nano science and Nanotechnology. The word Nanoscience refers to an inter section including materials science, physics and biology. Nanoscience addresses processing of materials at atomic and molecular scales. On the other hand, Nanotechnology refers to the capability of monitoring, measuring, tackling, compiling, managing, and manufacturing material at the Nanometer scale. The available information or accounts that illustrated the history of Nanotechnology and Nanoscience have not made a summary of both of them from the start to the present age with continuous happenings. Thus, there is an urgent needto outline the chief happenings in Nanoscience and Nanotechnology for a complete perception of their development in this area.

2. Difference between Nanotechnology & Nano-Science

Nanoscience is the study of the properties of matter at the Nanoscale; in particular, it focuses on the unique, size-dependent properties of solid-state materials. New methods of synthesis are required to make materials at the Nanoscale—both bottom-up and top-down techniques are employed. Equally important is that new characterization approaches are needed. Nanoscience can be carried out by studying particles in glass, as the Romans, Faraday, and Mie did. One can still deduce interesting, size-dependent properties of materials from ensemble, test tube measurements. So “Nanoscience” has been around for at least 150 years, ever since the sizes of atoms were first determined. In other words, Nanotechnology is the ability to manipulate a single Nanoscale object. It is the presence of the word “single” that makes all the difference. Noriguchi wanted to make a single, addressable electronic element that was at the Nanometer scale. It is true that the molecules in a glass of water are less than a Nanometer across, but one could not address, pick up, or manipulate individual water molecules. That all changed in 1981 with the advent of the scanning tunneling microscope and later with the invention of the atomic force microscope. These revolutionary tools allowed scientists the ability to see molecules under ambient conditions (more or less) and, for the first time, not just to observe them, as had been possible in ultrahigh vacuum with electron and ion microscopy, but to pick them up and to move them as single building blocks. Nanotechnology became possible with the advent of single-molecule manipulation, which only became possible in the 1980s.

The Importance of Nanotechnology

The following reasons indicate the importance of Nanotechnology.

- Scientists all over the world assert that Nanotechnology will give rise to a new scientific revolution in the following years, because of its unique principles and incredible potentials.
- The applications and inventions of Nanotechnology are utilized in different areas of our life: medical, biological, agricultural, industrial, electronic, petrochemical and military.
- Nanotechnology may solve the problems of the times like the water crisis, energy resources, health, poverty and unemployment; it can also provide job opportunities, decrease the price of some products, improve energy resources, and discover new ways of treatment and water purification.

3. Types of Nanoparticles

Nanoparticles and Nanomaterials have been investigated and approved for clinical use. Some common types of Nanoparticles are discussed below.

Micelles

Micelles are amphiphilic surfactant molecules that consist of lipids and amphiphilic molecules. Micelles spontaneously aggregate and self-assemble into spherical vesicles under aqueous conditions with a hydrophilic outer monolayer and a hydrophobic core, and thus can be used to incorporate hydrophobic therapeutic agents. The unique properties of micelles allow for the enhancement of the solubility of hydrophobic drugs, thus improving bioavailability. The diameter of micelles ranges from 10-100 nm. Micelles have various applications, such as drug delivery agents, imaging agents, contrast agents and therapeutic agents.

Dendrimers

Dendrimers are macromolecules with branched repeating units expanding from a central core and consists of exterior functional groups. These functional groups can be anionic, neutral or cationic terminals, and they can be used to modify the entire structure, and/or the chemical and physical properties. Therapeutic agents can be encapsulated within the interior space of dendrimers, or attached to the surface groups, making dendrimers highly bioavailable and biodegradable. Conjugates of dendrimers with saccharides or peptides have been shown to exhibit enhanced antimicrobial, antiprion and antiviral properties with improved solubility and stability upon absorption of therapeutic drugs. Polyamidoamine dendrimer-DNA complexes (called dendriplexes) have been investigated as gene delivery vectors and hold promise in facilitating successive gene expression, targeted drug delivery and improve drug efficacy. dendrimers are promising particulate systems for biomedical applications, such as in imaging and drug delivery due to their transformable properties.

Metallic Nanoparticles
Metallic Nanoparticles include iron oxide and gold Nanoparticles. Iron oxide Nanoparticles consist of a magnetic core (4-5 nm) and hydrophilic polymers, such as dextran or PEG. Conversely, gold Nanoparticles are composed of a gold atom core surrounded by negative reactive groups on the surface that can be functionalized by adding a monolayer of surface moieties as ligands for active targeting. Metallic Nanoparticles have been used as imaging contrast agents, in laser-based treatment, as optical biosensors and drug delivery vehicles.

Carbon Nanotubes
Carbon Nanotubes are cylindrical molecules that consist of rolled-up sheets of a single-layer of carbon atoms (graphene). They can be single-walled or multi-walled, or composed of several concentrically interlinked Nanotubes. Due to their high external surface area, carbon Nanotubes can achieve considerably high loading capacities as drug carriers. Additionally, their unique optical, mechanical and electronic properties have made carbon tubes appealing as imaging contrast agents and biological sensors.

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 3). Liposomes are biocompatible, versatile and have good entrapment efficiency. It finds application as long circulatory and in passive and active delivery of gene, protein and peptide.Liposomes are spherical vesicles with particle sizes ranging from 30 nm to several microns, that consist of lipid bilayers. Liposomes can be used to incorporate hydrophilic therapeutic agents inside the aqueous phase and hydrophobic agents in the liposomal membrane layer. Liposomes are versatile; their surface characteristics can be modified with polymers, antibodies and/or proteins, enabling macromolecular drugs, including nucleic acids and crystalline metals, to be integrated into liposomes. Poly (ethylene glycol) (PEG)elated liposomal doxorubicin (Doxil) is the first FDA-approved Nano medicine, which has been used for treatment of breast cancer, and it enhances the effective drug concentration in malignant effusions without the need to increase the overall dose.

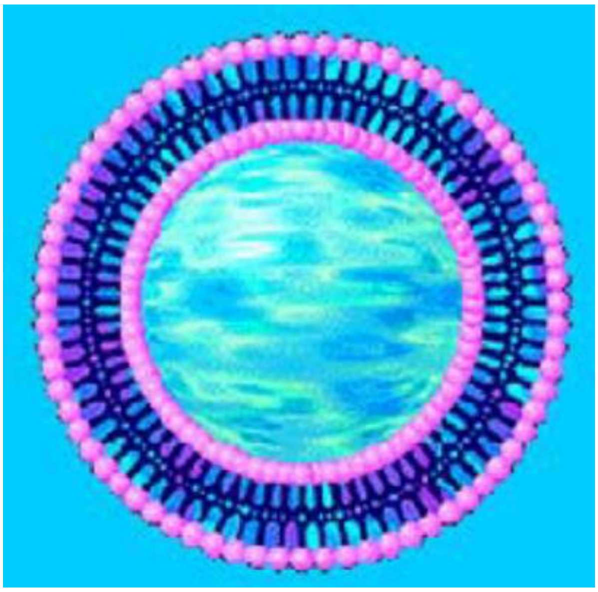

Figure 3: Structure of Liposomes

4. Characteristics of Nanoparticles

Physical features: Some Nanoparticles have high solidness with little weight.

Chemical features: The interaction of Nanoparticles increases if they are homogeneous and of the same size.

Electrical features: The possible energy of the ion can be managed by controlling the size and chemical nature of the secondary particle. Thermal features: when the size of a Nanoparticle becomes smaller, its dissolution temperature decreases.
Magnetic features: when the size of the Nanoparticles becomes smaller, they become more magnetic.

Optical features: if the size of the Nanoparticle is less than the critical wavelength of light, the particle becomes transparent.

5. Nano-Technology and its Application in Several Field:

The different fields that find potential applications of Nanotechnology are as follows:
1) Health and Medicine
2) Electronics
3) Transportation
4) Energy and Environment
5) Space exploration

Applications of Nanotechnology in energy and the environment
Nanotechnology will contribute largely in the following fifty years. The environment will be protected and enough power will be provided for an increasing world. The developed approaches of Nanotechnology are capable of providing support to many fields such as power storage, changing it into other shapes, ecofriendly manufacturing of materials and improving the sources of renewable energy. Another usage of Nanotechnology is to produce cheaper renewal

power. Also, it can be used in solar technology, fuel cells, Nano-catalysis and hydrogen technology. In addition, we can use the cells of carbon Nano tube fuel to maintain hydrogen that can be applied in power cars. We can also use Nanotechnology in the field of photovoltaic, to make them not heavy, inexpensive and more effective. This can decrease the burning of engine pollutants through Nano porous filters. The exhaust can be cleaned automatically with the aid of catalytic converters which contain Nano scale noble metal particles and through catalytic coverings on cylinder walls and catalytic Nanoparticles as additive for fuels. In addition, Nanotechnology supports the improvement of new green and ecofriendly technologies which can reduce the unwanted pollution. The lightening of solid state is able to decrease the total consumption of electricity. Finally, the techniques of Nanotechnology can result in a great decrease in the consumption of power for lighting.

Nanotechnology in healthcare and medicine

Nano-medicine is the term used to refer to the applications of Nanotechnologies in medicine and healthcare. Specifically, Nano-medicine uses technologies at the Nanoscale and Nanoenabled techniques to prevent, diagnose, monitor and treat diseases. Nanotechnologies exhibit significant potential in the field of medicine, including in imaging techniques and diagnostic tools, drug delivery systems, tissue-engineered constructs, implants and pharmaceutical therapeutics, and has advanced treatments of several diseases, including cardiovascular diseases, cancer, musculoskeletal conditions, psychiatric and neurodegenerative diseases, bacterial and viral infections, and diabetes.

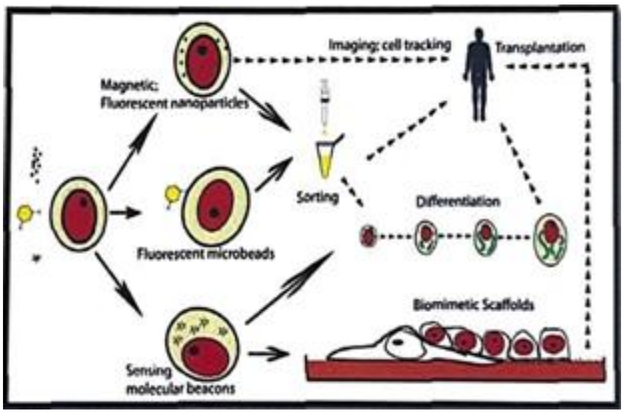

Figure 4: Nanotechnology in stem cell biology and medicine

Nanotechnology in diagnosis

Diagnosis of a disease is one of the most crucial steps in the healthcare process. All diagnoses are desired to be quick, accurate and specific to prevent 'false negative' cases. In vivo imaging is a non-invasive technique that identifies signs or symptoms within a patient's live tissues, without the need to undergo surgery. A previous improvement in diagnostic imaging techniques is the use of biological markers that can detect changes in the tissues at the cellular level. The aim of using a biological marker is to detect illnesses or symptoms, thereby serving as an early detection tool. Notably, some of these high precision molecular imaging agents have been developed through the use of Nanotechnologies. In addition to diagnosis, imaging is also vital for detecting potential toxic reactions, in controlled drug release research, evaluating drug distribution within the body and closely monitoring the progress of a therapy. Potential drug toxicity can be reduced with the possibility of monitoring the distribution of drugs around the body and by releasing the drug as required.

Nanotechnology in drug delivery

Therapy typically involves delivering drugs to a specific target site. If an internal route for drug delivery is not available, external therapeutic methods, such as radiotherapy and surgical procedures are employed. These methods are often used interchangeably or in combination to combat diseases. The goal of therapy is to always selectively remove the tumors or the source of illness in a long-lasting manner. Nanotechnologies are making a compelling contribution in this area through the development of novel modes for drug delivery, and some of these methods have proven effective in a clinical setting and are clinically used. For example, doxorubicin a drug which exhibits high toxicity, can be delivered directly to tumour cells using liposomes (Doxil) without affecting the heart or kidneys. Additionally, paclitaxel incorporated with polymeric mPEG-PLA micelles (Genexol-PM) are used in chemotherapeutic treatment of metastatic breast cancers. The success of Nanotechnologies in drug delivery can be attributed to the improved in vivo distribution, evasion of the reticuloendothelial system and the favorable pharmacokinetics.

Nanotechnology and cancer treatment

Staggering numbers of individuals suffer from cancer worldwide, highlighting the need for an accurate detection method and novel drug delivery system that is more specific, efficient and exhibits minimal side effects. Anticancer treatments are often regarded as superior if the therapeutic agent can reach the specific target site without resulting in any side effects. Chemical modifications of the surface of Nanoparticle carriers may improve this required targeted delivery. One of the best examples of modifications at the surface of Nanoparticles is the incorporation of PEG or polyethylene oxide. These modifications enhance not only the specificity of drug uptake, but also the tumour-targeting ability. Incorporating PEG avoids the detection of Nanoparticles as foreign objects by the body's immune system, thus allowing them to circulate in the bloodstream until they reach the tumor. Additionally, the application of hydrogel in breast cancer is a prime example of this innovative technology. Herceptin is a type of monoclonal antibody used in breast cancer treatment by targeting human epidermal growth factor receptor 2 (HER2) on cancer cells. A vitamin E-based hydrogel has thus been developed that can deliver Herceptin to the target site for several weeks with just a single dose. Due to the improved retention of Herceptin within the tumour, the hydrogel-based drug delivery is more efficient than conventional subcutaneous and intravenous delivery modes, thus making it a better anti-tumour agent. Nanoparticles can be modified in several ways to prolong circulation, enhance drug localization, increase drug efficacy and potentially decrease the development of multidrug resistance through the use of Nanotechnologies.

Potential risks of Nanotechnologies.

Although the emerging field of Nanotechnology has piqued the public's interest at large, Nanotechnologies have also resulted in extensive discussions regarding their safety and any health risks associated with their use. New challenges arise with the use of Nanomaterials, specifically in predicting, understanding and governing the potential health risks. Research has demonstrated that low-solubility Nanoparticles are more hazardous and toxic on a mass by mass basis than larger particles. Other potential risks posed by Nanoparticles include explosions and catalytic effects. It is important to note that only specific Nanomaterials are considered risky, particularly those with high reactivity and mobility. Until more thorough studies can confirm the hazardous effects of Nanomaterials, the mere presence of them in a laboratory setting will not in itself impose a threat to humanity and the environment.

6. Conclusions

Nanotechnology is a new integrative method which includes an application built on the structures of molecules in Nano-scale size range. In fact, Nanotechnology is considered as a new but fast evolving area which includes manufacturing, manipulating and practical utilization of structure, instrument and system by managing size and shape in Nanometer scale.

Nanoscience and Nanotechnology have recently become very critical to medical device applications, such as diagnostic biosensors, drug provision systems.

Nano materials have augmented surface area and Nano scale impacts, thus utilized as a successful means for improving the delivery of gene and drug, diagnostic biosensors and biomedical imaging. Nano materials contain distinctive biological and physicochemical characteristics in comparison to their bigger equivalent. Nano materials have features that can immensely affect their interplays with cells and bio molecules because of their specific shape, size, surface structure, chemical composition charge, solubility and agglomeration. Nanotechnology has a very brilliant future throughout its integrating with other technologies and the latter appearance of complicated and novel hybrid technologies. Biological technologies are integrated with Nanotechnology which has already utilized to cope with genetic material. Nano materials are already being strictures utilizing biological elements. The potentials of Nanotechnology to engineer material at the smallest scale can make a revolution in fields like biotechnology, cognitive science and I0/OfTP8tiOfl technology. Also, Nanotechnology les can lead to new fields and merge them with other fields.

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