International Journal of Pharmaceutical Research and Applications
Volume 7, Issue 4 July-Aug 2022, pp: 41-46 www.ijprajournal.com ISSN: 2456-4494

Leaf extract mediated green synthesis of silver nanoparticles: synthesis, characterization and antimicrobial property

Pawan K. Gupta[1]*, Nivedita Agrawal[2], Rohit Chaurasiya[1], Nandlal Gupta[1], Pramila Singh[3], Satish K. Patel[1]

[1]*Department of Chemistry, A.P.S. University, Rewa (M.P.) 486003*
[2]*Department of Chemistry, Girls Degree College, Rewa (M.P.) 486003*
[3]*Department of Environmental Biology, A.P.S. University, Rewa (M.P.) 486003*

Submitted: 01-07-2022 Accepted: 08-07-2022

ABSTRACT

Researchers create nanoparticles and nanomaterials using bionanotechnology methods because they are economical and environmentally beneficial. The current work confirms for the first time that Saccharum spontaneumplant extract may biosynthesize silver nanoparticles (AgNPs) when cultivated in vitro. The production of AgNPs was confirmed by the surface plasmon resonance seen at 450 nm. Additionally, nanoparticles' spherical form was seen in FESEM pictures. The crystalline character of the particles was further confirmed by XRD examination. The probable biomolecules involved in the bioreduction of silver ions were found by FTIR analysis. Gram-positive and Gram-negative bacteria were each successfully killed by biosynthesized Ag NPs in an antimicrobial experiment. The findings suggest that it is possible to create nanoparticles with desired characteristics by growing plants in controlled environments.

Keywords: silver nanoparticles, synthesis, characterization, applications, mechanisms, cancer therapy

I. INTRODUCTION

Due to their distinctive physical and chemical characteristics, silver nanoparticles (AgNPs) are increasingly employed in a variety of industries, including medicine, food, health care, consumer goods, and industry. Optical, electrical, and thermal characteristics, as well as high electrical conductivity and biological properties, are among them [1,2,3]. They've been used as antibacterial agents, in industrial, household, and healthcare-related products, in consumer products, medical device coatings, optical sensors, and cosmetics, in the pharmaceutical and food industries, in diagnostics, orthopaedics, drug delivery, and as anticancer agents, and have ultimately enhanced the tumor-killing effects of anticancer drugs [4].

AgNPs have recently been popular in a variety of fabrics, keyboards, wound dressings, and biomedical devices [2,5,6].Due to high surface-to-volume ratio, nanosized metallic particles are unique and may significantly modify physical, chemical, and biological characteristics; as a result, these nanoparticles have been used for a variety of applications [7,8]. In order to meet the need for AgNPs, different synthesis techniques have been used. In general, traditional physical and chemical approaches appear to be both costly and dangerous [1,9]. Biologically produced AgNPs, for example, have a high yield, solubility, and stability [1]. Biological techniques appear to be easy, quick, non-toxic, trustworthy, and green approaches for producing well-defined size and shape under optimum circumstances for translational research, among numerous synthetic methods for AgNPs. Finally, a green chemistry approach to AgNP synthesis has a lot of potential.

We employed Saccharum spontaneum for green nanoparticle production in this study. Saccharum spontaneum (wild sugarcane, Kans grass) is an Indian Subcontinent natural grass. It's a perennial grass with spreading rhizomatous roots that can reach three metres in height. Kasha-Saccharum spontaneum is an Ayurvedic herb used to cure burning urination, renal calculi, menorrhagia, bleeding piles, and to increase the amount of breast milk produced by breastfeeding mothers.

Precise particle characterization is required after synthesis since a particle's physicochemical qualities can have a major influence on its biological properties. It is vital to describe the manufactured nanoparticles before use in order to solve the safety problem of using the full potential of any nano material for human welfare, nanomedicines, or the health care business, among other things [10,11]. Before determining toxicity or biocompatibility, characteristics of nanomaterials such as size, shape, size distribution, surface area, form, solubility, aggregation, and so on must be assessed [12]. Many analytical methods, such as ultraviolet visible spectroscopy (UV-vis spectroscopy), X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), and dynamic light scattering, have been employed to analyse the synthesised nanomaterials (DLS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), and so on.

II. MATERIALS AND METHODS

Preparation of plant extract

The plant of Saccharum spontaneum were collected and washed with tap water, dried in the shade and pulverized. 50 ml distilled water was thoroughly mixed with 5 g dried fine powder of Saccharum spontaneum plant. For 15 minutes, the mixture was maintained in a water bath at 60 °C. After boiling the mixture was stirred for 30 minutes on a magnetic stirrer for proper extraction of plant components. Whatman No.1 filter paper was then used to filter the extract. Further research was conducted using filtrate extract.

Preparation of Silver nanoparticles

A biological approach was proposed using the leaf extract of Saccharum Spontaneum plant as reducing agent. Size of AgNPs was controlled by temperature, leaf broth concentration and $AgNO_3$amount. With 10 ml, 12 ml, and 14 ml of extracting solution of plant, 10^{-3} M, 10 ml solution of $AgNO_3$ was refluxed for 2 hours with 2000 rpm centrifugation, respectively.

Characterization

The physicochemical properties of nanoparticles are important for their behaviour, bio-distribution, safety, and efficacy. Therefore, characterization of AgNPs is important in order to evaluate the functional aspects of the synthesized particles. Characterization is performed using a variety of analytical techniques, including UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), dynamic light scattering (DLS) and scanning electron microscopy (SEM).

III. RESULTS AND DISCUSSION

FTIR analysis

The existence of certain functional groups and the dual activity of the plant extract as a capping and reducing agent were confirmed by FTIR analysis of the silver nanoparticle. A. indica leaf extract and water molecules overlap in a wide band between 3454cm^{-1}, which is caused by the N-H stretching vibration of group NH_2 and OH molecules. A peak at 2083 cm^{-1} can be attributed to an alkyne group present in the phytoconstituents of the extract, while the band at 1636 cm^{-1} corresponds to amide C=O stretching. The observed peaks at 1113 cm-1 denote -C-OC- linkages, or -C-O- bonds (Fig. 1 and 2).

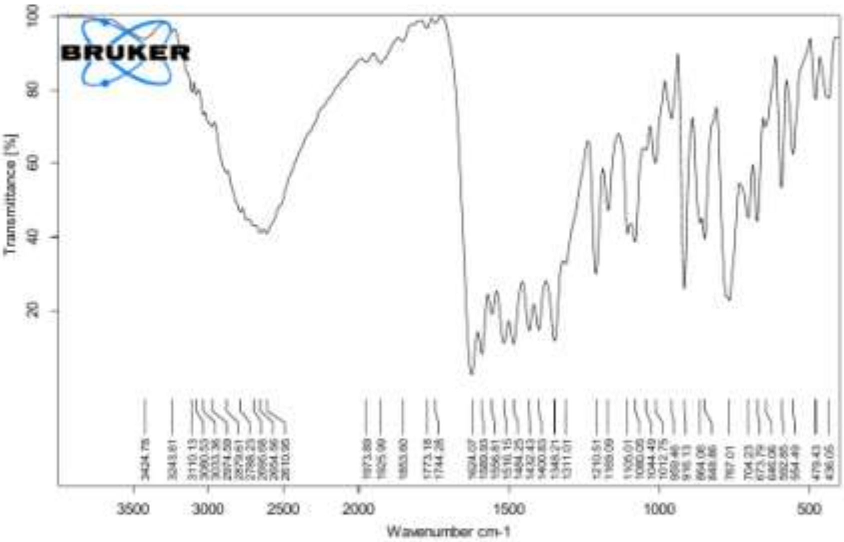

Fig. 1. FTIR spectra of leaf extract.

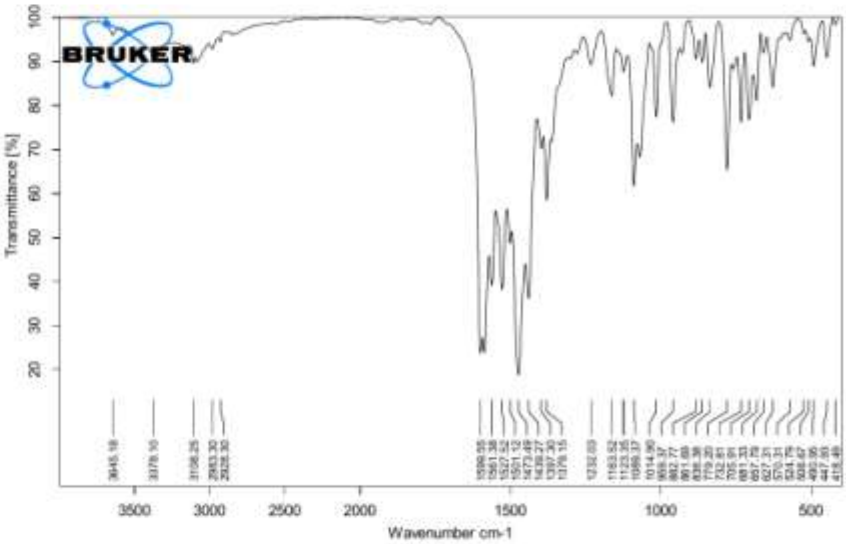

Fig. 2. FTIR spectra of AgNPs sample.

UV–Vis analysis

Fig. 3 displays the Ag NPs' UV-Vis absorption spectra. UV-Vis analysis produced a broad bell-shaped spectral curve. Various plant extract metabolites included into the solution widen the plasmon band because they are also able to be read in this spectrophotometric range. At 450 nm, silver exhibits surface plasmon resonance (SPR).This peak grew over time until it reached 360 minutes. As stated by Spherical nanoparticles under the Mie hypothesis exhibit just one SPR band. As variety rises, the number of peaks also rises. Shapes of particles. Consequently, it may be said that AgNPs produced during biosynthesis are uniformly spherical in shape.

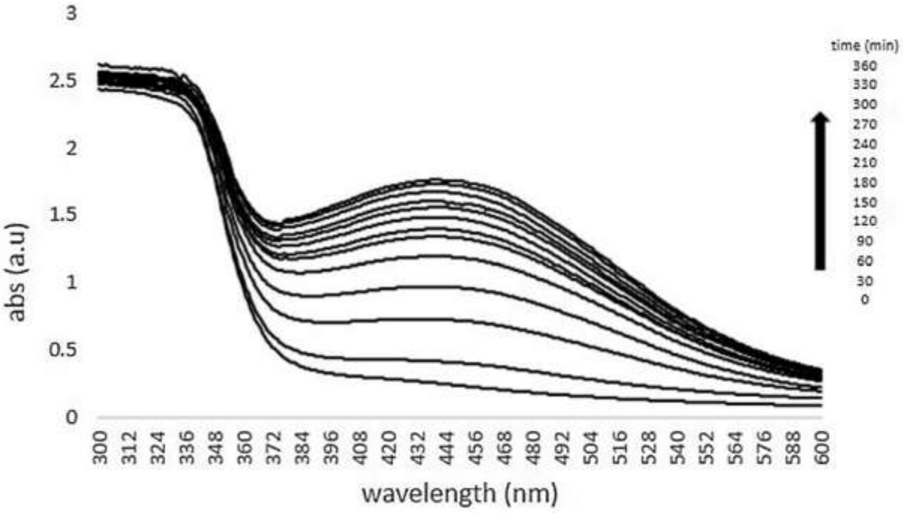

Fig. 3. UV–Vis absorption spectra of silver nanoparticles.

X-ray diffraction analysis

The 111, 200, 220, and 311 crystalline planes of AgNPs are responsible for the unique peaks at 2Ɵ values that were seen in the XRD pattern (Fig. 4). The face centered cubic lattice is linked to these peaks. The organic component of the plant extract can be attributed to additional peaks at 2Ɵ values in the AgNPs pattern. These peaks are consistent with findings and show the crystallisation of certain plant metabolite moieties on the surface of the Ag NPs.

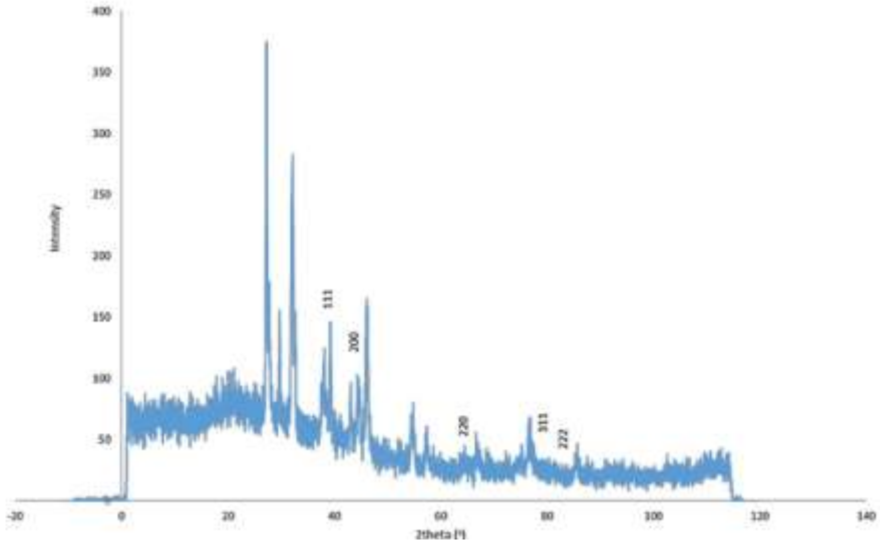

Fig. 4. X-ray diffraction profile from dried silver nanoparticles.

FESEM and DLS analysis

FESEM images were used to study the morphology of the AgNPs (Fig. 5a, b). The bulk of the particles were spherical, although some AgNPs were also oval in form. AgNPs that were biosynthesized had been evenly dispersed throughout the mixture. According to FESEM pictures, some chosen biosynthesized nanoparticles were between 19 and 125 nm in size. Dynamic light scattering (DLS) analysis was used to determine the average particle diameter. The bulk of the AgNPs had a diameter of 5.13 nm. The FESEM pictures demonstrate the biomolecule coating of the biosynthesized AgNPs. This layer supports the function of plant extract metabolites in the biosynthesis and stabilisation of AgNPs. These studies and outcomes are consistent.

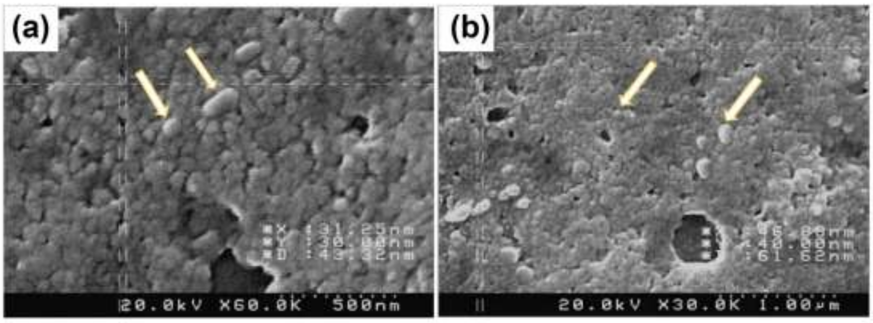

Fig. 5 a) FESEM images scale in a 500 nm and **b)** 1 µm. Nanoparticles coated with organic materials of plant extract have been indicated with arrows in two pictures.

Antibacterial activity of the AgNPs

Fig. 6 depicts the biosynthesized AgNPs' antibacterial activity. As a control, distilled water was used. The restriction zone for bacterial growth in B. subtilis, B. vallismortis, and E. coli had measured diameters of 15, 16, and 12, respectively. This result indicates that Gram-positive bacteria are more sensitive than Gram-negative bacteria. Numerous investigations have demonstrated the bactericidal action of AgNPs against a wide variety of bacteria. This capability of AgNPs confirms the AgNPs' comprehensive approach to the exposure of bacteria. The binding of Ag NPs to the cell wall and the production of free radicals are most likely the causes of the bactericidal action of AgNPs. Additionally, past investigations have demonstrated the existence of Ag NPs in the bacterial cell membrane. AgNPs' antibacterial action is brought on by the release of silver ions from the reservoir function of Ag NPs. According to this experiment, positively charged ions like Ag+ have a strong propensity to interact with the phosphorus and sulphur found in biomolecules like DNA and RNA. The functions of DNA and RNA are hampered by such an association.

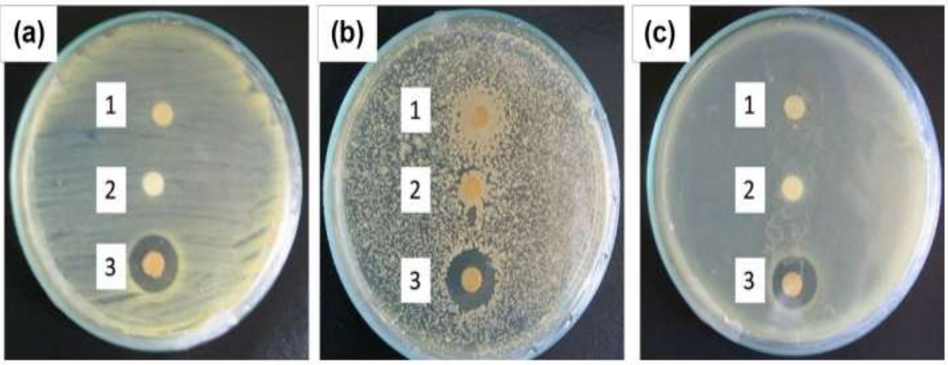

Fig. 6. Bactericidal activity of **(1)**Leaf extract, **(2)** distilled water and **(3)** biosynthesized AgNPs from S. spinosa extract, against **a** E. coli, **b**B. subtilis and **c** B. vallismortis.

IV. CONCLUSION

Biosynthesis of AgNPs using plant extract of Saccharum spontaneum grown in vitro under controlled condition was carried out for the frst time in this study. This study confrmed Saccharum spontaneum (cultured under controlled condition) capability for the biosynthesis of AgNPs. The characteristics of the bio-synthesized AgNPs were measured by different equipment's. Moreover, bactericidal activity assessment of the biosynthesized Ag NPs showed their inhibitory function against both Gram-positive and Gram-negative bacteria. In this study, possible functional groups and effective compounds responsible in reduction of silver ions were assigned.

REFERENCES

[1] Gurunathan S., Park J.H., Han J.W., Kim J.H. Comparative assessment of the apoptotic potential of silver nanoparticles synthesized by Bacillus tequilensis and Calocybe indica in MDA-MB-231 human breast cancer cells: Targeting p53 for anticancer therapy. Int. J. Nanomed. 2015;10:4203–4222. doi: 10.2147/IJN.S83953.

[2] Li W.R., Xie X.B., Shi Q.S., Zeng H.Y., Ou-Yang Y.S., Chen Y.B. Antibacterial activity and mechanism of silver nanoparticles on Escherichia coli. Appl. Microbiol. Biotechnol. 2010;8:1115–1122. doi: 10.1007/s00253-009-2159-5.

[3] Mukherjee P., Ahmad A., Mandal D., Senapati S., Sainkar S.R., Khan M.I., Renu P., Ajaykumar P.V., Alam M., Kumar R., et al. Fungus-mediated synthesis of silver nanoparticles and their immobilization in the mycelial matrix: A novel biological approach to nanoparticle synthesis. Nano Lett. 2001;1:515–519. doi: 10.1021/nl0155274.

[4] Chernousova S., Epple M. Silver as antibacterial agent: Ion, nanoparticle, and metal. Angew. Chem. Int. Ed. 2013;52:1636–1653. doi: 10.1002/anie.201205923.

[5] Li C.Y., Zhang Y.J., Wang M., Zhang Y., Chen G., Li L., Wu D., Wang Q. In vivo real-time visualization of tissue blood flow and angiogenesis using Ag_2S quantum dots in the NIR-II window. Biomaterials. 2014;35:393–400. doi: 10.1016/j.biomaterials.2013.10.010.

[6] Sondi I., Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: A case study on E. coli as a model for Gram-negative bacteria. J. Colloid Interface Sci. 2004;275:177–182. doi: 10.1016/j.jcis.2004.02.012.

[7] Li L., Hu J., Yang W., Alivisatos A.P. Band gap variation of size- and shape-controlled colloidal CdSe quantum rods. Nano Lett. 2001;1:349–351. doi: 10.1021/nl015559r.

[8] Sharma V.K., Yngard R.A., Lin Y. Silver nanoparticles: Green synthesis and their antimicrobial activities. Adv. Colloid Interface. 2009;145:83–96. doi: 10.1016/j.cis.2008.09.002.

[9] Gurunathan S., Kalishwaralal K., Vaidyanathan R., Venkataraman D., Pandian S.R., Muniyandi J., Hariharan N., Eom S.H.

Biosynthesis, purification and characterization of silver nanoparticles using Escherichia coli. Colloids Surf. B Biointerfaces. 2009;74:328–335. doi: 10.1016/j.colsurfb.2009.07.048.

[10] Lin P.C., Lin S., Wang P.C., Sridhar R. Techniques for physicochemical characterization of nanomaterials. Biotechnol. Adv. 2014;32:711–726. doi: 10.1016/j.biotechadv.2013.11.006.

[11] Pleus R. Nanotechnologies-Guidance on Physicochemical Characterization of Engineered Nanoscale Materials for Toxicologic Assessment. ISO; Geneva, Switzerland: 2012.

[12] Murdock R.C., Braydich-Stolle L., Schrand A.M., Schlager J.J., Hussain S.M. Characterization of nanomaterial dispersion in solution prior to in vitro exposure using dynamic light scattering technique. Toxicol. Sci. 2008;101:239–253. doi: 10.1093/toxsci/kfm240.