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Green Synthesis Of Ag-Nps Using *Azadirachta Indica* Extract And Its Antibacterial Activity

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ABSTRACT

Aqueous extract of *Azadirachta indica* is utilized as reducing agent for the eco-friendly synthesis of Ag-Nps. The nanoparticles were synthesized and characterize utilizing UV–vis, X-raydiffraction (XRD) and FTIR analysis. Crystallinity of the Ag-Nps is proved from the XRD pattern and Scanning Electron Microscopy (SEM). Bi-molecules accountable for capping are a variety of Ag-Nps as established by the FTIR spectra. The temperament of Ag-Nps synthesized to all examined by UV- vis spectra. The Ag-Nps were by means of a regular size of 7–15 nm and typically spherical exact by XRD pattern. The antibacterial activity of synthesized Ag-Nps was assessed with that of aqueous *Azadirachta indica* by diffusion technique. The Ag-Nps from *Azadirachta indica* sample prominently reserved bacterial development against multi drug resistant to the entire pathogens which is utilized in this investigation. Thus Ag-Nps displayed wide range antibacterial activity at lower attention and may be an excellent option therapeutic move toward in future.

KEYWORDS: *Azadirachta indica, Ag-Nps, XRD, SEM, FTIR*

1. INTRODUCTION

Nanotechnology is an important field of contemporary research that focuses on the synthesis, design, and application of particle arrangements ranging from 1 to 100 nm in size. Somewhere in this size range, the chemical, physical, and biological properties of atoms/molecules and the consequent size vary considerably. Depending on their size, dispersion, and shape, nanoparticles and nonmaterials are being rapidly exploited on a range of fronts due to their entirely new or enhanced capabilities. The development of environmentally friendly nanoparticle synthesis techniques is becoming a crucial aspect of nanotechnology.

There is a wealth of knowledge available regarding the usages of natural resource such as honey, yeast, fungi, bacteria, plants in the synthesis of Ag-Nps. The therapeutic application of nanotechnology is very promising for the possibility of miniaturization and micro-miniaturization, which can intentionally interact with biological objects like tissues, organs, as well as molecules. Therefore, nanotechnology is a light of hope for the

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event of latest medical methods for identification, treatment, or monitoring of patient.

Parveen et al recommended that, the advances in technology and nanotechnology unlocks the opportunities for a large range of natural examination subjects as well as clinical procedures at molecular level. Synthesis of NPs is often referred to as shrewdness and harmless to the ecosystem option in contrast to compound and actual strategies. Plant-intervened amalgamation of nanoparticles is environment friendly method that interfaces plant products with nanotechnology. New approaches for the synthesis of NPs are along these lines imagined that is molded at nearby temperatures, unbiased pH, less cost and harmless to the ecosystem style. The study discusses the synthesis of nanomaterials using various approaches. Other options such as natural products and plant extract appear as most ideal alternative. Those are cheap and need resources for synthesis. The benefits as well as detriments of the use of Nano science are huge. The study focuses on the various techniques and products beginning with the historical backdrop of nanotechnology, NP properties, different systems of union, the numerous benefits as well as burdens of various techniques along with the application

2 .Materials and Methods

2.1. General. All the media were prepared as per the recommended previously published composition. The media cultures and the inoculation tubes for the study were maintained as per the recommended procedures (Purvis, Collier, & Walls, 1966)(Tuite, 1969).

2.2.Glassware. The laboratory glassware (Corning/Borosil) to be used for experiments were dipped for few hours in cleaning solution. They are then taken out from the cleaning solution and washed with water so as to remove any cleaning solution. The washed glasswares were then dried using hot air oven.

2.3.Cleaning solution**.** The cleaning solution was prepared as per the composition referred by (Mahadevan & Sridhar, 1982)

Potassium dichromate - 60 g

Conc. H_2SO_4- 60 ml.

Distilled water - 1000 ml

In hot water Potassium dichromate was added followed by slow mixing of H2SO4. The solution prepared was used for cleaning glass materials.

2.4.Sterilization.

For sterilization of media and glassware, the items are packed adequately and autoclave at 15 PSI for 20 min.

2.5.Chemicals

All the supplied chemicals were of analytical grade manufactured by Hi-Media, and Sigma Chemicals (USA).

2.5.1. Leaf Collection of *Azadirachta Indica.*

The plant, *Azadirachta Indica* , is effectively accessible form trees of 15-20 m height, having a 20 m diameter. The leafs were collected from the college ground of Anna College,

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Chennai, followed by disinfection and processes for further experimental preparation.

2.5.2 Aqueous Extract of Plant Seed

The seeds collected were washed and cleaned numerous times using distilled water. The seeds were made into little pieces followed by boiling at 700°C for 10 min using 300 mL deionized water. The solution is mixed using a magnetic stirrer during the process of boiling. The solution was then filtered using Whatman No. 1 filter paper after it was cooled down. The extract was kept refrigerated until further use.

2.5.3 Silver Nanoparticles Synthesis

A stock solution of 1 mM (1×10^{-3}) $AgNO_3$ was prepared using deionized water. To 5 mL of 1×10-3M $AgNO_3$, different volumes of extract was added (2-10 mL) in which 15 mL of deionized water was also added. Formation of silver nanoparticles was indicated by change in the color of the solution from light yellow to brown post 3 hours of incubation. The brown color of the solution indicates the AgNPs formation.

3 RESULTS AND DISCUSSIONS.

3.1.Green synthesis of Ag-Nps using *Azadirachta Indica* extract and its antibacterial activity

3.1.1. XRD (X-ray diffraction)

XRD pattern of synthesised Ag-Nps utilising sample extract from A. indica are shown in Fig 4.1 at room temperature. Ag NPs extract's XRD patterns show that the compound's structure is face-centered cubic (fcc). Additionally, the 111, 200, 220, and 311 crystallographic planes could be responsible for the XRD peaks at 2θ of 38.103°, 44.31°, 64°, and 77° (JCPDS, file no.04-0783). In comparison to strong (1 1 1) reflection, the Bragg reflections at (2 0 0), (2 2 0), and (3 1 1) are weak and widened. High-resolution SEM measurements have proven that the nanocrystals are (1 1 1)-oriented by Shameli et al (2010). Additional unassigned peaks appear after the Bragg peaks indicative of fcc silver nanocrystals, indicating that the bio-organic phases crystallises on the nanoparticle surfaces. Ag-Nps generated from mushroom and geranium leaf extracts both produced the same effect by Shankar et al. (2003) and Philip et al. (2010) The nanoparticles' nanoregime was shown by the sharpness of their peaks. Theoretically, White et al. (2012) have shown that additional groups, including as amino acids, proteins, and enzymes, may be involved in the bio reduction of silver ions. This result demonstrates the highest peak intensity in A. indica, additional unassigned peaks arise following Bragg's peak suggestive of silver fcc nanocrystals, indicating that the bio-organic phase crystallises on the nanoparticle surfaces.

$$D = (m\ \lambda)/(\beta \cos\theta)$$

Where, diameter size of particle is D, full width at FWHM (half maximum) is β, constant m is equal to 1, wavelength is (0.1541 nm) for X-ray source k, the diffraction angle for the lattice plane h is (111). Based on equation by Debye-Scherrer, the size of crystallite in average for the A. indica sample was calculated to be 7 nm, that is slightly larger than the particle size discovered from the AgNPs TEM picture. This is due to the particles' small deviation from the spherical shape required

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by the Debye-Scherrer formula in Sadeghi et al. (2015) and Ulug et al. (2015).

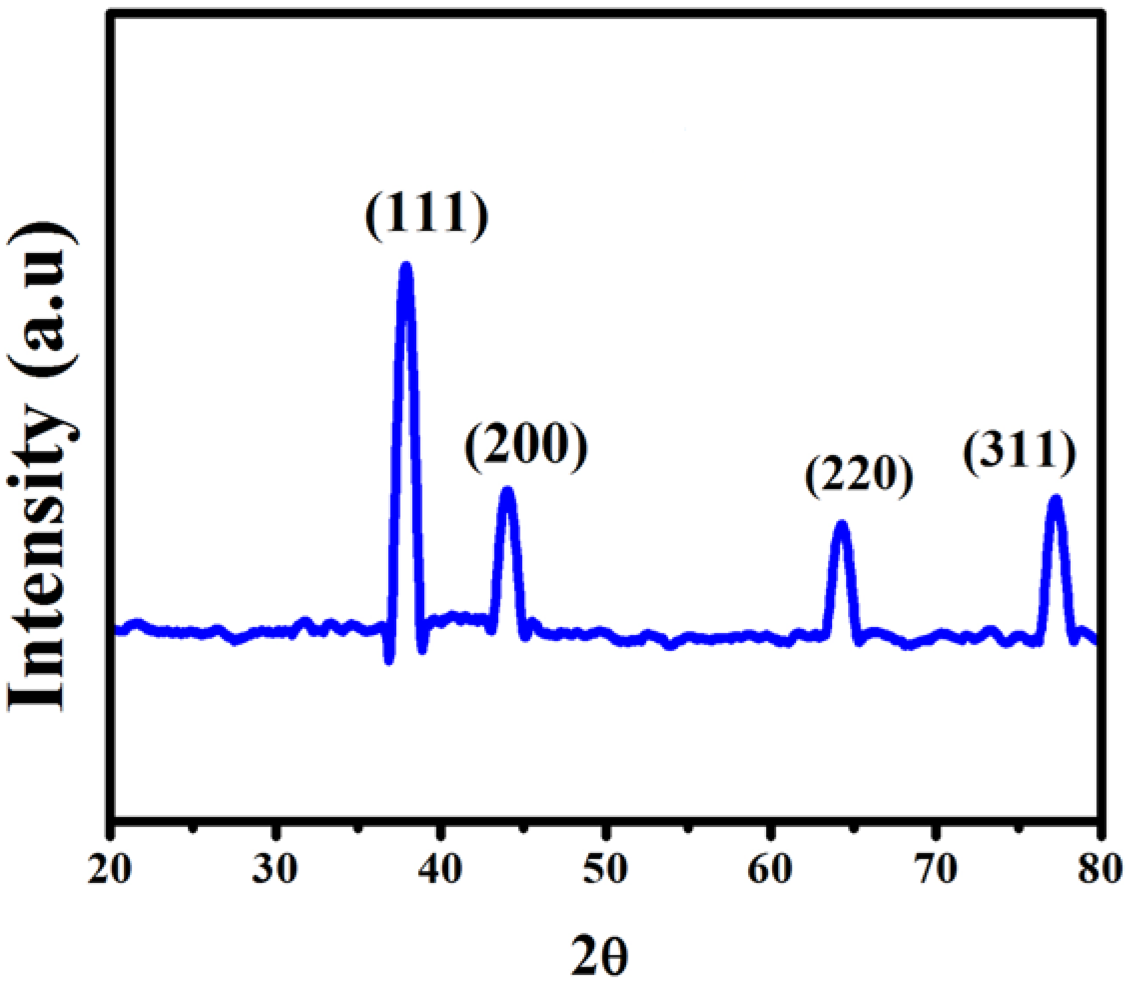

Fig-3.1: Ag nanoparticles made with aqueous extract of *A. indica* by XRD pattern

3.1.2 FTIR Analysis.

For identifying the potential biomolecules in the A. indica sample in charge of capping, which effectively stabilises the Ag-Nps, FTIR studies were performed. The FTIR spectra of the Ag nanoparticles made from sample extracts of A. indica is shown in Fig 4.2, and it shows absorption peaks at cm-1 values of 3777, 3395, 3285, 2924, 2855, 1643, 1541, 1238, 1030, 780, 618, 566, and 466. Among them, bands at 3200-3600 cm^{-1} reveal the characteristic signal for asymmetric & symmetric stretching for O-H group. At 1643 cm^{-1}, absorption peak indicates C=O group existence in extracts, while the peaks at 1541 cm^{-1} is attributed to C=C functional group. The in-plane flexing vibration of O-H

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is then compared to the absorbance bands at 1541, 1238, 1030, and 780 cm^{-1}, respectively. Polyphenolic components of the extracts, like quercetin 3-rutinoside, delphinidin 3-sambubioside, cyaniding 3-sambubioside, and others, may be the primary cause of these absorption peaks. In comparison to A. indica spectrum, the strength of flexing vibrations & O-H stretching highly decrease after lowered. According to research conducted by polyhydroxy groups of polyphenols (Oves et al. 2018), the major causes of the change could be a decrease in Ag (I) & Ag-O group development on the surface of Ag-Np. The water-soluble substances found in the tulsi leaf, such as flavonoids and terpenoids, give the vibrational bands such as -C=C (chain), C-O-C, -C-O, -C=C-(ring). This concludes that these biomolecules are in charge of capping and effective stability. These safe for the environment nanoparticles would be used in food, medicine, and cosmetics.

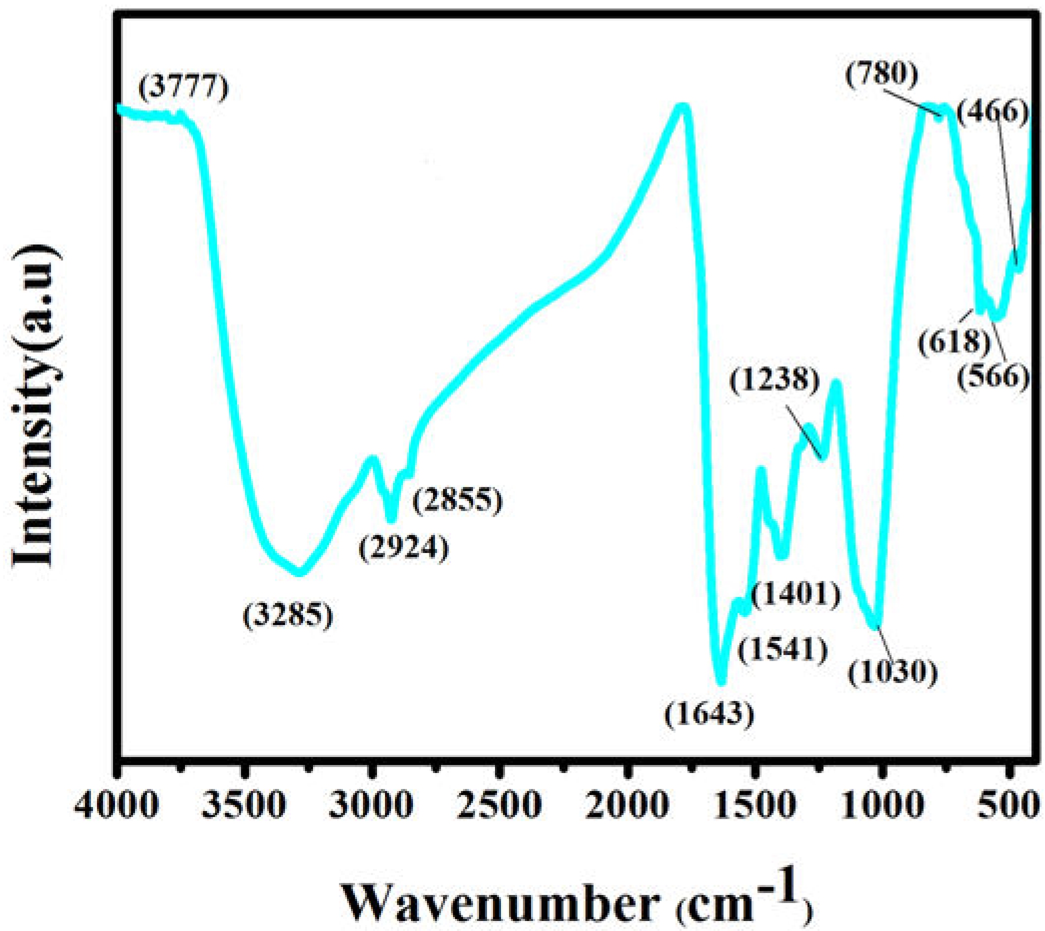

Fig-3.2: Ag nanoparticles made with aqueous extract of *A. indica* by FTIR analysis

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3.2.1.3 SEM Analysis

Through the use of SEM images (Fig 4.3 (a)), the morphology A. indica samples of the Ag NPs were recognised. Although some Ag NPs were also oval in shape, the bulk of the particles were spherical, Ag NPs that had been biosynthesized had been extensively increased in the mixture. According to SEM pictures, a small number of chosen biosynthesized nanoparticles were between 7 and 15 nm in size. DLS (Dynamic light scattering) analysis was utilized for determining average particle diameter. Most Ag NPs had 7.13 nm diameter.

FESEM image displays biomolecule coating on the biosynthesized Ag NPs. This layer demonstrated the function of plant extracts metabolites in biosynthesis & stabilisation of Ag NP. These findings concur with those of Oves et al. (2018). EDX was used to perform deposited elemental analysis on synthesised AgNPs. The presence of AgNPs was confirmed by the EDX image of the A. indica sample (Fig. 4.3(b)), which shows prominent peaks for silver metal in each sample. All EDX pictures showed strong metallic nanoparticle peaks at 2.9 keV (Fig. 4.3b), demonstrating the presence of silver as a key component of nanoparticles (Banerjee et al. 2014).

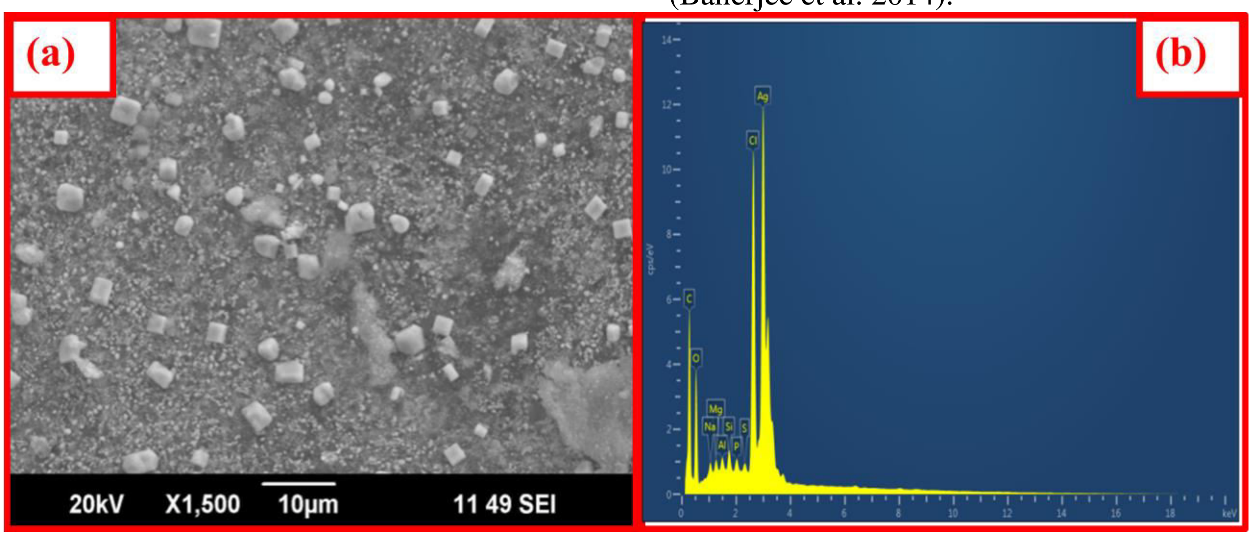

Fig-3.3: Ag nanoparticles made with aqueous extract of *A. indica* by SEM, EDAX analysis

4.2.1.4 Spectrum of UV–Vis absorption

In this section, spectrum of UV-Vis absorption is shown Fig. 4.4 displays Ag NP samples from A. indica. From UV-Vis research, a broad bell-shaped spectral curve was discovered. The plasmon band is expanded because many dissolved plant extract compounds are also detectable in this spectrophotometric region. Silver's surface plasmon resonance (SPR) wavelength is 450 nm. Over a period of four hours, this peak increased in height. The Mie theory states that round nanoparticles exhibit a single SPR band. More peaks are seen when there is a wider variety of particle forms (Raut Rajesh et al., 2009; Yadav et al., 2017; Sökmenet al., 2017). Therefore, it follows

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that the Ag NPs formed during biosynthesis must be round.

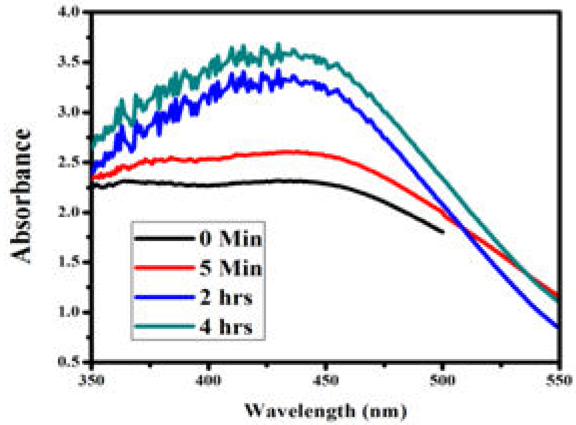

Fig-3.4: Ag nanoparticles made with aqueous extract of *A. Indica* by UV spectrum analysis

3.2.1.5 Antibacterial activity of plants based AgNPs

The public's health and the well-being of communities are always at risk from infectious diseases brought on by pathogenic microorganisms. Plants and plant components have been utilised to study this global issue since the beginning of time (Furno et al. 2004). The antibacterial efficacy of green Ag-Nps against dangerous pathogens was tested using the well diffusion method. Because they are extremely powerful against microbes and have a wide surface area, silver ions and silver compounds are harmful to them. Strong antibacterial properties were discovered to exist in silver ions and Ag-Nps. Antibacterial activities of Ag-Np containing A. indica sample showed that bacteria were suppressed to varying degrees by various treatments.

Table 3.1 shows the findings of the antibacterial analysis. These findings were consistent with earlier research by Bindhu and Umadevi (2013). A. indica, which showed the highest UV absorption and maximum activity across all bacteria, indicated the synthesis of large amount of Ag-Np. Bacteria differed in their sensitivity to Ag-Np due to differences in thickness & composition of their membranes by Kim et al. (2007).

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Table 4.1: Ag nanoparticles made with aqueous extract of *A. indica* by Antibacterial activity

strains	Zone of inhibition(mm) *A. indica*
E.coli (KF 918342)	14.6±0.9
S. Haemolyticus	14.3±0.7
Aeromonas hydrophila	13.3±1
Basillus subtilis	15.2±0.8
Cronobacter sakazakii	14.7±0.9
Aeromonas salmonicida	18±0.7

4 CONCLUSIONS

we have recorded for the first time the green synthesis of highly constant spherical Ag-Nps of 7 to 15 nm diameter from the plant extract of *A. indica*. The nanoparticles were described by UV–vis, XRD and FTIR measured by different equipment. The biosynthesized Ag NPs were found to have an inhibitory effect on several different types of bacteria, as determined by an evaluation of their bactericidal activity. Silver ion reduction was analyzed, and functional groups and efficient compounds were attributed where possible. A. indica sample appeared to be an excellent candidate for Ag-Nps synthesis and antibacterial activity.

Thus, the aqueous extract of Azadirachta indica is used as a reducing agent in the environmentally friendly production of Ag-Nps. Nanoparticles were generated and characterised using UV–vis, FTIR, XRD analysis. The XRD pattern & SEM reveal the crystalline nature of the Ag-Nps. According to FTIR spectra, the capping bimolecules consist of a number of Ag-Nps. Using UV-vis spectra, the disposition of synthesised Ag-Nps was investigated. Ag-Nps have an average size of 7–15 nm and are generally spherical, according to the

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XRD pattern. The antibacterial activity of synthesised Ag-Nps was compared to that of aqueous Azadirachta indica using the diffusion method.

REFERENCES

1. Dos Santos, C.A., Seckler, M.M., Ingle, A.P., Gupta, I., Galdiero, S., Galdiero, M., Gade, A., Rai, M.: Ag-Nps: therapeutical uses, toxicity, and safety issues. J. Pharm. Sci. **103**, 1931– 1944 (2014)
2. Narayanan, K.B., Sakthivel, N.: Biological synthesis of metal nanoparticles by microbes. Adv. Colloid Interface Sci. **156**, 1–13 (2010).
3. Raveendran P, Fu J, Wallen SL. A simple and ''green'' method for the synthesis of Au, Ag, and Au-Ag alloy nanoparticles. Green Chem 2006; 8: 34-38.
4. Armendariz V, Gardea-Torresdey JL, Jose Yacaman M, Gonzalez J, Herrera I, Parsons JG. Gold nanoparticle formation by oat and wheat biomasses. Proceedings of Conference on Application of Waste Remediation Technologies to Agricultural Contamination of Water Resources; 2002.
5. Song JY, Kim BS. Rapid biological synthesis of Ag-Nps using plant leaf extracts. Bioprocess Biosyst Eng 2008; 32: 79-84.
6. Liz-Marzan LM, Lado-Tourino I. Reduction and stabilization of Ag-Nps in ethanol by nonionic surfactants. Langmuir 1996; 12: 3585-3589.
7. Esumi K, Tano T, Torigoe K, Meguro K. Preparation and characterization of biometallic Pd-Cu colloids by thermal decomposition of their acetate compounds in organic solvents. J Chem Mater 1990; 2: 564-567.
8. Pileni MP. Fabrication and physical properties of self-organized silver nanocrystals. Pure Appl Chem 2000; 72: 53-65.
9. Sun YP, Atorngitjawat P, Meziani MJ. Preparation of Ag-Nps via rapid expansion of water in carbon dioxide microemulsion into reductant solution. Langmuir 2001; 17: 5707-5710.
10. Henglein A. Physicochemical properties of small metal particles in solution: microelectrode' reactions, chemisorption, composite metal particles, and the atom-to-metal transition. J Phys Chem B 1993; 97: 5457-5471.
11. Henglein A. Colloidal Ag-Nps: photochemical preparation and interaction with O2, CCl4, and some metal ions. J Chem Mater 1998: 10: 444-446.
12. Henglein A. Reduction of Ag (CN)-2 on silver and platinum colloidal nanoparticles. Langmuir 2001; 17: 2329-2333.
13. Klaus T, Joerger R, Olsson E, Granqvist CG. Silver-based crystalline nanoparticles, microbially fabricated. J Proc Natl Acad Sci USA 1999; 96: 13611-13614.
14. Nair B, Pradeep T. Coalescence of nanoclusters and formation of submicron crystallites assisted by Lactobacillus strains. Cryst Growth Des 2002; 2: 293-298.
15. Willner I, Baron R, Willner B. Growing metal nanoparticles by enzymes. J Adv Mater 2006; 18: 1109-1120.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11,S Iss 3, Dec 2022**

16. Vigneshwaran N, Ashtaputre NM, Varadarajan PV, Nachane RP, Paraliker KM, Balasubramanya RH. Biological synthesis of Ag-Nps using the fungus Aspergillus flavus. Mater Lett 2007; 61: 1413-1418.
17. Shankar SS, Ahmed A, Akkamwar B, Sastry M, Rai A, Singh A. Biological synthesis of triangular gold nanoprism. Nature 2004; 3: 482.
18. Shiraishi Y, Toshima N. Oxidation of ethylene catalyzed by colloidal dispersions of poly (sodium acrylate)-protected silver nanoclusters. Colloids Surf A Physicochem Eng Asp 2000; 169: 59-66.

19. Chang LT, Yen CC. Studies on the preparation and properties of conductive polymers. VIII. Use of heat treatment to prepare metallized films from silver chelate of PVA and PAN. J Appl Polym Sci 1995; 55(2): 371-374.
20. Raut, R.W., Lakkakula, J.R., Kolekar, N.S., Mendhulkar, V.D., Kashid, S.B., 2009. Phytosynthesis of silver nanoparticle using gliricidia sepium. Curr. Nanosci. 5, 117–122.
21. Dubey, S.P., Lahtinen, M., Sillanpa¨ a¨ , M., 2010. Green synthesis and characterizations of silver and gold nanoparticles using leaf extract of Rosa rugosa. Colloids Surf., A 364, 34–41.
22. Dwivedi, A.D., Gopal, K., 2010. Biosynthesis of silver and gold nanoparticles using Chenopodium album leaf extract. Colloids Surf., A 369, 27–33.
23. Jha, A.K., Prasad, K., 2010. Green synthesis of Ag-Nps using Cycas Leaf. Int. J. Green Nanotechnol. 1, 110–117.
24. Krishnaraj, C., Jagan, E.G., Rajasekar, S., Selvakumar, P., Kalaichelvan, P.T., Mohan, N., 2010. Synthesis of Ag-Nps using Acalypha indica leaf extracts and its antibacterial activity against water borne pathogens. Colloids Surf., B 76, 50–56.
25. Lin, L., Wang, W., Huang, J., Li, Q., Sun, D., Yang, X., Wang, H., He, N., Wang, Y., 2010. Nature factory of silver nanowires: plantmediated synthesis using broth of Cassia fistula leaf. Chem. Eng. J. 162, 852–858.
26. Philip, D., 2010. Green synthesis of gold and Ag-Nps using Hibiscus rosa sinensis. Phys. E 42, 1417–1424.
27. Roy, N., Barik, A., 2010. Green synthesis of silver nanoparticle from the unexploited weed resources. Inter. J. Nanotechnol. Appl. 4, 95–101.

28. Raghunandan, D., Mahesh, B., Basavaraja, S., Balaji, S., Manjunath, S., Venkataraman, A., 2011. Microwave-assisted rapid extracellular synthesis of stable bio-functionalized Ag-Nps from guava (Psidium guajava) leaf extract. Nanopart. J. Res. 13, 2021– 2028.
29. Veerasamy, R., Xin, T.Z., Gunasagaran, S., Xiang, T.F.W., Yang, E.F.C., Jeyakumar, N., Dhanaraj, S.A., 2011. Biosynthesis of Ag-Nps using mangosteen leaf extract and evaluation of their antimicrobial activities. J. Saudi Chem. Soc. 15, 113–120.
30. Philip, D., Unni, C., 2011. Extracellular biosynthesis of gold and Ag-Nps using Krishna tulsi (Ocimum Sanclum) leaf and Nanostructures. Phys. E 43, 1318–1322.

ISSN PRINT 2319 1775 Online 2320 7876

31. Roopan, S.M., Rohit, Madhumitha, G., Abdul Rahuman, A., Kamaraj, C., Bharathi, A., Surendra, T.V., 2012. Low-cost and eco-friendly phyto-synthesis of Ag-Nps using Cocos nucifera coir extract and its larvicidal activity. Ind. Crops Prod. 43, 631–635.
32. R. Sankar, A. Karthik, A. Prabu, S. Karthik, K.S. Shivashangari, V. Ravikumar, Origanum vulgare mediated biosynthesis of Ag-Nps for its antibacterial and anticancer activity, Colloids and Surfaces B: Biointerfaces 108 (2013) 80–84
33. D. Qu, W. Sun, Y. Chen, J. Zhou, C. Liu, Synthesis and in vitro antineoplastic evaluation of Ag-Nps mediated by Agrimoniae herba extract, International Journal of Nanomedicine 9 (2014) 1871–1882.
34. B. Ankamwar, M. Gharge, U. K. Sur, Adv. Sci. Eng. Med. 7 (2015) 480-484.
35. B. Ankamwar, V. Kamble, U. K. Sur, C. Santra, Appl. Surf. Sci. 366 (2016) 275-283.
36. B. Ankamwar, S. Pansare, U. K. Sur, J. Nanosci. Nanotechnol. 17 (2017) 1041-1045.

37. Ujjal Kumar Sura,b,d*, Balaprasad Ankamwarb,e*, Sanat Karmakarc, Animesh Halderc, Pulak Das, Green synthesis of Ag-Nps using the plant extract of Shikakai and Reetha. Materials Today: Proceedings 5 (2018) 2321–2329.
38. Saba Pirtarighat1 · Maryam Ghannadnia2 · Saeid Baghshahi, Green synthesis of Ag-Nps using the plant extract of *Salvia spinosa* grown in vitro and their antibacterial activity assessment. Journal of Nanostructure in Chemistry (2019) 9:1–9.
39. Melato FA, Mokgalaka NS & McCrindle RI (2016) Adaptation and detoxification mechanisms of Vetiver grass (*Chrysopogon zizanioides*) growing on gold mine tailings. Int J Phytorem18- 509-520.
40. Truong P (2002) Vetiver Grass Technology. In: Maffei M (ed) *Vetiveria*: the genus *Vetiveria*. Taylor and Francis Publication, London 6:114.
41. Xia HP (2004) Ecological rehabilitation and phytoremediation with four grasses in oil shale mined land. Chemosphere 54: 345-353.
42. Mao, L., Henderson, G., Bourgeois, W.J., Vaugh, J. A., Laine, R.A., 2006. Vetiver oil and nootkatone effects on the growth of pea and citrus. Ind. Crop. Prod. 23, 327–332.
43. Bizzo, H.R., Hovell, A.M.C., Rezende, C.M., 2009. Óleos essenciais no Brasil: aspectos gerais, desenvolvimento e perspectivas. Quim. Nova. 32, 588-594.
44. Danh, L.T., Mamucari, R., Truong, P., Foster, N., 2010. Response surface method applied to supercritical carbon dioxide extraction of *Vetiveria zizanioides* essential oil. Chem. Eng. J. 155, 617-626.
45. Monteiro, J.M., Vollú, R.E., Coelho, M.R.R., Fonseca, A., Gomes-Neto, S.C., Seldun, L. 2011. Bacterial communities within the rhizosphere and roots of vetiver (*Chrysopogon zizanioides* (L.) Roberty) sampled at different growth stages. Eur. J. Soil Biol. 47, 236-242.
46. Santos, T.C., Arrigoni-Blank, M.F., Blank, A., 2002. Propagação e conservação *in vitro* de vetiver. Hortic. Bras. 30(3), 507-513.
47. Hannan, J.M.A., Ojo, O.O., Ali, L., Rokeya, B., Khaleque, J., Akhter, M., Flatt, P.R., Abdel-Wahab, Y.H.A., 2015. Actions Underlying Antidiabetic Effects of Ocimum

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **© 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11,S Iss 3, Dec 2022**

sanctum Leaf Extracts in Animal Models of Type 1 and Type 2 Diabetes. Eur. J. Med. Plants. 5, 1-12.

48. Bariyah, S.K., 2013. An Extensive Survey of the Phytochemistry and Therapeutic Potency of Ocimum sanctum (Queen of Herbs). Pak. J. Chem. 3, 8-18.
49. Shameli, K., Ahmad, M.B., Yunus, W.M.Z.W., Ibrahim, N.A., 2010. Synthesis and characterization of silver/talc nanocomposites using the wet chemical reduction method. Int. J. Nanomed. 5, 743–751.
50. S.S. Shankar, A. Ahmad, M. Sastry, Biotechnol. Prog. 19 (2003) 1627.
51. D. Philip, Spectrochim. Acta A 73 (2009) 374.
52. G. Von White, P. Kerscher, R.M. Brown, J.D. Morella, W. McAllister, D. Dean, C.L. Kitchens, Green synthesis of robust, biocompatible Ag-Nps using garlic extract, J. Nanomater. 2012 (2012) 12.
53. Sadeghi B, Gholamhoseinpoor F. A study on the stability and green synthesis of Ag-Nps using Ziziphora tenuior (Zt) extract at room temperature. Spectrochim Acta Part A: Mol Biomol Spectrosc 2015;134:310–5.
54. Ulug B, HalukTurkdemir M, Cicek A, Mete A. Role of irradiation in the green synthesis of Ag-Nps mediated by fig (Ficus carica) leaf extract. Spectrochim Part A: Mol Biomol Spectrosc 2015;135:153–61.
55. J. Jacob, T. Mukherjee, S. Kapoor, Mater. Sci. Eng. C, 32 (2012) 1827–1834.
56. Gopal Suresh, Poosali Hariharan Gunasekar, Dhanasegaran Kokila, Durai Prabhu, Devadoss Dinesh, Nagaiya Ravichandran, Balasubramanian Ramesh, Arunagirinathan Koodalingam , Ganesan Vijaiyan Siva, Spectrochim. Acta, Part A, 127 (2014) 61–66.
57. J. Kasthuri, S. Veerapandian, N. Rajendiran, Colloids Surf. B, 68 (2009) 55–60.
58. Oves, M., Aslam, M., Rauf, M.A., Qayyum, S., Qari, H.A.,Khan, M.S., Alam, M.Z., Tabrez, S., Pugazhendhi, A., Ismail, I.M.: Antimicrobial and anticancer activities of Ag-Nps synthesized from the root hair extract of *Phoenix dactylifera*.Mater. Sci. Eng. C **89**, 429–443 (2018).
59. T. Rasheed, M. Bilal, H.M.N. Iqbal, C. Li, Green biosynthesis of Ag-Nps using leaves extract of *Artemisia vulgaris* and their potential biomedical applications, Colloids Surf. B. Biointerfaces. 1 (2017) 408-415.
60. Banerjee, P., Satapathy, M., Mukhopahayay, A., Das, P.: Leaf extract mediated green synthesis of Ag-Nps from widely available Indian plants: synthesis, characterization, antimicrobial property and toxicity analysis. Bioresour. Bioprocess.**1**, 1–10 (2014)
61. Raut Rajesh, W., Lakkakula Jaya, R., Kolekar Niranjan, S., Mendhulkar Vijay, D., Kashid Sahebrao, B.: Phytosynthesis of silver nanoparticle using *Gliricidia sepium* (Jacq.). Curr. anosci. **5**, 117–122 (2009)
62. R. Yadav, R.K. Khare, A. Singhal, Qualitative phytochemical screening of some selected medicinal plants of Shivpuri District (M.P.) Int. J. Life Sci. Scientific Res. 3 (2017) 844-847
63. M. Sökmen, S.Y. Alomar, C. Albay, G. Serdar, Microwave assisted production of Ag-Nps using green tea extracts, J. Alloy Compd. 725 (2017) 190-198.

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64. Furno, F., Morley, K.S., Wong, B., Sharp, B.L., Arnold, P.L., Howdle, S.M., Bayston, R., Brown, P.D., Winship, P.D., Reid, H., 2004. Ag-Nps and polymeric medical devices. J. Antimicrob. Chemother. 54, 1019–1024.
65. Bindhu, M.R., Umadevi, M., 2013. Synthesis of monodispersed Ag-Nps using Hibiscus cannabinus leaf extract and its antimicrobial activity. Spectrochimica Acta Part A 101, 184–190.
66. Kim, J.S., Kuk, E., Yu, K.N., Kim, J.-H., Park, S.J., Lee, H.J., Kim, S.H., Park, Y.K., Park, Y.H., Hwang, C.-Y., Kim, Y.-K., Lee, Y.-S., Jeong, D.H., Cho, M.-H., 2007. Antimicrobial effects of Ag-Nps. Nanomed.: Nanotechnol. Biol. Med. 3, 95–101.