Research Article

Synthesis of Biogenic Silver Nanoparticles Using *Sesamum laciniatum* Klein ex Willd

Veena. K. Rokhade, T.C.Taranath*
P.G. Department of studies in Botany, Environmental Biology Laboratory, Karnatak University, Dharwad, Karnataka, India.
***Corresponding author's E-mail:** tctaranath@rediffmail.com

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ABSTRACT

Biosynthesis of nanoparticles using higher plants is an emerging area of research in nanoscience and technology. In the present investigation, leaf mucilage of *S. laciniatum* was used for synthesis of silver nanoparticles. The biosynthesis of nanoparticles is a nontoxic and environmental friendly method. The change in the colour of reaction mixture from colorless to brown indicates the formation of silver nanoparticles. Further confirmed by characteristic UV-vis spectroscopy with a characteristic absorbance resonance peak at 436 nm. Fluorescence Spectroscopy is a powerful tool to study the tertiary structure of proteins. FTIR data reveals the various groups of biomolecules involved in bio reduction and capping for efficient stabilization silver nanoparticles. The SEM images showed spherical shaped nanoparticles and size ranges 10-20nm. XRD showed crystalline nature of nanosilver.

Keywords: Biosynthesis, SEM, *Sesamum laciniatum* Klein ex Willd., Silver nanoparticles, XRD.

INTRODUCTION

The field of nanotechnology has opened up frontier vista of possibility and has spawned a proliferation of new technology. Nanoscience and technology is a field that focuses on the development of synthetic methods and surface analytical tools for building structures and materials, to understand the change in chemical and physical properties due to miniaturization, and the use of such properties in the development of novel and functional materials and devices. In the current scenario synthesis of nanoparticles gaining importance due to their wide range of applications in the field of catalysis[1,2], optolectronics[3-5], biological tagging, drug delivery system and pharmaceutical application. The nanoparticles are synthesized by various physical and chemical methods, but these methods are expensive, toxic and pose serious threat to environment. Thus, there is a need for a safe, clean, nontoxic and environment-friendly method for the synthesis of nanoparticles. Researchers in the field of nanoparticles have laid emphasis on biological systems such as microorganism[6] and plants for synthesis of nanoparticles through biomimetic approach.

The various plant extracts were used for the synthesis of silver and gold nanoparticles such as alfalfa[7,8] neem[9] geranium[10], *Emblica officinalis* fruit extract[11], *Wattakaka volubilis*[12], *Cansjera rheedii*[13], Parthenium[14] and *Aloe vera.*[15] Silver and gold nanoparticles were also synthesized by sundried *Cinnamomum camphora* leaf[16] *Capsicum annum*[17], *Dioscorea bulbifera* tuber extract[18], *Citrus sinensis* peel extract[19], *Cissus quadrangularis*[20], *Rosa damascence*[21], *Calotropis procera*[22], *Argemone Mexicana*[23] and *Santalum album.*[24] Biogenic silver nanoparticles synthesized using *Nicotina tobaccum* leaf extract[25], *Ocimum tenuifloru*[26], lemon leaves[27] *Dodonaea viscosa*[28] and *Artemisia nilagirica*[29] were evaluated for their antibacterial activity against certain bacteria. *Sesamum laciniatum* Klein ex Willd. belonging to family Pedaliaceae occurring as wild on the barren rocks of Soundatti hills of deccan plateau was used for the synthesis of silver nanoparticles.

MATERIALS AND METHODS

Collection of mucilage

1gm of *S. laciniatum* leaves were immersed in 100 ml beaker containing 50 ml of distilled water for overnight. Care has been taken to avoid the contamination. The leaf material was separated by passing through the muslin cloth to get mucilage. The collected mucilage was used as source for bio reducing and capping agent for the formation of silver nanoparticles.

Biosynthesis of silver nanoparticles

The 5 ml plant leaf extract was added to 250 ml Erlenmeyer flask containing 100 ml of 1mM silver nitrate solution. The experiment was conducted in triplicate along with a control (without extract). The tightly capped flasks were kept in a shaker at a rotation speed of 200 rpm at 27^{o}C and pH of the solution was maintained slightly acidic (6.5-6.8). The change in the colour of solution to dark brown was noted after reaction period which indicates the formation of silver nanoparticles.

Characterization of nanoparticles

The process of bio-reduction of the Ag^{+} ions was monitored at regular intervals by drawing 2 ml aliquots of reaction mixture. UV-Vis spectroscopic analysis of silver nanoparticles was carried out as a function of bio reduction time at room temperature, by using U-3010 spectrophotometer operated at a resolution of 1 nm. Detection of tryptophan / tyrosine residues in proteins present in the reaction mixture were analyzed spectrophotometrically by the measurement of absorbance in the range between 200-300 nm wavelength regions by using U-3010 spectrophotometer. Fluorescence Spectroscopy is a powerful tool to study the tertiary structure of proteins. The Fluorescence of the solution of silver nanoparticles was studied by using F-7000FL spectrophotometer. FTIR Spectroscopy was used to study the secondary structure of the proteins in the extract. The solution was centrifuged at rotation speed of 6000 rpm for 20 min using 20 ml sterile distilled water and read the same with FTIR. After bio reduction, solution containing silver nanoparticles was dried at 60^{o}C for 2-3 days in an oven. Dried sample was collected for the determination crystalline structure of Ag nanoparticles by X' Pert pro X-ray diffractometer operated at an voltage of 40 kv and a current of 30mA with Cu Kα radiation. The bioreduced solution was dried at 60^{o}C in an oven. After complete drying, fine powdered material was separated and collected. This material was used for SEM observation. The material was mounted on clear aluminum stub using double sided adhesive cellotape. The sample was gold plated in a vacuum evaporator. SEM image was taken on JEOL, JSL 35 C model operated at an accelerating voltage of 20 kv at a magnification 27,000 X.

RESULTS AND DISCUSSION

UV-Visible Spectrum of silver nanoparticles

Formation of silver nanoparticles was evident from the colour change from colorless to brown. UV-Vis absorption spectroscopy is widely used to determine the formation of metal nanoparticles by their optical properties and electronic structure.[30] Control remained unchanged during the entire reaction period. The process of bio reduction of silver ions was gradually monitored in UV-vis spectroscopy Figure 1 depicts a series of absorption spectra recorded from the solution of silver nanoparticles at different time intervals. The absorption spectra showed an intense peak at 436 nm due to the surface Plasmon resonance (SPR) band of silver nanoparticles. It is well known that SPR is the excitation of free electrons within the conduction band leading to an in phase of oscillation[30].

The appearance of single prominent peak shows that the particles are spherical and uniform in size[31]. The optical absorption spectra of metal nanoparticles are dominated by surface Plasmon resonance in *S.laciniatum* showed by slightly red shift at about 440 nm after 48 hour but, completion of reaction period showed at 436 nm is blue shift region. This indicates that nanoparticles are smaller in size. Further in lower wavelength region of UV-Vis spectrum recorded from the reaction medium at 72 hrs (Figure 2) showed an absorption band at 250 nm is clearly indicates that presence of aromatic amino acid viz. tryptophan and tyrosine in the protein.[32] The presence of this amino acid which may be involved in reduction and capping of silver nanoparticles.

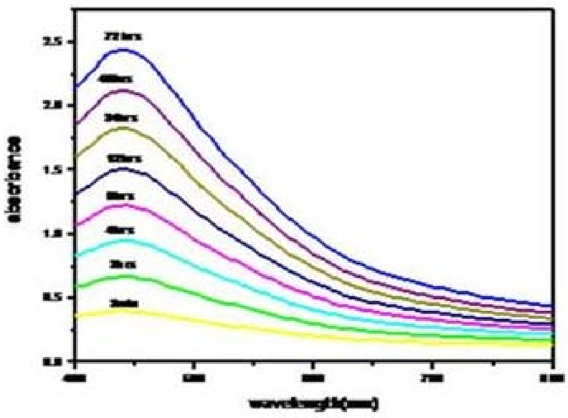

Figure 1: UV-Vis spectra recorded as a function of reaction time of silver nanoparticles

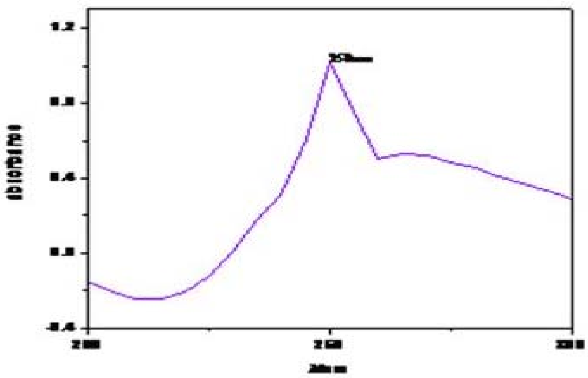

Figure 2: UV-Vis spectrum recorded at lower wavelength of silver nanoparticles

Fluorescence spectroscopic analysis

Figure 3 shows the fluorescence spectra recorded from the silver nanoparticles solution. An emission band observed at 336 nm due to proteins which are present in the solution are in their native form no change in the tertiary confirmation of proteins while the reduction process.[32]

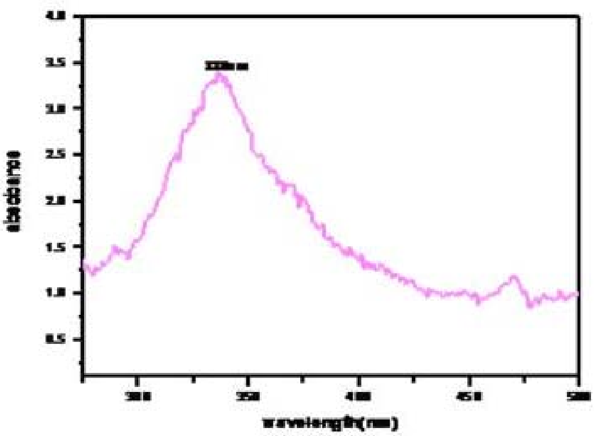

Figure 3: Fluorescence emission spectrum recorded from the solution of silver nanoparticles

FTIR Spectroscopic analysis

FTIR data helps to identify the biomoleclues which are bound on the surface of silver nanoarticles involved in bioreduction and capping of nanoparticles Figure 4 shows that the FTIR spectrum of silver nanoparticles. The absorption peak at 1640 cm-1 due to amide I was assigned to stretch mode of carbonyl group (C=O) coupled to amide linkage. The spectra exhibit an intense band at 2100 cm-1 and 1400 cm-1 were arised due to S-H and COH stretching vibration in amino acid residue[14]. The absorption spectra at 2900 and 2800 cm-1 were assigned to methylene anti symmetric and symmetric vibrations of hydrocarbons present in proteins. The band at 1250 cm-1 was stretching vibration of N-H group which is characteristic of amide band III. The broad intense peak at 3300 cm-1 was due to O-H group in phenols. The absorption peak and functional groups which were involved in the synthesis of nanoparticles are mentioned in the Table 1. The peak at 1730 cm-1 is a carbonyl stretch vibration in carboxylic acids and phenols. The functional groups bounded on the surface of nanoparticles which gave rise to the well known signature in the infrared region of the electromagnetic spectrum and for efficient stabilization of nanoparticles.

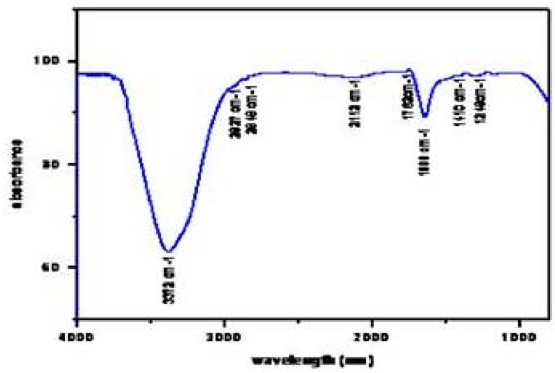

Figure 4: The FTIR spectrum of leaf mucilage of *S. laciniatum* after bioreduction of 1 mM silver nitrate solution.

Table 1: FTIR absorption peaks and their functional groups of silver nanoparticles synthesized by *S. laciniatum*.

Absorption peak(cm-1)	Functional groups
3372	Stretch frequency of the O-H band
2927	Stretch vibration in methyl groups
2848	Stretch vibration in methyl groups
2112	Stretching vibration in S-H
1762	Stretching vibration in carbonyl groups
1638	Amide-I band
1410	Bending vibration of COH groups
1249	Amide-III band

XRD analysis

The crystalline nature of the synthesized silver nanoparticles were analyzed by XRD. Figure 5 shows that the peaks were assigned to four diffraction lines are observed in each XRD pattern of silver nanoparticles synthesized by *S. lacinatum* at 2 θ 38.45°, 44.30°, 64.60° and 77.66° are characteristic of face centered cubic silver (fcc) which corresponds to (111), (200), (220) and (311) planes of fcc silver respectively. The average size of the silver nanoparticles was determined from the Debye-scherrer equation by using the width of the (111) Bragg's reflection.

$$D = K\lambda / \beta \cos \theta$$

Where K is the scherrer constant (K=0.94) λ is the wavelength of the X-ray, β is the FWHM (full width and half maximum) of the peak and θ is the half of the Bragg angle. The average particles size was found to be 15.4 nm.

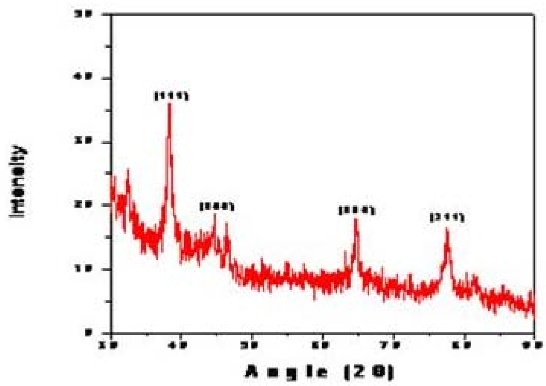

Figure 5: XRD pattern of silver nanoparticles

SEM analysis

The morphology and size of nanoparticles have been analyzed by using SEM. Figure 6 shows typical SEM image of the synthesized silver nanoparticles. The size of silver nanoparticles ranges 10-20 nm particles are monodispersed and spherical in shape.

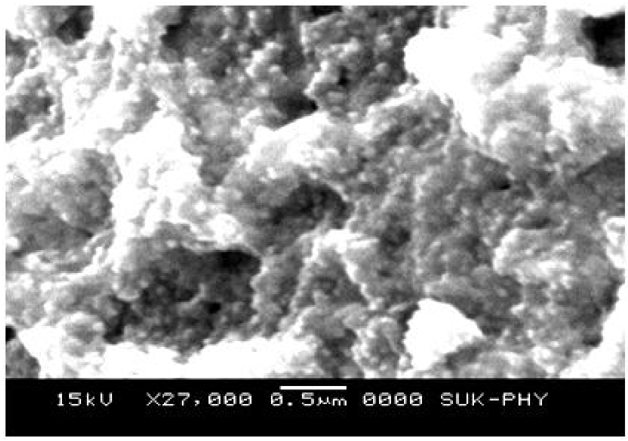

Figure 6: SEM images of silver nanoparticles synthesized from the *S. lacinatum*

CONCLUSION

The use of leaf mucilage as a novel system for biosynthesis of nanoparticles has come in vogue in recent past as an effective alternative method for synthesis. The present investigation, leaf mucilage of *S. laciniatum* was used for synthesis of silver nanoparticles. The extract contains amino acids like tryptophan and tyrosine which were involved in the bioreduction of silver ions to Ag^{o} and play an important role in capping and stabilizing the nanoparticles. These silver nanoparticles are crystalline in nature. The size of silver nanoparticles produced by *S. laciniatum*, ranges 10 to 20 nm and are spherical, monodispersed and uniform in size. The production of silver nanoparticles was very rapid in *S. laciniatum.* Plant mediated biosynthesis offers a rapid, cheap, clean, safe and eco-friendly approach.

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REFERENCES

1. Schmid G**,** Large clusters and colloids, Metals in the embryonic state, Chem**.** Rev**.,** 92**,** 1992**,** 1709**-**1727**.**
2. Hoffman AJ, Mills G, Yee H and Hoffmann MR, Q-sized cadmium sulfide: synthesis, characterization, and efficiency of photo initiation of polymerization of several vinylic monomers, J. Phys. Chem., 96, 1992, 5546–5552.
3. Alivisatos AP., Semiconductor clusters, nanocrystals, and quantum dots, Sci., 271**,** 1996, 933**-**937**.**
4. Brus LE, Electron–electron and electron–hole interactions in small of the lowest excited electronic state, J**.** Chem**.** Phys**.,** 80**,** 1984**,** 4403**–**4409.
5. Colvin VL, Schlamp MC, Alivisatos AP, Light-emitting diodes made from cadmium selenide nanocrystals and a semiconducting polymer, Natu, 370, 1994, 354 – 357.
6. Hulkoti NI and Taranath TC, Biosynthesis of nanoparticle using microbe-review, Colloids and surfaces B: Biointerface, 121, 2014, 474-483.
7. Gardea-Torresdey JL, Parsons JG, Gomez E, Peralta-Videa J, Troiani HE, Santiago P, Jose-Yacaman M, Formation and growth of Au nanoparticles inside live alfalfa plant, Nano. Lett., 2, 2002, 397-401.
8. Gardea-Torresdey J L, Gomez, E, Peralta-Videa, J, Parsons, JG, Troiani, H, and Jose-Yacaman, M, Alfalfa sprouts: A natural source for the synthesis of silver nanoparticles, Langmuir, 19, 2003, 1357-1361.
9. Shankar SS, Rai A, Ahmad A and Sastry M, Rapid synthesis of Au, Ag and bimetallic Au core-Ag shell nanoparticles using neem leaf broth, J. Colloid Interface Sci., 275, 496-502.
10. Shankar SS, Ahmad A, Sastry M, Geranium leaf assisted biosynthesis of silver nanoparticles, Biotechnol. Prog., 19**,** 2003, 1627-1631.
11. Ankamwar B, Damle C, Ahmad A, Sastry M, Biosynthesis of gold and silver nanoparticles using *Emblica officinalis* fruit extract, Their phase transfer and transmetallation in an organic solution, J. Nanosci.Nanotech., 5(10), 2005, 1665-1671.
12. Gokak IB and Taranath TC, Phytosynthesis of silver nanoparticle using leaf extract of Wattakaka volublis (L. F.) Stapf. And their antimicrobial activity, International journal of science, Environment and technology, 3, 1, 2014, 93-99.
13. Gokak IB and Taranath TC, Cansjera rheedii J.F.Gmel. A medicinal plant mediated synthesis of silver nanoparticles and their antibacterial activity, International journal of scientific engineering and technology, 3, 3, 293-296.
14. Parashar V, Parashar R, Sharma B, Pandey AC, Parthenium leaf extract mediated synthesis of silver nanoparticles: a novel approach towards weed utilization, Digest Journal of Nanomaterials and Biostructures, 4(1), 2009, 45-50.
15. Chandran SP, Chaudhary M, Pasricha R, Ahmad A, Sastry M, Synthesis of gold nanotriangle and silver nanoparticles using *Aloe vera* plant extract, Biotechnol. Prog., 22, 2006, 577-583.
16. Huang J, li Q, Sun D, Lu Y, Su Y, Yang, X, Wang H, Wang W, Shao Y, He N, Hong J, Chen C, Biosynthesis of silver and gold nanoparticles by using novel sundeied *Cinnamoum camphora* leaf, Nanotechnology, 18, 2007, 104-105.
17. Li S, Shen Y, Xie A, Yu X, Qiu L, Zhang L, Zhang Q, Green synthesis of silver nanoparticles using *Capsicum annum* L. extract. Green Chem., 9, 2007, 852-858.
18. Ghosh S, Patil S, Ahire M, Kitture R, Jabgunde A, Kale S, Pardesi K, Bellare J, Dhavale DD, Cametra S, Chopade B, Synthesis of silver nanoparticles using *Dioscorea bulbifera* tube extract and evalution of its synergistic potential in combination with antimicrobial agents, International Journal of nano medicine, 7, 2012, 483-496.
19. Kaviya S, Santhanlakshmi J, Viswanathan B, Muthumary J, Srinivasan K, Biosynthesis of silver nanoparticles using *Citrus sinensis* peel extract and its antibacterial activity, Spectrochimica Acta Part A, 79, 2011, 594-598.
20. Alagumuthu G, Kirirubha R, Green synthesis of silver nanoparticles using *Cissus quadrangularis* plant extract and their antibacterial activity, International Journal of Nanomaterials and Biostructures, 2(3), 2012, 30-33.
21. Ghoreishi SM, Behpour M, Khayatkashani M, Green synthesis of silver and gold nanoparticles using *Rosa damascene* and its primary application in electrochemistry, Physica E, 44, 2011, 97-104.
22. Gondwal M, Joshi G, Biological evaluation and green synthesis of silver nanoparticles using aqueous extract of *Calotropis procera*, Int J Pharma and Bio Sciences, 4(4), 635-643.
23. Singh, Jain D, Upadhyay MK, Khandelwal N, Verma HN, Green synthesis of silver nanoparticles using *Argemone Mexicana* leaf extract and evaluation of their antimicrobial activities, Digest Journal of Nanomaterials and Biostrures, 5(2), 2010, 483-489.
24. Swamy VS, Ram P, Green synthesis of silver nanoparticles from the leaf extract of *Santalum album* and its antimicrobial activity, Journal of optoelectronic and Biomedical Materials, 4(3), 2012, 53-59.
25. Prasad KS, Pathak D, Patel A, Dalwadi P, Prasad R, Patel P, Selvaraj K, Biogenic synthesis of silver nanoparticles using *Nicotiana tobaccum* leaf extract and study of their

antibacterial effect, African journal of Biotechnology, 10 (41), 2011, 8122-8130.

26. Rupali S, Patil R, Mangesh KS, Sanjay K, Bioinspired synthesis of highly stabilized silver nanoparticles using *Ocimum tenuiflorum* leaf extract and their antibacterial activity, Spectrochimica Acta Part A, 91, 2012, 234– 238.

27. Vankar PS, Shukla D, Biosynthesis of silver nanoparticles using lemon leaves extract and its application for antimicrobial finish on fabric, Applied Nanoscience, 2, 2012, 163-168.

28. Kiruba D, Vinothini GN, Subramanian KN and Sivakumar M, Biosynthesis of Cu, ZVI, and Ag nanoparticles using *Dodonaea viscose* extract for antibacterial activity against human pathogens, J. naopart Res., 15, 2013, 1319.

29. Vijayakumar M, Priya K, Nancy FT, Noorlidah A, Ahmed ABA, Biosynthesis, characterization and anti-bacterial effect of plant-mediated silver nanoparticles using *Artemisia nilagirica*, Industrial crops and products, 41, 235-240.

30. Vidhu VK, Philip D Spectroscopic, microscopic and catalytic properties of silver nanoparticles synthesized using *Saraca indica* flower, Spectrochimica Acta Part A: Molecular and Biomolecular spectroscopy, 117, 2014, 102-108.

31. Pal S, Tak YK, Song JM, Does the antibacterial activity of silver nanoparticles depend on the shape of the nanoparticles? A study of the gram negative bacterium *Escherichia coli*, Appl Environ. Microbiol., 73(6), 2007, 1712-1720.

32. Ahmad A, Mukherjee P, Senapati S, Mandal D, Khan MI, Kumar R, Sastry M, Extracellurlar biosynthesis of silver nanoparticles using the fungus *Fusarium oxysporum*, Colloids and Surfaces B: Biointerfaces, 28**,** 2003, 313-318.

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