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Mini Review

Impact of Nanotechnology in the Modern World

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Abstract

Human exposure to engineered nanomaterials in the modern world is extensive. Use of nanotechnology in food, medicine, cosmetics and environment is widespread and is expected to increase in the future. This new technology holds great promise. However, it faces many challenges that need to be overcome. Our understanding of the effect of nanotechnology on human health is limited. Therefore, its impact on human life is of public concern. This review indicates that more studies using the modern technologies are required to develop a better understanding of the role nanotechnology plays inhuman health.

Keywords: Nanomaterials; Engineered nanomaterials; Nanoscience; Nanotechnology; Food; Medicine; Cosmetics; Nanotoxicity; Nanomedicine; Human health

Introduction

The nanotechnology has seen exponential growth in recent years because of its applications in the manufacturing, communications, energy production, waste treatment, consumer products, and medicine. Nanomaterials are substances of the size between 1 and 100 nanometers. They occur naturally and also manufactured as engineered nanomaterials. They have unique physical and chemical properties because of their nano-size. They are highly reactive because of their large surface area-to-volume ratio. Nanoscience is the study of nanomaterials. Nanotechnology is the applied nanoscience. Nanotechnology is considered as a modern industrial revolution. It is a new technology developed in the 21st century. This new science and technology developed exponentially giving birth to its related new branches such as nanotoxicology and nanomedicine with a wide range of useful applications in the modern world. Nanotechnology is the application of nanoscience to produce significant scientific and technological advances in diverse fields including medicine, transportation, materials, energy, electronics, agriculture and environment as well as consumer and household products [1]. Nanotechnology is involved in the design, synthesis and application of nanomaterials. However, our understanding of the effect of nanotechnology on human health is limited. Therefore, the impact of nanotechnology is of public concern and requires more study and research.

Human Exposure

Human exposure to engineered nanomaterials is extensive in modern world. Humans are exposed to these nanomaterials present in consumer products in their daily lives. They are exposed to engineered nanomaterials through the skin, lungs and digestive system. The nanomaterials reach different organs of the body from the bloodstream and induce cell damage including DNA damage.

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Nanotechnology Applications in Medicine, Agriculture and Biotechnology

Due to their unique physical-chemical properties, nanomaterials act *via* different toxicological mechanisms than the bulk counterparts of the same materials [2]. For example, ZnO, known as a water-insoluble compound in bulk form, was shown to exert toxicity through released Zn-ions in the case of ZnO nanoparticles. The cellular uptake pathways of nanomaterials depend on their size, shape, and surface properties [2].

Nanomaterials are used for high-throughput screening of structure-activity relationships using libraries of nanoparticles with different properties. Also they are used for more sensitive omics-technology to detect toxicity at low exposure conditions. Kahru and Mortimer [2] have discussed how bacteria can respond to engineered nanomaterials and how they can be applied in nanomedicine and nano-agrochemicals. They argue for widespread application of engineered nanomaterials in medicine and agriculture.

Nanosilver is used in wound dressings, stents, catheters and bandages because of its antimicrobial properties. Nanogold is used in cancer chemotherapy to protect the patients from the adverse effects of the medication. Because of its optical properties the nanogold is also used to detect the presence of cancer in the body.

Carbon nanotubes are used in batteries, capacitors, water filters and various industrial applications. Many commercial sunscreens contain titanium dioxide and zinc oxide nanoparticles to enhance protection from UV radiation.

Nanotechnology Clinical Applications

Natural plant and herbal products are used to treat various diseases for a long time. These products provide chemical diversity and biological properties with molecular specificity. This observation led to the use of synthetic products and more recently engineered nanomaterials in medicine. Use of nanomedicines in delivery of natural and synthetic drugs for various diseases has been remarkable. Recently nanomedicine and nano-delivery systems find their use as useful diagnostic and drug-delivery tools. Nanotechnology is used for delivery of drugs to specific targets for treatment of various diseases [3]. An assembly of nanomaterials with hydrophobic cavities is used to administer poorly water soluble drugs to desired targets [4].

Nanotechnology and Medical Implants

Nanotechnology is applied to design and develop antibacterial, rigid and functional medical implants [5].

Fabrication of Bio-Nanocomposite Models for Photocatalytic Degradation of Dyes

Dye effluent containing chemicals from the cosmetic, leather, paper, dye and textile industries is one of the primary pollutants in the environment. Various bio-nanocomposite models for the photocatalytic degradation of these dyes have been developed using a synthesized ZnO and alginate polymer bio-nanocomposite [6].

Industrial Application of Nanotechnology

The nanotechnology is considered as "the next industrial revolution" [1]. Various industries use nanotechnology. They include food, medicine, cosmetics, agriculture and technology. The well-established nanotechnology is an undisputed challenge [7]. This journal "Editorial: Nanotoxicology: Challenges and solutions to safeguard human health and the environment" warns clearly that "The release of ENMs and particles to different environmental matrices (water, air, soil) has been demonstrated during the life cycle of consumer products. Consequently, both intentional and unintentional exposure to ENMs have raised concern about their potentially harmful effects on living organisms, including humans, from which emerged the recent research area of nanotoxicology. In this way, different characteristics of the ENMs (i.e., size, shape, charge, chemical composition) have been linked to toxicological effects. Moreover, ENMs can cause toxicity through different mechanisms, ranging from the simple physical adsorption, to the biological surface, to the triggering of complex processes that lead to oxidative stress. Recently, design approaches are gaining importance in the field of nanotechnology with the aim to develop safe and sustainable products".

Health Risks of Nanotechnology

Engineered nanomaterials have many potential benefits. They also present risks to human health and environment. Many things are still unknown about them. They appear to be double-edged swords. Some reports in literature indicate that inhaled carbon nanotubes can induce inflammation, pulmonary fibrosis, and genotoxicity. Nanosilver shows toxic effects on marine species in aquatic environments.

Security and Safety of Nanotechnology

A systematic discussion on environmental security and safety of nanotechnology and its biomedical applications, both *in vitro* cell cultures and *in vivo* living organisms, focusing on inorganic titanium dioxide nanoparticles and silver nanoparticles, has been presented by Zielińska et al. [8].

Conclusions and Future Directions

From nanoscience to nanotechnology is an impressive and exciting journey. Nanotechnology is applied nanoscience. It holds great promise for the future. It plays an important role in human life in the modern world. Significant progress has been made in recent years, but more information we need to know. Our understanding of the impact of this technology on human health is limited. It presents significant challenges for understanding all aspects of its interactions and their implications. These issues and knowledge gaps need to be addressed. More studies are required using up-to-date technologies and highlighting its future directions. Clinical applications of nanotechnology are evolving. It has found its role in clinical applications, but more are expected to be discovered. This review indicates that more work is required using current and new technologies to develop a greater understanding of the role the nanotechnology plays in human health and disease.

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