OPEN ACCESS Freely available online

Journal of Applied Pharmacy

ISSN: 1920-4159

Mini-Review

Green Synthesis of Silver Nanoparticles (Ag-NPs) their Advantages, Potential Role as Antibacterial, Antifungal Agent, Associated Patents and Future Perspectives: A Systematic Review

Sumel Ashique[1*], Aakash Upadhyay[1], Sneha Bag[2], Ayan Goswami[3], Sachin Tyagi[4]

[1]Department of Pharmaceutics, Bharat Institute of Technology (BIT-School of Pharmacy), Meerut, UP, India; [2]Department of Pharmaceutical Chemistry, Gurunanak Institute of Pharmaceutical Science and Technology, Kolkata, West Bengal, India; [3]Department of Pharmacology, Gurunanak Institute of Pharmaceutical Science and Technology, Kolkata, West Bengal, India; [4]Department of Pharmacology, Bharat Institute of Technology (BIT-School of Pharmacy), Meerut, UP, India

ABSTRACT

With the upgradation of nanotechnology, Silver Nanoparticles (Ag-NPs) have become one of the most promising nanoparticles due to their several advantages in the pharmaceutical field. Several methods are available for the synthesis of AgNPs like physical, chemical and biological methods. In physical and chemical methods unwanted toxic products are generated, requiring high energy and associated problems in stability. Biological or green mode of synthesis is more advantageous over other methods thus, there is an urgent need for greener synthesis of AgNPs in several drug delivery purposes. Greener synthesis of AgNPs offer reduced toxicity, cost-effectiveness and in the abundance of reducing raw agents. Additionally Silver Nanoparticles (AgNPs) have gained lots of attention because of efficient action against microbial infections, antibacterial and antifungal. This review has described the advantages of green synthesized Ag-NPs, their potential application, associated patents in the field of pharmacy and future perspectives briefly.

Keywords: Silver nanoparticles; Green synthesis; Antibacterial; Antifungal action; Patents

INTRODUCTION

Green synthesis is the organic synthesis of nanoparticles by utilizing plant extracts and the developed nanoparticles are called biogenic nanoparticles. Several findings have reported that a wide number of medicinal plants are used to synthesize the silver NPs [1,2] such as Mulberry leaves , Alternanthera dentate, Ocimum sanctum, Azadirachta indica, Brassica rapa, Coccinia indica, Vitex negundo, Melia dubia are already been utilized to synthesize and stabilize metallic nanoparticles, more significantly biogenic Silver (Ag) nanoparticles [3,4].

Recently the development of green synthesis of silver nanoparticles has become more acceptable throughout the world for the treatment of several disorders due to having several advantages including less toxicity, effective mechanism of actions, improved bioavailability and targeting. This green synthesis is used for the treatment of antibiotic-resistant bacteria, cancer because of having effective characteristics in comparison with other chemical ways and drugs [5].

To avoid the limitations of chemical methods, green synthesis methods (including bacteria, fungi, plant extracts, and small biomolecules like vitamins and amino acids) are mostly considerable which are simple, cost effective, dependable, and environmentally friendly options and high yield productions of AgNPs of defined size [6,7].

Correspondence to: Sumel Ashique, Department of Pharmaceutics, Bharat Institute of Technology (BIT-School of Pharmacy), Meerut, UP, India, E-mail: ashiquesumel007@gmail.com

Received: 03-Jan-2022, Manuscript No. JAP-22-329; **Editor assigned:** 05-Jan-2022, PreQC No. JAP-22-329(PQ); **Reviewed:** 19-Jan-2022, QC No. JAP-22-329; **Revised:** 21-Jan-2022, Manuscript No. JAP-22-329(R); **Published:** 28-Jan-2022, DOI:10.35248/1920-4159.22.14.329.

Citation: Ashique S, Upadhyay A, Bag S, Goswami A , Tyagi S (2022) Green Synthesis of Silver Nanoparticles (Ag-NPs) their Advantages, Potential Role as Antibacterial, Antifungal Agent, Associated Patents and Future Perspectives: A Systematic Review. J Appl pharm. 14: 329.

GREEN SYNTHESIS METHOD OF Ag-NP

Sources of green synthesis methods

Ag-NP are synthesized at industrial stage using physio-chemical strategies including chemical reduction, gamma ray radiation, micro-emulsion, electrochemical strategies, laser ablation, autoclaving, electrochemical techniques, microwaving, photochemical reduction. Having toxic outcomes, excessive cost, requirement of excessive energy, now green synthesis gives a potential and novel method which involves usage of bacteria, fungi, yeast, algae, plant extract [8] as reducing or stabilizing agents. extensively used microorganisms are Shewanella oneidensis, Trichoderma viride (*T. viride*), *Bacillus sp*., *Lactobacillus sp*., and a few vegetative parts of plants. Nanoparticles are frequently more catalytic, have electromagnetic capacity and are as a consequence more reactive. ROS technology ability makes them extra toxic than bulk counterparts [9]. Distinctive plant metabolites which includes carbohydrates, alkaloids, terpenoids, tannins, phenolic acids play a prime function in fabrication of Ag-NP by way of inexperienced synthesis. The maximum essential plant parts liable for reducing Ag particles for the formation of Ag-NP are polyol, polysaccharides, aqueous solvent heterocyclic blends [10]. In green synthesis of Ag-NP the use of plant components, the vital variables for Ag-NP preparations are plant source, herbal mixes in rough leaf elimination, concurrence of Ag particles, temperature, centralization of leaf concentrate shades and many others [11]. Plant separation would possibly act as reducing in addition to stabilizing agent in Ag-NP formation. In this used extract of Camellia sinensis (inexperienced tea) as reducing and stabilizing agents for the synthesis of gold silver nanoparticles in aqueous solution underneath ambient conditions [12]. In the mentioned synthesis of Ag-NP with the aid of lowering $Ag+$ ion in aqueous solution with supernatant of Bacillus licheniformis culture [13]. Ag-Np synthesized by means of this method has high established order and this technique additionally has an advantage over conventional strategies as microorganisms here used are nano pathogenic bacterium [14]. They are several techniques for synthesizing Ag-NP under water the use of non-poisonous and value effective compounds. green synthetic approach confirmed more capability in synthesis [15]. Green synthetic methods encompass mixed-valence polyoxometalates, polysaccharide, Tollens, irradiation, and biological etc. The mixed-valence polyoxometalates were conducted in water. solution of $AgNO_3$ that consists of glucose and starch in water produces starch protected silver nanoparticles. Pronounced a brand new and simpler technique for biosynthesis of gold and silver NPs [16]. The method includes tansy fruit (*Tanacetum vulgare*) extract for synthesis of gold and silver nanoparticles of round and triangular shapes.

Green synthesis using bacteria as a medium

Silver exhibits great biocidal properties; however there are some bacteria which are silver resistant. They accumulate silver on the cell wall to as much as 25% of their dry weight biomass, hence they can be used in industrial recovery of silver from ore materials. Therefore, the use of prokaryotic bacteria as nanofactories was first studied. First noble metal nanoparticle synthesis was done by using bacteria where silver resistant bacterial strains Pseudomonas stutzeri AG259 were cultured in high concentrations of silver nitrates. The bacterial cells accumulate silver in large quantities and the majority of the silver deposited in the form of particles was of 200 nanometers of diameter. Significant results were observed when silver nanoparticles were synthesized using bacteria Proteus mirabilis PTCC 1710. Depending on the cell culture medium (Broth) used during the incubation of bacteria, extracellular or intracellular synthesis can be promoted. These selection criteria make bacteria-based green synthesis flexible, inexpensive, and a suitable method for large-scale production [17].

Green synthesis using fungi as medium

Similar to bacteria, recent study showed fungi are quite beneficial in synthesis of silver nanoparticles. Due to their tolerance and metal bioaccumulation ability, high binding capacity and intracellular uptake, fungi have been of a great interest in biological production of the metallic nanoparticles. The mechanism of nanoparticle synthesis using fungi is different; fungi secrete some enzymes which are used to reduce the amount of silver ions that induce the formation of the metal nanoparticles. The synthesized nanoparticles were approximately 25 nm in diameter providing a rather good monodispersity and spherical morphology. In contrast to bacteria, AgNPs were formed below the surface of the fungal cells. The mechanism of the synthesis was studied and postulated that in fungi-based synthesis, the NPs were formed on the surface of the mycelia and not in the solution. It was suggested that in the first step silver ions ($Ag+$) were adsorbed on the surface of the fungal cells due to electrostatic interaction between negatively charged carboxylate groups in enzymes present in the cell wall of mycelia and positively charged silver ions. Finally, the silver ions were then reduced by the enzymes present in the cell wall, leading to the formation of silver nuclei. Compared to bacteria, fungi are known to secrete much higher amounts of proteins, which tend to significantly increase the productivity of this biosynthetic approach; moreover, fungi can be used for the production of large amounts of metal nanoparticles [18-21]. Extracellular synthesis is advantageous as the synthesized nanoparticles will not bind to the biomass and it is therefore possible to extend this approach for the biosynthesis of nonmaterial over a range of chemical compositions, such as oxides, nitrides, and so forth. The first used yeast strain for extracellular synthesis of silver nanoparticles was silver-tolerant MKY3. The outcome of the synthesis was satisfying due to simplicity of the separation of the nanoparticles when using differential thawing. Similar to moving from prokaryotic to eukaryotic green synthesis, the utilization of eukaryotic autotrophs widened the possibilities of green synthesis. For example, using marine algae Sargassum wightii allowed synthesis of more stable nanoparticles compared to other biological methods.

ADVANTAGES OF GREEN SYNTHESIZED SILVER NANOPARTICLE OVER OTHER SYNTHETIC PROCEDURE

Green synthesis of silver nanoparticles with controlled release, drug targeting, as well as appreciably increase the bioavailability of drugs, which subsequently overcome the fragility of traditional drug delivery. This silver nanoparticles furthermore provides several advantages including use of nontoxic chemicals, not expansive, eco friendly, involving living organisms, less energy is used to synthesize NPs. Biological components themselves act as reducing and capping agents, therefore reducing the overall synthesis process. Eco-friendly approach, as toxic chemicals are not used, external experimental conditions like high energy and high pressure are not required, leads to energy saving process, Green synthesis can be used at large scale production of nanoparticles. These biosynthetic strategies have a number of advantages. They are easy, price effective, deliver excessive yields, and are environmentally amusing. The idea of green chemistry was brought to the nanoparticle synthesis approach to decline the usage of poisonous chemicals and put off the manufacturing of unwanted or poisonous products. The widely recognized system for synthesis of metallic nanoparticles is a chemical reduction of organic and inorganic solvents that take the initiative as reducing agents *viz.* sodium borohydride, hydrazine, ascorbic acid, dimethylformamide and poly (ethylene glycol) (PEG). lots of literature has been stated to date on biological syntheses of silver nanoparticles using microorganisms such as micro organism, fungi and plants; due to their antioxidant or reducing properties generally responsible for the reduction of metallic compounds of their respective nanoparticles.it is the high-quality platform for synthesis of nanoparticles; being unfastened from toxic chemical substances as well as imparting natural capping agents for the stabilization of silver nanoparticles. Besides, use of plant extracts also diminish the cost of microorganisms isolation and their culture media which build up the cost competitive viability over nanoparticles synthesis by microorganisms. The biological synthesis of nanoparticles pivots on three factors, including (a) the solvent; (b) the reducing agent; and (c) the non-toxic material. The foremost merit of biological technique is the availability of amino acids, proteins, or secondary metabolites in the synthesis process, the removal of the subsidiary step vital for the prevention of particle aggregation, and the use of biological molecules for the synthesis of AgNPs is eco-friendly and pollution-free.

ANTIFUNGAL ACTIVITY OF AgNPs

Rapid increase in drug resistance in clinical strains of fungi, the researchers have focused on pharmaceutical companies to synthesize novel antifungal agents like AgNPs. Green synthesized derived AgNPs resulted in greater antifungal activities than synthetic antifungal drugs (toxic to the cell). The actual mechanism of action against fungal growth is not fully understood. They act by disrupting the structure of the cell membrane, membrane integrity thus reducing the budding process has been considered for the antifungal action against C. *albicans* species.

CONCLUSION

A growing consciousness towards green chemistry and use of green route for synthesis of silver nanoparticles result in a preference to broaden environment-friendly strategies. Advantage of synthesis of silver power efficient, value effective; offer healthier places of work and groups, shielding human fitness and surroundings leading to lesser waste and more secure merchandise. Green synthesised silver nanoparticles have enormous elements of nanotechnology through unrivalled applications. It has quantified benefits and is economically wonderful over the chemical and bodily strategies in addition to a number of the microbes additionally. The synthesis of nanoparticles using flora may be tremendous over different biological entities that could conquer the time ingesting procedure of employing microbes and preserving their culture which could lose their ability in the direction of synthesis of nanoparticles. There is nevertheless a need for a commercially viable, economic and environment pleasant direction to discover potential of natural reducing components to form silver nanoparticles which has no longer yet been studied.

REFERENCES

1. Singh J, Kaur G, Kaur P, Bajaj R, Rawat M. A review on green synthesis and characterization of silver nanoparticles and their applications: A green nanoworld. World J Pharm Pharm Sci. 2016; 5(7):730-762.
2. Singh J, Bajaj R, Harpreet K, Harjot K, Navneet K, Sukhmeen K, et al. Chemo-bio synthesis of silver nanoparticles. J Nanomed Res. 2016;4(3):00092.
3. Sathishkumar P, Vennila K, Jayakumar R, Yusoff AR, Hadibarata T, Palvannan T. Phyto-synthesis of silver nanoparticles using Alternanthera tenella leaf extract: An effective inhibitor for the migration of human breast adenocarcinoma (MCF-7) cells. Bioprocess Biosyst. Eng. 2016;39(4):651-659.
4. Singhal G, Bhavesh R, Kasariya K, Sharma AR, Singh RP. Biosynthesis of silver nanoparticles using Ocimum sanctum (Tulsi) leaf extract and screening its antimicrobial activity. J Nanopart Res. 2011;13(7): 2981-2988.
5. Mousavi SM, Hashemi SA, Ghasemi Y, Atapour A, Amani AM, Savar Dashtaki A, et al. Green synthesis of silver nanoparticles toward bio and medical applications: Review study. Artif Cells Nan Biotech. 2018;46(3): S855-S872.
6. Gurunathan S, Kalishwaralal K, Vaidyanathan R, Venkataraman D, Pandian SR, Muniyandi J, et al. Biosynthesis, purification and characterization of silver nanoparticles using Escherichia coli. Colloids Surf. B: Biointerfaces. 2009;74(1):328-835.
7. Kalimuthu K, Babu RS, Venkataraman D, Bilal M, Gurunathan S. Biosynthesis of silver nanocrystals by Bacillus licheniformis. Colloids and Surfaces B: Biointerfaces 2008;65(1):150-153.
8. Nel A, Xia T, Madler L, Li N. Toxic potential of materials at the nanolevel. Science 2006;311(5761):622-627.
9. Limbach LK, Wick P, Manser P, Grass RN, Bruinink A, Stark WJ. Exposure of engineered nanoparticles to human lung epithelial cells: Influence of chemical composition and catalytic activity on oxidative stress. Environ Sci Technol 2007;41(11):4158-4163.
10. Ahmad SA, Das SS, Khatoon A, Ansari MT, Afzal M, Hasnain MS, et al. Bactericidal activity of silver nanoparticles: A mechanistic review. Mater Sci Technol. 2020;3: 756-769.
11. Vilchis-Nestor AR, Sánchez-Mendieta V, Camacho-López MA, Gómez-Espinosa RM, Camacho-López MA, Arenas-Alatorre JA. Solventless

synthesis and optical properties of Au and Ag nanoparticles using Camellia sinensis extract. Mater let. 2008;62(17-18):3103-5.

12. Kalishwaralal K, Deepak V, Ramkumarpandian S, Nellaiah H, Sangiliyandi G. Extracellular biosynthesis of silver nanoparticles by the culture supernatant of Bacillus licheniformis. Mater let. 2008;62(29): 4411-3.

13. Natsuki J, Natsuki T, Hashimoto Y. A review of silver nanoparticles: Synthesis methods, properties and applications. Int J Mater Sci Appl. 2015;4(5):325-32.

14. Sharma VK, Yngard RA, Lin Y. Silver nanoparticles: Green synthesis and their antimicrobial activities. Adv colloid inter sci. 2009;145(1-2): 83-96.

15. Dubey SP, Lahtinen M, Sillanpää M. Tansy fruit mediated greener synthesis of silver and gold nanoparticles. Pro Biochem. 2010;45(7): 1065-71.

16. Remya VR, Abitha VK, Rajput PS, Rane AV, Dutta A. Silver nanoparticles green synthesis: A mini review. Chem Int. 2017;3(2): 165-71.

17. Kathiraven T, Sundaramanickam A, Shanmugam N, Balasubramanian T. Green synthesis of silver nanoparticles using marine algae Caulerpa racemosa and their antibacterial activity against some human pathogens. Appl Nanosci. 2015;5(4):499-504.

18. Britto JD, Gracelin DH, Kumar PB. Antibacterial activity of silver nanoparticles synthesized from a few medicinal ferns. Int J Pharm Res Dev. 2014;6:25-9.

19. Bagherzade G, Tavakoli MM, Namaei MH. Green synthesis of silver nanoparticles using aqueous extract of saffron (Crocus sativus L.) wastages and its antibacterial activity against six bacteria. Asian Pacific J Trop Biomed. 2017;7(3):227-33.

20. Tagad CK, Dugasani SR, Aiyer R, Park S, Kulkarni A, Sabharwal S. Green synthesis of silver nanoparticles and their application for the development of optical fiber based hydrogen peroxide sensor. Bio Chem. 2013;183:144-9.

21. Zuas O, Hamim N, Sampora Y. Bio-synthesis of silver nanoparticles using water extract of myrmecodia pendan (Sarang Semut plant). Mat Let. 2014;123:156-9.