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"Bio Synthesis Of Silver Nanoparticle And Their Application In Organic Transformation."

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Abstract:

Silver nanoparticle (NP's) have been the subjects of researchers because of their unique properties like shape and size depending optical, antimicrobial and electrical properties. In this review focuses on the synthesis of silver nanoparticle using various plant and biological sources. A detailed study on the reduction of silver ions to silver nanoparticles mediated through plant leaves, fruits, root and fungus , bacteria. Characterization of prepared silver nanoparticle is done with the scanning electron microscopy(SEM), transmission electron microscopy (TEM), Fourier Transform Infra Red spectroscopy (IR), X-Ray Diffraction and UV-visible microscopy. Silver nanoparticle is multifunctional bio- applications ; anti-microbial, anti-fungal, anti-viral, anti-inflammatory, anti-angiogenic, and anti- cancer agents and anti-cancer activities of AgNPs .

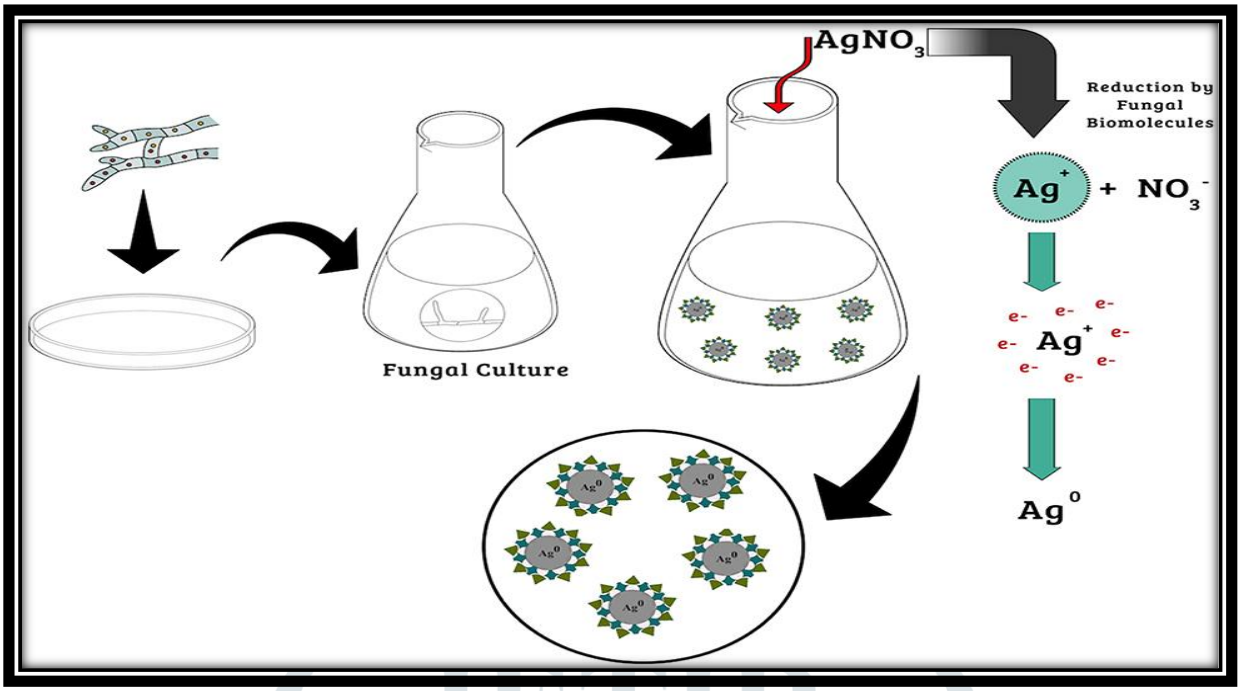
Silver nanoparticles play an integral part in the evolution of new antimicrobials against the broad ranges of pathogenic microorganisms. Recently, biological synthesis of metal nanoparticles using plant extracts has been successfully consummated. In the present study, the biosynthesis of silver nanoparticles (AgNPs) was conducted using the leaf extract of plant Protium serratum, having novel ethnomedicinal. The synthesized AgNPs were characterized using UV-Visible spectroscopy, dynamic light scattering spectroscopy (DLS), Fourier transform infrared spectroscopy (FTIR), and scanning electron microscopy.

Key Words: Biosynthesis, Nano Particles, Transformation, Bacteria, Silver Particles, silver nanoparticle, biosynthesis, anti-microbial , anti-fungal , anti-cancer.

Introduction:

Nanotechnology is one the most significant fields of science that demonstrates dramatic advance and applications as it could establish incredible characteristics such as bio sensing, electrical magnetics ,thermal ,metal detection, optical sensing and catalytic traits when the particle size reduced. The unique properties of Nanomaterial's have spurred numerous investigations and applications in electrons Nano medicines , biomaterials energy & food.

For over centuries silver based compounds were as nontoxic inorganic antibacterial agents owing to their biocide properties in many applications such as wood preservations water purification in hospitals in wound or burn dressing. Silver based compounds are much cheaper than gold's based one. A large no of in vitro studies indicates that AgNp's are toxic skin, liver, lungs, brain vascular system , reproductive organs. There are various methods like physical and biological were available to size of silver nanoparticle. A variety of preparation techniques have been reported for the synthesis of silver NP's ; example include laser ablation, gamma irradiation, electron irradiation. Chemical reduction, photochemical methods, ,microwave processing &biological synthetic methods. Silver nanoparticle were synthesized in different alcoholic medium such as solvothermal method. Nanoparticle have been successfully synthesized by reduction of silver nitrate. Silver nanoparticles (AgNP's) are increasing used in various fields , including medical ,food health care, consumer and industrial purposes due to their unique physical and chemicals properties.



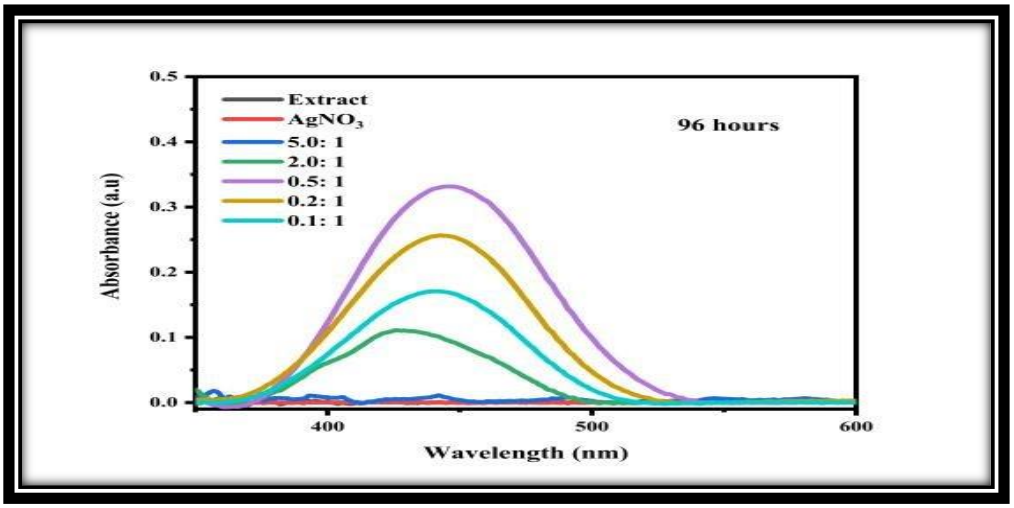
Nowadays, there is a growing need to use toxic chemicals in the synthesis of ecofriendly nontoxic reducing and stabilizing agents are the most important issues which must be considered in green synthesis of Np's. The methods are still in development stage and the experienced problems are the stability and aggressions of Np's controls of crystals growth morphology ,size and size distribution. The characterization done on the basis of SEM, XRD, FT-IR, and uv-visible spectroscopy. Extraction and purification of produced NP'S for further applications are still important issues.

This review article present an overview of silver nanoparticle preparation by green synthesis approaches and bio applications.

Biosynthesis of silver nanoparticle

Author Lubna sherin , Ayesha sohail and team systhesied Biogenic silver nanoparticles were synthesized using novel Terminalia bellerica kernel extract. Optimal synthesis of silver nanoparticles was achieved at 0.016 mg/mL kernel extract and 2.0 mM silver nitrate concentrations under ambient conditions. Silver nanoparticles were characterized by ultraviolet–visible absorption spectroscopy, transmission electron & scanning electron microscopy, energy dispersive X-ray analysis, X-ray diffraction, and Fourier transform infrared spectroscopy.

Author Majid Sharifi-Rad Pawel Pohl described In this research, silver nanoparticles (AgNP's) were synthesized through the high-efficient, cost-effective green and facile process, using the Astragals tribuloides Delile root extract as a bio reduction and capping agent at room temperature. UV–Vis spectroscopy was applied for the investigation of the reaction proceedings. To characterize the greenly synthesized AgNPs, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction spectroscopy (XRD), and transmission electron microscopy (TEM) analyses were utilized. triploids root extract had appropriate antioxidant, antibacterial, and anti-inflammatory activities and, therefore, can be considered as a promising candidate for various biomedical applications.



Author Peter Logeswari , Sivagnanam Silambarasan, Jayanthi Abraham uses Plants extract from Ocimum tenuiflorum, Solanum tricobatum, Syzygium cumini, Centella asiatica and Citrus sinensis was used for the synthesis of silver nanoparticles (Ag NPs) from silver nitrate solution. Ag NPs were characterized by UV–vi spectroscopy , (XRD), (AFM) and (SEM). The silver nanoparticles have been produced by O. tenuiflorum, S. tricobatum, S. cumini, C. asiatica and C. sinensis extracts, which is an economical, efficient and eco-friendly process.

Literature Review:

In this paper Rice husk extract, obtained using acid and alkali pretreatment extraction (AAPE), contains bioactive compounds and exhibits reducing abilities. Rice husk extract, obtained using acid and alkali pretreatment extraction (AAPE), contains bioactive compounds and exhibits reducing abilities. Characaterisation of nanoparticles by SEM ,TEM ,FT-IR.

Author R. Renuka a K. Renuka Devi a their team uses Indian gooseberry (phyllanthus emblica) to green synthesis silver nanoparticle by bio reduction methods. The functional groups of phyllanthus emblica fruit extract and the silver nanoparticles were diagnosed by using , FTIR , FCC, SEM , XRD. silver nanoparticles was success fully prepared from an eco - friendly, easy, rapid and convenient greener method using phyllanthus emblica fruit extract. `

Author Peter Logeswari, Sivagnanam Silambarasan, Jayanthi Abraham *Plants extract from Ocimum tenuiflorum, Solanum tricobatum, Syzygium cumini, Centella asiatica and Citrus sinensis was used for the synthesis of silver nanoparticles (Ag NPs) from silver nitrate solution. The aqueous silver ions were reduced to silver nanoparticles when added to natural plant extract of O. tenuiflorum, S. tricobatum, S. cumini, C. asiatica and C. sinensis. It was observed that the color of the solution turned from yellow to bright yellow and then to dark brown. Ag NPs were characterized by UV–vis spectrophotometer, X-ray diffractometer (XRD), atomic force microscope (AFM) and scanning electron microscope (SEM). . The observation indicated that the reduction of the Ag+ ions took place extracellularly.

Author Srikar , S. , Giri, D. , Pal, D. , Mishra, P. and Upadhyay , S. described green syntheses of AgNPs have been performed using plant extracts, microbial cell biomass or cell free growth medium and biopolymers. Parts like leaf, bark, root, and stem have been used for the AgNP synthesis. The active ingredient responsible for reduction of Ag+ ions varies depending upon organism/extract used. Centrifugation is most important separation methods used to separate nanoparticle. Characterization of silver nanoparticle is done with the of different methods , SEM, TEM, XRD, uv-silver nitrate (AgNO3) was prepared and used for the synthesis of silver nanoparticles. 5 mL of leaf extract of Clitoria ternatea and Solanum nigrum was added to 45 mL of 0.1 M AgNO3 solution for bioreduction process at room temperature.

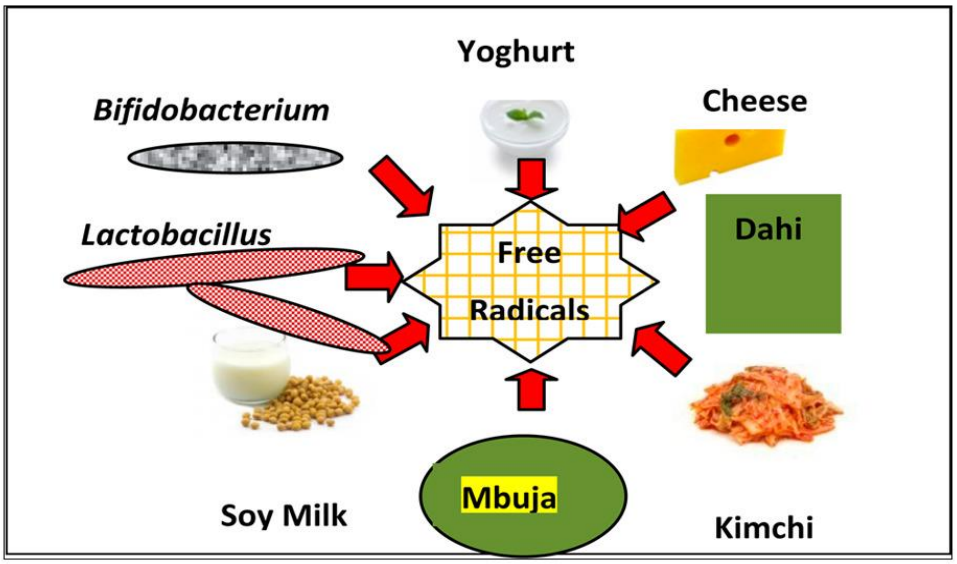
Author Narayanaswamy Krithiga,1 Athimoolam Rajalakshmi,1 and Ayyavoo Jayachitra dicussed in the paper that 0.1 M of aqueous solution of silver nitrate (AgNO3) was prepared and used for the synthesis of silver nanoparticles. 5 mL of leaf visible spectroscopy. It is carries antimicrobial , antifungal , anti-parasitic and anti-fouling agents properties.

In this paper , AgNPs were synthesized using a reduction of aqueous Ag+ with the culture supernatants of Aspergillus terreus at room temperature. Aspergilllus terrus is a fungus worldwide in soil. The synthesized AgNPs could efficiently inhibit various pathogenic organisms, including bacteria and fungi. silver nanoparticles (AgNPs) were synthesized using a reduction of aqueous Ag+ ion with the culture supernatants of Aspergillus terreus. AgNPs obtained were characterized by transmission electron

microscopy and X-ray diffraction. The synthesized AgNPs were polydispersed spherical particles ranging in size from 1 to 20 nm and stabilized in the solution.

Authour Monali Gajbhiye, MSc, Jayendra Kesharwani, MSc, Avinash Ingle, MSc, Aniket Gade, MSc, Mahendra Rai, PhD Here, report the extracellular biosynthesis of Ag-NPs using a common fungus, Alternaria alternata. Also in this study, these nanoparticles were evaluated for their part in increasing the antifungal activity of fluconazole against Phoma glomerata, Phoma herbarum, Fusarium semitectum, Trichoderma sp., and Candida albicans. The anti fungal activities properties is tested against fungus by using AgNPs nanoparticle. Characterizations was done by the SEM, TEM, XRD,FT-IR and uv-visible spectroscopy

The present study reported the biological synthesis of AgNPs using the cell-free aqueous leaf extract of P. serratum and evaluation of its potential application as an antibacterial agent against two Gram negative (Pseudomonas aeruginosa MTCC 2453 and Escherichia coli MTCC 739) and two Gram positive (Bacillus subtilis MTCC 736, Staphylococcus aureus MTCC 2940) food borne pathogenic bacteria along with antioxidant potentials in terms of DPPH and OH radical scavenging activity. Moreover, the cytotoxicity test against L-929 cell line (normal fibroblast) was carried out to evaluate the biocompatibility as well as multifunctionality for potential pharmaceutical and biomedical applications. Usage of these plant materials in the green synthesis of metal nanoparticles could proficiently prove the cost effective approach.



Materials and Methods

Collection and Preparation of Plant Extract

Healthy leaves of P. serratum were collected from forest of Similipal Biosphere Reserve (21°–28′ and 22°–08′ North latitude and 86°–04′ and 86°–37′ East longitude), Mayurbhanj, Odisha, India during the months of January to March 2015. The identified plant specimen was deposited in the Department of Botany, North Orissa University. The shed dried leaves were powdered and sieved using a 20-mm mesh in order to maintain a uniform size. To make aqueous leaf extract, 5 g of leaf powder was mixed with 50 ml of sterile distilled water and sonicated for 15–20 min. The sonicated aqueous extract was purified by repeated centrifugation. The purified extract was filtered through Whatman filter paper no. 40 and the filtrate was stored at 4°C for further use.

Biosynthesis of Silver Nanoparticles (AgNPs)

For the biosynthesis of silver nanoparticles, the suitable reaction mixture was prepared by adding 1 ml of aqueous leaf extract and 9 ml of 1 mM AgNO3 solution in a clean 25 ml Erlenmeyer flask. On the contrary, same experimental set up of 1 ml of aqueous leaf extracts with 9 ml distilled water was kept as control. Both flasks were incubated for 2–4 h in the rotary shaker under dark conditions at 25°C. Later, the synthesized silver nanoparticles (AgNPs) were separated and purified by continuous centrifugation (9000 rpm; 20 min; 10°C) with sterile miliQ water. The dried AgNPs were kept at 4°C for further characterization and bioactivity study (Mohanta et al., 2016a).

Characterization of Silver Nanoparticles

The biosynthesis of the silver (Ag) nanoparticles (bio reduction of the Ag+ ions) in aqueous solution was monitored periodically in UV-Vis spectrophotometer (Lambda 35® PerkinElmer, USA) within the range of 400–600 nm. The UV–visible spectra of the resulting reaction solution was monitored as a function of reaction time at a resolution of 1 nm room temperature (25°C). The average size and surface charge of the silver (Ag) nanoparticles were analyzed by Zetasizer (ZS 90, Malvern, UK). The purified samples were 10-folds diluted with the phosphate buffer saline PBS (0.15M, pH 7.2). The aliquots were later sampled in dynamic light scattering (DLS) cuvettes and examined for equivalent diameters, size distribution and zeta potential. The particle diameters were assessed at scattering angle of 90° at room temperature (25°C). Fourier Transform Infra-Red spectra of the silver (Ag) nanoparticles were studied in FT-IR spectrophotometer (8400S, Shimadzu, Japan) in transmission (%) mode with a 200 scans. The AgNPs were pelletized with potassium bromide (KBr) having 1% sample concentration (w/w) and was analyzed against the background of pure KBr pellet.

The nano-scale size of silver particles were confirmed by analysis of morphological structure under scanning electron microscope (Jeol 6480LV JSM, USA) performed at acceleration voltage of 15 KV (Mohanta and Behera, 2014; Nayak et al., 2015).

Antibacterial Activity against Food Borne Pathogens

Microbial Strains

Common food borne pathogens viz. B. subtilis (MTCC 736), S. aureus (MTCC 2940), P. aeruginosa (MTCC 2453), and E. coli (MTCC 739) were used for the tests of antibacterial assay. All strains were procured from Microbial Type Culture Collection, Chandigarh, India.

Agar Well Diffusion and Micro Broth Dilution Methods

A single colony of each bacterial strain was inoculated from an agar slant in 1 mL Muller Hinton broth medium (0.2% beef extract, 0.015% soluble starch and 1.75% casamino acids) under aseptic conditions. The reaction tubes were incubated overnight (200 rpm; 37°C).

The antibacterial activities of AgNPs were investigated against bacterial species using well diffusion method on Muller Hinton Agar. To test the antibacterial activity, Muller Hinton Broth culture (100 µl) of each test organisms were seeded over the Muller Hinton Agar plates. Wells were made of approximately 5 mm in diameter and 2.5 mm deep. Each well was filled with 50 µl of AgNPs. Simultaneously, 50 µl of AgNO3 solution was kept to serve as control while standard antibiotic Gentamicin was used as a reference. The plates were incubated at 37°C for 24 h. After the incubation period, the diameter of the growth inhibition zones was measured. The AgNPs with the zone of inhibition greater or equal to 8-mm diameter were regarded as the positive activity.

Further, the confirmatory antibacterial activity was observed through micro broth dilution method along with calculation of the minimum inhibitory concentration (MIC) of AgNPs on bacterial strains (Panda et al., 2016). The percentage of inhibition more than 90% in micro broth dilution method was considered as potential activity and further experiments were conducted to calculate the MIC. Briefly, for MIC calculation, the test inoculum (190 µL; A600 = 0.1) with different concentrations of AgNPs (10 µL) ranges from 500 to 31.25 µg/ml (twofold dilution) were taken until the percentage of inhibition was found to be <50%. The micro broth dilution study was conducted in 96-well plates and the microbial growth or inhibition was measured in Microplate Reader (Biorad, USA) at 600 nm. The MIC was calculated by IC50/IC90 Laboratory Excel Calculation Tools and expressed as IC50. All the experiments were conducted in triplicates and the zone and percentage of inhibitions were expressed in mean ± SD.

Qualitative Phytochemical Analysis

The qualitative phytochemical analysis of P. serratum extract was performed following the standard method (Parekh and Chanda, 2008; Arunachalam et al., 2012). The obtained results were qualitatively expressed as positive (+) or negative (-) Guruvaiah et al., 2012). The chemicals and reagents used for the study were purchased from Sigma–Aldrich (India).

Quantitative Phytochemical Analysis and In vitro Antioxidant Properties

Total Phenolic Content Determination

Total phenolic quantity in the leaf extract was measured using Folin–Ciocalteu method with slight modifications (McDonald et al., 2001). All the experiments were performed in triplicates. The TPC was expressed as gallic acid equivalent (GAE) in mg/g sample.

Total Flavonoids Content Determination

Total amount of flavonoids were estimated by a modified aluminum chloride method (Chang et al., 2002). All estimations were carried out in triplicate. The TFC was expressed as GAE in mg/g sample.

DPPH Radical Scavenging Activity

Potential antioxidant activity was determined using 1, 1-diphenyl-2-picryl-hydrazil (DPPH) assay with sufficient modification wherever it seemed necessary (McDonald et al., 2001). Various concentrations, such as 5, 10, 15, and 20 µg/ml of AgNPs were taken for study of DPPH scavenging capacity. The MIC was calculated and results were presented IC50 value. The results were expressed as percentage (%) radical scavenging activity. The equivalent concentrations of ascorbic acid were taken as a positive control.

Hydroxyl Radical Scavenging Activity

The method was adapted with slight modification as reported by Tanamatayarat (2016). Fifty percent of the inhibitory concentration (IC50) was calculated from the percentage of scavenging capacity. Ascorbic acid was taken as a positive control. Different concentrations such as 20, 40, 60, 80, 100, 120, and 140 µg/ml of AgNPs and Ascorbic acid were taken for OH scavenging capacity and MIC determination.

Biocompatibility Study

The biocompatibility of AgNPs was evaluated by calculating % of viability of cells by treating AgNPs on L-929 normal fibroblast cell line. The L-929 cells were seeded in flask with Dulbecco's Modified Eagle's Medium (DMEM) and M-199 medium supplemented with 10% fetal bovine serum (FBS) and incubated at 37°C (5% CO2) for 24 h. Following the incubation period, the attached cells were trypsinized for 3–5 min to get the individual cells and centrifuged (800 rpm, 10 min.). The cells were counted and distributed in 96 well Enzyme-linked immunosorbent assays (ELISA) plate with 5000 cells in each well and incubated for 24 h to form ~70 to 80% confluence as a monolayer (Nayak et al., 2015). The AgNPs have the capacity to strongly reduce the Adenosine Triphosphate (ATP) content of the cell which ultimately cause mitochondrial damage and increase the production of reactive oxygen species (ROS) in a dose-dependent manner (Nayak et al., 2016). Hence the toxicity of AgNPs was determined at different concentrations ranges from 100 to 700 µg/ml in triplicates. To detect the cell viability, 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) solution 200 µl was added to each well and left for incubation (4–5 h). Later, the MTT solution was discarded and 200 µl of DMSO solvent was added to each well under dark followed by 15–20 min. of incubation and later the optical density (OD) of the formazan product was measured at 595 nm in a micro-triter plate reader (Biorad, USA) (AshaRani et al., 2009). The media, antibiotics and other chemicals used in these experiments were purchased from Sigma–Aldrich (India).

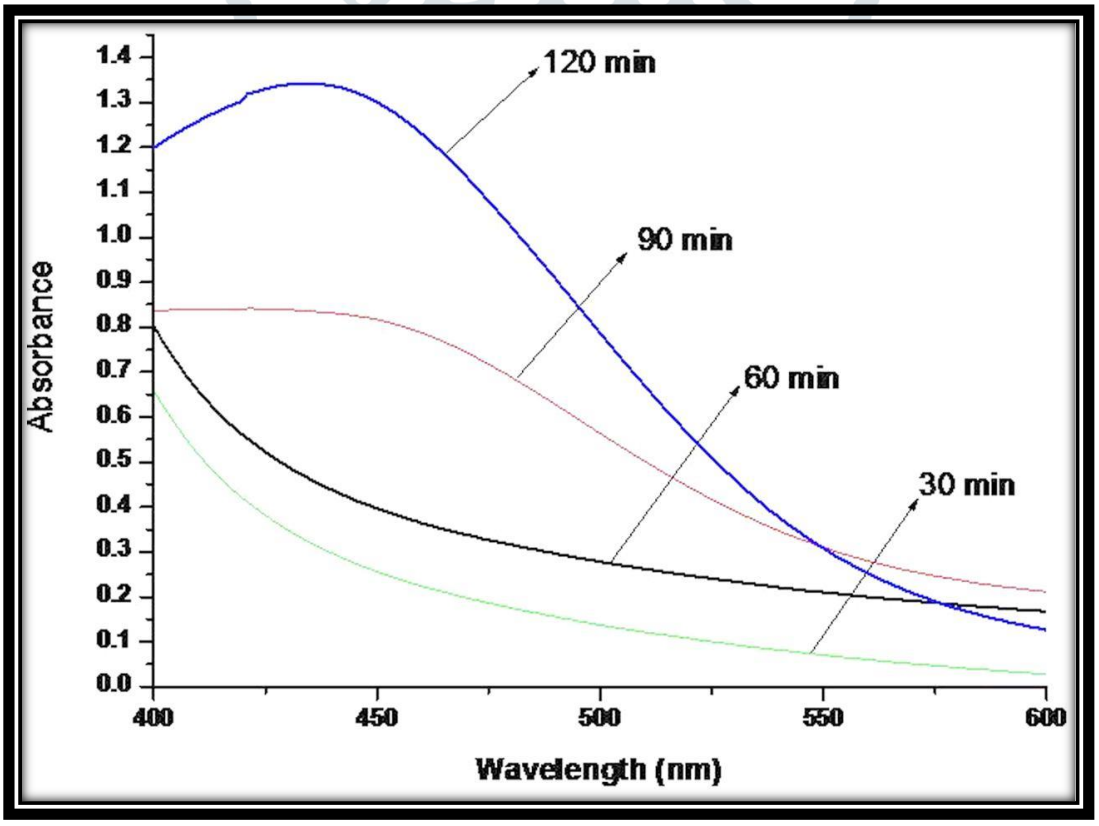
Statistical Analysis

Each activity assay was performed in triplicates in order to determine their reproducibility. The antioxidant results were expressed as percentage of inhibition whereas the cytotoxicity results were represented as percentage of viability with respect to control values. The values of antioxidant and cytotoxicity assays results were compared by Student's t-test with their control values. The antibacterial data were subjected to analysis of one way ANOVA and Duncan's Multiple Range Test using the SPSS statistics program (IBM SPSS statistics 19). A significant difference was considered statistically significant at $p \leq 0.05$.

Results and Discussion

Biosynthesis and UV-vis Spectra Analysis of AgNPs

The UV–vis spectroscopy is an indirect method to examine the bioreduction of Ag nanoparticles from aqueous AgNO3 solution. Initially 9 ml of 1mM AgNO3 solution was taken for the bioreduction of silver by aqueous leaf extract. Two hours post-addition of leaf extract to the AgNO3 solution, a visible color change was observed from pale yellow to dark brown. The intensity of the color increased with increase in incubation time due to the excitation of surface plasmon vibrations in the metal nanoparticles (Jain et al., 2007). The AgNPs synthesized by P. serratum extract exhibited characteristic peak at 432 nm. Previous studies reported that the silver ions give absorption in between 430 and 440 nm due to its surface plasmon resonance (Chung et al., 2016). The AgNPs from P. serratum extract has shown peak at 432 nm which confirms the biosynthesis Ag nanoparticles (Figure 1). In the present study, the Ag nanoparticles was observed to be very stable in the solution, even after 6 months of their synthesis, which strongly validates the use of aqueous leaf extract of P. serratum in synthesis of AgNPs. The P. serratum leaf is rich in flavonoids, sugar, phenolic compounds, tannins and terpenoids, which contribute to its distinct aroma (Tanamatayarat, 2016). The terpenoids were believed to play an important role in biosynthesis of AgNPs through the reduction of Ag ions to its elemental form. Shankar et al. (2003) reported about the possible role of terpenoids from Geranium leaf in the synthesis of nano-sized Ag particles (Shankar et al., 2003). Polyols such as terpenoids, flavones and polysaccharides in the Cinnamomum camphora leaf were reported to be the main cause of the bioreduction of silver and chloroaurate ions (Huang et al., 2007). A similar mechanism might have operated in the present case as well where the flavonoids and phenolic compounds extracted from P. serratum leaf might have act as capping and stabilizing agents. To summarize these results, the water-soluble fractions comprised of complex polyols (Sharma et al., 2009) in the biomass were believed to have played a major role in the bioreduction of Ag ions.

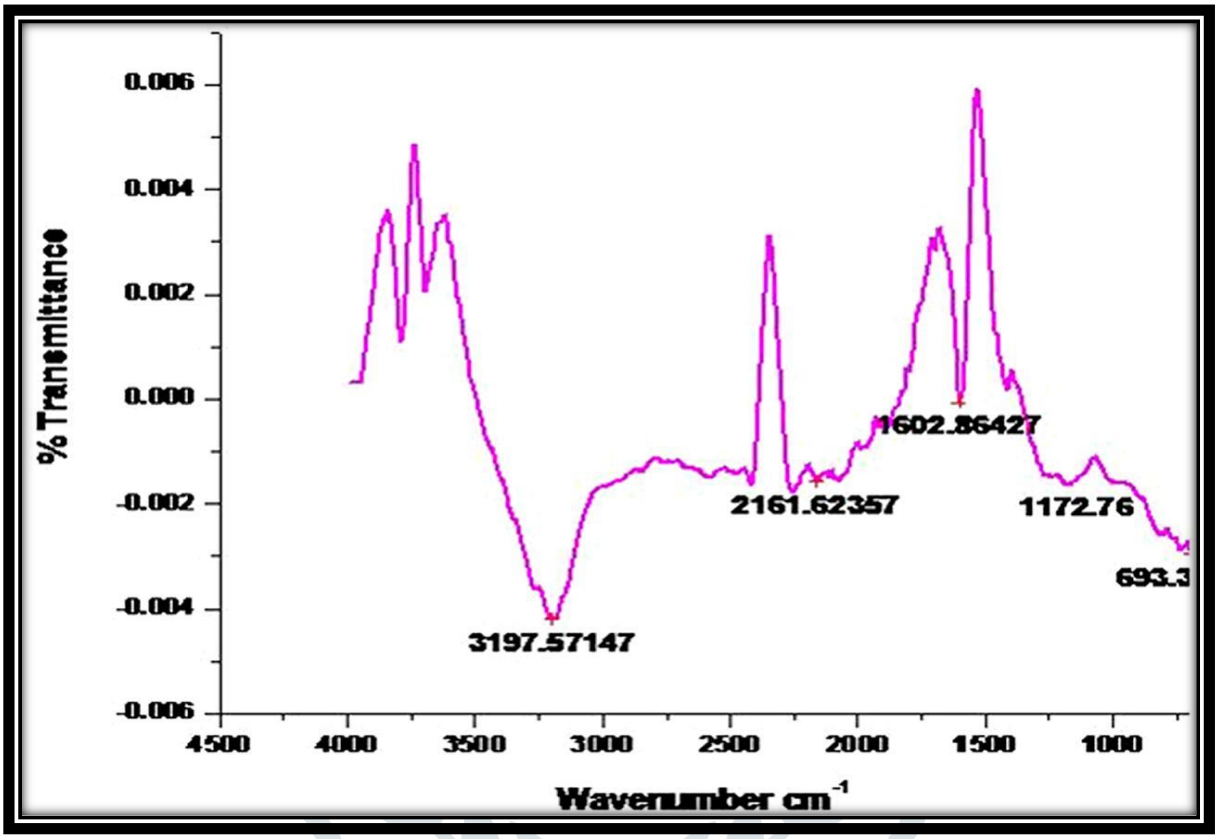


DLS Analysis

The size distribution and surface charge of the AgNPs were determined using DLS in aqueous solution. It was found that the average size and charge of the AgNPs were 74.56 ± 0.46 nm and −25.0 ± 7.84 mV, respectively (Figures 2A,B). The average size and potential contribute a strong characteristic of AgNPs to be used in biomedical sciences. The size of the particle is very important in cellular transportation. Smaller the size, it is easier to pass through the plasma membrane of the cell. So the nano size particle <100 nm was considered to be useful particles for different applications in drug delivery as well as in development of biosensors (Mukherjee et al., 2014). Besides the size of the AgNPs, the surface charge of the nanoparticles was considered to be important for interaction with different macromolecules as well as biochemical pathways present in the cell (Nayak et al., 2015).

FTIR Spectroscopic Analysis

The FTIR spectra of the AgNPs was recorded in order to identify the functional groups of the biomolecules present in the aqueous extract of P. serratum leaf involved in the synthesis and stabilization of the nanoparticles. The interaction of nanoparticles with phytochemicals of P. serratum showed intense peaks at 3197.57; 2161.62; 1602.86; 1172.76 and 693.3 cm-1 (Figure 3). A strong absorption peak was found at 3197.57 cm-1 strongly suggested the binding of silver ion with hydroxyl group and the broad spectrum at 2161.62 cm-1 was referred as the strong stretching of -OH group. The other three bands ~1602.86 cm-1, ~1172.76, and ~693.3 cm-1 were due to stretching vibrations of C = O, C-C, C-N and O-H functional group, respectively. The C = O and C-N stretching are generally found in the proteins involve in the reduction of the metal ions. The observations suggested that the hydroxyl and carbonyl groups might be responsible for the synthesis of AgNPs.



Qualitative and Quantitative Assessment of Phytochemicals and Corresponding Anti-oxidative Activities

Qualitative and quantitative phytochemical examinations of the aqueous leaf extracts has summarized in Tables 3, 4. The phytochemical analysis revealed the existence of flavonoids, tannins, phenolic, sugars and triterpenoids whereas glycoside, steroids and sterols were found to be absent. The phytochemical study of the leaf extract of P. serratum showed that flavonoids, tannins, phenolic compounds, sugars were present in the extract which may be the principal chemicals constituents responsible for the synthesis of AgNPs. Shankar et al. (2003) reported the possible of role of terpenoids from Geranium leaf in the synthesis of nano-sized Ag particles (Shankar et al., 2003). Polyols such as terpenoids, flavones and polysaccharides in the C. camphora leaf were reported to be the main cause of the bioreduction of silver and chloroaurate ions (Huang et al., 2007).

Cytotoxic Activity/Biocompatibility Study

It is very pivotal to understand the biocompatibility of AgNPs for its successful implication in biomedicine and its direct use by human beings as food additives. The cytotoxicity of AgNPs was also tested against normal fibroblast cell lines L-929 to check their biocompatibility. The safety use of AgNPs is a major concern along with toxicity against normal cell lines which can impact on the biological applications. In the present study, AgNPs have not been observed of inhibition against L-929 cell line at lower concentrations.

The percentage of cell viability of normal fibroblast cells is declined with an increase in concentration of AgNPs (Figure 8). The IC50 value of AgNPs against normal L-929cell lines was calculated as 600.28 ± 0.75 µg/mL. The IC50 value indicates the high biological compatibility and safe use of AgNPs in human body. The plant extract did not show any toxicity against L-929cell line and proved its potential use in synthesis of AgNPs. The AgNPs were also previously studied for its biocompatibility against

Chinese hamster ovary (CHO) cell line (Netala et al., 2016). The study of Netala et al. (2016) corroborated with our present findings. In fact, the AgNPs should be thoroughly studied for its safety and biocompatibility before its practical application as product.

Conclusion:

This review reviled that various methods of green synthesis of silver nanoparticles. Conclusion and future prospective of production of silver nanoparticles using natural resources are the important area of nanotechnology. The natural resources used in the production of AgNPs are sustainable, eco-friendly and cost effective and free chemical contamination for biological and medical applications and purity is major concern. Synthesis of silver nanoparticle via green synthesis is more stable and effective in comparison with those product of physico-chemical methods.

Silver nanoparticles exhibited enormous antibacterial potency against three food borne pathogens. Such positive results highly recommend that AgNPs can be used in food packaging materials and also as disinfectant and cleaning agents. Further, the antioxidant activity of AgNPs revealed the protection from oxidation due to external factors as well as radical activity. The AgNPs were also very much stable and biocompatible to the human cell lines. Ethno-medicinal report suggests that P. serratum extract is not harmful to the human body and oral administration of its leaf extract is highly effective against gastrointestinal disorders and also stomach ulcer (Panda et al., 2016). Hence the present research highlights the potential involvement of nanoscience in food industry.

References:

1)Lubna Sherina,∗ , Ayesha Sohailb , Um-e-Salma Amjadc , Maria Mustafac , Riffat Jabeend , Anwar Ul-Hamide biosynthesis of silver nanoparticlehttps://doi.org/10.1016/j.colcom.2020.10027 2019; Received in revised form 19 May 2020.

2) Majid Sharifi-Rad 1,*, Pawel Pohl 2,* , Francesco Epifano 3 and José M. Álvarez-Suarez 4,5, https://doi:10.3390/nano10122383 Received: 6 November 2020; Accepted: 26 November 2020; Published: 29 November 2020

3) Logeswari, P. et al., Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property. Journal of Saudi ChemicalSociety(2012), http://dx.doi.org/10.1016/j.jscs.2012.04.007.

4) Liu Y-S, et al., Silver nanoparticle biosynthesis by using phenolic acids in rice husk extract as reducing agents and dispersants, Journal of Food and Drug Analysis(2017), http://dx.doi.org/10.1016/j.jfda.2017.07.00

5) R. Renuka a , * , K. Renuka Devi a , M. Sivakami b , T. Thilagavathi c , R. Uthrakumar d , K. Kaviyarasu e Received 20 December 2019; Received in revised form 3 February 2020; Accepted 6 March 2020 , https://doi.org/10.1016/j.bcab.2020.101567

6) Srikar, S. , Giri, D. , Pal, D. , Mishra, P. and Upadhyay, S. (2016) Green Synthesis of Silver Nanoparticles: A Review. Green and Sustainable Chemistry, 6, 34-56. doi: 10.4236/gsc.2016.61004.

7) Received: 8 November 2011 / Revised: 23 November 2011 / Accepted: 15 December 2011 / Published:29December2011 https://doi.org/10.3390/ijms13010466

8) R. Renukaa, K. Renuka Devi a , M. Sivakamib , T. Thilagavathic , R. Uthrakumard , K. Kaviyarasue synthesized silver nanoparticle using Indian gooseberry. https://doi.org/10.1016/j.bcab.2020.101567

9)NarayanaswamyKrithiga, Athimoolam Rajalakshmi, and Ayyavoo Jayachitra used to different plants extract to synthsied silver nanoparticle. https://doi.org/10.1155/2015/928204

10) M. Gajbhiye, J. Kesharwani, A. Ingle, A. Gade, M. Rai, Fungus-mediated synthesis of silver nanoparticles and their activity against pathogenic fungi in combination with fluconazole. Nanomedicine: NBM 2009;5:382-386, doi:10.1016/j.nano.2009.06.005

11) Wright GD. Resisting resistance: new chemical strategies for battling superbugs. Chem Biol 2000;7:R127-32

12) Majid Sharifi-Rad 1,*, Pawel Pohl 2,* , Francesco Epifano 3 and José M. Álvarez-Suarez 4,5, Green synthesis of silver nanoparticle Astragalu tribuloides doi:10.3390/nano10122383

13) Sharma, A. et al. Algae as crucial organisms in advancing nanotechnology: a systematic review. J Appl Phycol 28, 1759–1774, https://doi.org/10.1007/s10811-015-0715-1 (2015).

14) Pandey, S., Goswami, G. K. & Nanda, K. K. Green synthesis of biopolymer-silver nanoparticle nanocomposite: an optical sensor for ammonia detection. Int J Biol Macromol 51, 583–589, https://doi.org/10.1016/j.ijbiomac.2012.06.033 (2012).

15) Bankura, K. et al. Synthesis, characterization and antimicrobial activity of dextran stabilized silver nanoparticles in aqueous medium. Carbohydr Polym 89, 1159–1165, https://doi.org/10.1016/j.carbpol.2012.03.089 (2012).

16) Paszkiewicz, M. et al. Te Antibacterial and Antifungal Textile Properties Functionalized by Bimetallic Nanoparticles of Ag/Cu with Diferent Structures. J Nanomater 2016, 1–13, https://doi.org/10.1155/2016/6056980 (2016).

17) Medda S, Hajra A, Dey U, Bose P, Mondal NK (2014) Biosynthesis of silver nanoparticles from Aloe vera leaf extract and antifungal activity against Rhizopus sp. and Aspergillus sp. Appl Nanosci. doi:10.1007/s13204-014-0387-1

18) Gurunathan S, Jeong JK, Han JW, Zhang XF, Park JH, Kim JH (2015) Multidimensional effects of biologically synthesized silver nanoparticles in Helicobacter pylori, Helicobacter felis, and human lung (L132) and lung carcinoma A549 cells. Nanoscale Res Lett 10:35. doi:10.1186/s11671-015-0747-0

19) Prabakar K, Sivalingam P, Mohamed Rabeek SI, Muthuselvam M, Devarajan N, Arjunan A, Karthick R, Suresh MM, Wembonyama JP (2013) Evaluation of antibacterial efficacy of phyto fabricated silver nanoparticles using Mukia scabrella (Musumusukkai) against drug resistance nosocomial gram negative bacterial pathogens. Coll Surf B 104:282–288

20) Ahmed , S. , Ikram , S. , 2015 . Silver nanoparticles: one pot green synthesis using Terminalia arjuna extract for biological application . J. Nanomed. Nanotechnol. 6 , 1 –6 2015 . https:// doi. org/ 10. 4172/ 2157 - 7439 - 1000309 .

21) Gomathi , M. , Rajkumar , P. V. , Prakasam , A. , Ravichandran , K. , 2017 . Green synthesis of silver nanoparticles using Datura stramonium leaf extract and assessment of their antibacterial activity . Res. Efficient Technol. 3 , 280 –284 2017 . https:// doi. org/ 10. 1016/ j. reffit. 2016. 12. 005 .

21) Jayaprakash , N. , Judith Vijaya , J. , Kaviyarasu , K. , Kombaiah , K. , John Kennedy , L. , Jothi Ramalingam , R. , Munusamy , M. A. , Al - Lohedan , H. A. , 2017 . Green synthesis of Ag nanoparticles using Tamarind fruit extract for the antibacterial studies . J. Photochem. Photobiol. B Biol. 169 , 178 –185 2017 . https:// doi. org/ 10. 1016/ j. jphotobiol. 2017. 03. 013 .

22) Kumar , B. , Smitha , K. , Cumbal , L. , Debut , A. , 2017 . Green synthesis of silver nanoparticles using Andean blackberry fruit extract . Saudi J. Biol. Sci. 24 , 45 –50 2017 . https:// doi. org/ 10. 1016/ j. sjbs. 2015. 09. 006 .

23) Mittal , A. K. , Chisti , Y. , Chand Banerjee , U. , 2013 . Synthesis of metallic nanoparticles using plant extract . Biotechnol. Adv. 31 , 346 –356 2013 . https:// doi. org/ 10. 1016/ j. biotechadv. 2013. 01. 003 .

24) Nayagam , V. , Gabriel , M. , Palanisamy , K. , 2018 . Green synthesis of silver nanoparticles mediated by coccinia grandis and phyllanthus emblica: a comparative comprehension . Appl. Nanosci. 8 , 205 –219 2018 . https:// doi. org/ 10. 1007/ s13204 - 018 - 0739 - 3 .

25) Sudha , A. , Jayakanthan , J. , Srinivasan , P. , 2017 . Green synthesis of silver nanoparticles using Lippia nodiflora aerial extract and evaluation of their antioxidant, antibacterial and cytotoxic effects . Res. Efficient Technol. 3 , 506 –515 2017 . https:// doi. org/ 10. 1016/ j. reffit. 2017. 07. 002 .

26) Ponarulselvam , S. , Paneerselvam , C. , Murugan , K. , Aarthi , N. , Kalimuthu , K. , Thangamani , S. , 2012 . Synthesis of silver nanoparticles using leaves of catharinthus roseus Linn. G. Don and their antiplasmodial activities . Asian Pac. J. Trop. Biomed. 2 , 574 –580 2012 . https:// doi. org/ 10. 1016/ S2221 - 1691 (12) 60100 - 2 .

27) Valan Arasu , M. , Arokiyaraj , S. , Viayaraghavan , P. , Sujin Jeba Kumar , T. , Duraipandiyan , V. , Abdullah Al - Dhabi , N. , Kaviyarasu , K. , 2019 . One step green synthesis of larvicidal, and azo dye degrading antibacterial nanoparticles by response surface methodology . J. Photochem. Photobiol. B Biol. 190 , 154 –162 2019 . https:// doi. org/ 10. 1016/ j. jphotobiol. 2018. 11. 020 .

28) Patra , J. K. , Hun Beak , K. , 2016 . Green synthesis of silver nanoparticles using prunus percica L. outer peel extract an investigation of antibacterial, anticandidal, antioxidant potential . Green Chem. Lett. Rev. 9 (2) , 132 –142 2016 . https:// doi. org/ 10. 1080/ 17518253. 2016. 1192692 .

29) Ezhilarasi , A. A. , Vijaya , J. J. , Kennedy , L. J. , Kaviyarasu , K. , 2020 . Green mediated NiO nano - rods using Phoenix dactylifera (Dates) extract for biomedical and environmental applications . Mater. Chem. Phys. 241 , 122419 2020 . https:// doi. org/ 10. 1016/ j. matchemphys. 2019. 122419 .

30) Gaire , B. P. , Subedi , L. , 2014 . Phytochemistry, pharmacology and medicinal properties of Phyllanthus emblica Linn . Chin. J. Integr. Med. 11 , 1 –8 2014 . https:// doi. org/ 10. 1007/ s11655 - 014 - 1984 - 2 .

31) A. , Kaviyarasu , K. , Ravindran , B. , Chang , S. W. , Arokiyaraj , S. , 2019 . Rapid biosynthesis and characterization of silver nanoparticles from the leaf extract of Tropaeolum majus L. and its enhanced in - vitro antibacterial, antifungal, antioxidant and anticancer properties . J. Photochem. Photobiol. B Biol. 191 , 65 –74 2019 . https:// doi. org/ 10. 1016/ j. jphotobiol. 2018. 12. 010 .

32) Mahidul Masum , I. M. , Mahfuja Siddiqa , M. , Arif Ali , K. , Zhang , Y. , Abdallah , Y. , Wen Qiu , E. , Yan , C. , Li , B. , 2019 . Biosynthesis of silver nanoparticles using Phyllanthus emblica fruit extract and its antibacterial activity against rice brown stripe pathogen Acidovorax oryzae . Front. Microbiol. 10 , 820 –838 2019 . https:// doi. org/ 10. 3389/ fmicb. 2019. 00820 .