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Influence of Nano Materials in Medicine for next generation

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ABSTRACT

Nano particles, because of their special properties attracted researchers from both theoretical and practical point of view. Many efforts have been made in the past two decades using novel nanotechnology and nanoscience knowledge to get nanomaterials with determined functionality. Nanomaterials are objects with the three external dimensions at the nanoscale. The main type of nanomaterial used in medicinal application are semiconductor nanomaterials, metal nanoparticles, magnetic nanomaterials, hydro gel nanocomposites, carbon nanomaterials, dendrimers, liposomes, , polymer nanocomposites, and biodegradable polymers. In this article, we have provided a concise review of the most common and popular nanomaterials viz., titania, carbon nanotubes (CNTs), zero-valent iron, zirconia (zirconium oxide), dendrimers, gold and silver nanomaterials which are currently used in medical field. Although expectations are too high but safety of nanomedicine is not yet completely proved. Over the next coming years, it is predicted that nanotechnology going to evolve and expand in different fields of life sciences and its achievements being applied in medicine like diagnostics, tissue engineering and patient improvement which play crucial role in treatment of human diseases and also in improving human physiology.

KEY WORDS: Nanomaterials, nanotechnology, carbon nanotubes, nanomedicine.

1. INTRODUCTION

Nanotechnology is the "science and technology where dimensions and tolerances are in the range of 0.1 nanometer (nm) to 100 nm play a critical role." Nanotechnology in medicine currently focuses on applications of nanoparticles as well as longer term research that involves the use of manufactured nano-robots to make treatment at the cellular level. Nanotechnology is considered an emerging technology because of its special properties to create new products with totally new characteristics and functions with enormous potential in a wide range of applications. The existing health care system is focused on treating disease rather than preventing disease. Patients are generally not tested until physiological re taken and sent to laboratories for analysis, the results often symptoms are present and they meet with their physicians. When samples of tissue or blood fluid an take several days and can be inconclusive if the disease is at an early stage. Consequently, many diseases are not detected until long after taking root in the body. In addition to various industrial uses, great innovations are foreseen in biotechnology, biology, in metrology, medicine, medical technology, information and communication technology, etc. It is anticipated that nanotechnology will have a huge positive influence on human health. Basically, internal processes of living organisms occur at nanometre scale. Proteins or cell membranes and elementary biological units like DNA are of this dimension. With nanotechnology, these biological units are going to be better guided. Increasing the precision to nanometre scale, makes it an essential feature of procedures and biomedical products in post genomic era. Nanoscale devices are similar in size to large biomolecules such as receptors and enzymes. Nanoscale devices which are smaller than 20 nm can move in and out of blood vessels as they circulate through the human body. Applications of nanotechnology in the field of biomedicine present an opportunity to fight against many dreadful diseases. An area with near-term potential is detecting molecules associated with diseases such as diabetes, cancer, neurodegenerative diseases, mellitus, as well as detecting microorganisms and viruses associated with infections, such as pathogenic bacteria, fungi, and HIV viruses. For example, in the field of cancer therapy, promising novel nanoparticles will respond to externally applied physical stimuli in ways that make them suitable therapeutics or therapeutic delivery systems. Nano technology is even used in biomaterials. For example in orthopedic implants or as scaffolds for tissue engineered products. Nanotechnology prevents non-specific protein adsorption by nano-structured surfaces. By gaining the control over the surface properties at nanolevel, biocompatibility of the materials can be increased.

Nanomaterials and nanoparticles in medicine: A new approach: In future, nanotechnology will enable a shift to preventive medicine and the use of "point of care" diagnostics to quickly identify diseases. In contrasts to the laboratory analysis, "point of care" testing is performed closed to the patient, at the time that care is required. Just as kits are available today for women to obtain instant information about pregnancy, portable diagnostic kits will become available to test whether a person is genetically predisposed to a specific disease, or have the earliest symptoms of a disease. Long before any physiological symptoms of the disease are present, a doctor (or even a patient in the comfort of her own home) will be able to take a sample of blood or saliva and insert the sample into a small chip. The chip consists of nanoscale sensors which will detect particular molecules associated with certain diseases, and will quickly provide feedback to the doctor or patient. "Point of care" diagnostics present a significant market opportunity for companies that can move disease detection out of complex laboratories and into clinics, nursing homes, pharmacies and workplaces. Many companies are now focusing on making diagnostics simpler, smaller and more widely available in the many places patients receive treatment.

Nanomaterials and Nanoparticles in Biomedical Applications: The advanced applications of micro- and nanotechnology in medicine are the microchip-based drug delivery systems, which are devices incorporating micrometer-scale pumps, valves and flow channels. They allow controlled release of single or multiple drugs on demand. Micro- and nanotechnology-based methods (e.g. UV-photolithography, chemical vapour deposition, electron beam evaporation, reactive ion etching) can be used for the fabrication of these silicon-based chips. A lot of studies are going, on the applications of micro and nanotechnologies in chips for medical molecular diagnostics. For example protein microarrays (protein chips), DNA microarrays (gene chips), cell chips and lab-on-a-chip devices. These devices or systems are constructed by using micro/nanoscale fabrication methods. They are used for processing, manipulation, delivery, analysis or construction of biological and chemical entities. Inkjet printing methods are used in DNA microarrays for human genomics and in protein microarrays (or protein chips), which are useful for molecular diagnostics. For the detection of diseases either radionuclide-based markers or fluorescence- or surface Plasmon resonance spectroscopy can be applied.

Carbon nanotubes: Carbon nanotubes are of diameter of 1-20 nm. Gold-coated silica nanoshells, magnetic iron oxide nanoparticles and carbon nanotubes can transform electro-magnetic energy into heat. By increasing irradiation with an external laser source of near infra-red light or increasing magnetic field causing an increase in temperature which is lethal to cancer cells the very location where these nanoparticles are bound to or internalised within tumour cells, there by blasting them without causing any damage to healthy cells.

Quantum dots (2-10 nm): Due to their relatively inexpensive and simple synthesis, quantum dots have already entered the market for experimental biomedical imaging applications. Quantum dots can emit light at any wavelength in the visible and infrared ranges, and can be inserted anywhere, including liquid solution, dyes etc. Quantum dots can be inserted into a variety of organisms through surface ligands for in-vivo research.

Dendrimers: Dendrimers are hyper branched, tree-like structures. It contains three different regions: core moiety, branching units, and closely packed surface. It has globular structure and encloses internal cavities. Its size is less than 10 nm. These are used for long circulatory, controlled delivery of bioactive material, targeted delivery of bioactive particles to macrophages and liver targeted delivery. Anionic dendrimers have been shown to have antiviral activity. Having approximately the size of a virus, dendrimers are designed to bind multivalent either to the viral components or to the host cell surface through electrostatic forces, causing inhibition of infection at the stage of entry of virus to the cell. Dendrimer not only inhibit entry of virus but also inhibit its replication. (Gong, 2002). Activity has been shown against HSV, RSV and HIV while Starpharma's Vivage lTM, a vaginal dendrimeric formulation against HIV is currently entering clinical trials phase II (Gong, 2005). Dendrimers have also been shown to exhibit antimicrobial activity. Typically these dendrimers have cationic surface groups, usually lysine.

Nanotechnology and Nanomedicine: New Medical concept:

Nanomedicine: The use of nanobiotechnology in medicine is termed nanomedicine. Thus, nanomedicine is an offshoot of nanotechnology, referring to highly specific medical treatment at the molecular scale for therapeutic purposes (involving repairing damaged tissues or curing diseases), and for the development of diagnostics for rapid monitoring, targeted cancer therapies, localized drug delivery, improved cell material interactions, scaffolds for tissue engineering and genetics. Nanomedicine can focus on several topics, such as Engineering Topics including, for example, peptide nanoparticles for medical applications, the transition from semiconductors to biochemistry in the lithography industry; Clinical Applications (like nanomedicine and protein misfiling diseases); Topics in Genetics (e.g. nano structured probes for gene detection in living cells, detecting UV damage to individual DNA molecules with AFM, etc.); Topics in Diagnostics, with its main focus on early diagnosis in vitro and in vivo; Policy and Commercialization Topics, including initiative in nano medicine to focus efforts in research, development and applied nanotechnology for improving the diagnostics, therapeutics and treatment of cancer; Experimental Research Topics, which are an important basis for preclinical study, like nanodiagnostic imaging; Topics on Basic Nanomedicine, Pharmacology Topics and Topics on Oncology and on Toxicology.

Nanorobots and Nanodevices: Imagine going to the doctor to get treatment for a persistent fever. Instead of a tablet or pill, the doctor sends you to a special medical team which introduces a nano robot into your bloodstream. The robot travels to the appropriate system, detects the cause of your fever and provides medication directly to the infected area. Actually, we are not that far from using such nanodevices in medical procedures. Engineering teams are working hard to design nanorobots that will eventually be used to treat everything from hemophilia to cancer. The preliminary design is for the following specific applications:

Tumours: Tumours are cells grouped in a clumped mass. The treatment is not to replace them but to destroy timorous tissue to minimize the risk of reoccurrence. The technique is intended to be able to treat tumours that cannot be accessed via conventional surgery, such as deep brain tumours. However, since the technique is extremely effective and much less debilitating than conventional surgery, it should be used, if possible, as a replacement for conventional surgery in this application.

Arteriosclerosis: This is caused by fatty deposits on the walls of arteries. The device should be able to remove these deposits from the artery walls. This will allow for both improving the blood flow through them and the flexibility of the walls of the arteries. Removing these accumulated fatty acids and leaving these particles into blood stream should allow the body's natural processes to remove the overwhelming preponderance of material.

Blood clots: They (fatty acids) cause damage when they travel through the bloodstream where they can block the flow of blood to a vital area of the body. This can result in damage to vital organs in very short order. In most of the cases, these blood clots are only detected when they cause a blockage and damage the organ in question, often but not always the brain. By introducing a nanorobot into the body to blast such clots into smaller pieces before they have a chance to break free and move on their own, the chances of damage can be greatly reduced.

Nanotechnology in Orthopaedic Implants: Biomaterials is one of the most important applications of nanotechnology in medicine. Example: in orthopaedic implants or in tissue engineered products. Next generation of orthopaedic implant depends completely on Nanostructured materials.

They create a surface environment more conducive for osteoblast. An important field of application for nanotechnology in medicine is the biomaterials. Example: in orthopaedic implants or in tissue engineered products. Next generation of orthopaedic implant depends completely on Nanostructured function. The nanoscale composition of bone substitute materials emulates the hierarchic organization of natural bone, shows initiation of the desirable formation of an appetite layer. Nanotechnology also improved the quality of surgical blades and cutting performance. Nanofibrous membrane wound dressings containing antibacterial properties reduces postoperative infection rates. Drug delivery, including nanotherapeutics for treating bone cancer and arthritis are the most notable applications of nanotechnology in orthopaedics. Nanotechnology is used in orthopaedics, and likely will play a valuable role in future developments.

Nanotechnology in Cardiology: Nanotechnology has various applications in the field of cardiology research not only for diagnostic but also for therapeutical purposes. Recently, University of Michigan researchers developed a nanoparticle that could be the key to a targeted therapy for cardiac arrhythmia, a condition that causes the heart to beat erratically and can lead to heart attack or heart stroke. The cells that cause cardiac arrhythmia are precisely targeted and destroyed within the heart by nanotechnology. The U-M team in their studies conducted on rodents and sheep, found that the treatment successfully kills the cells that cause cardiac arrhythmia while leaving surrounding cells unharmed. In the journal, Science Translational Medicine, they published their findings.

Nanotechnology against Cancer: The use of nanotechnology in cancer treatment gives a new hope of fighting this dreadful disease. This technology has the capability to destroy cancer tumours with a minimum effect on healthy organs and tissues. Nano robots can detect and eliminate cancer cells before they form tumours. Cancer treatment through nanotechnology is at research or development stage. National Cancer Institute, The Alliance for Nanotechnology in Cancer in U.S., is promoting innovation and collaboration among researchers to resolve some of the major challenges in the application of nanotechnology to cancer. In addition, there are many universities and companies worldwide working in this area. In a decade or so, cancer can be eliminated completely by these efforts. (Similar to smallpox elimination by vaccines).

Nanotechnology against antibacterial activity: Nano TiO_2 is excellent photo catalyst used in antiseptic which can not only inhibit reproduction ability of bacterium, but also decompose its structure of cell membrane which will degrade microorganisms completely and thus avoid a second time pollution caused by creatoxin.

Titanium Oxide Nanoparticle is a non-dissolved material which does not dissolve itself when degrades organic contaminant and kills germs. It kills germs and degrades organic contaminants. TiO_2 nanoparticle is widely used as UV-resistant material and in the field of producing chemical fibre, printing ink ,plastics, coating, self-cleaning ceramics, self-cleaning glass, air purification, antibacterial material, , chemical industry and sewage treatment, cosmetics- natural white moisture protection cream ,sunscreen cream, beauty and whitening cream, moistening refresher, morning and night cream, skin protecting cream , vanishing cream and face washing milk. They are also used in powders in make-up and foods packing material.

Coating for paper-making industry: TiO_2 nano particles are used for improving the opacity and impressionability of the paper. Ferrotitanium alloy, carbide alloy, Titanium etc. can be produced from these nanoparticles, in the metallurgical industry, astronautics industry. It is also used in manufacture of moisture sensor, gas sensor and conducting materials.

2. CONCLUSION

Nanotechnology in modern medicine and nanomedicine is in infancy, having the potential to change medical research dramatically in the 21st century. Due to their small sizes, surface area modification capacity and unique biological properties, nanomaterials have a broad scope of application in analytical, imaging, detection, diagnostic and therapeutic purposes and procedures, such as targeting cancer, gene delivery systems, improving cell-material interactions, scaffolds for tissue engineering, and drug delivery and provide innovative opportunities in the fight against incurable diseases. Thanks to nanotechnology tools and techniques, there has been a huge progress on understanding the function of biological structures and their interaction and integration with several non-living systems, but there are still open issues to be answered, mainly related to biocompatibility of the materials and devices which are introduced into the body. The vision is to improve health by enhancing the efficacy and safety of nanosystems and nanodevices. In addition, early diagnosis of cancer causing tumour, blood clot which might lead to a heart attack or diabetes helps to cure them with a minimum treatment. In the coming years, nanotechnology will play a key role in the medicine of tomorrow providing revolutionary opportunities for early disease detection, therapeutic procedures and diagnostics to improving health and enhancing human physical abilities, and enabling precise and effective therapy tailored to the patient.

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