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PRODUCTION AND CHARACTERIZATION OF SILVER NANOPARTICLES (Agnps) BY BIOLOGICAL (GREEN SYNTHESIS) METHOD FROM NEEM TREE LEAVES (*Azadirachta Indica*) FROM MULAI WARD, JERE L.G.A BORNO STATE NIGERIA.

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ABSTRACT

Nanotechnology is an advanced discipline of science and technology for dealing with material sizes on the nanoscale. Nanoparticles, which have a dimension of less than 100 nm are among those materials. In this study, five different neem tree leaf *(Azadirachta indica)* were collected from Mulai ward, Maiduguri Borno state and used for the synthesis of silver nanoparticles synthesis for five different mM concentration (1 mM – 5 mM). Morphological and chemical characteristics of the highest yield synthesized AgNPs. The synthesized nanoparticles were characterized using, UV spectrum analysis, and Fourier transform infrared spectroscopy (FT-IR) analysis were done. Color change from yellow to brown, and 400 nm surface plasmon resonance (SPR) peak after were obtained. FT-IR showed 12 peaks with some functional groups contributing to the synthesis of Ag nanoparticle. XRD was done to determine the crystalline nature of AgNPs and the resulted peaks were found at (2θ) 15. 5^o ,23.2^o, 26.4^o. Other peaks at 2θ values in AgNPs pattern can be ascribed to the residues of the organic content of the plant extract. It was determined that AgNps have elemental (Ag) and spherical crystalline structure. The mean crystal size was calculated at prominent peak (15.5^o) using the Debye-Scherrer equation i.e., 11.237 A^o .

INTRODUCTION

Nanoparticles can be synthesized using various approaches including chemical, physical, and biological. Although chemical method of synthesis requires short period of time for synthesis of large quantity of nanoparticles, this method requires capping agents for size stabilization of the nanoparticles [8] Chemicals used for nanoparticles synthesis and stabilization are toxic and lead to non-ecofriendly by products. The need for environmental non-toxic synthetic protocols for nanoparticles synthesis leads to the developing interest in biological approaches which are free from the use of toxic chemicals for the process/synthesis [13]. Thus, there is an increasing demand for "green nanotechnology" [23]. Many biological approaches for both extracellular and intracellular nanoparticles synthesis have been reported till date using microorganisms including bacteria, fungi and plants [5]. Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as

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well as provide natural capping agents. Moreover, use of plant extracts also reduces the cost of microorganism isolation and culture media enhancing the cost competitive feasibility over nanoparticles synthesis by microorganisms [8]. Metal nanoparticles have a high specific surface area and a high fraction of surface atoms. Because of the unique physicochemical characteristics of nanoparticles, including catalytic activity, optical 2 properties, electronic properties, antiantibacterial properties, and magnetic properties [20]. They are gaining the interest of scientist for their novel methods of synthesis. Over the past few years, the synthesis of metal nanoparticles is an important topic of research in modern material science[1]. Nano-crystalline silver particles have been found tremendous applications in the fields of high sensitivity biomolecular detection, diagnostics, antimicrobials, therapeutics, catalysis and micro-electronics [18]. However, there is still need for economic commercially viable as well as environmentally clean synthesis route to synthesize the silver nanoparticles. Silver is well known for possessing an inhibitory effect toward many bacterial strains and microorganisms commonly present in medical and industrial processes [7]. In medicines, silver and silver nanoparticles have an ample application including skin ointments and creams containing silver to prevent infection of burns and open wounds, medical devices and implants prepared with silver-impregnated polymers. In textile industry, silver embedded fabrics are now used in sporting equipment [6].

Nanoparticles are the fundamental components of Nano technology [32]. Nano technology is the science of the small; the very small. It is the use and manipulation of matter at a tiny scale. At this size, atoms and molecules work differently, and provide a variety of interesting and surprising uses [17]. The prefix “nano” drives from the Greek word “nanos”, which means dwarf and was defined by the Los Alamos National laboratory as the creation of functional materials devices and systems through the control of matter on nanometer (1 - 100 nm) length scale and the exploitation of real properties and phenomena developed at the scale[10]. A nanometer is one billionth of a meter in length and depending on the size of the atom between three and six atoms will fit inside nanometer (nm) [29]. Nanoparticles are often in the range 1 -100 nm, and this is the size as that of human proteins which have attracted much attention in biology and biochemistry[9]. Nanoparticles possess a very high surface to volume ratio which can be utilized in areas where high surface areas are critical for success. Mainly in catalytic industry; some nanoparticles actually have proven to be good catalyst. And some of them also show bactericidal effects [13].

Synthesis of Nanoparticles

The nanoparticles are synthesized by various methods that are categorized into Physical and chemical method as well as biological method.

MATERIALS AND METHODS

Equipments

Ultraviolet-Visible spectroscopy (T80+UV/VIS Spectrometer), Centrifuge (Model 800D), Drawell

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Digital Analytical Balance (Model FA 1004N), Portal Stainless Steel Autoclave (Model WT 280A), Electrothermal Incubator (PCD-C6 (5) 000 Series) and Thermostat Oven (DHG- 9030A) 3.1.2 Chemicals Silver nitrate

Plant Material Collection

The plant material was obtained in Mulai ward, Jere LGA, Borno State.

Method

Preparation of Leaf Extract

Aqueous leave extracts were prepared by the following procedure: fresh leaves of Azadirachta indica was collected and washed with tap water at first, and then the surface was washed under running water with distilled water until no impurities remained [15]. Then, the fresh leaves were dried in room temperature under shade in an open air for five days [4]. Then 50 g of coarse powder was crushed by using grinder and 10g was weighed and put into a beaker with 100 ml of distilled water [19]. Then the mixture was heated for 20 minutes at 60°C while stirring occasionally and then allowed to cool at room temperature. The mixture was then filtered using the Whatman no:1 filter paper. The extract was stored in the refrigerator for further use and synthesized Ag nanoparticles from the $AgNO_3$ precursor solution [12].

Biological Synthesis of Ag Nanoparticles

$AgNO_3$ powder was dissolved in distilled water to prepare a 10 mM $AgNO_3$ stock solution from which a series of 1 mM, 2 mM, 3 mM, 4 mM, and 5 mM $AgNO_3$ solutions were prepared [27]. The $AgNO_3$ solutions were mixed with the aqueous extract of Azadirachta indica fresh leaves at a ratio of 1:1 (v/v) to a volume of 50mL in a flask [28]. The flask was wrapped with an aluminum foil and was then heated in a water bath at 60°C for 1 hour. After different time intervals, the color change of reaction mixture is observed from transparent yellow to dark brown indicates that the formation of AgNPs and then finally silver nanoparticles were prepared. Further analyzed by using UV - Vis spectrophotometer. Furthermore, the mixture was stored in the refrigerator for characterization [26].

Separation of AgNPs

The separation of AgNPs was done by Centrifugation technique which is mostly used by researchers to obtain the pellet or powder form of synthesized silver nanoparticles. The AgNPs suspensions was also been oven dried to obtain the product in powder form and quantify the AgNPs [24].

Characterization of Silver Nanoparticles

The creation of AgNPs was examined by Ultraviolet–Visible absorbance. Absorbance for produced AgNPs is in the range of 201 to 801 on Ultraviolet-Visible spectroscopy (T80+UV/VIS Spectrometer) [33]. UV-visible absorption spectroscopy: Absorbance spectroscopy is used to determine the optical properties of a solution. A Light is sent through the sample solution and the amount of absorbed light is measured. When the wavelength is varied and the absorbance is measured at each wavelength. The absorbance can be used to measure the concentration of a solution by using Beer Lamberts Law. The optical measurement of UV-visible spectrophotometer has different absorbance peak like 410 nm [16]. Fourier transform

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infrared spectroscopy (FT-IR) FT-IR was used to identify the types of chemical bonds and determine the chemical functional groups present in the silver nanoparticle. The dried and powdered silver nanoparticle was placed in the FT-IR, then the FT-IR spectrum was recorded [30]

RESULTS AND DISCUSSION

AgNPs yield Twenty-five (25) different results of AgNPs have been obtained via biological process (Green Synthesis method) [31]. The $AgNO_3$ solution was mixed with the aqueous extract of fresh leaves at a ratio of 1:1 (v/v) to a volume of 50 mL in a flask. Table 4.1 shows the various amount obtained at five (5) different concentration (1 mM, 2 mM, 3 mM, 4 mM, and 5 mM) of the metal precursor ($AgNO_3$), by the procedure of [26] which was done in India, Manonmaniam Sundaranar University, Alkwarkurichi – 62741, India. which produces twenty-five (25) different results which increases with an increase in mM concentration of the AgN_{O3} at the same leave extract concentration of each sample [21].

Table 1. Mass in grams (g/50ml) of AgNPs.

Samples	1mM	2mM	3mM	4mM	5mM
A	0.04	0.12	0.14	0.14	0.19
B	0.12	0.13	0.12	0.12	0.13
C	0.14	0.14	0.12	0.14	0.14
D	0.14	0.19	0.17	0.23	0.19
E	0.17	0.23	0.21	0.22	0.22

Sample E shows the highest yield of AgNPs produced at most varied concentration and sample B is the least. [25] reported the synthesis of AgNPs by biological entities is due to the presence of large number of organic chemicals like carbohydrate, fat, proteins, enzymes & coenzymes, phenols flavonoids, terpenoids, alkaloids, gum, etc. capable of donating electron for the reduction of Ag^+ ions to Ag0. The active ingredient responsible for reduction of Ag^+ ions varies depending upon organism/extract used.

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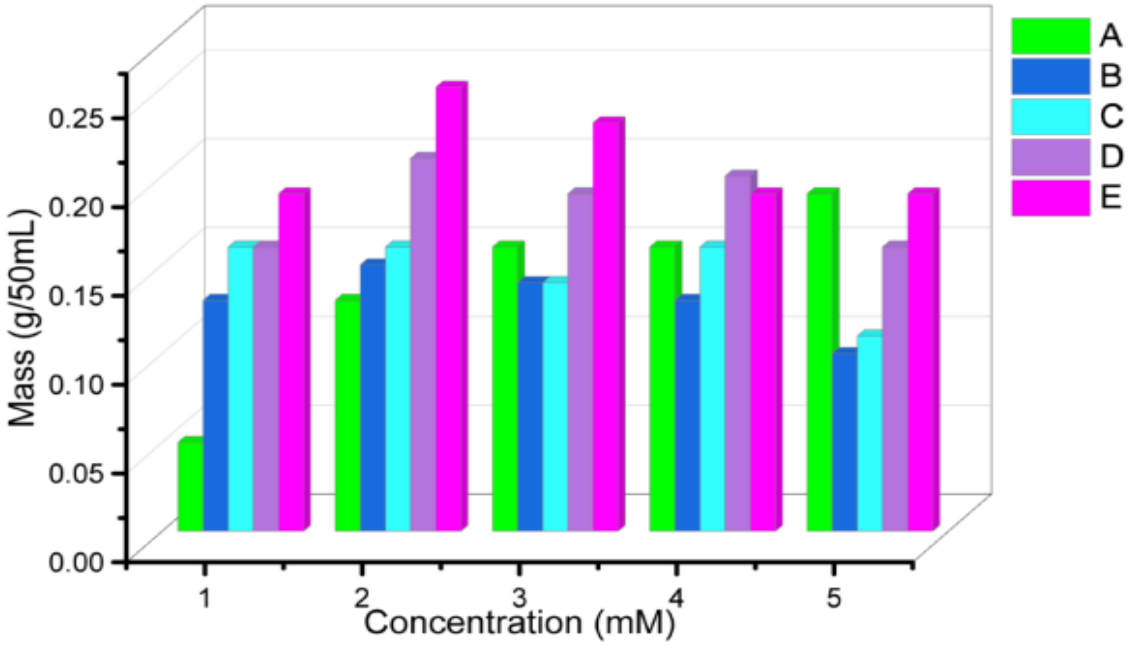

Figure .1: silver nanoparticles (AgNps) bar chart.

Characterization of AgNPs

The first qualitative indicator for the synthesis of AgNPs is the color-change of the solution from yellow to brown [2]. There are many techniques employed for characterization of nanoparticles, based on their size, shape, morphology, surface area, optical activity, thermal stability and dispersity. These techniques include UV-Visible spectrophotometry, Fourier Transform Infrared Spectroscopy (FT-IR), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray analysis (EDX), X-Ray Diffraction analysis (XRD) e.t.c.

Ultraviolet spectroscopy

Figure 2 illustrates the UV spectroscopy of prepared silver nanoparticle. An absorption peak was observed between 400 nm – 500 nm, the peak at 400 nm wavelength range indicating the reduction of silver nitrate. [19] evaluated the synthesis of silver nanoparticle by Aspergillus sp. and obtained similar result during the UV spectrum analysis showing plasmon resonance at 400 nm. The UV spectra clearly demonstrate the increase in silver nitrate solution intensity with time, which indicates the production of more silver nanoparticles in the solution [3]. At 24 hrs the UV spectrum analysis showed no peak, it declined due to the slow production of the nanoparticle. Compared to the result of the UV analysis recorded after 48 hrs a peak could be observed indicating the gradual formation of the silver nanoparticle [34]

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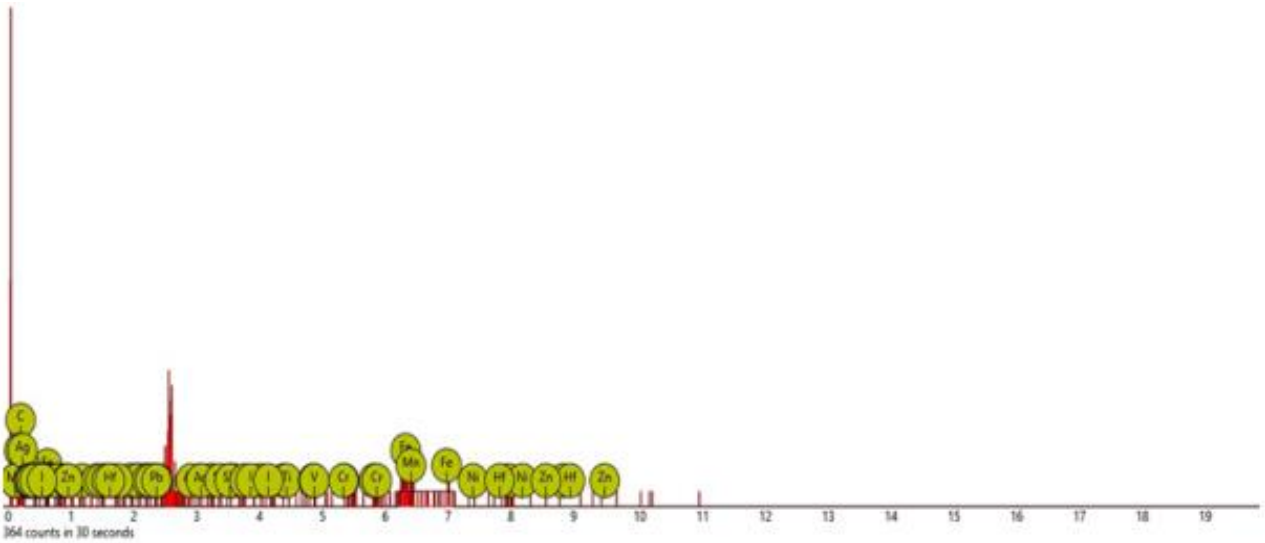

Fig 2. Fourier Transform Infrared Spectroscopy (FT-IR)

FT-IR technique is used to investigate and identify the functional groups (such as ketones, ammines, and aldehydes) of both plant extracts and AgNPs. The spectra of synthesized AgNPs using Neem Three leaf extract (figure 2.) showed absorption bands above 3331 cm-1 attributed to the presence at corresponding wavenumber (3300 cm-1 – 3500 cm-1) of N-H or OH of phytochemicals on the surface of Nanoparticles. The peak 1582 cm-1 which is around 1637 cm-1 shows the presence of C=O stretching vibration of carboxylic acid or esters. Absorption bands at 2113 cm-1 , 2173 cm-1 and 2084 cm-1 are due to C-H triple bond (alkynes) stretching vibration. The peak at 1480 cm-1 is due to the C-H bending vibration of alkanes. peak at 1089 cm-1 is due to the C-N stretching vibration of amines or amides. The peak at 1007 cm-1 is due to the C-H bending vibration of aromatic rings. [14] reported the medium bands at ca 1500 and 1380 cm-1 are attributed to -C=C- stretching mode and C-N stretching vibrations of aromatic amines respectively. bands at 1050 cm-1 and 850-900 cm-1 are due to C-OH stretching of alcohols and C-O-C vibrations respectively. The peak at 2926.29 cm−1 indicates an alkane C-H stretching vibration. The peak at 1728.45 cm−1 indicates the strong aldehyde C=O stretching (Chan and Don 2013). Therefore, FTIR analysis of the synthesized AgNPs using both neem and bitter leaves extracts respectively showed that these functional groups from the aqueous extracts of neem and bitter leaf were responsible for the reduction Ag+ to Ago , the AgNPs synthesis and stabilization, and are present on the surface of the synthesized nanoparticles. This identifies the peaks in the differential pattern, using this will help to determine the crystal structure and composition. The XRD pattern of synthesized AgNPs using Azadirachta indica leaf extract was shown in Fig 3.

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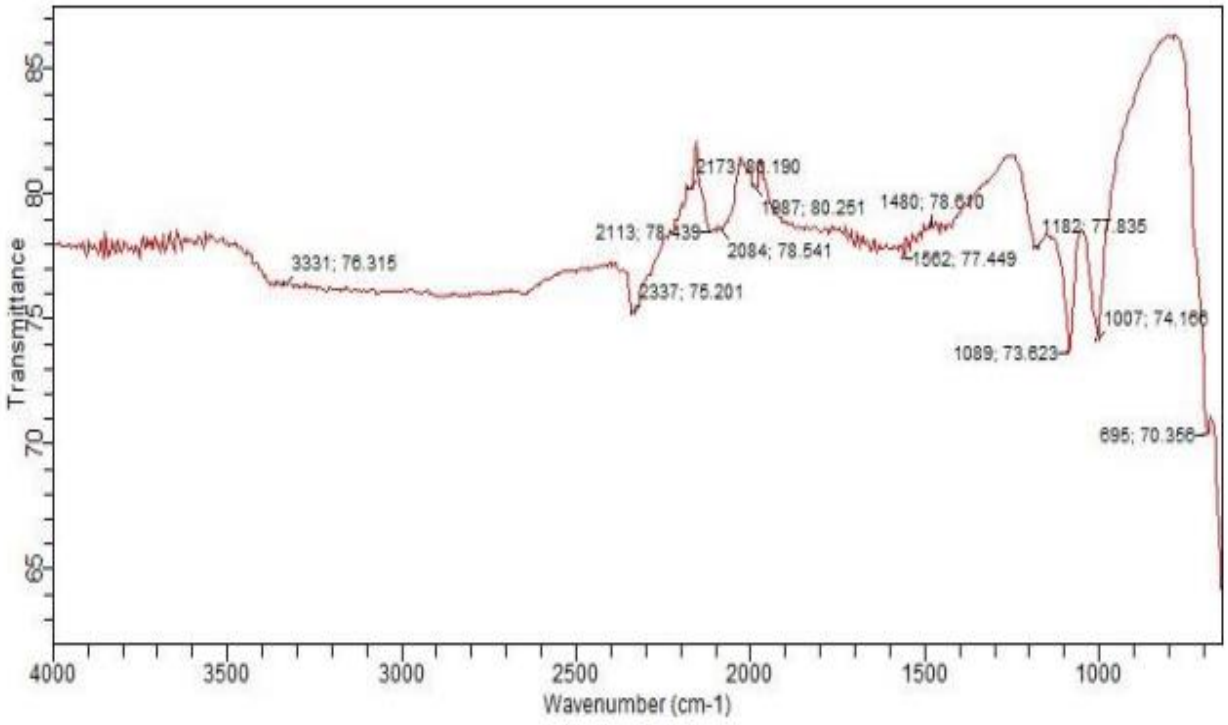

Figure 3. X-Ray Diffraction (XRD) Analysis

The XRD was done to determine the crystalline nature of AgNPs and the resulted peaks were found at (2θ) 15.5^{o} , 23.2^{o} , 26.4^{o} . Other peaks at 2θ values in Ag NPs pattern can be ascribed to the residues of the organic content of the plant extract. It was determined that AgNps have elemental (Ag^{o}) and spherical crystalline structure. The mean crystal size was calculated shown in the Table 2 at prominent peak using the Debye-Scherrer equation [11]: D = Kλ / (β cosθ) (Eq. 4.1). In the equation, D is particle size (nm), K is constant (0.90), λ is wavelength X-ray (1.5406 oA), β is full width at half maxima angle of the highest peak value (FWHM) and θ is the refractive angle. The inter planer space was calculated using bragg's equation (Nakamura *et al*., 2019). $d = \lambda/2sin\theta$ (4.2). The corresponding (hkl) values were obtained from Miller indices (ChemLibertext).

Table 2: A brief summary of silver nanoparticles obtain from XRD results.

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sample	Peak position (2θ)	d space (A°)	FWHM, (β) Degree	Corresponding (hkl) values	Crystalline Size (D) (A°)
1	15.5	6.20	0.13	(111)	11.237
2	23.2	3.86	0.19	(200)	7.782
3	26.4	3.45	0.17	(220)	8.743

CONCLUSION

The biological synthesis of AgNps from Azadirachta indica leaf extract was successful with five (5) different leaf extract collected from various neem trees from Mulai ward, Jere LGA, Borno state. The AgNPs yield varied at each different mM concentration of the metal precursor (AgNO3). The SEM analyses showed that the AgNps produced were spherical and in the range of 20 nm-100 nm with a capping material around it. The EDX presented a strongest signal from Silver (Ag) region and weaker signals from Cl, C and Na atoms. The FTIR spectra showed a peak of carbonyl group (C=O) bonds stretching vibration which confirms the presence of capping ligand which are the proteins available in neem leaf extract around the synthesized nanoparticles. The SEM result of the AgNPs showed is irregular in shape, with some appearing larger and others smaller, indicating a range in size. The average diameter of the AgNPs was found to be 206.4 nm from neem leaf extract.

REFERENCES

1. Amica, P., Ashish K. M., Mahesh D., Narendra K. P., Sachin K. S., and Bimlesh K. (2021). Silver Nanoparticles – A Review. European Journal of Medicine and Oncology, 5(2):95–102.

2. Alaalah (2020). Comprehensive Review of Structural Components of Salvia hispanica and Its Biological Applications. International Journal of Biochemistry, Biophysics and Molecular Biology, 5(1):1-7.

3. Chan, Y.S and Don M.M. (2013). Biosynthesis and structural characterization of Ag nanoparticles from white-rot fungi. Materials Science and Engineering, 33, 1-7

4. Chaguthi, P., Mittal A., Singh S., Baghel D.S. (2018). An overview on therapeutic potential of Azadirachta indica. Physicochemical properties and perspectives. Journal of Advanced Research, 4(2):5-12.

5. Chauhan, A., Anand, J., Parkash, V., and Rai, N. (2022). Biogenic synthesis: A sustainable approach for nanoparticles synthesis mediated by fungi. Inorg. Nano-Metal Chemistry, 3(4):1-14.

6. Djibril, D., Mamadou F., Gérard V., Geuye M.D.C., Oumar S., Luc R. (2015). Physical characteristics, chemical composition and distribution of constituents of the neem seeds (Azadirachta indica A. Juss) collected in Senegal. Research Journal Chemical Science, 3(1):606-612.

7. Dudhagara, P., Alagiya J., Bhagat, C., Dudhagara D., Ghelani A., Desai J., Patel R., Vansia A., Nhiem D.N., and Chen Y. (2022). Biogenic synthesis of antibacterial, hemocompatible, and antiplatelets lysozyme functionalized silver nanoparticles through the one-step process for therapeutic applications. Processes, 10(623):3-9.

ISSN 0795 - 22066

8. Gattu, S., Yih-Yuan C., Neelamegam R., Muthukalingan K., Kayalvizhi N., and Douglas J. H. S. (2022). Biologically Synthesized Silver Nanoparticles and Their Diverse Applications. Nanomaterials, 12(3126):2-20.

9. Gong, C.P., Li, S.C., and Wang, R.Y. (2018). Development of biosynthesized silver nanoparticles based formulation for treating wounds during nursing care in hospitals. Journal of Photochemical and Photobiology, 183(3): 137–141.

10. Khalil, M.A., El Maghraby, G.M., Sonbol, F.I., Allam, N.G., Ateya, P.S., and Ali, S.S. (2021). Enhanced Efficacy of Some Antibiotics in Presence of Silver Nanoparticles Against Multidrug Resistant Pseudomonas Aeruginosa Recovered from Burn Wound Infections. Front. Microbiology, 12(2): 64-85.

11. Khan, F. A., Zahoor, M., Jalal, A., Rahman, A. U. (2016): Green synthesis of silver nanoparticles by using Ziziphus nummularia leaves aqueous extract and their biological activities. – Journal of Nanomaterials 21, Article ID: 8026843.

12. Marslin, G., Siram K., and Maqbool Q. (2018) Secondary metabolitesin the green synthesis of metallic nanoparticles. Materials, 11(6):940-946.

13. Moses, E., Thliza, B.A., and Shanu, B.U. (2020). Nanotechnical production and optimization of Biofuel (Biodiesel) from an Edible Seed Oil (Palm-Olein). Annual Research & Review in Biology, 35(5) 20-31.

14. Nilesh, P., Rajveer B., Vishal V., Rahul D., Vaishnavi K., and Yogesh P. (2021). Overview on Methods of Synthesis of Nanoparticles. International Journal of Current Pharmaceutical Research, 13(2):11-16.

15. Phanjom, P., Zoremi, E., Mazumder, J., Saha, M., Baruah, S. B. (2012): Green synthesis of silver nanoparticles using leaf extract of Myrica esculenta. – Int J NanoSci Nanotechnol 3: 73-79 Rajagopal, K. (2020). Activity of phytochemical constituents of Curcuma longa (turmeric) and Andrographis paniculata against coronavirus (COVID-19): an in silico approach. Future journal of pharmaceutical sciences, 6(1):1-10.

16. Rakib-Uz-Zaman, S.M., Ehsanul, H. A., Mohammed, N. M., Sadrina Afrin M., Mst Gitika K., Shah S.J., Nahid A., Azizur M., Khan., Shuborna N,S,, Shahriar M.S., and Kashmery K. (2022). Biosynthesis of Silver Nanoparticles from Cymbopogon citratus Leaf Extract andEvaluation of Their Antimicrobial Properties. Challenges, 13(18):2-17.

17. Ranjit, K., and Baquee, A.A. (2013). Nanoparticles: an overview of preparation, characterization and application. International Research Journal of Pharmacy, 4(4), 47-57.

18. Sampath, G., Govarthanan, M., Rameshkumar, N., Krishnan M., Sivasankar P., and Kayalvizhi, N. (2021). Eco-friendly biosynthesis metallic silver nanoparticles using Aegle marmelos (Indian bael) and its clinical and environmental applications. Applied Nanoscience, 3(2):1 12

19. Sasidharan, D., Namitha T.R., Johnson S.P., Jose V., and Mathew P. (2020). Synthesis of silver and copper oxide nanoparticles using Myristica fragrans fruit extract: Antimicrobial and catalytic applications. Sustain. Journal of Chemical and Pharmaceutical Sciences, 16(3):10-25.

20. Shahzad, S. M., and Hassan, S.M. (2022). Comparative Study of AgO Nanoparticles Synthesize Via Biological, Chemical and Physical Methods: A Review. American Journal of Materials Synthesis and Processing, 7(2):15-28. 48

21. Shrirangasami, S.R., Murugaragavan, R., Rakesh, S.S., Ramesh, P.T. (2020). Chemistry behind in neem (Azadirachta indica) as medicinal value to living forms-A review. Journal of Pharmacognosy and Phytochemistry, 9(2): 467-469.

ISSN 0795 - 22066

22. Singh, M. K. and Mehata, M.S. (2020). Enhanced photoinduced catalytic activity of transition metal ions incorporated TiO2 nanoparticles for degradation of organic dye: Absorption and photoluminescence spectroscopy. Optical Materials, 109(3):11-30.

23. Souza, A.O., Oliveira, J.W.D.F., Moreno C.J.G., de Medeiros M.J.C., Fernandes-Negreiros, M.M., Souza F.R.M., Pontes D.L., Silva M.S., Rocha H.A.O. (2022). Silver nanoparticles containing fucoidan synthesized by green method have anti-Trypanosoma cruzi activity. Nanomaterials, 12(4):20-59.

24. Srikar, S.K., Deen, D.G., Dan, B. P., Pradeep, K. M., and Siddh, N. U. (2016). Green Synthesis of Silver Nanoparticles: A Review. Green and Sustainable Chemistry, 6(2):34-56.

25. Sutharsingh, R., Kavimani, S., Jayakar, B., Varani, M., Thangathirupathi, A. (2011). Quantitative Phytochemical Estimation and Antioxidant Studies On Aerial Parts of Naravelia Zeylanica Dc. International Journal of Pharmaceutical Studies and Research. 2(2): 52-56

26. Swetha, V., Lavanya, S., Sabeena, G., Pushpalaksmi, E., Jenson, S. J., and Annadurai, G. (2020). Synthesis and Characterization of Silver Nanoparticles from Ashyranthus aspera Extract for Antimicrobial Activity Studies. Journal of Applied Science and Environmental Management, 24(7):1161-1167.

27. Swamy, M. K., Akhtar, M. S., Mohanty, S. K., Sinniah, U. R. (2015): Synthesis and characterization of silver nanoparticles using fruit extract of Momordica cymbalaria and assessment of their in vitro antimicrobial, antioxidant and cytotoxicity activities. – Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 151: 939-944

28. Thomas, R., Mathew, S., Nayana, A.R., Mathews, J., and Radhakrishnan, E.K. (2018). Microbially and phytofabricated Ag NPs with different mode of bactericidal action were 49 identified to have comparable potential for surface fabrication of central venous catheters to combat Staphylococcus aureus biofilm. Journal of Photochemical and Photobiology, 171(12):96–103.

29. Uzzaman, S. (2020). Pharmacological activities of neem (Azadirachta indica): A review. International Journal of Pharmacognosy Life Science, 3(1):38-41.

30. Vahabi, K. and Sedigheh, K. D. (2017). Biosynthesis of Nanoparticles by Fungi: Large-Scale Production. Springer, 12, 1-14.

31. Vanaja, M., Paulkumar, K., Baburaja, M., Rajeshkumar, S., Gnanajobitha, G., Malarkodi, C., Sivakavinesan, M., & Annadurai, G. (2014). Degradation of methylene blue using biologically synthesized silver nanoparticles. Bioinorganic Chemistry and Applications. http://dx.doi.org/10.1155/2014/742346.

32. Varma, M.M., Sunil K. T., and Srivalli, I.D. (2021). A Review on Nanoparticles: Synthesis, Characterization and Applications. World Journal of Pharmaceutical and Medical Research, 7(8): 169 – 179.

33. Veeraswamy, T. and Ankur, V. B. (2020). Characterization of Silver Nanoparticles Synthesized using Chemical Method and its Antibacterial Property. Biointerface Research in Applied Chemistry, 10(6):7257 – 7264.

34. Velan, R.P., Ayyasamya P.M., R. Kathiravanb , and B. Subashnic (2015). Rapid decolorization of synthetic melanoidin by bacterial extract and their mediated silver nanoparticles as support. Journal of Applied Biology & Biotechnology, 3(02):006-011

35. Yadav, D.K., Bharitkar, Y.P., Chatterjee, K., Ghosh, M., Mondal, N.B., Swarnakar, S. (2016). Importance of neem leaf: An insight into its role in combating diseases. World Journal of Pharmaceutical and Medical Research, 3(1):4-9.

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