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ORIGINAL ARTICLE

BIO-SYNTHESIS OF SILVER NANOPARTICLES

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Abstract:

Nanoparticles of different materials have so far been synthesized in the past and are continuously being synthesized so by bringing about reduction of certain precursors using strong chemical reducing agents. Often chemical synthesis method leads to presence of some of the toxic chemical absorbed on the surface that may have adverse effect in the medical applications.

These reducing agents have been found to be possessing lot much of toxic potential and thereby health hazardous. Therefore present article reviews the different methods used for synthesis silver nanoparticles. Thus silver nanoparticles have been continuously synthesize from different materials using green reducing agents which have biological origin and efficient both in terms of economy and energy. Biological methods for synthesis have thus paved way for the "greener synthesis" of nanoparticles and these have proven to be better methods due to slower kinetics. Green synthesis provides advancement over chemical and physical method as it is cost effective, eco-friendly, easily scaled up for large scale synthesis.

KEYWORDS:

Nanoparticles, Plant extracts, Biosynthesis, Green synthesis, Medical application.

INTRODUCTION

Due to the wide range of applications offered by silver nanoparticles in different fields of science and technology hence different protocols have been designed for their synthesis of silver nanoparticles (Reddy 2006). The nanoparticles can be synthesized using the top-down (physical) approach which deals with methods such as thermal decomposition, diffusion, irradiation, arc discharge, etc., and bottom-up (chemical and biological) approach which involves polyol synthesis and seeded growth method, electrochemical synthesis, chemical reduction, and The nanoparticles can be synthesized using the top-down (physical) approach which deals with methods such as thermal decomposition, diffusion, irradiation, arc discharge, etc., and bottom-up (chemical and biological) approach which involves polyol synthesis and seeded growth method, electrochemical synthesis, The nanoparticles can be synthesized using the top-down (physical) approach which deals with methods such as thermal decomposition, diffusion, irradiation, arc discharge, etc., and bottom-up (chemical and biological) approach which involves polyol synthesis and seeded growth method, electrochemical synthesis, biological entities for fabrication of nanoparticles and chemical reduction.

Different synthesis methods involve the use of different types of chemical, physical, and biological agents to yield nanoparticles of different sizes and shapes. The most often method used for the chemical synthesis of silver nanoparticles is the chemical reduction method, in which the reduction of metal particles to nanoparticles by using chemical reducing agents like sodium borohydride or sodium citrate (Jana et al. 2000; Cao and Hub 2009; Kim 2007; (Hanaper et al. 2007, Rodrı´Guez-Sa´nchez et al. 2000, Sau and Rogach 2010).

Physical methods used for the synthesis of nanoparticles include thermal decomposition, electrolysis, laser irradiation, condensation and diffusion. The thermal decomposition method is used for the synthesis of monodisperse nanoparticles. Fatty acids are dissolved in hot NaOH solution and mixed with metal salt solution which leads to formation of metal precipitate (Yang and Aoki 2005). Several researchers had developed various techniques for synthesis of nanoparticles (Ashkarran et al. 2009 , Fernandez-Pacheco et al. 2006,Rodrguez-Perez et al. 2006, Aslan et al. 2006).

Biological agents used for the synthesis of nanoparticles include mainly microbes (Gajbhiye et al. 2009, Birla et al. 2009, Ingle et al. 2008, Duran et al. 2007, Lengke and Southam 2006, Konishi et al. 2004, Sastry et al. 2003) and plants (Song and Kim 2009, Huang et al. 2007,Chandran et al. 2006, Shankar et al. 2004 , Gardea-Torresedey et al. 2003). The biological methods used for the synthesis of nanoparticles include both extracellular and intracellular methods (Shaligram et al. 2009, Mukherjee et al. 2008, Rai et al. 2008, Ahmad et al. 2003).

GREEN NANOSCIENCES:

Green chemistry is that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products. There were 12 principles of green chemistry have now been applied to design a wide range of chemical products and processes with the aims of minimizing chemical hazards to health and the environment, reducing waste and preventing pollution. Employing these principles toward Nanosciences will facilitate the production and processing of inherently safer nonmaterial's and nanostructured devices (Lankey, Rebecca L. et al. 2002; Kenneth J. Klabunde 2001; Lankey, Rebecca L. et al. 2002..

NEED OF GREEN NANOSCIENCES:

The use of nonmaterial's as catalysts for greater efficiency in current manufacturing processes by minimizing or eliminating the use of toxic materials. The use of nonmaterial's and nanodevices to reduce pollution and the use of nonmaterial's for more efficient alternative energy production are achieved. Unfortunately, there is a flip side to these benefits. The development of new chemical or physical methods to produce nonmaterial's, the concern for a negative impact on the environment is also heightened; some of the chemical procedures involved in the synthesis of nonmaterial's use toxic solvents, could potentially generate hazardous by products, and often involve high energy consumption .This is leading to a growing awareness of the need to develop clean, nontoxic, and eco-friendly procedures for the synthesis of nanoparticles. Scientists are now use biological organisms to literally grow nonmaterial's (Kenneth J. K. labunde 2001).

The development of green method for the synthesis of silver nanoparticles is an important branch of nanotechnology. Today, nonmetal particles, especially silver, have drawn the attention of scientists because of their extensive application in the development of new technologies in the areas of electronics, material sciences and medicine at the nanoscale. Silver nanoparticles might be used as spectrally selective coatings, electrical batteries, optical receptors, catalysts in chemical reactions, biolabelling, and as antimicrobials. Many reports have been published in the literature on the biogenesis of silver nanoparticles using several plant extracts, particularly Neem leaf broth (Azadirachta indica) and germanium leaves (P/ graveolens) (Anastas, Paul T. et al. 1998).

TYPES OF NANOPARTICLES:

Nanoparticles can be broadly grouped into two, namely, organic nanoparticles. Which include carbon nanoparticles (fullerenes) while, some of the inorganic nanoparticles include magnetic nanoparticles, noble metal nanoparticles (like gold and silver) and semi-conductor nanoparticles (like titanium oxide and zinc oxide).

BENEFITS OF BIOGENIC SYNTHESIS OF NANOPARTICLES:

Nanotechnology is an developing field as a result of its wide-ranging applications in different areas of science and technology. The term nanotechnology deals with the structures sized between 1 to 100 nanometer in at least one dimension and are a multidisciplinary field and involves research and development in different fields of physics, chemistry, material science, biotechnology and nanotechnology (Ray et al. 2008, Huang et al. 2007). Nanoparticles are metal particles with size 1–100 nm and exhibit different shapes like rod spherical and triangular. Research on synthesis of nanoparticles is the current area of interest due to the unique visible properties (chemical, physical, optical, etc.) of nanoparticles compared with the bulk material (Ray et al. 2009a; Saul and Roach 2010).

Progress in the field of nanotechnology has been rapid and with the development of innovative synthesis protocols and characterization techniques but most of the synthesis methods are limited to synthesis of nanoparticles in small quantities and poor morphology (Sharma et al. 2009, Saul and Roach 2010). Chemical and physical synthesis methods often result in synthesis of a mixture of nanoparticles with poor morphology, and these methods also prove to be hazarded to the environment due to the use of hazarded chemicals and also of elevated temperatures for synthesis process (Ray et al. 2008; Birla et al. 2009). Biogenic synthesis of nanoparticles with controlled morphology needs more attention, as the biogenic synthesis of nanoparticles is carried out by using biological means like bacteria (Hussein et al. 2007; Shahverdi et al. 2007, 2009), fungi (Govender et al. 2009, Gajbhiye et al. 2009, Parikh et al. 2008 and Kumar et al. 2007). actinomycetes (Ahmad et al. 2003).lichens (Shahi , Patra 2003), algae (Chakraborty et al. 2009 and Singaravelu et al. 2007). The biogenic entities are found to secrete large amount of proteins which are found to be responsible for metal–ion reduction and morphology control (Thakkar et al. 2010, and Ingle et al. 2008). Biogenic nanoparticles are toward a greener approach and eco- friendly, as no toxic chemical is involved in synthesis and synthesis process takes place at ambient temperature and pressure conditions (Gade et al. 2008, Mukherjee et al. 2008). Due to various applications of silver nanoparticles a number of researchers are focusing toward the synthesis of biogenic nanoparticles compared with the chemically or physically synthesized nanoparticles (Thakkar et al. 2010, Kumar and Yadav 2009, Ingle et al. 2008, Duran et al. 2007, Riddin et al. 2006, Bhattacharya and Gupta 2005)

METHODS FOR SYNTHESIS OF NANOPARTICLES:

To the wide range of applications offered by nanoparticles in different fields of science and technology, different protocols have been designed for their synthesis (Reddy 2006). The nanoparticles can be synthesized using the top-down (physical) approach which deals with methods such as thermal decomposition, diffusion, irradiation, arc discharge, etc., and bottom-up (chemical and biological) approach which involves seeded growth method, polyol synthesis method, electrochemical synthesis, chemical reduction, and biological entities for fabrication of nanoparticles.

Different synthesis methods involve the use of different types of chemical, physical, and biological agents to yield nanoparticles of different sizes and shapes.

Table 1: Various Species of Microorganisms Synthesizing Silver Nanoparticles
Bacteria:

Sr. No.	Organism Size (nm)	Author (year)
1	Pseudomonas stutzeri AG259	Tanjia et al. (1999)
2	Lactobacillus Strains 500	Nair and Pradeep (2002)
3	Bacillus megaterium 46.9	Fu et al. (1999)
4	Klebsiella pneumonia (culture supernatant) 50	Ahmad et al. (2007)
5	Bacillus licheniformis 50	Kalimuthu et al. (2008)
6	Bacillus licheniformis (culture supernatant) 50 Corynebacterium sp. 10 – 15	Kalishwaralal et al. (2008) Zhang et al. (2005)
7	Bacillus subtilis (culture supernatant) 5 – 60	Saifuddin et al. (2009)
8	Geobacter sulfurreducens 200	Law et al. (2008)
9	Morganella sp. 20 – 25	Parikh et al. (2008)
10	Bacillus subtilis 5 – 60	Saifuddin et al. (2009)
11	Escherichia coli 1 – 100	Gurnathan et al. (2009a, b)
12	Proteus mirabilis 10 – 20	Samdi et al. (2009)
13	Bacillus sp. 5 – 15	Pugazhenthiran et al. (2009)
14	Bacillus cereus 4 and 5	Ganesh Babu and Gunasekaran (2009)
15	Staphylococcus aureus 1–100	Nanda and Saravanan (2009)
16	Lactic acid bacteria 11.2	Sintubiin et al. (2009)
17	Brevibacterium casei 50	Kalishwaral et al. (2010)

Fungi:

Sr. No.	Organism Size (nm)	Author (year)
1	Fusarium oxysporum 5–50	Ahmad et al. (2003)
2	Aspergillus fumigatus 5–25	Bhainsa and D'Souza (2006)
3	Aspergillus niger 20	Gade et al. (2008)
4	Phanerochaete chrysosporium 100	Vigneshwaran et al. (2006)
5	Aspergillus flavus 8.92	Vigneshwaran et al. (2007)
6	Cladosporium cladosporioides 10–100	Balaji et al. (2009)
7	Fusarium semitectum 10–60	Basavaraja et al. (2008)
8	Trichoderma asperellum 13–8	Mukherjee et al. (2008a, b)
9	Cladosporium cladosporioides 10–100	Balaji et al. (2009)
10	Trichoderma viride 5–40	Fayaz et al. (2010)
11	Penicillium fellutanum 1–100	Kathiresan et al. (2009)
12	Penicillium brevicompactum WA 2315 23–105	Shaligram et al. (2009)
13	Verticillium sp. 25 – 12	Mukherje et al. (2001)
14	Fusarium solani 5–35	Gade et al. (2009)
15	Fusarium acuminatum 5–40	Ingle et al. (2008)
16	Aspergillus clavatus 10–25	Verma et al. (2010)

Plants :

Sr. No.	Organism Size (nm)	Author (year)
1	Azadirachta indica 50	Shankar et al. (2004)
2	Cinnamomum camphora leaf 55–80	Huang et al. (2007)
3	Glycine max (soybean) leaf extract 25–100	Vivekanndhan et al. (2009)
4	Jatropha curcas 10–20	Bar et al. (2009)
5	Cinnamomum camphora Leaf 5–40	Huang et al. (2008)
6	Phyllanthus amarus 18–38	Kasthuri et al. (2009)
7	Carica papaya 60–80	Mude et al. (2009)
8	Gliricidia sepium 10–50	Raut et al. (2009)
9	Coriandrum sativum leaf extract 26	Sathyavathi et al. (2010) 20 V. Deepak et al

Source : (Deepak et al 2011)

MULTIPLE FUNCTIONS OF NANOPARTICLES:

Nanotechnology is an integration of different fields of science which holds promise in the pharmaceutical industry, medicine and agriculture (Mohanpuria et al. 2008). The unique properties of nanoparticles different from the bulk material have attracted the attention of several workers to harness the multiple functionalities of nanoparticles. Silver nanoparticles are utilized in the area of electronics, silica-coated Ag nanowires, and electric circuits (Kvistek and Prucek 2005 cure. Tsai et al. (2007) Nanoparticles can be used in the construction of miniaturized devices, which can be helpful in drug delivery (Nair and Laurencin 2007). Thiol-stabilized nanoparticles are used as "bio-catalyst" (Brust and Kiely 2002). Nanoparticles can be used as fluorescence labeling system in microbial detection (Liu 2006). Nanoparticles can be widely used as signal reporters to detect biomolecules in DNA assay, immunoassay and cell bioimaging (Liu 2006). Catheters coated with nanocrystalline silver serve as a tool to prevent infections.

Silver nanoparticles are found to be active against most of the nonsocial infections related to catheters and also predominantly accumulate at the site of insertion. Thus, silver nanoparticles function as a protective agent against infection with no risk of systemic toxicity (Roe et al. 2008). and Marazzi et al.(2007) stated that the Nanosilver dressings are found to induce major improvements in the healing of wounds with respect to antimicrobial efficiency, ease in using and faster reepithelialization and Rai et. al(2009) reported that re-epithelialization in a patient with a third-degree burn was observed as a result of the treatment of Nanosilver dressing as it provided a protection against infections and also promoted early formation of endodermis and uncomplicated wound closure.

CONCLUSION:

The synthesis of nanoparticles is in lime light of modern nanotechnology. Biosynthesis of silver nanoparticles by plant extracts is currently under exploitation.

The biological agents in the form of microbes, fungi, plant extracts etc. have emerged up as an efficient candidate for the synthesis of silver nanoparticles. These silver nanoparticles are lower cost, easily to synthesize, and attend toward a greener approach. Moreover, biological methods have the greater advantage of easy bulk synthesis which can be exploited for industrial scale production too over chemically synthesized nanoparticles by stabilizers. Since the biological methods for synthesize silver nanoparticles are eco-friendly, minimizing chemical hazards to health and the environment and preventing pollution.

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