Research Journal of Recent Sciences ISSN 2277-2502
Vol. 4(**ISC-2014**), 9-11 (**2015**) *Res. J. Recent. Sci.*

A Review on Nanoparticles: Their Synthesis and Types

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Available online at: www.isca.in, www.isca.me
Received 24th November 2014, revised 9th February 2015, accepted 11th February 2015

Abstract

Nanotechnology refers to the creation and utilization of materials whose constituents exist at the nanoscale; and, by convention, be up to 100 nm in size. Nanotechnology explores electrical, optical, and magnetic activity as well as structural behavior at the molecular and submolecular level. It has the potential to revolutionize a series of medical and biotechnology tools and procedures so that they are portable, cheaper, safer, and easier to administer. Nanoparticles are being used for diverse purposes, from medical treatments, using in various branches of industry production such as solar and oxide fuel batteries for energy storage, to wide incorporation into diverse materials of everyday use such as cosmetics or clothes, optical devices, catalytic, bactericidal, electronic, sensor technology, biological labelling and treatment of some cancers. due to their exceptional properties including antibacterial activity, high resistance to oxidation and high thermal conductivity, nanoparticles have attracted considerable attention in recent years. Nanoparticles can be synthesized chemically or biologically. Metallic nanoparticles that have immense applications in industries are of different types, namely, Gold, Silver, Alloy, magnetic etc. This study aims to present an overview of nanoparticles, with special reference to their mechanism of biosynthesis and types.

Keywords: Nanoparticles, silver, bactericidal, thermal conductivity, optical devices.

Introduction

Nanotechnology refers to an emerging field of science that includes synthesis and development of various nanomaterials. Nanoparticles can be defined as objects ranging in size from 1-100 nm that due to their size may differ from the bulk material. Presently, different metallic nanomaterials are being produced using copper, zinc, titanium, magnesium, gold, alginate and silver. Nanoparticles are being used for diverse purposes, from medical treatments, using in various branches of industry production such as solar and oxide fuel batteries for energy storage, to wide incorporation into diverse materials of everyday use such as cosmetics or clothes [1].

Synthesis of Nanoparticles

Nanoparticles can be synthesized chemically or biologically. Many adverse effects have been associated with chemical synthesis methods due to the presence of some toxic chemical absorbed on the surface. Eco friendly alternatives to Chemical and physical methods are Biological ways of nanoparticles synthesis using microorganisms[2,3], enzymes[4], fungus[5], and plants or plant extracts[6,7]. The development of these eco friendly methods for the synthesis of nanoparticles is evolving into an important branch of nanotechnology especially silver nanoparticles, which have many applications[8-10].

Biosynthesis: Mechanism

Biosynthesis of nanoparticles by microorganisms is a green and eco-friendly technology. Diverse microorganisms, both prokaryotes and eukaryotes are used for synthesis of metallic nanoparticles viz. silver, gold, platinum, zirconium, palladium, iron, cadmium and metal oxides such as titanium oxide, zinc oxide, etc. These microorganisms include bacteria, actinomycetes, fungi and algae. The synthesis of nanoparticles may be intracellular or extracellular according to the location of nanoparticles[11,12].

Intracellular synthesis of nanoparticles by fungi: This method involves transport of ions into microbial cells to form nanoparticles in the presence of enzymes. As compared to the size of extracellularly reduced nanoparticles, the nanoparticles formed inside the organism are smaller. The size limit is probably related to the particles nucleating inside the organisms[13].

Extracellular synthesis of nanoparticles by fungi: Extracellular synthesis of nanoparticles has more applications as compared to intracellular synthesis since it is void of unnecessary adjoining cellular components from the cell. Mostly, fungi are known to produce nanoparticles extracellularly because of their enormous secretory components, which are involved in the reduction and capping of nanoparticles[13].

Microbes for production of nanoparticles: Both unicellular and multicellular organisms produce inorganic materials either intra- or extracellularly[14]. The ability of microorganisms like bacteria and fungi to control the synthesis of metallic nanoparticles is employed in the search for new materials.

Because of their tolerance and metal bioaccumulation ability, fungi have occupied the center stage of studies on biological generation of metallic nanoparticles[15].

Nanoparticles: Types

Silve: Silver nanoparticles have proved to be most effective because of it's good antimicrobial efficacy against bacteria, viruses and other eukaryotic micro-organisms[16,17]. They are undoubtedly the most widely used nanomaterials among all, thereby being used as antimicrobial agents, in textile industries, for water treatment, sunscreen lotions etc[18,19]. Studies have already reported the successful biosynthesis of silver nanoparticles by plants such as *Azadirachta indica*[20], *Capsicum annuum* [21] and *Carica papaya*[22].

Gold: Gold nanoparticles (AuNPs) are used in immunochemical studies for identification of protein interactions. They are used as lab tracer in DNA fingerprinting to detect presence of DNA in a sample. They are also used for detection of aminoglycoside antibiotics like streptomycin, gentamycin and neomycin. Gold nanorods are being used to detect cancer stem cells, beneficial for cancer diagnosis and for identification of different classes of bacteria[23,24].

Alloy: Alloy nanoparticles exhibit structural properties that are different from their bulk samples[25]. Since Ag has the highest electrical conductivity among metal fillers and, unlike many other metals, their oxides have relatively better conductivity [26], Ag flakes are most widely used . Bimetallic alloy nanoparticles properties are influenced by both metals and show more advantages over ordinary metallic NPs[27].

Magnetic: Magnetic nanoparticles like Fe_3O_4 (magnetite) and Fe_2O_3 (maghemite) are known to be biocompatible. They have been actively investigated for targeted cancer treatment (magnetic hyperthermia), stem cell sorting and manipulation, guided drug delivery, gene therapy, DNA analysis, and magnetic resonance imaging (MRI)[28]

Table-1
Synthesis of metallic nanoparticles by different microorganisms

Microorganism	Type	Location	Size
Fungi			
Phoma sp.	Ag	Extracellular	71.06–74.46
Fusarium oxysporum	Au	Extracellular	20–40
Verticillium sp.	Ag	Intracellular	25 ± 12
Aspergillus fumigates	Ag	Extracellular	5–25
Trichoderma asperellum	Ag	Extracellular	13–18
Phaenerochaete chrysosporium	Ag	Extracellular	50–200

Applications

Nanomedicine has tremendous prospects for the improvement of the diagnosis and treatment of human diseases. Use of microbes in biosynthesis of nanoparticles is an environmentally acceptable procedure. Nanotechnology has potential to revolutionize a wide array of tools in biotechnology so that they are more personalized, portable, cheaper, safer, and easier to administer.

Conclusion

Due to their incredible properties, nanoparticles have become significant in many fields in recent years such as energy, health care, environment, agriculture etc. Nanoparticle technologies have great potentials, being able to convert poorly soluble, poorly absorbed and labile biologically active substance into promising deliverable substances.

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