Int.J.Curr.Microbiol.App.Sci (2022) *11*(01): 151-158

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 11 Number 01 (2022)**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2022.1101.018

Biogenic Synthesis of Metallonanoparticles: A Review

Diksha Sadana[1] and Anshu Sibbal Chatli[2*]

[1]Department of Biotechnology, Guru Nanak Girls College, Model Town, Ludhiana, India
[2]Farm Value Foods Private Limited, Ludhiana, India

*Corresponding author

Keywords

Nanoparticles, Plant material, Applications

Article Info

Received: 05 December 2021
Accepted: 30 December 2021
Available Online: 10 January 2022

ABSTRACT

Owing to their distinctive properties in comparison to their bulk counterparts, nanomaterials have broadened the horizon of applications of science. Properties such as high surface area ratio, electrical conductivity, magnetism, stability, etc have enabled their mulitidisciplinary use. Biological synthesis of nanoparticles using plant material extract has proved to be cost effective, nontoxic and more efficient as compared to other methods. In this review, biogenic synthesis of nanoparticles has been discussed in addition to their properties, applications and characterization.

Introduction

Nanotechnology is derived from the Greek word "Nano" implying 'dwarf' or very small in size, refers to a science and art of manipulating matter at nanoscale to create new and unique material and products. Nanotechnology was started in 1958 by Richard Feynman (Feynman, 1906). It comprises of the study of extremely small sized structures ranging from 1 to 100 nm. Nanobiotechnology is a branch of nanotechnology and it refers to the intersection of Nanotechnology and Biology. An important area of research in nanobiotechnology is the synthesis of nanoparticles with different chemical compositions, size, morphologies and controlled disparities. Nanoparticles are microscopic particles generally defined as particulate matter with at least one dimension that is less than 100nm. Nanoparticles have large surface area to volume ratio and this property helps in the development of antibiotic resistant microbial strains leading to their increase in survival rate in soils (Gonzalez *et al.*, 2021).

Structure of nanoparticles

Structurally, Nanoparticles are divided into shell and core part. The term "shell" is outer layer of inorganic nanomaterial. The "core" is essentially centred of the nanoparticle and refers as nanoparticle itself. In general, the properties of interest to the physics and chemistry communities are generally dominated by the properties of core. The core of nanomaterials plays a key role in nanoparticle toxicity (Christian *et al.*, 2008)

Classification of Nanoparticles

Nanoparticles are classified as Silver, Gold, Alloy and magnetic based on their metallic composition. Each type of nanoparticles has distinguished characteristics enabling to their various applications. Silver nanoparticles have proved to be most effective because these particles have great antimicrobial properties against bacteria, virus and other eukaryotic microorganisms. Their antimicrobial properties can be applied in paints, varnishes, textile industries for waste water treatment, cosmetics etc. Gold nanoparticles are used in immunochemical studies for identification of protein interactions. They are used as a tracer in DNA finger printing and identification of wide range of bacterial species (Das *et al*., *2012*). Magnetic nanoparticles like iron oxide are known to be biocompatible. They have been actively investigated for targeting cancer treatment, gene therapy and DNA analysis etc (Hassan, 2015).

Properties of Nanoparticles

The properties of nanoparticles influence their behaviour in vivo. Morphological properties like shape and size can influence nanoparticles circulation and targeting within body (Christian *et al.*, 2008). Nanoparticles have unique properties due to their high surface area to volume ratio. Silver nanoparticles can be produced with various sizes and shapes depending up on their preparation methods. Silver sphere, rods, wires, and plates can be produced by varying the manufacturing methods. Silver nanoparticles can be functionalized with wide range of materials. Polymers such as polyvinylpyrrolidone (PVP) and tannic acid are commonly used as capping agents for silver nanoparticles material as a biological application (Baalausha *et al.,* 2008).

Manufacturing Approaches

Manufacturing of nanomaterials is an interdisciplinary field covering Physics, Chemistry, Biology, Materials science and Engineering. Two approaches widely used in manufacturing of Nanomaterials are Top down approach and Bottom up approach (Charitidis *et al.*, 2014)

Top down approach

The nano objects are made from large entities without involving the control at atomic level. It involves construction of parts through carving, moulding and cutting. Laser ablation, milling, hydrothermal technology, lithographic and electrochemical method uses top down approach for build-up nanomaterials. It is increasingly used in miniaturization in Computer technology, which relies on silica-based chips (Wolfsteller *et al.*, 2010).

Bottom up approach

It helps in building components which are made up of single molecules and covalent forces which hold them together are far stronger than forces that hold macro scale components. This approach starts with atom or molecule to build up nanostructure. Enormous amount of information could be obtained from bottom up approaches by use of AFM, liquid phase technique based on inverse micelles, sol gel processing, chemical vapour deposition and molecular self-assembly for nanoscale material manufacturing. The bottom up approach is largely the realm of nanoscience and nanobiotechnology.

Applications of Nanoparticles

Nanomaterials vaccines are used to produce greater immunity to pathogens by delivering medications directly to specialized dendrite cells in immune system e.g. like hepatitis and malaria vaccines (Singh, 2017). Haque *et al.,* In his research they concluded that when nanoparticles activated with X-rays, generate electron that cause destruction of only cancer cells.

This method is used in place radiation therapy with lesser damage to healthy cells (Haque *et al.,* 2010). Chemotherapy nanoparticles integrate multimodal imaging with combination therapy, have been introduced to eliminate tumour impressively and increasing researchers focus in the field of nanodrug (Zhao *et al.*, 2018).

Nanotechnology as drug delivery system improve bioavailability of drug, efficacy and selectivity as well as reduce side effects and toxicity of drug (Witharena *et al.*, 2016). The nanoparticulate systems have great potential, to convert poorly soluble, poorly absorbed and labile biologically active substance into promising deliverable drugs (Velavan *et al.*, 2015). Through the manipulation of molecular size and surface properties, researchers are able to deliver drugs at particular target site for longer period of time with less frequent dosing (Rizvi *et al., 2018*).

Nanoparticles have widely used to recognized as the best to achieve safe and targeted delivery of siRNA, but there is much progress still needed for curing cancer using siRNA (Tatipari *et al.*, 2017). Gold nanoparticles are efficient carrier of siRNA for gene silencing (Bonoiu *et al.*, 2009).

Silver nanoparticles are used for different textile fibres in textile industries. The cotton fibre containing Silver nanoparticles exhibit high antibacterial activity against *E. coli* (Natsuki *et al.*, 2015).

Silver nanoparticles shows inhibition activity against breast cancer cells, it inhibits proliferation and arresting cell cycle phase of human breast cell line MCF7 (Abdel-Fateah *et al.*, 2018).

Zinc nanoparticles have been known to demonstrate distinctive antimicrobial activites and tus can be used in the manufacturing of food and cosmetics. Gonzalaz *et al.*, 2021)

Synthesis of Silver nanoparticles

Silver nanoparticles are increasingly used in various fields including food, health care and industrial purposes owing to its physical and chemical properties such as size, shape, surface area, solubility and aggregation. Optical, electrical, thermal and high electrical conductivity and biological property (Natsuki *et al.*, 2015). Synthesis of silver nanoparticles can be carried out using physical, chemical or biological methods (Goutam *et al.*, 2019).

Physical methods

Metallo nanoparticles are generally synthesized by evaporation condensation and laser ablation physical approaches. It has more advantages in comparison with chemical methods because of uniform distribution of solvent nanoparticles. Nanoparticles formed are highly stable because the temperature of heater surface does not fluctuate with time. Laser ablation method is advantageous as it aids in production of metal colloids even in the absence of chemical reagents in the solutions. The ablation efficiency and characteristics of nanoparticles depends upon wavelength of laser, duration of laser pulses, laser influence, ablation time duration and effective liquid medium, with or without the presence of surfactants.

Chemical methods

Chemical approach is the most commonly used for the synthesis of silver nanoparticles by organic and inorganic reducing agents viz ascorbate, sodium citrate, sodium borohydride, elemental hydrogen, tollen reagent, polymers are used for reduction of silver ions in aqueous or non-aqueous solution.

The reduction of agent Ag^+ lead to the formation of metallic silver Ag° which is followed by agglomeration into oligomeric clusters. These clusters eventually lead to formation of metallic colloidal silver particles. Use of protective agents such as surfactants e.g. thiols, amines, acids and alcohols help in stabilizing particle growth of nanoparticles during preparation process and also protect from sedimentation agglomeration and maintain their surface properties. It has been reported that small changes in synthesis process can lead to drastic changes in nanoparticle structure, average size, size distribution width, stability and self-assembly patterns. Microemulsion techniques help to synthesize uniform and controlled size of silver nanoparticles.

Biological methods

Biological methods are eco-friendly, non-toxic, safer and low-cost process as compared to chemical methods. Synthesis of silver nanoparticles using plant extract is more popular. Silver nanoparticles prepared by eco- thermal hydrothermal method using *Aloevera* plant leaf extract (Tippayawat *et al.*, 2016).

Leaf extract of *Datura metel*can also be employed for the biosynthesis of AgNPs (Banupriya *et al.*, 2016). Additionally, AgNPs can be prepared from *Brassica oleracea* and *Brassicaoleracea capitata* using silver nitrate and incubated 15 minutes at room temperature (Tamileswari *et al.*, 2015). Leaf extract of *Acalypha indica* can be used for formation of silver nanoparticles within 30 minutes (Krishnaraj *et al.*, 2010).

Biological based methods employ Bacteria, yeast, fungi, and the plant for synthesis of highly stable and well characterized nanoparticles. Size and morphology of nanoparticles can be controlled by altering some experimental conditions including substrate concentration, pH, light, temperature, and buffer strength, electron donor (e.g. glucose or fructose) (Gudikandula *etal*., 2016).

Materials and Methods

Plant Material: *Datura metel*

Silver nanoparticles can be biosynthesized from leaf extracts of *Datura metel* plant. *Datura metel* has been extensively used as a medicinal plant and it is very well known due to their ayurvedic properties. Medicinal property of *Datura metel* leaves extract can be recognised due to presence of several active phytochemical components.

Biosynthesis of Silver Nanoparticles from *Datura metel* leaf extract

Datura metel leaves extract was prepared using hot percolation method and subjected to different experimental conditions in order to access its anti-microbial properties (Ahmed *et al.*, 2016). Bio reduction of Ag^{+} to Ag° was observed when extract was augmented with silver nitrate solution and placed at different experimental temperatures (60°C and 100°C) and concentrations (2.5 ml and 4.5 ml) conditions. (Kaur *et al.*, 2019).

Characterization of Silver nanoparticles

The preliminary characterization of nanoparticles was done by change in colour and calorimetric analysis at specific concentrations at 540 nm. Further, confirmatory analysis was performed using TEM (Transmission Electron Microscopy) and SEM (Scanning Electron Microscopy). (Kaur *et al.*, 2019) and by UV-vis, FTIR spectroscopy and XRD technique (Bharathi *et al.*, 2014).

Potential antimicrobial medicinal properties of silver nanoparticles extracted from *Datura metel* plant leaves against four pathogenic strains via two bacterial strains (*E. coli* and *Pseudomonas* sp.) and two fungal strains (*Aspergillus Niger* and *Penicillium* sp.) (Kaur *et al.*, 2019), were assessed by disc diffusion method (Bauer *et al.*, 1959)

It is justified by various scientists that low temperature is favourable to growth of nanoparticles but as the temperature increases the nanoparticles become smaller in size and their activity increases (Liu *et al.*, 2017). The antifungal activity may be due to production of some inhibitory compounds produced by leaf extracts of Datura (Dellavalle *et al.*, 2011).

Antimicrobial activities of *Datura metel*

Rao Venkateswara *et al.*, (2016) observed the antimicrobial activity of silver nanoparticles extracted from *Datura metel* leaf extract against pathogenic bacteria such as *Pseudomonas aeruginosa* and *Escherichia coli* by disc diffusion method. They showed that silver nanoparticle extract shows abrupt zone of inhibition in case of *Pseudomonas aeruginosa* as compared to *E. coli*.

Antibacterial Activity

Aqueous extracts of leaf, stem bark and roots of *D. metel* were investigated against eight clinical bacterial isolates (*Streptococcus betahemolytic*, *S. dysenteriae Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Bacillus cereus* and *Salmonella typhi*). The leaf and stem bark extracts were antagonistic against the test bacteria species with inhibitor Activity (Guchande *et al.*, 2013).

Antifungal Activity

Different preparation of solvent extracts such as hexane, chloroform, acetone and methanolic fractions of *D. metel* were showed significant antifungal activity against many different pathogenic species. The compound was found to be active against different species of Candida and Aspergillus such as *Candida albicans*, *C. tropicalis*, *A.fumigatus*, *A. flavus* and *A. Niger* (Dabur *et al.*, 2005). Asma *et al.*, 2013., Results showed that *F.oxysporum f.* sp. *melonis* was more sensitive to *D. metel* aqueous extracts than *F. oxysporum f.* sp. *lycopersici* (Asma *et al.*, 2013).

Results and Discussion

The production of silver nanoparticles from Datura leaf extract was regulated by several factors such as temperature, and pH which exhibited prominent affects such as antimicrobial activity, change in absorbance, etc. Morphological characteristics of nanoparticles were almost identical viz spherical shape with size of 20 nm, as observed by Gupta *et al.*, 2018.

Datura metel leaf extract has been successfully used for green synthesis of silver nanoparticles. Reduction of metal ions with reducing agent of Silver nitrate from leaf extracts leads to the formation of silver nanoparticles. Major success of such silver nanoparticles synthesised from biogenic extract is that it is alternative to chemical synthesis and is nontoxic, safe and low-cost process. Silver nanoparticles were characterized by Colour change and UV- vis Spectrophotometer readings. The Confirmatory analysis was performed by Transmission Electron Microscope (TEM) and Scanning Electron Microscope (SEM). These nanoparticles have antimicrobial properties too.

References

Abou.El-Nour, M. M. K., Eftaiha, A., Al-warthan, A. and Ammar, A. A. R. (2010). Synthesis and applications of silver nanoparticles. *Arabian Journal of chemistry*., Vol.3(3): 135-140.

Ahmed, S., Ahmad, M., Swami, L. B. and Ikram, S. (2015). A Review on Plant Extract mediated Synthesis of Silver nanoparticles for antimicrobial applications; A green expertise. *Journal of Advanced Research.*, Vol.7(1):17-28.

Akhariyi, F. C. (2011). Antibacterial, Phytochemical and Antioxidant activities of *Datura metel*. *International Journal of Pharm tech Research*., Vol.3(4): 478- 483.

Anandalalkshmi, K., Venugobal, J. and Ramasamy, V. (2016). Characterization of silver nanoparticles by green synthesis method using Pedalium murex Leaf Extract and their antibacterial activity. *Journal of Applied Nanoscience*., Vol.6(3): 399-408.

Arole, M. V. and Munde, V. S. (2014). Fabrication of nanomaterials by top down and bottom-up approaches - An overview. *Journal of Advance Applied science and Technology*., Vol.1(2): 89-93.

Alabri, A. H. T., Salin Al Musalami, H. A., Amzad Hassain, Mohammad and Mohammed weli, A. and Al Riyami, Q. (2014). Comparative study of phytochemical screening, antioxidant and antimicrobial capacities of fresh and dry leaves crude plant Extracts of *Datura metel* L. *Journal of king saud University - Science*., Vol.26(3): 237-243.

Al-snafi, E. A. (2017). Medical importance of *Datura metel*. *IOSR Journal of pharmacy*., Vol.7(2): 43- 58.

Asma, R., Remedi, D. M., Ladhari, A. and Omezzine, F. (2013). Antifungal activity of *Datura metel* L. Organic and aqueous extracts on some pathogenic and antagonistic fungi. *African Journal of Microbiology Research*., Vol. 7(16): 1605- 1612.

Baalousha, M. and Hofmann, T. (2008). Nanoparticles: structure, properties and behavoiur in Environmental media. *Journal of Ecotoxicology*., Vol. 17(5):326-43.

Banupriya, K. and Muthu, K. (2016). Green synthesis of silver nanoparticles using *Datura metel* leaves Extract. *International Journal of Applied and Pure Science and Agriculture*. Vol. 2(2): 215- 219.

Bauer, A. W., Perry, M. D. and Kirby, M. M. W. (1959). Single disc antibiotic sensitivity testing of Staphylococci. *A.M.A. Arch. Intern. Med.* Vol.104:208–216.

Bonoiu, C. A., Mahajan, D. S., Ding, H. and Rou, I. (2009). Nanotechnology approach for drug addiction therapy: Gene silencing using delivery of gold nanorod- siRNA nanoplex in dopaminergic neurons. *Journal of Proceedings of the National Academic of Sciences*., Vol. 106(14): 5546- 5550.

Burduse, C. A., Gherasim, O., Grumezeseu, M. A., Mogoanata, L., Ficai, A. and Andronesui, E. (2018). Biomedical Application of Silver nanoparticles: An up-to- Date overview. *Journal of Nanomaterials*., Vol.8:25.

Chadha, S. (2013). Nanotechnology and its application. *International Journal of Agriculture and food science technology*., Vol.4(10): 1011-1018.

Charitidis, A. C., Georgiou, C. P., Koklioti, M. and Trompeta, F. A. (2014). Manufacturing nanomaterials: From research to industries. *Journal of Manufacturing Review.*, Vol.1:19.

Christian, P., Kammer, D. V. F., Baalousha, M. and Hofmann, T. (2008). Nanoparticles: structure, Properties, preparation and behaviour in environmental media. *Journal of Ecotoxicology*., Vol.17(5): 326-43.

Das, M., Shim, H. K. and Keeyi, D. (2012). Review on gold nanoparticles and their application. *Journal of Toxicology and Environment Health Science*., Vol. 3(4): 193-205.

Feynman, R. (1906). There's plenty of room at the bottom (reprint from speech given at annual meeting of the American physical society). *Journal of Eng sci*., Vol.23: 22-36.

Gachande, B. D. and Khillare, E. M. (2013). In-Vitro Evaluation of Datura species for potential Antimicrobial Activity. *Journal of Bioscience Discover*., Vol.4(1): 78-81.

Gonzalez, A., Aboubakr, H. A., Brockgreitens, J. *et al*., *(2021).* Durable nanocomposite face masks with high particulate filtration and rapid inactivation of coronaviruses. *Sci Rep* 11, 24318.

Goutam, P. S., Saxena, G., Roy, D. and Yadav, K. A. (2019). Green synthesis of Nanoparticles and their Applications in water and wastewater treatment. Bioremediation of industrial waste for Environment Safety: Industry waste and its management. Book….

Gudikandula, K. and Maring, C. S. (2016). Synthesis of Silver Nanoparticles by chemical and biological methods and their antimicrobial properties. *Journal of Experimental Nanoscience*., Vol. 11(9):714-721.

Gupta, N., Komal, R., Chatli, S. A., Expression of organically synthesized metallonanoparticles. LAP LAMBERT Academic Publishing, Mauritius, Pg.no. 1-80 (2018)

Hassan, S. (2015). A Review on Nanoparticles; their synthesis and types. *Research Journal of Recent Science*., Vol.4: 1-3.

Krishnaraj, C., Jagan, G. E., Rajasekar S., Selvakumar, P., Kalaichelvan, T. P. and Mohan, N. (2010). Syntheis of silver nanoparticle using *Aclypha indica* leaf Extracts and its antibacterial activity against water borne pathogens. *Journal of colloids and surfCes B: Bioinformatics*. Vol. 76(1):50-56.

Kaur, J., Gupta, N., Kaur, M. and Chatli, A. S. (2019) Antibacterial Effects of Green Synthesized AgNPs from *Datura metel* Leaf Extracts. *International Journal of Pure and Applied Biosciences*., 7(1): 247-252.

Natsuki, J., Natsuki, T. and Hashincoto, Y. (2015). A review of silver nanoparticles: Synthesis methods, Properties and Application. *International Journal of Material Science and Applications*., Vol. 4(5):325-332.

Rao Venkateswara, M., Kishore, M. and Rao Hanumantha, X. (2016). Green nanoparticles synthesized from roots of *Datura metel* and Evaluation of antimicrobial activity. *Journal of pharmacy Research*., Vol. 10(11): 730-734.

Sidhu, B. S., Chatli, A. S. and Beri, V. (2007). Practical Manual (soils 429), Soil Biology, college of Agriculture (Punjab Agriculture University) Ludhiana: 1-58.

Krishnan, U. J., George, M. and Ajesh, G. (2017). Phytochemical status, Antibacterial Activity and Antioxidant property of *Datura metel* L. *International Journal of current Pharmaceutical Research*., Vol.9(3): 106:110.

Adapoid, V. and G. K. Kaladhar, V. S. D. (2012). Antimicrobial study of plant Extracts of *Datura metel* L. Against some important diseases causing pathogens. *Asian Pecific Journal of Tropical Disease*., Vol.2: 594-597.

Zhang, F. X., Liu, G. Z. and Gurunathan, S. (2016). Silver nanoparticles: Synthesis, Characterization, Properties, Applications and therapeutic Approaches. *International Journal of Molecular Sciences*., Vol.17(9): 34.

How to cite this article:

Diksha Sadana and Anshu Sibbal Chatli. 2022. Biogenic Synthesis of Metallonanoparticles: A Review. *Int.J.Curr.Microbiol.App.Sci*. 11(01): 151-158. doi: https://doi.org/10.20546/ijcmas.2022.1101.018