The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 2 | Issue 10 | October 2024
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Plant-mediated biosynthesis and characterization of silver nanoparticles using the leaf extract of *Mukia maderaspatana*

J. Thomas Joseph Prakash
PG and Research Department of Physics, Government Arts College (Affiliated to Bharathidasan University, Tiruchirappalli–620 024, Tamil Nadu),
Tiruchirappalli, Tamil Nadu 620 022, India.

K.Sowmiya
Department of Physics, Dhanalakshmi Srinivasan College of Arts and Science for Women (Autonomous) (Affiliated to Bharathidasan University,
Tiruchirappalli–620 024, Tamil Nadu), Perambalur, Tamil Nadu 621212, India.

D.Saran
Research Scholar, PG and Research Department of Physics, Government Arts College
Affiliated to Bharathidasan University, Tiruchirappalli–620 024, Tamil Nadu),
Tiruchirappalli, Tamil Nadu 620 022, India.

C.Pavithra
Research Scholar, PG and Research Department of Physics, Government Arts College
(Affiliated to Bharathidasan University, Tiruchirappalli–620 024, Tamil Nadu),
Tiruchirappalli, Tamil Nadu 620 022, India.

M.Ragu
Research Scholar, PG and Research Department of Physics, Government Arts College
Affiliated to Bharathidasan University, Tiruchirappalli–620 024, Tamil Nadu),
Tiruchirappalli, Tamil Nadu 620 022, India.

ARTICLE DETAILS

Research Paper

Keywords:
silver nanoparticles, $AgNO_3$, Mukia maderaspatana,

DOI:
10.5281/zenodo.14107630

ABSTRACT

In this investigation, the aqueous leaf extract from Mukia maderaspatana was utilized as the synthesis technique for silver nanoparticles (AgNPs). This procedure, which belongs to the class of "green synthesis methods," is not only economical but also compliant with green standards. Numerous phytochemicals, including flavonoids, polyphenols, proteins, and important vitamins like C and K, are present in the medicinal plants used in this synthesis. These bioactive substances are essential for the reduction of AgNO3's silver ions into silver nanoparticles. Many sophisticated analytical methods were used to examine and describe the produced silver nanoparticles. UV-visible spectroscopy, powder X-ray diffraction, scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy were some of the techniques used. By employing these techniques, the researchers were able to gain valuable insights into the optical and structural properties of the produced AgNPs. Making stable silver nanoparticles using the green synthesis method was one of the study's main conclusions. This feature is especially important since it shows how these nanoparticles may be used in a variety of biological applications and how viable they are. The resultant silver nanoparticles can be seen as a viable alternative for additional investigation and application in biologically relevant situations by taking advantage of the environmentally benign aspects of the green synthesis method.

1. Introduction

Richard Feynman, a physicist, was the first to discuss the concept of nanotechnology. He said, "There's plenty of Room at the Bottom," which opens the door to a new scientific field. A nanoparticle can have a diameter of one to one hundred nm. Its optical, physical, chemical, and mechanical properties are all unique. The conventional approaches of producing nanoparticles are costly, hazardous, and unfavorable to the environment.
To tackle these problems, we can create plant-based nanoparticles by using green synthesis techniques. It is created by a bottom-up approach. It's a novel approach that is simple, economical, and safe for biological systems. The likelihood of contamination is lower. Materials are therefore more resilient. Green synthesis byproducts are not hazardous. Plants are capable of producing a variety of chemical substances.

AgNPs are an amazing antibacterial agent that also kills microorganisms. It has demonstrated encouraging outcomes in the detection and treatment of cancer due to its special qualities. The green-synthesised AgNPs have several potential applications, including drug delivery, cancer treatment, DNA analysis, antibiotics, gene therapy, biosensors, catalysis, SERS, and magnetic resonance imaging (MRI).

Its unique nanoscale system makes it easy to produce. AgNPs are the driving force behind advances in medicine.
It is feasible to produce AgNPs using plants. Climbers with hair shoots, Mukia maderaspatana, are found in Tamil Nadu's tropical and subtropical climates. It is an edible plant that has phytochemicals including vitamin C, vitamin K, carotenoids, lutein, and folate as well as polyphenolic components like flavonoids.

This leaves of this plant contain a large number of phenolic chemicals, which have strong antioxidant properties and are employed as a reducing agent. The current study employed Mukia maderaspatana as a medicinal plant to synthesize AgNPs. The produced AgNPs were investigated using FTIR, SEM, and UV-Vis spectroscopy.

2. Materials and methods

2.1 Materials:

We purchased Whatman No. 1 filter paper and silver nitrate (AgNO3) from the Precision Scientific Co. in Tiruchirappalli. Mukia maderaspatna fresh leaves were gathered at the Perambalur garden in Tamil Nadu, India. Additionally, water that had been double-distilled was acquired from Precision Scientific Co. Every other chemical utilized in this experiment was of analytical quality.

2.2 Preparation of Plant extracts:

To get rid of dirt and contaminants, fresh and healthy Mukia maderaspatna leaves were chosen and properly cleaned with distilled water. The leaves are allowed to dry in the shade at room temperature for four weeks. They pulverized the dried leaves into a fine powder. A heated plate at 30°C was used to boil 2 g of leaf powder for 20 minutes after adding 20 ml of double-distilled water. Whatman No. 1 filter paper was then used twice to filter the extracts. Then, for use in subsequent tests, this plant extract was kept in the refrigerator at 4 °C.

2.3 Synthesis of Silver Nanoparticles:

A solution of 200ml double-distilled water and 0.18g silver nitrate (AgNO3) was stirred. REMI 1MLH magnetic stirrer was used to constantly stir the combination of silver nitrate solution at 400 RPM for one hour. In order to use the solution later, it was left unaltered for a whole day. A magnetic stirrer set at 400 RPM was used to vigorously swirl 10 ml of freshly produced plant extracts with 100 ml of the aqueous AgNO3 for one hour. Following a 24-hour period, the solution took on a brown hue, signifying the creation of silver nanoparticles. AgNO3 is reduced to Ag+ ions as seen by this. Filtered and examined to learn more about the properties of the dark brown precipitate.

2.4 Characterization of synthesized AgNPs:

Standard techniques like scanning electron microscopy, PXRD, Fourier transform infrared spectroscopy, and UV-Vis spectra were used to investigate the synthesized silver nanoparticles. UV-Vis spectral analysis was used to examine the optical characteristics of silver nanoparticles. FTIR was used to characterize the functional groups that were present in the particles. Using SEM, the morphological characteristics of the produced AgNPs were examined. Powder X-ray diffraction was used to determine that the produced silver nanoparticles were crystalline.

2.5 UV -Vis spectral analysis:

The most crucial method and straightforward approach to verify the creation of nanoparticles is UV-Vis spectroscopy. The reduction of Ag+ ions into nanoparticles was seen using the UV-visible spectra. By periodically collecting the reaction mixture and using a **(PERKIN ELMER-Lambda 35)** spectrophotometer to scan the absorption maxima, the synthesized silver nanoparticles were verified. The colloidal sample's absorbance spectra were obtained using a spectrophotometer in the 200-800 nm range.

2.6 FT-IR spectral analysis:

In order to determine the functional groups of the chemical components of the leaf extracts and AgNPs samples that were produced by applying these extracts, FT-IR analysis was carried out on both samples. FT-IR spectrometer measurements were made to analyze the bio-reducing agent found in each extract. For ten minutes, the diluted silver nitrate solution was centrifuged at 10,000 rpm. Following centrifugation, the separated silver nanoparticles were placed in the hot plate for 20 minutes. FTIR measurements were performed using the acquired dried materials. The range in which the spectra was recorded was 4000 cm^{-1} to 400 cm^{-1}. The **(PERKIN ELMER – Spectrum Two)** spectrometer was used for the FT-IR analysis.

2.7 SEM:

In order to investigate the shape and elemental makeup of the nanoparticles, the AgNPs solution was dried, mounted on a thin slide, and examined using a SEM analyzer. To create a picture, a focused electron beam is scanned across a surface using a scanning electron microscope (SEM). Information on the surface topography and composition can be obtained by utilizing the different signals produced by the interaction between the electrons in the beam and the sample. Without requiring any further steps, SEM provided an easy way to visualize metal nanoparticles of nanoscale size. We used the CAREL ZEISS-EVO 18 for scanning electron microscopy (SEM) investigation.

2.8 Powder X-Ray Diffraction

The sample was dried and gathered as a powder following high-speed centrifugation. Utilizing Cu Kα radiation (λ = 1.5406 Å) and operating at 40 kV and 30 mA, an X'Pert PRO powder X-ray diffractometer conducted the X-ray diffraction (XRD) study for the prepared sample of silver nanoparticles. Data was collected in 0.04-degree increments for the 2θ range of 10° to 80°.

3. Results and Discussion

3.1 UV-Vis spectral analysis

Using an aqueous solution of Mukia maderaspatna leaf extract, the UV-Vis spectra of the produced AgNPs were recorded at various intervals. When leaf extract was added to the reaction mixture, the AgNO3 solution, which had been colorless before, turned brown. The formation of silver nanoparticles in the aqueous medium is amply demonstrated by this shift in the color of the silver solution. The UV-Visible spectrophotometer was used to record the absorbance for wavelength in the range of 200 to 800 nm. From the (Fig.1), the absorption maxima were observed at **444.60 nm**, which confirms the actual presence of AgNPs in the solution and the minimum absorbance peak at 255.10 nm

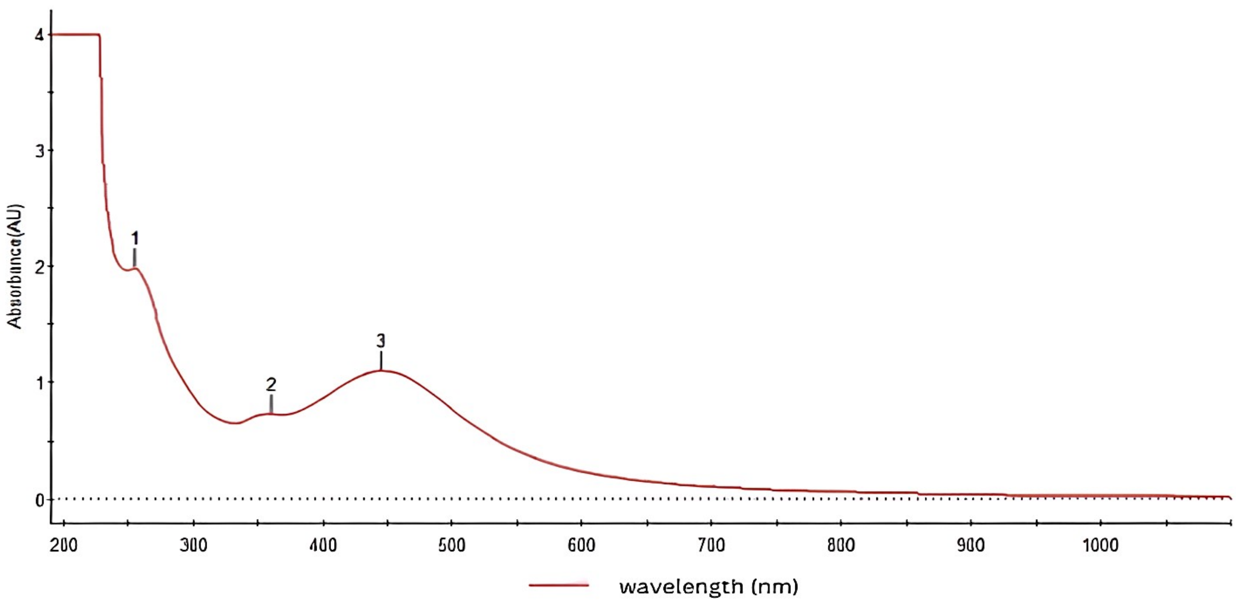

Fig.1 UV-Vis absorption spectra of green synthesized AgNPs

3.2 FTIR

To ascertain which potentially bioactive substances in the leaves aid in the synthesis of silver nanoparticles, FTIR spectroscopy was employed. These bioactive substances cause silver nanoparticles to diminish and become more stable. The FTIR spectrum was captured between 400 and 4000 cm-1 (Fig. 2). The plant extract's alcohol group is extended from O to H, which results in a band at 3408.37 cm-1. There are bands at 2923.27 and 2852.79 cm-1 because of the C-H stretching of the alkane group. The band at 2426.56 cm-1 shows the O-H stretching of a carboxylic acid group.

The band at 2095.03 cm-1 showed the stretching of the isothiocyanate group N=C=S. The band located at 1630.90 cm-1 is caused by the C=C stretching of the alkene group. The aromatic group's C=C stretching is responsible for the band at 1497.53 cm-1. The C-H bending of the alkane group is seen from the strong band at 1384.26 cm-1. The band at 1232.91 cm-1 is caused by the C-N stretching of the amine group. The alcohol group's C-O stretching is responsible for the bands at 1109.11 and 1051.90 cm-1. This presence of alkene group C-H bending was demonstrated by the bands at 839.56, 824.77, 785.23, and 650.15 cm-1.

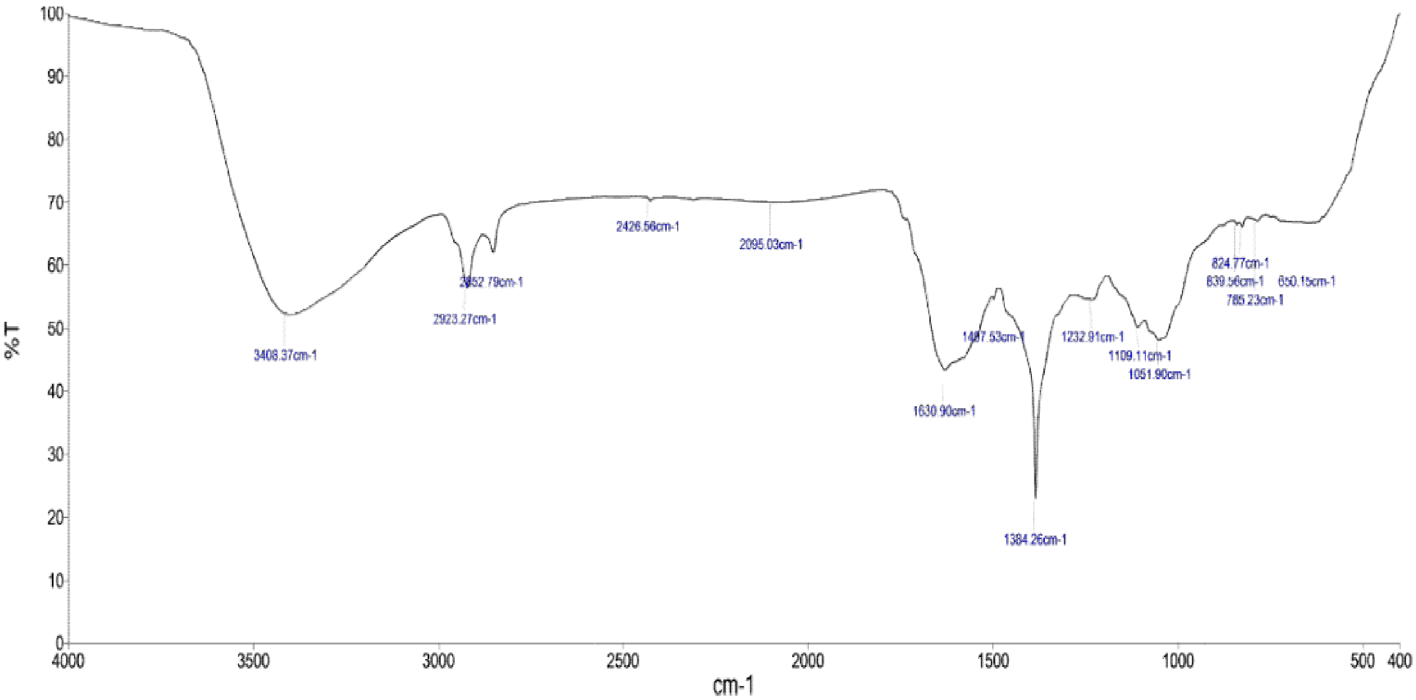

Fig.2 FTIR spectra of green synthesized AgNPs

3.3 SEM

The morphology of the produced silver nanoparticles was examined using a scanning electron microscope. The presence of tiny, uniformly spherical nanoparticles is confirmed by the SEM image (Fig. 3). The nanoparticles ranged in size from 70 to 90 nm on average.

The kind of plant extract used determines how silver nanoparticles are synthesized. The size of the nanoparticles decreases as the plant extract concentration rises. The average size of the synthesized AgNps particles was determined to be **62 nm** based on the SEM image.

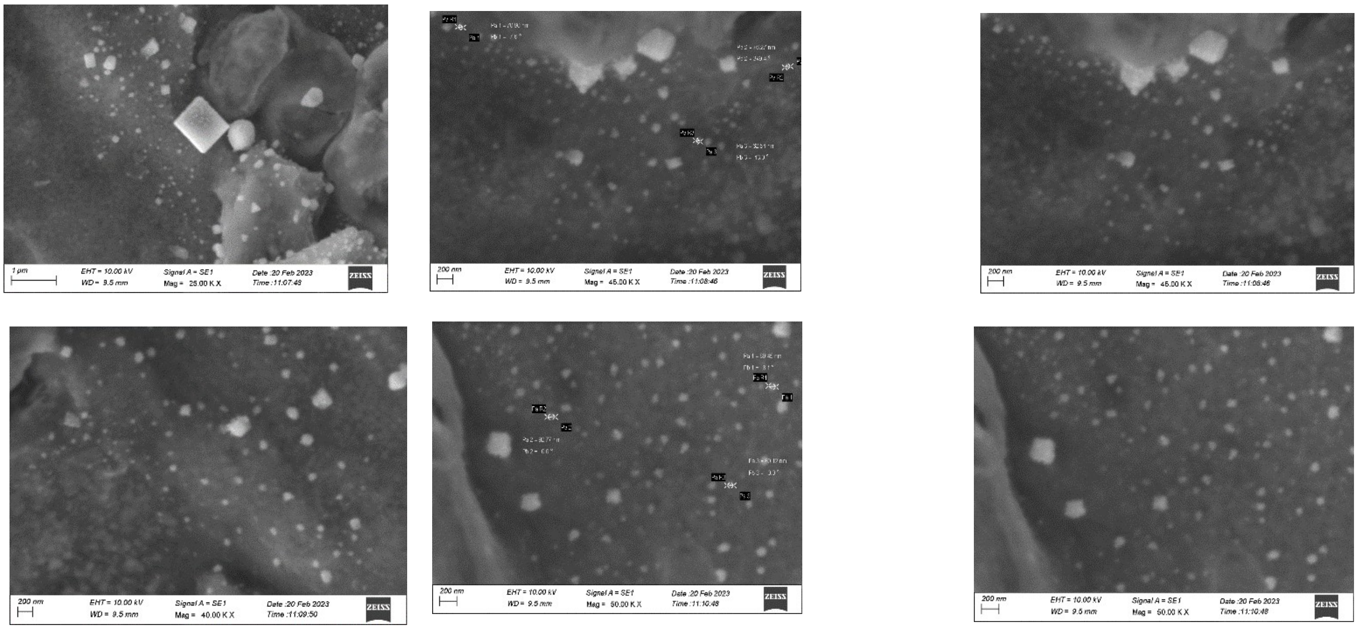

Fig.3 SEM image of AgNPs

3.4 Powder X-Ray Diffraction

The produced AgNPs' powder X-ray diffraction study is provided in Table 3. The JCPDS card No. 04-0783 has been compared to the diffractogram (Fig. 4). The face-centered cubic crystal structure is shown by the peak at 2θ values of 38.5290 degrees indexing to the (111) plane. Thus, the PXRD analysis verified that silver nanoparticles were present and that they were crystalline. Crystalline organic substances found in the extract are responsible for the unknown peaks in the diffractogram at 12.1815, 23.3083, 29.0560, and 32.3744 degrees.

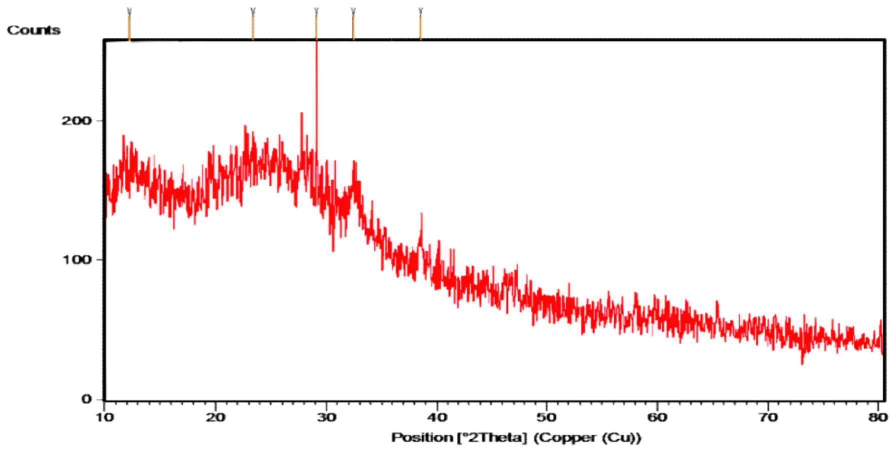

Fig.4: Powder X-Ray Diffraction pattern of AgNPs

4. Conclusion

Stable silver nanoparticles, with an average size of 62 nm, were created using a green synthesis approach using the aqueous extract of the medicinal herb Mukia maderaspatana as a stabilizing and reducing agent. This medicinal plant was utilized in the current study as a source of bioactive chemicals to convert AgNO3 to AgNps. These artificially produced silver nanoparticles can also help the bioactive substances that are present on the surface of plants. The acquired samples were analyzed by means of PXRD, FTIR, SEM, and UV-Vis spectroscopy. By using UV-Vis absorption spectrum analysis, the synthesis of AgNPs was verified. All of the functional groups in the leaf extract that are in charge of reducing AgNPs were revealed by FTIR analysis. Using SEM, the morphological characteristics of the produced AgNPs were examined. The existence of spherical silver nanoparticles over the crystalline phases of extracts was verified by the SEM image. By using XRD, AgNPs' crystalline nature was verified. In conclusion, the plant extract from Mukia maderaspatana can synthesize Ag nanoparticles in an environmentally benign and green manner, offering a straightforward, economical, and effective process. As such, it has the potential to be used in a variety of biomedical applications.

5. References

1. Subha, V., S. Kirubanandan, and S. Renganathan. "Green synthesis of silver nanoparticles from a novel medicinal plant source roots extract of Mukia maderaspatana." *Colloid and Surface Science* 1.1 (2016): 14-17.
2. Devi, Guruviah Karthiga, and Kannaiyan Sathishkumar. "Synthesis of gold and silver nanoparticles using Mukia maderaspatna plant extract and its anticancer activity." *IET nanobiotechnology* 11.2 (2017): 143-151.
3. Sowmiya, K., and J. Thomas Joseph Prakash. "Green-synthesis of silver nanoparticles using Abies webbiana LEAVES and evaluation of its antibacterial activity." *Journal of Pharmacognosy and Phytochemistry* 7.5 (2018): 2033-2036.
4. Akintelu, Sunday Adewale, et al. "Antibacterial potency of silver nanoparticles synthesized using Boerhaavia diffusa leaf extract as reductive and stabilizing agent." *Int. J. Pharma Sci. Res* 10.12 (2019): 374-380.
5. Jassim, Abdulkadir Mohammed Noori, et al. "Green synthesis of silver nanoparticles using Carica papaya juice and study of their biochemical application." *Journal of Pharmaceutical Sciences and Research* 11.3 (2019): 1025-1034.
6. Bharathi, Devaraj, and V. Bhuvaneshwari. "Evaluation of the cytotoxic and antioxidant activity of phyto-synthesized silver nanoparticles using Cassia angustifolia flowers." *BioNanoScience* 9 (2019): 155-163.
7. Rajkumar, P. V., et al. "Green synthesis of silver nanoparticles using Gymnema sylvestre leaf extract and evaluation of its antibacterial activity." *South African Journal of Chemical Engineering* 32.1 (2020): 1-4.
8. Nair, Bharath, et al. "Green synthesis of silver nanoparticles using aqueous extract of leaves of salacia gambleana and its evaluation of antimicrobial activity." *World J. Pharm. Pharm. Sci* 9.9 (2020): 2039-2050.
9. Tailor, Giriraj, et al. "Green synthesis of silver nanoparticles using Ocimum canum and their anti-bacterial activity." *Biochemistry and Biophysics Reports* 24 (2020): 100848.
10. Widdatallah, Marvit Osman, et al. "Green synthesis of silver nanoparticles using Nigella sativa seeds and evaluation of their antibacterial activity." *Advances in Nanoparticles* 9.2 (2020): 41-48.

11. Widdatallah, Marvit Osman, et al. "Green synthesis of silver nanoparticles using Nigella sativa seeds and evaluation of their antibacterial activity." *Advances in Nanoparticles* 9.2 (2020): 41-48
12. Mahajan, Namrata, and Manojkumar Chopda. "Green synthesis, characterization and biological activity of silver nanoparticles from Musa paradisiaca L. and Cynodon dactylon."
13. Rao, B. Lakshmeesha, G. Parameshwara Gouda, and C. S. Shivananda. "Green synthesis of silver nanoparticles using Hibiscus Rosa Sinensis flower extract." *AIP Conference Proceedings*. Vol. 2220. No. 1. AIP Publishing LLC, 2020
14. Preetha, N., S. Padmavathi, and B. Mahalakshmi. "Green Synthesis of Silver Nanoparticles Using Mukia Maderaspatana." *Journal of Physics: Conference Series*. Vol. 1979. No. 1. IOP Publishing, 2021.
15. Kanthimathi, G., et al. "Green Synthesis of Silver Nanoparticles using Vitex Negundo Extracts and their Application in the Effluent Treatment of Cracker Industries." *Journal of Physics: Conference Series*. Vol. 2070. No. 1. IOP Publishing, 2021.
16. Elangovan, Murugan, Dhayalan Ramachandran, and Krishnan Rajesh. "Green synthesis of silver nanoparticles using flower extract of hemigraphis colorata as reducing agent and its biological activity." *Letters in Applied NanoBioScience* 10.4 (2021): 3343-3356.
17. Vanlalveni, Chhangte, et al. "Green synthesis of silver nanoparticles using plant extracts and their antimicrobial activities: A review of recent literature." *RSC advances* 11.5 (2021): 2804-2837.
18. Rizwana, Humaira, et al. "Green synthesis, characterization, and antimicrobial activity of silver nanoparticles prepared using Trigonella foenum-graecum L. leaves grown in Saudi Arabia." *Green Processing and Synthesis* 10.1 (2021): 421-429.
19. Renganathan, Senthil, et al. "antibacterial, antifungal, and antioxidant activities of silver nanoparticles biosynthesized from Bauhinia Tomentosa Linn." *Antioxidants* 10.12 (2021): 1959.
20. Edith, Egbunu Iganya, and Philip Felix Uzor. "Green Synthesis of Silver Nanoparticles Using Euphorbia hirta Leaf Extract and the Determination of Their Antimicrobial Activity." *Advances in Bioscience and Bioengineering* 9.4 (2021): 124.
21. Mehata, Mohan Singh. "Green synthesis of silver nanoparticles using Kalanchoe pinnata leaves (life plant) and their antibacterial and photocatalytic activities." *Chemical Physics Letters* 778 (2021): 138760.
22. Nayak, Smita, Priyanka Ghugare, and Bhaskar Vaidhun. "Green-synthesis of Silver Nanoparticles by Hygrophila auriculata Extract: Innovative Technique and Comprehensive Evaluation." *Indian J. Pharm. Educ. Res* 55 (2021): S510-S517.

23. Kumar, Vasantha.S.,et al."A Review on Pharmacological Activities of Mukia Maderaspatana." *International Journal of Health Sciences* III: 4449-4459.
24. Miri, Abdolhossein, et al. "Plant-mediated biosynthesis of silver nanoparticles using Prosopis farcta extract and its antibacterial properties." *Spectrochimica acta part a: molecular and biomolecular spectroscopy* 141 (2015): 287-291.
25. Chandraker, Sandip Kumar, et al. "Justicia adhatoda L. mediated green synthesis of silver nanoparticles and assessment of their antioxidant, hydrogen peroxide sensing and optical properties." *Materials Technology* 37.10 (2022): 1355-1365.
26. Rakib-Uz-Zaman, S. M., et al. "Biosynthesis of silver nanoparticles from Cymbopogon citratus leaf extract and evaluation of their antimicrobial properties." *Challenges* 13.1 (2022): 18.
27. Rasheed, Tahir, et al. "Green biosynthesis of silver nanoparticles using leaves extract of Artemisia vulgaris and their potential biomedical applications." *Colloids and Surfaces B: Biointerfaces* 158 (2017): 408-415.
28. Chahardoli, Azam, Naser Karimi, and Ali Fattahi. "Nigella arvensis leaf extract mediated green synthesis of silver nanoparticles: Their characteristic properties and biological efficacy." *Advanced Powder Technology* 29.1 (2018): 202-210.
29. Hassanisaadi, Mohadeseh, et al. "Eco-friendly biosynthesis of silver nanoparticles using Aloysia citrodora leaf extract and evaluations of their bioactivities." *Materials Today Communications* 33 (2022): 104183.
30. Khatoon, Aisha, et al. "Silver nanoparticles from leaf extract of Mentha piperita: eco-friendly synthesis and effect on acetylcholinesterase activity." *Life sciences* 209 (2018): 430-434.