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Nanoparticles: Their Synthesis, Biosynthesis and Types

Anupriya Chandrasekar[1]

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Abstract:

The creation and utilization of materials whose constituents exist at the nanoscale and by convention be up to 100 nm in size is referred as nanotechnology. Nanotechnology includes Electrical, optical, and magnetic activity as well as structural behavior at the molecular and sub-molecular level. It has the tendency to make revolution in a series of medical and biotechnology tools and procedures, as they are portable, cheaper, safer, and easier to administer. Nanoparticles are very useful for various purposes such as in medical treatments, used in various branches of industry production such as solar and oxide fuel batteries for energy storage, in wide incorporation into various materials of everyday use such as cosmetics, clothes, optical devices, catalytic, bactericidal, electronic, sensor technology, biological labelling and treatment of some cancers. Nanoparticles have attracted considerable attention in recent years due to their properties such as antibacterial activity, high resistance to oxidation and high thermal conductivity. It can be synthesized both chemically and biologically. This study presents discussion about the nanotechnology and nanoparticles along with their types and synthesis.

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Authors:

1. *Bharath Institute of Higher Education and Research, Selaiyur, Chennai, Tamil Nadu, INDIA*

Introduction

In 1959, Richard Feynman was the first person who talked about nanotechnology which many years after inspired conceptual foundations of nanotechnology. Nanotechnology includes synthesis and development of various nanomaterial which refers to an emerging field. The particles range from 1-100 nm in size and can differ from the crowd of materials is called nanoparticles. Nowadays, there are so many metallic nanomaterial are being manufactured by the use of copper, zinc, titanium, magnesium, gold, alginate and silver. Nanotechnology impacts on human life. Nanoparticles are being used for many purposes such as medical treatment, being used in many branches of industry including solar and oxide fuel batteries for energy storage, to wide incorporation into diverse materials of everyday use such as cosmetics and clothes.

Nanoparticles

Since ancient times, nanoparticles are being used in pottery and medicine. There are many ideal methods of synthesizing the nanoparticles. Many aspects such as neural pH, low cost and environmental friendly fashion are involved in the synthesis of nanoparticles. The nanoparticles which are produced from the plants, are more stable and have higher rate of synthesis than obtained from other organisms (Siavash Iravani and Behzad Zolfaghari, 2013). In upcoming days, as the synthesis of nanoparticles is of effective cause and does not require any maintenance, therefore, these synthesizing method of nanoparticles got modified and developed in other methods. They are classified into two groups which are: Organic nanoparticles which are carbon nanoparticles and the other one is Inorganic nanoparticles which are magnetic and semiconductor nanoparticles.

Types of Nanoparticle

1. Inorganic Nanoparticles

Inorganic nanoparticles developed a role in the field of modern material sciences, which are based upon their unique physical properties and particularly in biotechnology. They have certain physical properties which are based upon these two factors of inorganic nanoparticles and also includes size dependent optical, magnetic, electronic and catalytic properties. For preparing these interesting nanoparticles, bio related applications are involved such as iron oxides, gold, silver, silica, quantum dots etc.

2. Polymeric nanoparticles

In recent years Polymorphic nanoparticle has an incredible development in the field of research and is also a type of nanoparticle. Two strong strategies i.e., dispersion of performed polymers and the polymerization of monomers are mainly involved for preparation. The nanoparticles which are involved with the solid particles have a size ranging from 10-1000 nm.

3. Solid lipid nanoparticles

Solid lipid nanoparticles are the certain alternate carrier systems to emulsions, liposomes and polymeric nanoparticles as a colloidal carrier system and played a dominant role in controlling the drug delivery in 1990s.

Synthesis of Nanoparticles

Since nanoparticles can be synthesized by both chemically or biologically but chemical synthesis methods are associated with many adverse effects due to the presence of some toxic chemical absorbed on the surface. Biological ways of nanoparticles synthesis are the ecofriendly alternatives of chemical and physical methods using microorganisms, enzymes, fungus and plants or plants extracts. These ecofriendly methods for the synthesis of nanoparticles are developing into an important branch o nanotechnology. There are many methods to synthesize the nanoparticles which are as follows:

1. **Sol-Gel Technique:** This is a chemical technique of synthesizing the nanoparticles. In this technique, discrete particle which are integrated network precursors are involved in chemical solutions which are used for the fabrication of metal oxides. The precursor sol can be either used to synthesize powders deposited on the substrate or to form a film.

2. **Solvothermal Synthesis:** In this process, polar solvents are involved in different condition which includes the condition of under pressure at versatile low temperature and at temperatures above their boiling points. The solubility of reaction get significantly increases in solvo thermal condition hence, the reaction does not involve in the lower temperature.

3. **Chemical Reduction:** There are many reducing agents such as Sodium borohydride, hydrazine, hydrate and sodium citrate in which the ionic salts get involved in reduction process by an appropriate medium in the presence of surfactant.

4. **Laser ablation:** The technique used for removing the materials from a solid surface, is the laser ablation. On heating the material at low laser flux, it absorb laser energy and evaporates. In case of

higher flux, the material is converted to plasma, for example, carbon nanotubes can be produced by this method.

Strategies Used to Synthesize Nanoparticles

Nanoparticles were produced only by means of physical and chemical methods traditionally. Ion sputtering, solvothermal synthesis, and sol gel technique are some of the commonly used physical and chemical methods. Nanoparticles can be synthesized by two approaches which are namely the bottom up approach and the top down approach. Scientists tried to express nanoparticles using larger ones to direct their assembly in the top down approach. In this process fine particles are converted by the bulk material. Bottom up approach is a process that builds towards larger and more complex systems by starting at the molecular level and maintaining precise control of Molecular structure. In this process, atom is processed to nuclei and finally to nanoparticles, these are the process employed for the synthesis of nanoparticles.

Biosynthesis

Biosynthesis is a green and ecofriendly technology of biosynthesis of nanoparticles. In the synthesis of metallic nanoparticles (silver, gold, platinum, zirconium, palladium, iron, cadmium) and metal oxides (titanium oxide, zinc oxide etc.), both the eukaryotic and prokaryotic microorganisms are used. These microorganisms are bacteria, actinomycetes, fungi and algae. According to the location of nanoparticles, synthesis of nanoparticles may be intracellular or extracellular.

1. **Intracellular synthesis of nanoparticles by fungi:**

In this method, for the formation of nanoparticles, transport of ions into microbial cells takes place in the presence of enzyme. The nanoparticles formed inside the organism are smaller than the size of extracellularly reduced nanoparticles. The particles nucleating inside the organisms relate to the size limit.

2. **Extracellular synthesis of nanoparticles by fungi:**

Since extracellular synthesis is void of unnecessary adjoining cellular components from the cell, therefore it is more applicable as compare to the intracellular synthesis. Fungi has enormous secretory components, which are involved in the reduction and capping of nanoparticles hence fungi is known to produce nanoparticles extracellularly.

Microbes for the production of nanoparticles:

The inorganic materials are produced by both unicellular and multicellular organisms either intra or extracellularly. Microorganisms such as bacteria and fungi has the ability to control the synthesis of metallic nanoparticles which is employed in the search for new materials. Fungi have occupied the center stage of studies on biological generation of metallic nanoparticles due to their tolerance and metal bioaccumulation ability.

Synthesis of metallic nanoparticles by different microorganisms

Silver: Silver nanoparticles have good antimicrobial efficacy against bacteria, viruses and other eukaryotic micro-organisms therefore it have proved to be the most effective. It is being used as antimicrobial agents in textile industries, for water treatment, sunscreen lotions etc and they are the widely used nanomaterial among all. Siver nanoparticles can be synthesized by the plants such as *Azadirachta indica, Capsicum annuum and Carica papaya* and it already reported.

Gold: It is used for the purpose of identification of protein interaction in immunochemical studies. They are also involved in DNA fingerprinting as a lab tracer to detect the presence of DNA in a sample. Aminoglycoside antibiotics such as streptomycin, gentamycin and neomycin can be detected by these gold nanoparticles. Cancer stem cells can also be detected by the gold nanorods which is very beneficial for cancer diagnosis and also for the identification of different classes of bacteria.

Alloy: Alloy nanoparticles have different structural properties from their bulk samples. Ag flakes are most widely used because of their highest electrical conductivity than the other metal fillers and their oxides have relatively better conductivity. Bimetallic alloy nanoparticles properties are influenced by both metals and shows more benefits over ordinary metallic nanoparticles.

Magnetic: The magnetic nanoparticles such as Fe_3O_4 (magnetite) and Fe_2O_3 (maghemite) are biocompatible. They have been actively used in the investigation of targeted cancer treatment (magnetic hyperthermia), stem cell sorting and manipulation, DNA analysis, guided drug delivery, gene therapy, and magnetic resonance imaging (MRI).

Review of Literature

Debnath *et al*., (2010) studied on the preparation and evaluation of Chitosan Nanoparticles containing Cytarabine. Rapid deamination to the biologically inactive metabolite decreases the activity of cytarabine. Encapsulating the drug into chitosan nanoparticles investigate the protection of cytarabine

from fast degradation and elimination. Non-Fickian solute diffusion mechanism is the mechanism by which drug is being released. The initial burst release was retarded or delayed due to adsorption of coating material is proved by the result. The results showed that the nanoparticles were having better distribution of drug than the free drug in different organs like spleen, lungs, kidney etc.

Zargar *et al*., (2011) reported the biosynthesis of silver nanoparticles using *Vitex negundo* L. extract and its antimicrobial properties. For producing the silver nanoparticles, different biological methods are gaining recognition due to their multiple applications. The use of silver nanoparticles as an antibacterial agent is the most important application of it. They characterized the resulting silver particles using transmission electron microscopy (TEM), X-Ray diffraction (XRD) and UV-Visible (UV-Vis) spectroscopic technique. Their results suggested that *Vitex negundo* plays an important role in the reduction and stabilization of silver to silver nanoparticles. They also found that the silver *Vitex negundo* shows antibacterial activity on both gram positive and gram negative bacteria.

Khan *et al*., (2014) reviewed on the synthesis and applications of gold nanoparticles in the field of medicine and targeted drug delivery. Nanotechnology has become more advanced and interesting area of research in this field. They said gold nanoparticles have special advantages due to its unique properties such as small size and high surface are to volume ratio among all the nanoparticles. They achieved targeted delivery and programmed release of therapeutic drugs to the specific site by using gold nanoparticles because they can bear high drug load and release it to the specific site through various administration routes and can interact with cancerous cell.

Zola *et al*., (2014) worked on cobalt nanoparticles preparation using three different methods for evaluating the effects of synthesis variables that can influence the nanoparticles size distribution and particle shape. The characterized nanoparticles by the transmission electron microscopy. The resulted nanoparticles were seen spherical with low size distribution. Nanoparticles with undefined shape was produced when using polyol process at high temperature. Their results suggested that the solution composition, i.e. the amount of trioctylphosphine and oleic acid was not suitable to control both size and shape of nanoparticles. For each method, a different variable exists for the control of the distribution size and the shape of the formed particles, indicated by their results.

Ziauddin *et al*., (2014) reviewed on production, properties and impact of Carbon nanotubes on human health. They are being used in many products and their production is also being increased to meet the market demand. Carbon nano tubes are toxic to humans and there exists inconsistency among the reports on cytotoxicity of carbon nanotubes which may be caused due to variation in the synthesis methods, purification method, mode of carbon nanotubes exposure i.e., suspension in the media, immobilization, aerosol etc.

Zhang *et al*., (2016) discussed the synthesis of silver nanoparticles using physical, chemical and biological methods and also discussed the properties of silver nanoparticles and methods for their characterization. Silver nanoparticles plays a crucial role in nanoscience and nanotechnology especially in nanomedicine. Silver nanoparticle is one of the most fascinating and vital nanomaterial than the all other metallic nanoparticles which are involved in biomedical applications. They suggested their paper as a helping source for the researchers of the nanoscience and nanotechnology community to develop biocompatible, safer, efficient cancer or anti-angiogenic agents containing silver nanoparticles.

Balasooriya *et al*., (2017) worked on honey mediated green synthesis of nanoparticles a new era of safe nanotechnology. This involves the synthesis of nanoparticles from microorganisms, macro organisms, and other biological materials. This method does not produce any toxic biproducts and requires room temperature. A simple cost effective, biocompatible, reproducible, rapid, and safe method is provided by honey mediated green synthesis of nanoparticles. Valuable end products with numerous applications can be provided by the special activity of honey functionalized nanoparticles in diverse fields.

Conclusion

Nanoparticles has become significant in many fields in recent years such as energy, health care, environment, agriculture etc. due to their incredible properties. The conversion of poorly soluble, poorly absorbed and labile biologically active substance into promising deliverable substances by the nanotechnologies is very easy because these techniques have a higher potential to do so. For increasing the efficiency and performance of the object or process, various new applications have been tested and these applications reduce the cost and accessible for everyone. Due to the environmental friendly property and its efficacy, the nanotechnology has a great future.

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