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A ROLE OF NANOTECHNOLOGY RECENT ADVANCES IN DIFFERENT SECTORS OF SCIENCE FOR HUMAN WELFARE: A REVIEW

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ABSTRACT

Nanotechnology is currently studied in various aspects of the technology industry sectors. Nanoparticles can be produced by different methods like physical, chemical, or biogenic in the length scale of approximately 1 to 100 nm range. In this review, the authors have highlighted the role and the importance of potential uses of various types of nanoparticles or nanomaterials in different sectors such as agriculture, cosmetics like dental paste and sunscreen lotion, medicine, marine bioremediation, mini DNA barcoding and DNA barcoding (for identification of unknown species and phylogenetic analysis), health sector, industries, aquaculture, fishery, forensic science, nanorobotics, diagnosis of common diseases, molecular biology, treatment in COVID-19 and also in astrobiology to detection of life on Mars and other worlds. The main objective of this review is to study of nanotechnology in different and recent science and engineering sectors.

KEYWORDS: Nanotechnology, DNA Barcoding, COVID-19, Bioremediation, Nanorobotics, Nanospace, Molecular Biology.

INTRODUCTION

Nanotechnology involved in a number of fields resulted in rewarding the requirement of human beings. Biosynthesis of nanoparticles by means of physical and chemical processes, in this the DNA, RNA, and protein-based applications provoked by nanotechnology are known as biomolecular applications such as in medicine, cosmetics, and research. Biological organisms and plants are important, safe, and easily available of metabolites that may aid in the reduction and so many researchers have been done with plants and animals, and microorganisms with respect to phytochemicals and biochemicals. Microorganisms ranging from bacteria fungi have been used in recent years to develop a non-hazardous, safe, and environmentally friendly method to synthesize nanoparticles (Bhatacharya and Ranjinder, 2005). Synthesis of nanoparticles using microbes often better size control through compartmentalization in the periplasmic space and vesicles. Marine microorganisms play several important roles in synthesize nanoparticles used in medical applications like drug preparation, treatment, and diagnosis of diseases for human life improvement. Nanomaterials exhibit unique physical and chemical properties such as morphology, size, charge, surface area, distribution, and crystallographic characterization. According to their synthesis method nanoparticles are categorized into different types (Rizwan et al., 2014) and as follows:

1. Carbon nanoparticles (eg: ZnO, Fe2O3, Fe3O4, MgO, BaCO3, BaSO4, TiO2).
2. Metal nanoparticles (eg: Pt, Rh, Pd, Ir, Ag, Au, Cu, Co, Ni, FeN. ZnS).
3. Nanocomposite (eg: Fluoropolymers, polyethyleneglycol, polyester polyamides).
4. Polymer nanomaterials (eg: polypyrrole, polyaniline)
5. Bionanomaterials (eg: Viruses, plasmids, and protein nanoparticles.

The main purpose of this review is to understand the safety research, health, environmental applications of different types of nanoparticles (nanotechnology) or nanoscale materials that may be used in commercial or consumer products, medical treatments, and research.

Role of Nanoparticles in Dental Paste

The nanomaterial containing hydroxyapatite (nano-HA) have been developed to positively interfere in dental caries development and progression, bringing new perspectives for high-risk patients, The nano- Ha material containing hydroxyapatite (HA), the main constituent of the inorganic phase of the tooth and can able to provide phosphate and calcium ions for decreasing the tooth demineralization and/or tooth demineralization. The paste with nanoparticle may penetrate into tooth porosities and it produces a

protective layer on the tooth surface which is similar to natural (Cochrane et al., 2010; Haung et al., 2011; Nongonierma and Fitzgerald, 2012).

Some of the previous studies revealed that paste and toothpaste containing nano- HA have some potential to increase enamel and dentine remineralization in vitro and in situ (Najibfard et al., 2011; Tschoppe et al., 2011; Pepla et al., 2014). By using nano-HA compared to micro-Ha is that the nano-HA has similar morphology, solubility, size, crystal structure, and biocompatibility when compared to dental apatite (Balasundaram et al., 2006) and also have the ability to remineralization bovine and human enamel and dentine carious lesions especially to prevent tooth demineralization. Saliva and biofilm seem to positively interfere in the interaction between nano-HA paste and the tooth (Zang et al., 2015). So that nano-HA paste is used to improve human saliva and the formation of dental biofilm in the oral cavity for better simulating the clinical condition especially on the reduction of dental demineralization (Beatriz et al., 2015)

Unique Role of Nanotechnology In (Dna-Gold Nanoparticle Sensors) In Mini –Dna Barcoding

DNA-gold nanoparticle sensors are used to rapidly detect diseases, mycotoxins, and microorganisms (Cho and Irudayaraj, 2013; Kong et al., 2016). The size of the gold nanoparticles are (AuNps) very small (1-100nm in diameter), possess high electron density, dielectric properties, and able to perform catalysis. Gold nanoparticles can bind with different types of biomacromolecules, bioactive compounds, and biocompatible oligonucleotides (Daniel and Astruc, 2004; Wang et al., 2010). These gold nanoparticles are used to evaluate plant materials, detect genetically modified organisms. Mini-bar-coding combined with DNA gold nanoparticles sensors are used to study genetically modified organisms and also to detect related species (Gao et al., 2019).

DNA barcoding is versatile for certain species in multicomponent mixtures because the universality of barcodes can reduce the accuracy of species but mini-barcoding is used to identify specific targets for medicinal plants. Lei et al. established a sequencing free nano gold electrochemical DNA biosensor which was able to discriminate between two Chinese herbal species Fritillaria thunbergii and Fritillaria cirrhosa (Lei et al., 2015).

Role of Nanoparticle in Sunscreens

Sunscreen or sunblock formulations have traditionally included a variety of organic and inorganic compounds with absorption bands in various regions of the sun is often divided into three different classes that related to the response of the skin are UVC (270-290 nm), UVB (320-340 nm) and UVA are subdivided into UVA2 (290-320 nm) UVA1 ((340-400 nm). The high refractive index and broad absorption in the UVB and UVA regions of titanium dioxide and zinc oxide particles have been utilized in early and modern sunscreen and sunblock formulation (Serpone et al., 2007; Weir et al., 2012). One of the earlier reports indicated that UV-damaged skin is more permeable to nanoparticles (Riveire et al., 2011).

UV-absorbing inorganic nanoparticles basically Titanium dioxide (TiO2), Zinc oxide (ZnO2), and Ceria (CeO2) as the active ingredients, and these are mainly used for UV-blocking, photocatalytic, and sunscreen applications due to having the properties of synthesis, dispersion, and surface fictionalization. Some of the authors from the major cosmetic companies indicate that the risk for humans from the use of nano-sized ZnO2 and TiO2 is negligible (Schilling et al., 2010).

Importance of Nanotechnology in Treatment of Covid-19 Disease

Coronavirus is an epidemic disease which was first appeared in Wuhan city Hubei province, China (Syed, 2020). Covid-2019 is spreading and rising rapidly all over the world. Due to the increasing intimidating number of cases all over the world, the World health organization (WHO) acknowledged Coronavirus as a global health emergency. This virus has been transferred from animal species (Bat) to humans and right now are transferred to individuals (Cui et al., 2019) through the cough, breathing droplets, human contact, sneeze or talk and is created for the period of hacks or wheezes from an infected individual. The symptoms may include fever, dry cough, fatigue, sore throat, body pains, conjunctivitis, diarrhea, loss of flavor/ loss of odor, headache, rashes on the skin, difficulty to breathe, loss of speech or movement chest pain or pressure which leads to the dangerous condition of life.

Recent developments in nanotechnology proved that they can help in the production of vaccines in a brief timeframe for quick immunization improvement and the capability and implementation of nanotechnology to combat coronavirus disease (Rangayasami et al., 2021). Nanomedicine, the application of nanomaterials to medicine is used in vectors, biosensors, drugs, and gene delivery leads to improved therapeutic efficacy through enhanced drug bioavailability, specific delivery to target sites in cellular and intracellular levels, and reduces side effects. Nanoparticles such as iron oxide, silver, zinc oxide, carbon-based particles possessing unique physical and chemical properties showed virucidal activities (Weiss et al., 2020). Nanoparticles can be applied for the co-encapsulation of the candidate drugs such as Remdesivir and hydroxychloroquine, to treat Covid-19. Carbon nonmaterial derived from ethylenediamine/ citric acid and boronic acid ligands and which inhibit and inactive HcoV-229E entry in a concentration-dependent manner (Loczechin et al., 2019) and the functional groups of these carbon quantum dots interacting with HcoV-229E entry receptors and inhibits viral replication.

Role of Nanoparticles in Agriculture Sector

Agriculture provides food for humans, directly and indirectly, so agriculture the backbone of most of the developing countries due to their income comes from the agriculture sector and more than half of the population depends on it for their livelihood. It is necessary to use modern technologies such as bio and nanotechnologies in agricultural sciences (Singh et al., 2015). Nanotechnology helps in the agriculture sector by reducing environmental pollution by the production of chemical fertilizers and pesticides by using nanoparticles and nanocapsules to increase crop yield.

Some of the important nanoparticles such as carbon, silver, silica, and alumina-silicates used for controlling the different types of plant diseases caused by several phytopathogens. Nanosilver (1.5 nm average diameter) is the most utilized nanoparticle which has a high surface area and a high fraction of surface atoms, has high antimicrobial and high antifungal effect. It eliminates unwanted microorganisms in planter soils and hydroponics systems. It is also used as a foliar spray to stop fungi, molds, rot, and several other plant diseases. Magnetic nanoparticles (Mornet et al., 2004; Jurgons et al., 2006) and titanium oxide (Yao et al., 2009) were used in the treatment of various diseases and phytopathogenic disinfection.

Nnanoparticles Play an Important Role in Bioremediation In The Marine Environment

Now a day's one of the most demanding undertakings of the 21st Century is to develop new eco-friendly, sustainable, and economically sound technologies to clean up the marine environment from chemical pollutants. In the last years, different physical, chemical, and biological technologies have specifically focused on actions to protect and restore the marine environment from pollutants.

In this circumstance, the development of nanotechnology and the incorporation of the use of nanomaterials and Nanoparticles can represent (Ccecchin et al., 2017) a hopeful innovation able to enhance the bioremediation action and to go beyond the actual limitations for in-situ or ex-situ applications. Hazardous and radioactive waste pollution, groundwater and wastewater treatment, heavy metal, and hydrocarbons contaminated sediments remediation are only a few of the most known potential applications of nanomaterials in bioremediation processes (Rizwan et al., 2014). Nanoparticles can directly catalyze the dilapidation of different types of pollutants and toxic materials and, at the same time, can promote the development of microorganisms able to degrade different toxic pollutants in the marine environment.

Role of Nanotechnology in Space Research

Nanotechnology is also play an important role in space technology, especially in astrobiology to detection of life on Mars and other worlds. Carbon nanotubes exhibit significant mechanical electrical properties and play a wide variety of roles in future space systems, such as wiring, high-strength lightweight composite materials, thermal protection, and cooling systems and electronics or sensors. Successful development of these technologies is highly dependent on a reliable method to produce controlled carbon nanotubes.

Nanotechnology Are Used in Zero Waste Management

Nanotechnology is one of the most important emerging trends in environmental protection especially in waste management in air, soil, and water bodies. Nanotechnology-based waste management treatment is more effective than the other conventional chemical methods due to their high specific area to volume ratio (Shan et al., 2009). The effectiveness of nanotechnology in environmental waste management is mainly based on the selection of suitable nanomaterials for the targeted pollutants and the existing conditions. Metal (Iron) and carbon-based nanomaterials are presently among the most commonly used, while zero-valent iron is the most extensively used nanomaterial in the environmental protection industry. Among carbon-based nanomaterials, the carbon nanotubes are the most commonly used nanoparticle and also the other metal-based materials, such as zinc, silver, bimetallic or magnetic (e.g. magnetite) nanoparticles, and polymeric nano adsorbents have shown high efficiency for liquid waste management nanotechnology can be employed either for in-situ or ex-situ waste management technologies. Some of the ecotoxicological studies represent the toxic effects of nanoparticles on mammalian cell types and to some aquatic organisms like daphnia or fish. However, there is still a poor understanding of how nanoparticles affect humans and other animals. When this nanomaterial is exposed to ultraviolet (UV) light (sunlight) it produces hydroxyl radicals, which are highly reactive and can oxidize contaminants (Dermatas et al., 2018).

Role of Nanotechnology In Robotic Science (Nanorobotics)

Robots are programmable machines. They range from micromachines to macro-crane size constructions. Like nanotechnology, robotics is the use of technology to design and construct machines built for definite purposes. Nanorobotics is dealt with the controlled manipulation of objects with nanometer-scale dimensions and nanomanipulation is the most effective process. It is concerned with the construction and programming of robots with overall dimensions at the nanoscale. All of the current developments in technology directs humans a step closer to nanorobot production. Nanorobots can also helpful in the treatment of common diseases in the 20th century. Although research into nanorobots is in its beginning stages, the undertaking of such technology is endless. Nanorobotic is mainly used to cure skin disease by using cosmetic cream and it can be used as a mouthwash to do all brushing and flossing. Nanorobotic science is helpful to prevent heart diseases,

cancer, and also the Study of the Immune system by finding and eradicating different types of microorganisms such as bacteria and viruses and also monitor potentially harmful microorganisms in the ocean.

A Recent Application of Nanotechnology In Molecular Docking (*In Silico*) Studies

Nanoinformatics is an emerging science that contains databases and tools. Nanotechnology is also used in molecular docking studies especially to predict protein-ligand interactions. Human serum albumin is one of the most important transport proteins in the bloodstream and can bind to any type of ligand injected into the bloodstream and play an important role in the drug delivery system. CuO nanoparticles bind to subdomain III-A of human serum albumin (HAS) i. e fatty acid binding site 3 thus CuO can also be studied for drug delivery approach for 4-PBA in order to understand its kinetics. Moreover, CuO could also be applied with applications like micelles formation to overruled fatty acid-binding potential with serum albumin protein by targeting fatty acid binding site 3 in HSA protein. Both CuO and TiO2 nanoparticles showed HSA binding properties, with TiO2 nanoparticles having a slightly higher affinity towards human serum albumin. Molecular docking studies were carried out using the Auto Dock 4.2 tool to predict the preferred binding mode and binding site of TiO2 and CuO with human serum albumin (Sandesh Chibber and Ireshad Ahmad, 2016).

CONCLUSION

The present review indicates that nanoparticles are very small, light, transparent and their size varies from 1to 100 nm which are used in different sectors (recent advances) like biomedical, health safety, agriculture, cosmetics, robotics space technology, pollution management on soil, and water, defense, molecular docking studies, DNA Barcoding for identification of new species and diagnosis of different types of diseases for human welfare.

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