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BIOSYNTHESIS OF SILVER NANOPARTICLES AND CHARACTERIZATION

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ABSTRACT

In current science, nanotechnology has been thriving at a tremendous rate in all aspect of Science and Technology. It deals with between 1 to100 nm sizes of nanoparticles in at least one dimension and involves in developing different devices. Currently, nanobiotechnology is a commercial alternate process for chemical and physical methods for synthesis of various nanoparticles with specific functions. It is new branch of nanotechnology and combines the biological principles with physical and chemical methods. Silver nanoparticles were biosynthesized using plant extract and the biosynthesized nanoparticles was observed within 30 min. The characterization of silver nanoparticles detected by UV-Visible spectrophotometer, FTIR Spectroscopy, DLS and Zeta potential for support of the biosynthesis, average particles size. This article represented about preparation methods of silver nanoparticles and its characterization and also applications of biosynthesized silver nanoparticles.

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INTRODUCTION

Currently, dynamic of nanotechnology in every aspect of Science and Technology has been thriving at a tremendous rate. Truly, its journey started from the organic chemistry, this has now even reached to aeronautical research and a special attention has been drawn in medical and allied branches for exploitation of the nanotech for attending the limitation of the current scenario. Carrying foreword the success of the nanotechnology in field of physical, chemical and biological science, it has now started revolutionizing the drug deliver sciences.

History of Nanobiotechnology

Nanotechnology is the study of manipulating material on an atomic and molecular scale, and it deals with between 1 to 100 nm size structures in at least one dimension and involves in developing different materials/devices within that size. Nanotechnology mainly consists of the processing of, separation, consolidation and deformation of materials by one atom or by one molecule, was described by Tokyo Science University Professor Norio Taniguchi in 1974. Nanotechnology and nanoscience got started in early 1980's with two major developments (1) the birth of cluster science and the invention of the scanning tunneling microscope and (2) the synthesis and properties of semiconductor nanocrystals was studied and this led to a fast increasing number of metal and metal oxide nanoparticles and quantum dots. In 1980, Dr. K. Eric Drexler was promoted the technological significance of nanoscale phenomena and devices via speeches and books Engines of Creation: The coming Era of Nanotechnology.

Nanotechnology has dynamically developed as significant vicinity of modern research with potential effects in medicine and electronics (Glomm 2005, Boisselier and Astruc 2009). Nanobiotechnology is a new branch nanotechnology which combines biological principles with physical and chemical methods to generate nano-size particles with specific functions and it is an economic alternative method for chemical and physical methods of formation of nanoparticles. Intra- and extra-cellular biosynthesis processes are usually implicated in synthesis of nanoparticles through nanobiotechnology (Ahmad *et al.*, 2005). This integration of nanoparticles with biological molecules has lead to the development of diagnostic devices, important tools in cancer therapy etc. thus nanobiotechnology can play a vital in developing and implementing many useful tools in the study of life.

Nanobiotechnology describes an application of biological systems for the production of new functional material such as nanoparticles. Biosynthetic methods can employed either microorganisms or plant extracts for synthesis of nanoparticles. In nanotechnology two main approaches are used for synthesis nanoparticles and nanostructures (3), (i) bottom up approach, materials and devices are built from the molecular components which are assemble themselves are used in nanotechnology (4), (ii) top-down approach, nano-objects are constructed from the larger entities without atomic level control (Rodgers, 2006). Biosynthesis of nanoparticles is an exciting recent addition to the large selection of nanoparticles synthesis methods, nanoparticles have entered a commercial investigation era. Presently, silver nanoparticles are under intensive study for different applications in biological sensor, chemical sensor, optoelectronic device, and used as catalysts.

NANOPARTICLES

A nanoparticle is used to describe a particle with size in range of 1-100 nm, at least in one of the three possible dimensions, one dimension (surface films), two dimensions (strands or fibers), or three dimensions (particles). In this size range, the physical, chemical and biological properties of the nanoparticles changes in fundamental ways from the properties of both individual atoms/molecules and of the corresponding bulk materials. Nanoparticles can be made of different materials like metals, metal oxides, silicates, non-oxide ceramics, polymers, organics, carbon and biomolecules. (5). Nanoparticles can be groups into two (i) organic nanoparticles, which includes fullerenes (carbon nanotubes) (ii) inorganic nanoparticles, which includes magnetic nanoparticles, gold and silver nanoparticles (metal nano particles) and semi-conductor nanoparticles (titanium oxide and zinc oxide nanoparticles). They can exist in several different morphologies such as single, fused, sphere, cylinders, platelets, tubes and irregulars shapes.

Generally the nanoparticles are designed with surface modifications tailored to meet the needs of specific applications they are going to be used for. Nanomaterials have applications in the field of nanotechnology, especially growing interest in inorganic nanoparticles, particularly metal nanoparticles (silver and gold nanoparticles) (6) suitable to their size features and advantages over available chemical imaging, drug agents and drugs. The inorganic nanoparticles have been used as potential tool for medical imaging and treating diseases. At present these have been widely used in cellular delivery systems due to their versatile feature like good compatibility, functionality and capability of target drug deliver and controlled release of suitable drugs in biological systems pathways (Xu Z P *et al.*, 2006). (7)

Silver nanoparticles

Silver is a metallic chemical element with chemical symbol Ag and atomic number 47. It is a soft, white, lustrous transition metal and has the highest thermal and electrical conductivity of any metal. Pure silver has the highest thermal conductivity and one of the highest optical reflectivity. Generally, it is used to make jewelry, ornaments, utensils and currency coins and in recent days it is also used in electrical contacts, electrical conductors, mirrors and catalysis of chemical reactions. (8, 9)

Synthesis of nanoparticles:

Currently, a number of physical, chemical, biological and hybrid methods are available for synthesis of different type of nanoparticles however physical and chemical methods are popular for synthesis of nanoparticles, use of toxic compounds limits their application. The development of eco-friendly for biogenetic production is now of more interest due to simplicity of procedures and adaptability. The following different methods have been reported for the synthesis of metallic nanoparticles (Figure-1).

Reverse micelles process:

Yingwei Xie, Ruqiang Ye, Honglai Liu (2005) prepared nano silver by reverse micelles process method, reverse micelles system was used to form metal nanoparticles by Boutonnet *et al.* However, most surfactants (10) used were toxic and will pollute the environment. Bio surfactant (BS) (M.Banat *et al.*, 2000 and J.D.Desai, *et al.*, 1997) as a natural surfactant, which derived from microbial origin are bulky and have complicated structures, higher biodegradability, lower toxicity, and excellent antiviral activities. So bio surfactant as a green stabilizer is one of the best candidates. It is believed that bio surfactant will be increasingly attraction as multifunctional materials for the new century (D. Kitamoto *et al.*, 2002).

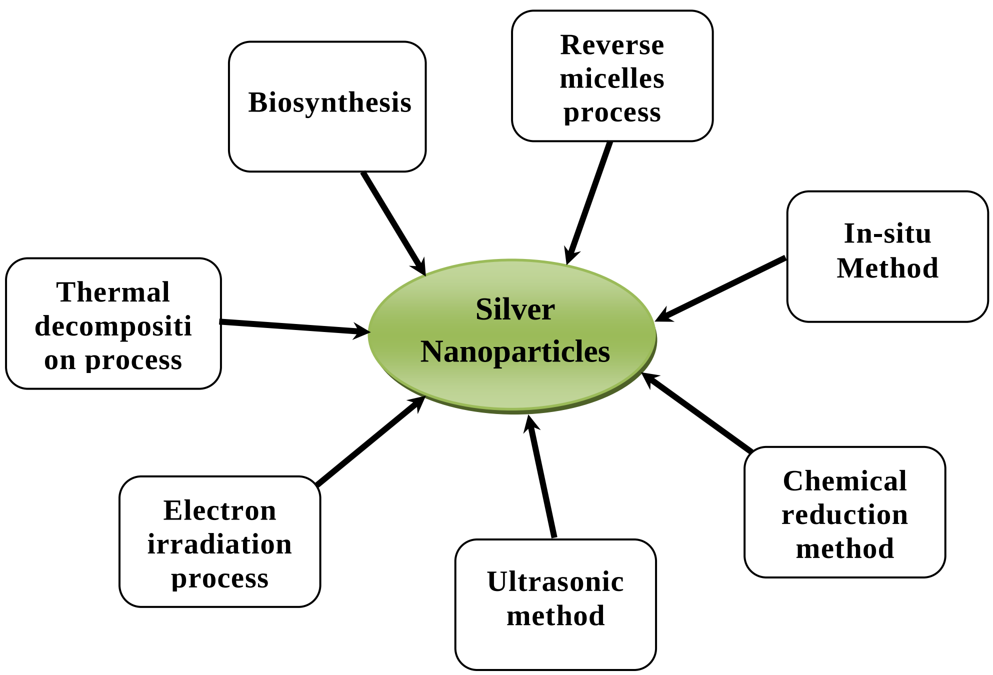

Figure-1: Different methods for synthesis of Silver nanoparticles.

In-situ Method:

The in-situ nanoparticle synthetic methodology first reported by M.F. Rubner *et al.*, 2000, by utilizing LBL assembled thin films as nano-reactor, nanometer-sized metal particles have been synthesized *in-situ* in the films. For instance Rubner utilized PAH/PAA polyelectrolyte multilayer thin film as nano-reactor to synthesize *in situ* nanometer-sized metal AgNPs in hydrogen atmosphere (Joly, R. Kane *et al.*, 2000 and T.C. Wang *et al.*, 2000). (11, 12). Moreover, Rubner prepared the antibacterial coatings based on hydrogen-bonded multilayer containing *in-situ* synthesized AgNPs on planar surfaces and on magnetic colloidal particles (D.Lee *et al.*, 2005). This *in-situ* nanoparticle synthesis in LBL assembled films as nano-reactor afforded facile and precise control of the concentrations of homogeneously dispersed nanoparticles. However, owing to the electron active polyelectrolyted multilayer films, the process required the ion exchange and sequential reduction in hydrogen atmosphere. Kim reported that single crystalline silver nanowires were synthesized inside the pores of self-assembled electrochemically active calyx 4 hydroquinones (CHQs) nanotubes by electro/photochemical redox reaction (B.H. Hong *et al.*, 2001). Ag-ions were included in the cavity of CHQ s through cation-p interactions. (13)

Chemical reduction method:

Ivan Sondiet *et al.*, (2002) used chemical reduction methods for synthesis of silver nanoparticle (A. Henglein, 1993) through precipitation process, described here, yields highly concentrated and stable dispersions of monodispersed (14, 15) silver nanoparticles in a simple and cost-effective manner, by reduction of concentrated aqueous solutions of silver nitrate with ascorbic acid in aqueous medium. Daxad was selected as the most suitable dispersant for this purpose, based on preliminary evaluations of the protective ability of several classes of dispersing agents. Obtaining such a desired system is a subject of many limitations, including the mentioned choice of the stabilizing agent (16) and of other experimental parameters specifically concentration of reactants, pH and method of mixing.

Ultrasonic method:

Amir Reza Abbasi *et al.,* (2009), reported the synthesis of silver nanoparticle by ultrasonic method. The effect of ultrasonic irradiation on chemical reactions is to accelerate them and to initiate new reactions that are difficult to carry about under normal conditions (K.S.Suslick, 1990 and R.Morones, *et al.*, 2005). The advantage of using ultrasound radiation is that it does not need high temperatures during the reactions, use of surfactants is not necessary and its yields smaller particles. Also, the reaction rate increased with increasing sonic amplitude. The effects of ultrasound radiation on chemical reactions were reported in the recent works (K.H.Kim *et al.*, 2008). Amir Reza Abbasi *et al.*, developed a simple sonochemical route for preparation of nanostructures of AgI and studied some parameters, such as effects of stirring, temperature, concentration, sonication time and reaction time on growth and morphology of the AgI nano-structures and the results show that with change in reaction conditions, nanoparticle structures changes to nanowires.

Electron irradiation process:

K.A Bogle *et al.,* (2006) developed a new method based on electron irradiation for the synthesis of nanoparticles. This method is easy in operation, and even a period of about 10 min. is sufficient to obtain the signature of the nanoparticles through the change in colour of the solution (J.W.Chen *et al.*, 1967). In this work, silver nanoparticles have been synthesized by irradiating solutions, prepared by mixing $AgNO_3$ and PVA in different ratios, with 6 MeV electrons at room temperature. (17)

Thermal decomposition process:

Don Keun Lee and Young Soo Kang formed silver nanocrystallites by the thermal decomposition of Ag^{+1} oleate complex, which was prepared by a reaction with $AgNO_3$ and sodium oleate in a water solution. The resulting monodispersed silver nanocrystallites were produced by controlling the temperature (290°C) (K.S.Suslick *et al.*, 1986). Transmission electron microscopic images of the particles showed a 2-dimensional assembly of the particles with a diameter of 9.5±0.7 nm, demonstrating the uniformity of these nanocrystallites. An energy-dispersive X-Ray (EDX) spectrum and X-Ray Diffraction (XRD) peaks of the nano-crystallites showed the highly crystalline nature of the silver structure. (18)

Biosynthesis of nanoparticles:

A number of physical and chemical methods are using to synthesize metal-nanoparticles. Synthesis of large quantity of nanoparticles through chemical methods requires a short period of time and requires capping agent for size stabilization of the nanoparticles, therefore chemical are used for synthesis of nanoparticles and their stabilizations, the used chemicals are toxic and lead to non-ecofriendly by products. Hence need for environmental non-toxic synthetic methods for synthesis of nanoparticles leads to developing interest in biological methods which are free from all toxic chemicals as byproducts, thus there is an increasing demand for green nanotechnology (Garima Singhal , R.B *et al.*, 2011). Many biological approaches for both extracellular and intracellular nanoparticles synthesis have been reported till date using microorganisms including bacteria, fungi and plants. Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as well as provide natural capping agents. Nature has devised various processes for the synthesis of nano- and micro-length scaled inorganic materials which have contributed to the development of relatively new and largely unexplored area of research based on the biosynthesis of nanomaterials. (19)

Biosynthesis of nanoparticles is a kind of bottom up approach where the main reaction occurring is reduction/oxidation. The microbial enzymes or the plant phytochemicals with anti-oxidant or reducing properties are usually responsible for reduction of metal compounds into their respective nanoparticles. The three main steps in the preparation of nanoparticles that should be evaluated from a green chemistry (20) perspective are the choice of the solvent medium used for the synthesis, the choice of an environmentally benign reducing agent and the choice of a non toxic material for the stabilization of the nanoparticles. Most of the synthetic methods reported to date rely heavily on organic solvents. This is mainly due to the hydrophobicity of the capping agents used.

PRINCIPLE OF BIOSYNTHESIS OF NANOPARTICLES:

Development of reliable and eco-friendly process for synthesis of metallic nanoparticles is an important step in the field of application of nanotechnology. The production of metal-based nanoparticles by chemical reduction, thermal treatment, irradiation and laser ablation often times requires use of organic solvents and toxic reducing agents like sodium borohydride and N,N-dimethylformamide.

Therefore, biological and biomimetic approaches for the synthesis of nanomaterials are being explored. Cell mass or extracellular components from microorganisms, such as *Klebsiella pneumoniae*, *Bacillus licheniformis*, *Fusarium oxysporum*, *Aspergillus flavus*, *Cladosporium cladosporioides*, *Aspergillus clavatus*, and *Penicillium brevicompactum* (Ahmad *et al.*, 2003; Shahverdi *et al.*, 2007; Kalishwaralal *et al.*, 2008; Balaji *et al.*, 2009; Shaligram *et al.*, 2009; Verma *et al.*, 2010) have been utilized for the reduction of silver ions to AgNPs. (21)

Synthesis of nanoparticles using plant extracts is the most adopted method of green, eco-friendly production of nanoparticles and also has a special advantage that the plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites. The unexploited plant resources for the synthesis of silver nanoparticles, various plant leaf extracts such as *Helianthus annus*, *Basella alba*, *Oryza sativa*, *Saccharum officinarum*, *Sorghum bicolour* and *Zea mays*; *Capsicum annuum* L.; *Pelargonium graveolens*; *Carica papaya*; *Chenopodium album*; *Rosa rugosa*; *Jatropha curcas*; *Aloe vera*; *boswellia* ovalifoliolata (Leela and Vivekanandan 2008; Shankar *et al.*, 2008; Mude *et al.*, 2008; Dwivedi and Gopal 2010; Dubey *et al.*, 2010; Bar *et al.*, 2009; Chandran *et al.*, 2008; Ankanna *et al.*, 2010). The first report of the plant employed in the synthesis of nanoparticles is attributed to *Medicago sativa* (alfalfa) which was capable of synthesizing gold and silver nanoparticles. Most of the studies confer the production of nanoparticles by plants that were known to be stable than nanoparticles synthesized by microorganisms. The production of nanoparticles by plants relays on various factors among which, type of processing with optimized parameters is very much essential towards synthesis of nanoparticles such as growing plant in a media incorporated with raw material for the synthesis of nanoparticles, use of dried powdered plant material which is employed in the synthesis of plant material, drying plant material and evaluating nanoparticles synthesis, and employing fruits and flowers in the synthesis of nanoparticles.

The principle of preparation of silver nanoparticles by using microorganism is a bioreduction process; the silver ions are reduced by the extracellular reductase enzymes produced by the microorganisms to silver metal in nanometer range. The mechanism which is widely accepted for the synthesis of silver nanoparticles is presence of an enzyme is Nitrate reductase and it is an enzyme in the nitrogen cycle responsible for the conversion of nitrate to nitrite. The reduction mediated by the presence of the enzyme in the organism has been found to be responsible for the synthesis of silver nanoparticles.

The use of a specific enzyme a-NADPH dependent nitrate reductase in the *in vitro* synthesis of nanoparticles is important because this would do away with the downstream processing required for the use of these nanoparticles in homogeneous catalysis. During the catalysis, nitrate is converted to nitrite, and an electron will be shuttled to the incoming silver ions. This has been excellently described in the organism *B. licheniformis*. *B. licheniformis* is known to secrete the cofactor NADH and NADH-dependent enzymes, especially nitrate reductase, that might be responsible for the bioreduction of Ag^+ to Ag^0 (Figure-2 and Figure.3) and the subsequent formation of silver nanoparticles. Figure-3 shows that the nitrate reductase presents in bacteria may aid the synthesis of silver nanoparticles. Although silver nanoparticles synthesis is considered as a capability of the organism, it is primarily considered as a defense mechanism by organisms to the incoming very reactive silver ions. Silver ions are very reactive and are known to bind with various vital components of the cells inducing cell death.

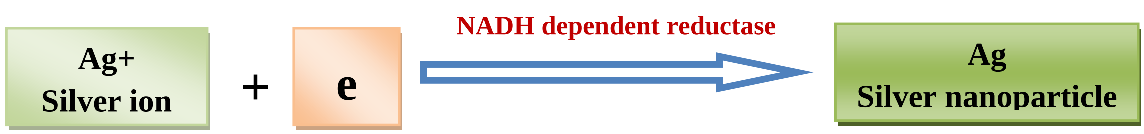

Figure-2: Reaction showing preparation of silver nanoparticles.

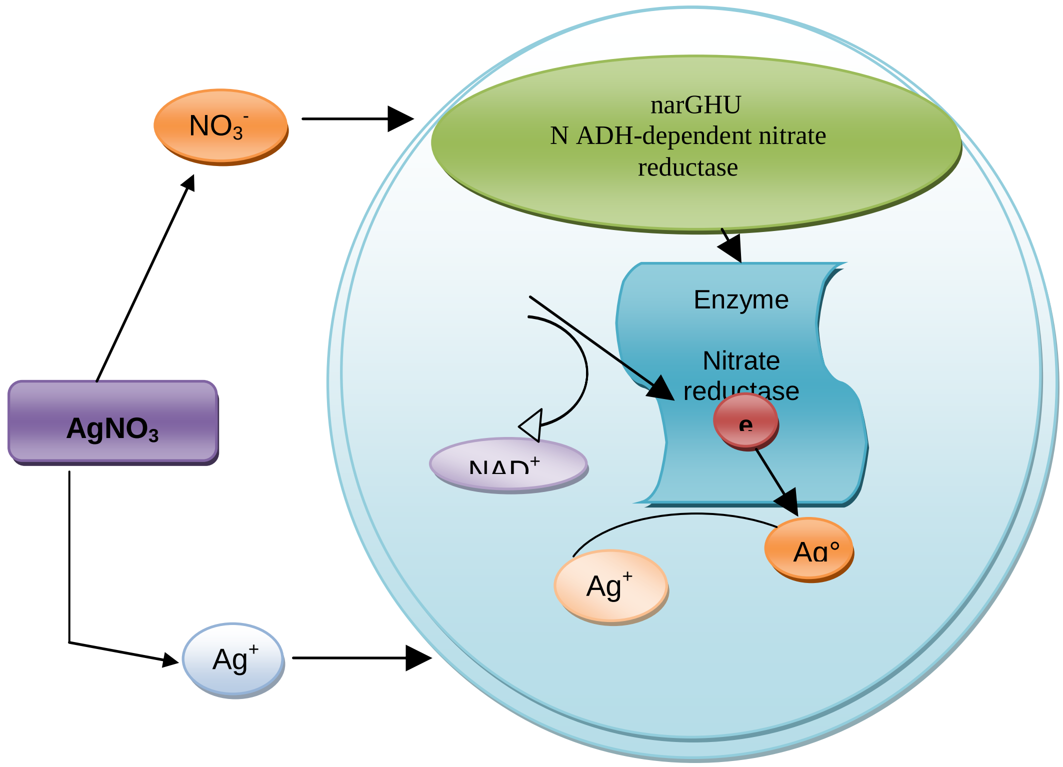

Figure-3: Schematic representation of synthesis of silver nanoparticles from silver ions to reduced form of silver atom by the activity of nitrate reductase enzyme.

The incoming silver ions were also shuttled with electrons and this leads to the growth of the crystals. This defense mechanism is applicable to various metals, where the difference occurs only in the respective enzyme. Besides, when the condition of the silver nanoparticle synthesis is alkaline, the synthesis will be faster than in acidic conditions. The synthesis of nanoparticles enhances as the pH increases towards alkaline region and reaches the maximum at pH 10 after which the speed of the nanoparticle synthesis decreases (Figure-4). At alkaline conditions there is no need of agitating the mixture for the formation of silver nanoparticles and all the silver ions supplied will be converted to silver nanoparticles even within 30 min.

The nanoparticles size control can also be achieved in biological methods, silver nanoparticles of various sizes and shapes could be synthesized. At room temperature, silver nanoparticles of 50 nm are synthesized whereas at 60ºC nanoparticles of 15 nm are synthesized. Similarly at acidic pH the size of the nanoparticles ranged 45 nm whereas at pH 10 the size is just 15 nm. Even the size of 2–20 nm silver nanoparticles could be synthesized by organisms such as *Verticillium* sp.

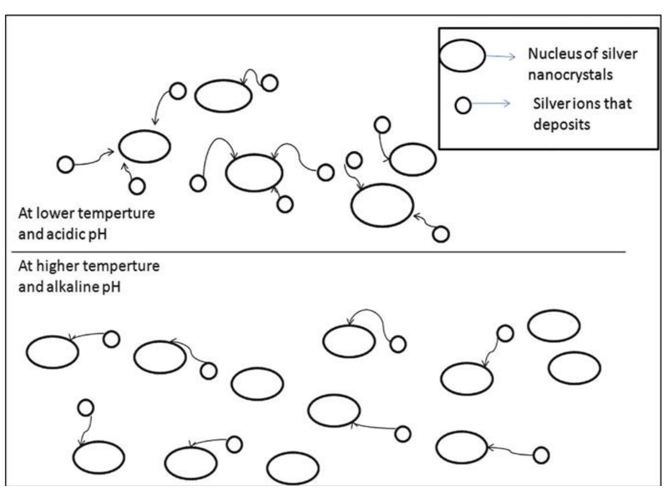

Figure-4: A schematic imaginary diagram that depicts the reason for size control over the synthesis of silver nanoparticles. At lower temperature and pH, less nucleation occurs thereby forming larger particles whereas at higher pH and temperature more nucleation may occur thus forming smaller particles.

It is concluded that the reductase involved in bioreduction for preparation of silver nanoparticles is an NADH-dependent reductase. The enzyme reductase gains electrons from NADH and oxidizes it to NAD^+. The enzyme is then oxidized by the simultaneous reduction of Silver ions forming silver metal in nano form. In some cases a nitrate-dependent reductase is responsible for the bioreduction process, whereas, in case of rapid extracellular synthesis of nanoparticles the reduction happens within few minutes, therefore, a complex electron shuttle materials may be involved in the biosynthesis process. (22)

ADVANTAGES OF SILVER NANOPARTICLE:

Nanotechnology is expected to open some new aspects to fight and prevent diseases using atomic scale tailoring of materials. The ability to uncover the structure and function of biosystems at the nanoscale stimulates research leading to improvement in biology, biotechnology, medicine and health care. The size of nanomaterials is similar to that of most biological molecules and structures, therefore, nanomaterials can be useful for both *in vivo* and *in vitro* biomedical research and applications. The integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications and drug delivery vehicles. In all the nanomaterials with antibacterial properties, metallic nanoparticles are the best. Nanoparticles increase chemical activity due to crystallographic surface structure with their large surface to volume ration.

The development of new resistant strains of bacteria to current antibiotics has become a serious problem in public health therefore there is a strong incentive to develop new bactericides (P.Raveendran *et al.,* 2003). Bacteria have different membrane structures which allow a general classification of them as gram-negative or gram positive. The structural differences lie in the organization of a key component of the membrane, peptidoglycan. Gram negative bacteria exhibit only a thin peptidoglycan layer (2-3nm) between the cytoplasmic membrane and the outer membrane (M. Amanullah *et al.*, 2005), in contrast, Gram –positive bacterial lack the outer membrane but have a peptidoglycan layer of about 30 nm thick. Silver has long been known to exhibit a strong toxicity (23) to a wide range of microorganisms (A. Panacek *et al.*, 2006), for this reason silver based compound have been used extensively in many bactericidal applications. Silver compounds have also been used in the medical field to treat burns and a variety of infections. Several salts of silver and their derivatives are commercially employed as antimicrobial agents. Commendable efforts have been made to explore this property using electron microscopy, which has revealed size dependent interaction of silver nanoparticles with bacteria. Nanoparticles of silver have thus been studied as a medium for antibiotic delivery and to synthesize composites for use as disinfecting filters and coating materials. However, the bactericidal property of these nanoparticles depends on their stability in the growth medium, since this imparts greater retention time for bacterium nanoparticle interaction. There lies a strong challenge in preparing nanoparticles of silver stable enough to significantly restrict bacterial growth.

A recent medical study showed that only silver nanoparticles with sized less than 10 nm were able to enter cells and disrupt them. The same study showed that silver nanoparticles are highly toxic to the bacteria that colonize the lungs of cystic fibrosis sufferers often with fatal consequences.

CHARACTERIZATION TECHNIQUES

The biosynthesized Silver Nanoparticles (AgNPs) were characterized using the following characterization techniques.

UV-Visible Spectrophotometer:

The optical property of AgNPs was determined by UV-Vis spectrophotometer, after the addition of $AgNO_3$ to the plant extract, the spectrum was taken between 350 nm to 500 nm.

Fourier Transform Infrared Spectroscopy:

The chemical composition the synthesized was studied by Fourier Transform Infrared Spectroscopy and the extract was characterized in the range of 4000-400 cm^{-1}.

Dynamic Light Scattering (DLS) and Zeta Potential:

The average particles size of bio reduced Silver Nanoparticles (AgNPs) was calculated by using Dynamic Light Scattering (DLS) which is based on laser diffraction method with multiple scattering techniques. The solution of plant extract was centrifuged at 25° C with 5000 rpm for 15 min and the supernatant was collected. Then the supernatant was diluted for 4 to 5 times and then set for DLS and Zeta-Potential analysis. From this measurement, the mean size of particles inside the sample is obtained along with the correlation between the numbers of particles of particular size versus the size of the nanoparticles.

APPLICATIONS OF SILVER NANOPARTICLES

The biological molecules undergo highly controlled assembly for making them suitable for the metal nanoparticle synthesis which was found to be reliable and eco-friendly (Harekrishna Bar, D.K.B., *et al.*, 2009). The synthesis of metal and semiconductor nanoparticles is a vast area of research due to its potential applications which was implemented in the development of novel technologies. Over the past few years, the synthesis of metal nanoparticles is an important topic of research in modern material science. (24)

Nano-crystalline silver particles have been found tremendous applications in the fields of high sensitivity bio molecular detection, diagnostics, antimicrobials, therapeutics, catalysis and micro-electronics. However, there is still need for economic commercially viable as well as environmentally clean synthesis route to synthesize the silver nanoparticles. Silver is well known for possessing an inhibitory effect toward many bacterial strains and microorganisms commonly present in medical and industrial processes (Jiang H, M.S., *et al.*, 2004). In medicines, silver and silver nanoparticles have ample application including skin ointments and creams containing silver to prevent infection of burns and open wounds (Duran N, M.P *et al.,* 2005), medical devices and implants prepared with silver-impregnated polymers (RO, B., 1999). In textile industry, silver-embedded fabrics are now used in sporting equipment (Klaus T, J.R., *et al.*, 1999).

Silver nanoparticles have important applications in the field of biology such as antibacterial agents and DNA sequencing. Silver has been known to exhibit strong toxicity to wide range of microorganisms (antibacterial applications). Antibacterial property of silver nanoparticles against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli* has been investigated (Rai *et al.*, 2009). Silver nanoparticles were found to be cytotoxic to *E. coli* it was showed that the antibacterial activity of silver nanoparticles was size dependent. Silver nanoparticles mainly in the range of 1 -10 nm attach to the surface of cell membrane and drastically disturb its proper function like respiration and permeability (Morones *et al.*, 2005).

The fluorescent bacteria were used to investigate the antibacterial properties of silver nanoparticles (Gogoi *et al.*, 2006). The green fluorescent proteins (GFPs) were adapted to these studies. The general understanding is that silver nanoparticles get attached to sulfur containing proteins of bacteria cell causes the death of the bacteria. The fluorescent measurements of the cell-free supernatant reflected the effect of silver on recombination of bacteria. (25)

The high synergistic activity of silver nanoparticles and antibiotics was observed with erythromycin against *Staphylococcus aureus* (Shahverdi *et al.*, 2007b). The antibacterial properties of the biosynthesized silver nanoparticles when incorporated on textile fabric were investigated (Kong and Jang 2008). The silver nanoparticles were also used for impregnation of polymeric medical devices to increase their antibacterial activity. Silver impregnated medical devices like surgical masks and implantable devices showed significant antimicrobial efficiency (Furno *et al.*, 2004).

The current investigation that use of silver ion or metallic silver as well as silver nanoparticles can be exploited in medicine for burn treatment, dental materials, coating stainless steel materials, textile fabrics, water treatment, sunscreen lotions, etc. (Duran *et al.*, 2007).

CONCLUSION

The reduction of metal ions through the plant extracts leading to the formation silver nanoparticles (AgNPs) of well-defined dimensions. This green synthesis technique has many advantages towards the synthesis of AgNPs. The silver nanoparticles were characterized using UV-Visible spectrophotometer, Fourier Transform Infrared Spectroscopy (FTIR), DLS and Zeta Analyzer techniques. Nanoparticles are very small in size for which they are energetically very unstable so the nanoparticles undergo for agglomeration or aggregation to stabilize them. The antimicrobial activity of silver nanoparticles was confirmed by Zone of inhibition Applications of such eco-friendly nanoparticles in bactericidal, wound healing and other medical and electronic applications makes this method potentially exciting for the large-scale synthesis of other nano-materials. Article concluded that the environmental non-toxic synthetic methods for synthesis of nanoparticles leads to developing interest in biological methods which are free from all toxic chemicals as byproducts, thus there is an increasing demand for green nanotechnology.

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