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Biogenic Synthesis of Nano particles

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Abstract
When bulk materials are converted to the range of 1 to 100 nm, the material phase change occurs accompanied with wide range of possible applications from nanoscale optics, sensors, electronics to Nano- medicine and quantum phenomena which focuses on metal nanoparticles and nanostructures with their conspicuous properties. The synthesis of nanoparticles of different compositions, sizes, shapes and controlled dispersing is an important aspect of nanotechnology. Generally, there are two nanoscale preparation either top-down physical, or bottom- up paths in chemical, and biological method when nanoparticles interact with microbes, algae, agro wastes or higher-order animal. The biosynthesized nanoparticles exhibit superior bioactivities; antimicrobial, cytotoxic, and catalytic anticancer, and antioxidant.

Keywords: Biogenic Synthesis, Nano particles

Introduction
Several breaking methods of materials either physically by pyrolysis, ultraviolet irradiation, lithography, laser ablation, ultrasonic fields, or chemical techniques have been used successfully to produce nanoparticles, (1,2). Sono-chemical, non-hydrolytic methods are expensive and the use of toxic chemicals can't be avoided causing adverse environmental effects, (3-5). Hence, the biological synthesis of NPs is preferred. Many microbes are known to produce metallic nanoparticles with similar properties to the chemically synthesized ones. Biosynthesis of nanoparticles is confirmed by impressive natural sources of reductants like plants and microorganisms because of their low cost, and exchanging impact, (6). Other metal NPs such as metal oxide -, metal sulfide -, and even bimetallic or alloy NPs were reported. Size, shape and applications of NPs are determined by their source. The microorganisms- assisted metal nanoparticles synthesis may be either intracellular or extracellular, (7). In the intracellular mechanisms ions are absorbed within the cells where transformed enzymatically to mobilized metal ions, (8). This molecular synthesis passes via several cellular, biochemical steps that mediate transportation, regulation and binding metal ions. Cellular enzymes and proteins result in complex bimetallic nanoparticles, which are difficult to produce with normal chemical and physical processes, (9). In extracellular mechanisms, metal ions were seized on the cellular surface and were enzymatically reduced due to functionalizing surface groups such as –OH, –NH2, –SH2, –CHO, and –COOH in proteins present on the cell wall or the periplasmic space thus providing binding sites to metal ions and stabilize them leading to their reduction which produces biosynthetic nanoparticles, (10).
The attachment of nanoparticles to bacteria depends on several factors, such as the particle composition, and the cell -particle surface characteristics which determine the sign and magnitude of the interaction forces between electrostatic tendencies, (11). Multidrug resistance and lack of new antibiotics direct towards metals having

antimicrobial property in the form of different nanomaterials, (12). The outer membrane of Gram-negative bacterial cells controls the permeability of many molecules in and out of cells and so become resistant to chemical agents than Gram-positive cell, (13). The metal-, metal oxides and fullerene nanoparticles were shown to be effective bactericides by affecting bacterial signal transduction, loss of bacterial cell membrane and causing leakage, or depleting intracellular ATP levels, (14,15).

Classification of Nanoparticles

There are many ways to classify nanoparticles. NBs can be metallic, semi-conducting, insulating, or hybrid type. Carbonaceous composite, inorganic- and organic nanoparticles as cellulose and chitosan NBs are examples. Bottom up and top-down approaches depending on starting material of nanoparticle is another approach (2, 16).

Nanoparticles can also be classified to zero, one-, two- and three-dimensional nanoparticles. One-dimensional nanoparticles include thin films used in electronics and sensor devices. Two-dimensional nanoparticle includes carbon nanotubes which have high adsorption ability and stability. Three-dimensional nanoparticles contain dendrimers, quantum dots… etc., (17). Regarding morphology nanoparticles may be flat, spherical and crystalline in structure. Also, they may be present in single form or in composites. Nanoparticles can further be classified as oxide -, sulfide - and magnetic nanoparticles.

Biological Production of Metal and Nonmetal Nanoparticles

Microorganisms are known for their capability to bio-sorb and bio-reduce metal ions to corresponding nanoparticles. Various eco-friendly precursors for the synthesis of NPs such as bacteria, fungi, yeast, algae, waste materials, plant and extracts plants (5, 18 -22) are documented. Both metallic- and non-metallic nanoparticles are of specific sizes, shapes with controlled mono-dispersion but the microbial surface differs significantly in their attraction, e.g., silica nanoparticles are associated with microbes in the following order: fungal spores larger than the microalgae and bacteria. This depends on the interaction of capping agent; biomolecules with a particular facet of a metal or metal oxide crystal, (2,23).Binding biomolecules to nanoparticle with the average particle size ranging between 1 and 50 nm result in their cytotoxicity ,antibacterial, electrical, magnetic, mechanical, and chemical features.(24,26) .The interaction of biomolecules especially peptides on the metal surface proceed in the stabilization of nanostructures , and its adsorption on the surface of a particle and hence, improving their suitability as sensors in biomedical devices and electronics. Due to Nanoparticles' dissolution, agglomeration and the reduced grain size, i,e, increased surface area to volume ratio that result in various melting points at the surface atom which affects chemical and physical properties responsible for cytotoxicity that affect oxidative stress to cell functions, consequent damage and cell death. (27, 28). The secondary metabolites flavonoids and terpenoids present in the Chaetomorpha linum algae extract were found to be effective capping stabilizing agents and resulted in the poly dispersed and spherical formation of metallic Ag NPs, (29). Ag–$CaCO_3$ Nano Composite was constructed by this microalga as a bio-template applying efficient, biomimetic access. (30), (31) demonstrated that the bacterium Ochrobactrum sp. used to convert toxic tellurite oxy -anions into useful TeNPs. Also, biosynthesis of gold, silver, gold-silver alloy, selenium, tellurium, platinum, palladium, silica, zirconia, quantum dots, magnetite and uraninite nanoparticles by S-layer bacteria, actinomycetes, plant residues, fungi, yeasts, bacteria, viruses were reported (7,32-35).

Noble Metal Nanoparticles Bio Synthesis

Au, Ag, Pt, Ru, Rh, Os, Ir and Pd NPs biosynthesis from noble metal salt precursors is important due to their electronic properties, high stability, easy synthesis, tunable surface functionalization and compatibility with bio-materials, (36) .Electrochemically active biofilms of the bacterial strain Shewanella loihica PV-4 were used to synthesize Pt and PdNPs , (37).Gold nanoparticles are widely studied as model metal nanoparticles due their electrical, thermal, chemical and optical properties, (38) . Gold nanoparticle clusters were fastened to the bacterial cell wall possibly at sites that were rich in negatively charged functional group. The piercing gold nanoparticles appeared to have different shapes than the original spheres, (11). The bacterial species for the synthesis of AgNPs include Escherichia coli, Lactobacillus sp., Bacillussp) Acinetobacter sp., Pseudomonas sp., Corynebacterium sp. and Klebsiella pneumonia, (39, 40).

Impact of Nanomaterials on Health and Environment

Microbes might cause nanoparticle aggregations as negatively charged nanoparticles could hide positively charged solids, thus further inhibiting the electron transfer process, (11). i.e., block electron transfer from the cell membrane to solid electron acceptors by physical hindering direct contact between cells and electron acceptors. In iron-reducing bacterium, Shewanella putrefaciens, microbial cells coated by nanoparticles, and this coating separated solid ferri-hydrite from bacterial cells, thus inhibiting the electron transfer efficiency. The electron transfer process can be helped by electron shuttling compounds, such as anthraquinone-2, 6-disulfonate (AQDS). In the absence of these shuttles, direct contact is the main mechanism. This direct contact may be broken off if other solids are present in the system, such as nanoparticles. Also, the microbes become physically deprived from approaching nutrients. Nanoparticles act scavenging of heavy metals on their surfaces, may be beneficial to microbes in aquatic environments.

Role of Capping Agents in Nanoparticles Synthesis

Controlled monodispersed nanoparticles using microorganisms is an emerging target, (41), Alkaloids, flavonoids, proteins, reducing sugars, polyphenols play role as reducing, stabilizing capping agents (37,42) that act as a potential precursor for the synthesis of novel metallic nanomaterials. Similarly, peptides, poly-amino acids, poly hydroxyl alkanoate, polysaccharides, and other biological macromolecules used as stabilization matrix. The charged interfaces could be lipid membranes, mica, colloids, metal oxides, actin molecules, proteins, or even cells. Other bioactive compounds are DNA (43), canonical membrane proteins, Nicotinamide Adenine Dinucleotide (NADH) and Nicotinamide Adenine Dinucleotide Phosphate (NADPH) dependent enzymes acting as a driving force for the designing of greener, safe and environmentally benign protocols capping agents that prevent the overgrowth and coagulation of NB. Controlling morphology, and NBs surface results in a separation of the dispersed phase from the continuous phase and consequently the ability of NPs to bind with organic compounds to form a stable complex stabilizing/capping agents. (44, 45). The energy and growth rate of a crystal is controlled by the introducing a suitable templating agent or a surfactant which lowers the interfacial energy, (46, 47). Many surfactants have been reported to be used as capping agents for altering the desired shape and size of the NPs but they are difficult to remove, to degrade and are hazardous to the environment (48, 49). However, despite their stability, biological nanoparticles are not monodispersed and the rate of synthesis take several hours. To overcome these problems, several factors such as microbial cultivation methods, the extraction techniques and the combinatorial approach such as photo biological methods have to be optimized (50). Mycogenic nanoparticles produced by fungal biomass play an important function in defending plants against pests and pathogenic genera. Actinomycets, diatoms, yeasts, (51, 52) and viruses assisted NBs have been also reported. The nanoparticles catalysts are more popular than common catalysts due to their unique properties and high available active specific surface. The controlled growth of NPs in solution is believed to be kinetically controlled process where low energy faces of any crystal results into a particular shape. The most important driving forces for biomolecule adsorption on a source are electrostatic interactions, van-der-Waals interactions, hydrogen bonds, and hydrophobic interactions, (53).

Apart from metal NPs, bacteria have also been used to biosynthesize metal oxide NPs, such as Ag2O, CuO, ZnO, TiO2, MnO2, MgO and Fe2O3, which have a wide range of applications in the food industry, therapeutic, diagnostic, and delivery agents in Nano-medicine, (54).

Characteristic Features of NBs

Particle surface area play critical roles in controlling Nano size magnetic dimensions. The physicochemical, optoelectronic, and electronic properties of nanoparticles are determined by their surface energy, chemical potential, oxidation process, and catalysis, (55). As physical properties were caused by the large surface atom, large surface energy, lattice parameter, spatial confinement and reduced imperfections hence the formation of antimicrobial agents.

The unique NBs biological and morphological properties based on size, shape, density and crystallinity facilitate the successful separation of polymerases into monodisperse fractions. The characterization of purified nanoparticles can be done by Fourier-Transform Infrared Spectroscopy(FTIR), dynamic light scattering (DLS), atomic force microscopy (AFM), (56), X-ray Crystallography (XRD), Energy-dispersive X-ray Spectroscopy (EDX), Scanning Electron Microscope (SEM), Transmission Electron microscopy (TEM) and UV–Visible spectroscopy , (57) .TEM was used as a complementary technique to examine nanoparticle–microbe associations., (14) .The adsorbed biological molecules on NP surface lead to the so “called protein-corona” PC complex formation change bio distribution, efficacy, and prolonged retention time at the targeted place of delivery. NPs are not simple molecules itself and therefore composed of three layers i.e. the surface layer, which may be functionalized with a variety of small molecules, metal ions, surfactants and polymers. Mostly small molecules are used because it forms a covalent bond with surface particles and contains groups which can carry a charge, the shell layer is the outer layer of inorganic NMs which is chemically different material from the core in all aspects, and the core, which is essentially the central portion of the NP and usually refers the NP itself. In particular properties of NMs are depending upon core composition. The core will play a key role in NMs toxicity but this doesn't mean that the environmental behavior of NMs will depend on core composition, (58).

Collective Factors Influencing the Synthesis of Nanoparticles

The shape, micelle growth, arrangement symmetry, composition of NPs can be governed by the environmental conditions such as culture medium, reactant concentrations, reaction time, biomass and the metallic salt to be reduced, (59, 60). Also, pressure, temperature, concentration of metal ions plays an important role in optimization of synthesis, (61,62) i.e. the surrounding conditions have an impact on the physical chemistry of the nanoparticles or availability of organic functional groups on the cell wall of bacterium which initiate/induce the reduction of metal ions.

Application in Agriculture and Medicine

Besides biomedical waste management, nanoparticles have solved the problem of cell resistance to the drug providing a new field in medicine industry, and in cosmetics (63, 64). In medicine, non-metallic nanoparticles commonly used are derived organic biomolecules. The C- mediated NBs-; silica, carbon nanotubes interact with RBCs, platelets, and plasma proteins including albumin in coagulation factor and immunoglobulin, (65). Copper nanoparticles are invested in wound dressings to give them biocidal properties. Because of their high surface area NBs have beneficial impacts on the environment in removal of chemical contaminants. The mobility and sportive capacity of natural or human-made nanoparticles make them potent carriers’ vectors in the transport of chemical pollutants as phosphorus from sewage in sanitation processes but still there are some adverse effect or health hazard concerns due to their uncontrollable use and their discharge to natural environment especially in case of heavy metals. The difficulty in estimation of nontoxicity is due to an absence of appropriate guidelines for NPs use in ecological topography. Biocompatibility, solubility, non-toxicity, and chemical stability, are major factors for the applicability of NPs as biosensors, optoelectronics, sunscreens, nano superconductors, semiconductors, batteries, light ceramics, flame retardants and food packaging. NBs are capable of combating abiotic and biotic stress in agriculture and the bio stimulant capacity of NMs upon plant growth was reported, (66, 67). Some nanoparticles are able to reduce the functioning naturally occurring microbial communities, in industrial and textiles processes, (68,69). Furthermore, copper nanoparticles have potential industrial use such as gas sensors, catalytic processes, environmental remediation, and wastewater treatment, (70).

Toxicity of Nanoparticles in Biomedical Application

The in vivo fate of NPs or whether they have undesirable effects on the body is not known, since they change their performance in terms of absorption. Nanoparticles easily enter the body due to their small size and reach very sensitive organs through different routes. Some were observed to penetrate the cell membrane possibly causing cell death and leaking of the internal contents of the cell. Cell lysis would account for the decreased bacterial growth observed in the presence of nanoparticles, (71). Nanoparticles can also affect health as exposure to some quantities can cause cellular damage in the lungs.

Based on potential toxicity NB are classified into CMAR, fiber- like and bio persistent granular. The adverse effects of NB happened because they can very easily perforate and move into biological systems through the cell walls and membranes, and can remain inside long enough to perform their desired activities. They can delay or prolong the toxicity effects, that are normally hard to predict, (72,73) Nano toxicology provides information for the safety estimation of nanoparticles and helps to develop Nano medicine by giving data about their undesirable properties and ways to avoid them, (74).

Conclusion

The bio-synthesis of noble metal nanoparticles lead to beneficial impacts on the environment and appear to contribute to all natural processes. More research includes locomotion delivery robot and others must be performed. Various biological applications to bring the development of bio-synthesized nanoparticles into more advanced steps and application in all life aspects must be done.

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