JOURNAL OF CRITICAL REVIEWS

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

Silver Nanoparticles (Ag-Nps): Synthesis And Characterization

Thanusha Punugoti[1], Meena Vangalapati[2*]

[1]Department of Mechanical Engineering, AU College of Engineering, Andhra University, Vizag, India
[2*]Department of Chemical Engineering, AU College of Engineering, Andhra University, Vizag, IndIndia
E-mail: meenasekhar2002@yahoo.com

***Corresponding Author:** Meenavangalapati
*Department of Chemical Engineering, AU College of Engineering, Andhra University, Vizag, IndIndia
E-mail: meenasekhar2002@yahoo.com

Abstract
Biosynthesis of nanoparticles is popular due to its efficiency, eco-friendliness, and low toxicity. This study examined the effect of aqueous Nutmeg seed extract on silver nitrate bioreduction to AgNPs. Silver nanoparticles (AgNPs) are effective because of their antimicrobial, anti-inflammatory, and anti-proliferative properties. The goal of this study was to produce silver nanoparticles conjugated with a flavonoid called Kaempferol using nutmeg, a seed from the plant, and to study their antifungal properties. Seed extract was used to dissolve AgNPs in order to create *Myristica fragrans* AgNPs and was described using FTIR, EDAX, and SEM analysis. Nanoparticles produced by this method contained distinct functional groups, as demonstrated by FTIR spectroscopy and showed protein molecules in the extract may act as a reducing and capping agent. The SEM image shows homogeneous particles. EDAX analysis confirmed the presence of Silver and oxygen, as well as the fact that silver had been oxidised. Myristica fragrans seed extract was tested for its antifungal properties using growth zone inhibition. The seed extract of *Myrsitica fragrans* has the best antifungal properties, according to the research. Antifungal AgNPs phyto-formulated with nutmeg extracts, according to these findings, could be used to treat fungal diseases

Keywords: *Myristicafragrans*; AgNP, SEM; FTIR; Antifungal activity; *Saccharomyces cerevisiae.*

Introduction

Nanotechnology has branches in chemical, pharmaceutical, mechanical, and food processing industries [1,2]. Nanotechnology is used in computers, power production, optoelectronics, drug delivery, and environmental science. Traditional nanoparticle synthesis methods require long-term processing, high prices, time-consuming procedures, and in some cases, hazardous compounds. Due to these restrictions, most relevant research focuses on developing environmentally friendly and time-efficient nanomaterial synthesis processes. Material scientists have prioritised eco-friendly nanomaterial synthesis in recent years. Nanobiotechnology has applications in biotechnology, chemistry, medicine, and material science [3,4]. Green NP synthesis, using plant extracts, is a growing trend in green chemistry because it's simple, economical, and non-toxic. Green nanoparticles offer physical, chemical, and bioactivity advantages over standard approaches.

High density and surface area give metal oxide nanoparticles unique chemical and physical properties. Developing eco-friendly metal nanoparticle production technologies requires non-toxic chemicals [5]. The use of environmentally friendly materials for the synthesis of metallic nanoparticles, such as plant leaf extract, bacteria, fungi, and enzymes, has many advantages in terms of eco-friendliness and compatibility for pharmaceutical and biomedical applications. Researchers are interested in silver nanoparticles' electric [6], optical [7], catalytic [8], antioxidant [9], antimicrobial [10], antibiofilm [11], antifungal[12], anti-inflammatory[13], and anti-viral[14] properties, as well as their anti-angiogenesis[15], larvicidal effects[16], and anticancer activities[17]. *Jujuba seeds* [18], *Oryzae sativa*, *Helianthus annus, and Zea mays* [19], *Jatropha curcas*[20], *Trianthema decandra roots*[21], *Ocimum sanctum stems and roots*[22], *Banana peel*[23], *Acacialeucophloea*[24], *Ficussycomorus*[25], *Helianthustuberosus*[26], *and Azardictha indica*[27]

In tropical climates, *Myristica fragrans* is grown as an evergreen shrub. Some call the seeds nutmeg and the arils mace. Nutmeg is a sweet and savoury spice. It's dried *Myristica fragrans* seed. It's antibacterial, antifungal, antiinflammatory, antioxidant, anticarcinogenic, and antidiarrheal. Camphene, elemicin, eugenol, isoelemicin, isoeugenol, methoxyeugenol, pinene, sabinene, safrol, myristic acid, and myristicin are chemicals in nutmeg extract that can act as reductants to form AgNPs[28]. This study investigated the bioactive potential of nutmeg components and tested biosynthesized AgNPs against Saccharomyces cerevisiae.

2.1. Plant material Collection

The dried, ripe seeds of *Myristica fragrans* (nutmeg) were purchased from a local source. The material was twice rinsed with double distilled water after being cleared of the flith and other foreign debris. Following the removal of the dirt and

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

other foreign objects, double-distilled water was used to rinse the equipment. To obtain a uniform size for the extraction of the active plant components, the dried plant material was ground using a mortar and pestle.

2.Chemicals

The chemicals utilised were all of the analytical variety. From Sigma-Aldrich, silver nitrate (AgNO3) was bought. Throughout the tests, deionized water was used.

2.3. Nutmeg seed extract preparation

100 ml of water were used to dissolve 8 g of dried nutmeg seed powder. The aqueous solution was then stirred at 95°C for one hour. After cooling, the solution was filtered through Whatmann No. 1 filter paper with a particle size of 25 microns. It was then centrifuged at 8000 rpm for 15 minutes. The Myristica fragrans seed extract used for the production of silver nanoparticles was the supernatant solution created after centrifugation.

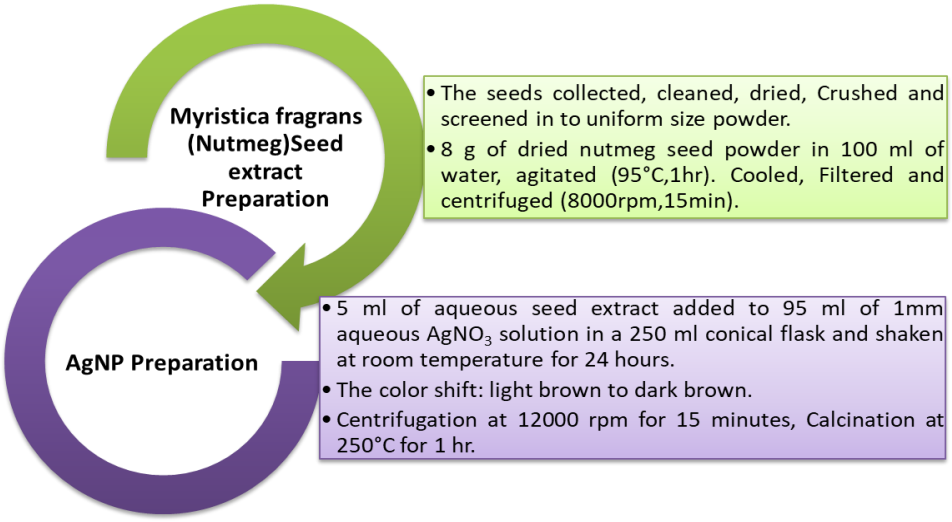

Fig.1: Schematic description of the Green synthesis process

2.4. Green synthesis and Characterization of AgNPs

For the biosynthesis of AgNPs, 95 ml of 1 mM aqueous AgNO3 solution and 5 ml of aqueous seed extract were combined in a 250 ml conical flask and agitated for 24 hours at room temperature. Silver nitrate was bioreduced to silver nanoparticles as evidenced by the change in colour from light brown to dark brown(Fig.2A&B) Centrifugation at 12000 rpm for 15 minutes was used to collect the AgNPs. The pellet was collected and then given two washes in double-distilled water. The produced AgNPs underwent a 1-hour calcination process at 250 °C.

A.Without Silver nitrate B.With Silver nitrate

Fig.2. Color change of Myristica fragrans seed extract from yellow to brown(A&B)

2.5 Characterization of AgNP:

A physical alteration in hue will make the bioreduction of Ag+ ions in solution visible. The functional groups that were present in the sample could be identified and recorded using a Bruker FT-IR spectrophotometer with a resolution of 2 cm-1 extending from 4000 to 400 cm-1. Studies using scanning electron microscopy will show the size and shape of the

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

produced nanoparticles. The elemental makeup of the produced AgNPs is ascertained by an energy dispersive X-ray analysis, or EDAX. The investigation's purpose called for the use of a Carl Zeiss FE-SEM.

3. RESULTS AND DISCUSSION:

3.1 Characerization of AgNP:

By examining the colour changes brought on by the reduction of silver ions into silver particles, the production of AgNPs is proven. After the seed extract was added to the AgNO3 solution, a paler brown hue was noticed, and after 24 hours, the color's intensity increased to a darker brown. AgNPs are being formed when a dark brown colour appears in the reaction mixture; this is caused by the surface plasmon vibration being excited during the synthesis process. The silver nanoparticles' SEM picture was captured and is displayed in Fig. 3. (a,b). The SEM image demonstrates unequivocally that the particles are present in a homogenous state, and that the homogeneity of nanoparticles is crucial to the various functions they perform. EDAX analysis was used to examine the nanoparticles, and the results showed that elemental silver was present. The silver components are associated to the peaks around 3 keV. (Fig.3c). The outcomes agree with earlier research[28]. FTIR analyses of the created silver nanoparticles were conducted (Fig. 3(d)) to learn more about potential interactions between proteins and silver nanoparticles. The peaks at 2819cm-1 are due to phenols' OH stretching vibrations. The peaks corresponding to wavenumbers 2748, 1647, and 1345cm-1 show evidence of C-H stretching. The 1647 cm-1 peak further supports the existence of aldehyde groups in the methanolic extract of Myristica fragrans, which are in charge of capping and stabilising the green-produced silver nanoparticles. Functional groups like alkene, carbonyl, and amine are confirmed by the spectrum[29,30].

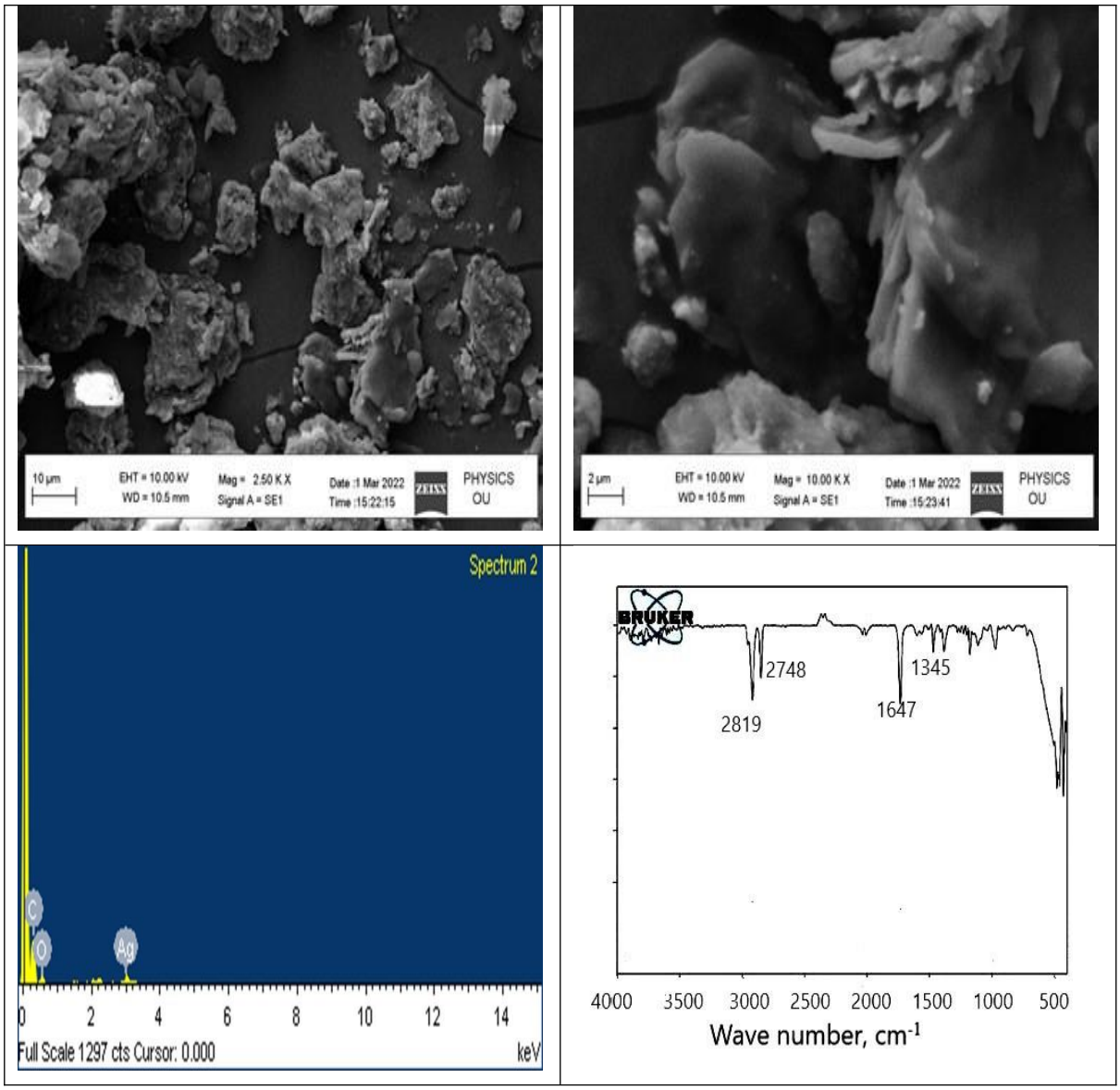

Fig.3: a) b) SEM images c) EDAX analysis d) FTIR graph of AgNP

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

3.2. Optimization results of physicochemical parameters for the batch extraction process.

3.2.1. Effect of different solvent percentages on the extraction of Kaempferol:

Mixtures of methanol with different proportions of water have shown to be more effective in extracting phenolic compounds compared to mono-component solvent systems. The addition of a small quantity of water to organic solvent usually leads to a more polar medium, which facilitates the polyphenols extraction. The dried *Myristica fragans*(nutmeg)seed powder was extracted with various percentages of the methanol (20%,40%,60%,80%,100%) were checked for the maximum extraction yield of Kaempferol and the results are shown in Fig 4.

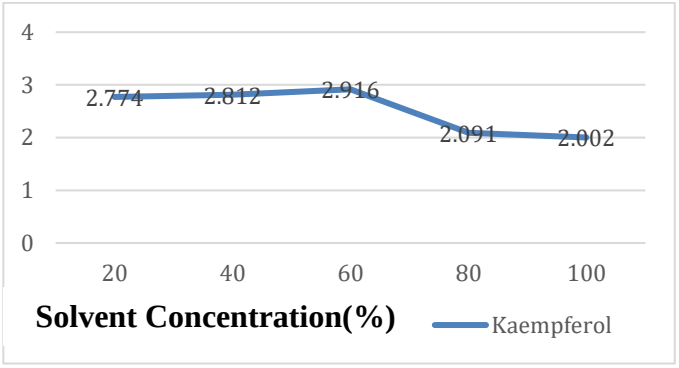

Fig .4 Concentration of Kaempferol vs Solvent percentage(%)

The results showed the maximum concentration of Kaempferol of 2.916 µg/ml was observed at 60% methanol.

3.2.2. Effect of soaking time on the extraction of* Kaempferol*:

Soaking time represents another key parameter in optimizing Kaempferol extraction. The nutmeg seed powder was soaked in the 60% methanol for different periods like 30 min,60 min,90 min,120 min,160 min, and observed the extraction result as shown in Fig 5.

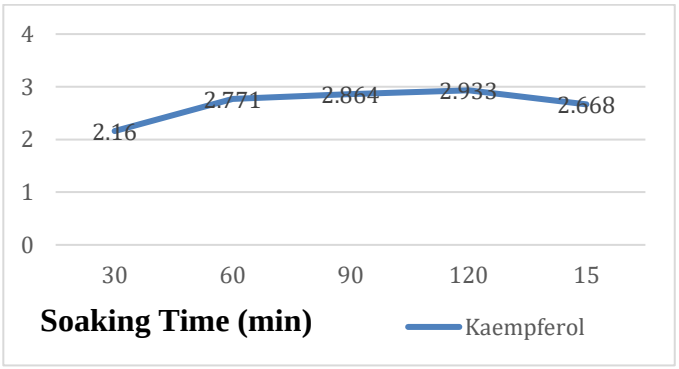

Fig 5. Concentration of Kaempferol vs Extraction Time(min)

Extraction time beyond 120 minutes induced loss of Kaempferol content. The more the extraction time is, the lesser the content of polyphenol obtained. This could be the result of loss of phenolic compounds, via oxidation, which might polymerize into insoluble compounds.

The results showed higher concentration of Kaempferol of 2.933 µg/ml was observed at 120 minutes of incubation of nutmeg seed powder in 60% methanol.

3.2.3. Effect of pH on the extraction of* Kaempferol*:

The extraction yield of components was observed at different pH values namely 5,6,7,8,9 and 10 were used. Results are shown in Fig 6.

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

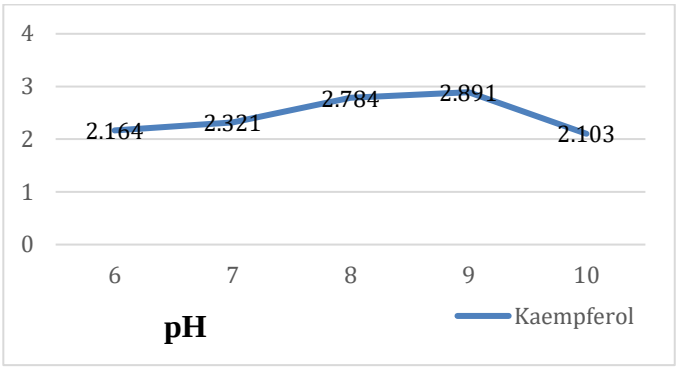

Fig 6. Concentration of Kaempferol vs pH

The results showed the maximum concentrations of Kaempferol 2.891 µg/ml, was obtained at pH-9 using 60% methanol as a solvent for 90 minutes.

3.2.4.Effect of Temperature on the extraction of Kaempferol:

The effectiveness of the extraction process of phenolic compounds are largely regulated by different parameters and mainly by the extraction temperature. Extraction at different temperatures such as 32℃,34℃,36℃,38℃were used to extract the optimum yield of Kaempferol. The results were shown in Fig 7.

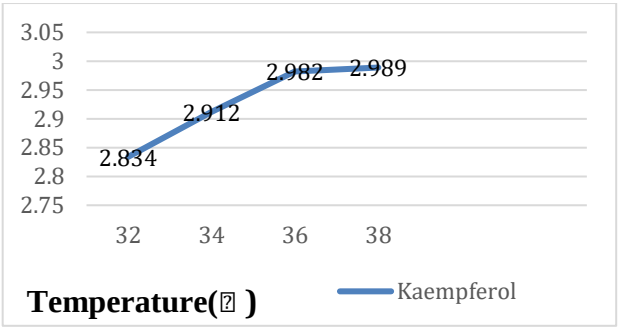

Fig 7. Concentration of Kaempferol vs Extraction Temperature

The results showed the maximum concentrations of Kaempferol 2.989 µg/ml, was obtained at 38℃ temperature and pH-9 using 60% methanol as a solvent for 90 minutes

3.3 Antifungal activity Analysis:

The antifungal effects of *Myristica fragrans* seed extract on a yeast strain called *Saccharomyces cerevisiae*. Using a well-difusion process, we determined the antimicrobial properties of synthesized Silver nanoparticles against *Saccharomyces cerevisiae* (Fig.8). One of the positive control for the experiment was Gentamicin. A ZOI of 2.12 0.047 cm was found. The plate was then kept at 30°C for 48 hours of incubation. AgNPs synthesized with *Myristica fragrans* (nutmeg) had Zone of Inhibition (ZOIs) of 1.06 0.072 cm against yeast strain. The Zone of Inhibition was determined as the lowest extract concentration that, when compared to control, resulted in an 80% reduction in discernible growth, as well as when the mic value was 100 g/ml or less. With an increase in seed extract concentration (mg/ml), the extracts' antifungal properties grew. The methanolic extract of *Myristica fragrans* was found to be ineffective against the test bacteria. The outcomes demonstrated that *Saccharomyces cerevisiae* is sensitive to these silver nanoparticles potent dose-dependent antifungal activity.

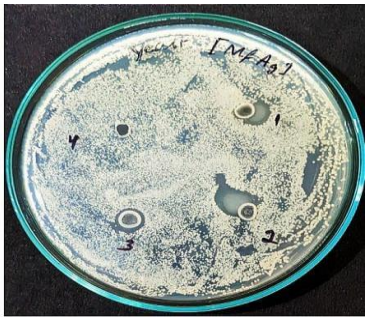

Fig.8: Zone of inhibition of *Myristica fragrans* AgNPs against *Saccharomyces cerevisiae.*

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

4. Conclusion:

Silver nanoparticles (AgNPs) are effective because of their antimicrobial, anti-inflammatory, and anti-proliferative properties. The goal of this study was to produce silver nanoparticles conjugated with a flavonoid called Kaempferol using nutmeg, a seed from the *Myristica fragrans* plant, and to study their antifungal properties. Seed extract was used to dissolve AgNPs in order to create *Myristica fragrans* AgNPs and was described using FTIR, EDAX, and SEM analysis. The diameters of these AgNPs are homogenous, according to SEM analysis. EDAX analysis confirmed the presence of Silver and oxygen, as well as the fact that silver had been oxidised. Nanoparticles produced by this method contained distinct functional groups, as demonstrated by FTIR spectroscopy. *Myristica fragrans* seed extract was tested for its antifungal properties using growth zone inhibition. The seed extract of *Myrsitica fragrans* has the best antifungal properties, according to the research. Antifungal AgNPs phyto-formulated with nutmeg extracts, according to these findings, could be used to treat fungal diseases. This method can therefore be used for the quick, affordable, and environmentally friendly green synthesis of silver nanoparticles for use in industry and medicine.

References

1. Raveendran P, Fu J, Wallen SL. Completely "green" synthesis and stabilization of metal nanoparticles. J Am Chem Soc. 2003 Nov 19;125(46):13940-1. DOI: 10.1021/ja029267j. PMID: 14611213.
2. Bhattacharya R, Mukherjee P. Biological properties of "naked" metal nanoparticles. Adv Drug Deliv Rev. 2008 Aug 17;60(11):1289-1306. DOI: 10.1016/j.addr.2008.03.013. Epub 2008 Apr 10. PMID: 18501989.
3. Ahn, EY., Jin, H. & Park, Y. Green synthesis and biological activities of silver nanoparticles prepared by Carpesium cernuum extract. Arch. Pharm. Res. 42**,** 926–934 (2019).
4. Balakrishnan, S., Sivaji, I., Kandasamy, S. et al. Biosynthesis of silver nanoparticles using Myristica fragrans seed (nutmeg) extract and its antibacterial activity against multidrug- resistant (MDR) Salmonella enterica serovar Typhi isolates. Environ Sci Pollut Res **24,** 14758–14769 (2017).
5. Huang H, Yang Y (2008) Preparation of silver nanoparticles in inorganic clay suspensions. Compos Sci Technol 68:2948–2953
6. Tricoli A, Pratsinis SE. Dispersed nanoelectrode devices. Nat Nanotechnol. 2010 Jan;5(1):54-60.
7. Jin R, Cao YC, Hao E, Metraux GS, Schatz GC, Mirkin CA (2003) Controlling anisotropic nanoparticle growth through plasmon excitation. Nature 425(6957):487–490.
8. Severin N, Kirstein S, Sokolov IM, Rabe JP (2009) Rapid trench channeling of graphenes with catalytic silver nanoparticles. Nano Lett 9(1): 457–461
9. Vidya V, Daizy P, Joseph M (2016) Essential oil mediated synthesis of silver nanocrystals for environmental, anti-microbial, and antioxidant applications. Mater Sci Eng C 61:429–43
10. Sivalingam P, Antony JJ, Siva D, Achiraman S, Anbarasu K (2012) Mangrove Streptomyces sp. BDUKAS10 as a nano factory for fabrication of bactericidal silver nanoparticles. Colloid Surf B 98: 12–17
11. Murugan K, Selvanayaki K, Kalyanasundaram VB, Al-Sohaibani S (2013) Nanotechnological approach for exploring the antibiofilm a potential of an ethnomedicinal herb Andrographis paniculata for controlling lung infection causing Pseudomonas aeruginosa. Dig J Nanomater Bios 8(1):1117–1126
12. Chladek G, Mertas A, Barszczewska-Rybarek I (2011) Antifungal activity of denture soft lining material modified by silver nanoparticles- a pilot study. Int J Mol Sci 12(7):4735–4744
13. Martinez-Gutierrez F, Thi EP, Silverman JM, de Oliveira CC, Svensson SL, Vanden Hoek A, Sánchez EM, Reiner NE, Gaynor EC, Pryzdial EL (2012) Antibacterial activity, inflammatory response, coagulation, and cytotoxicity effects of silver nanoparticles. Nanomedicine 8(3):328–336
14. Mohammed Fayaz A, Ao Z, Girilal M, Chen L, Xiao X, Kalaichelvan PT, Yao X (2012) Inactivation of microbial infectiousness by silver nanoparticles-coated condom: a new approach to inhibit HIV and HSV-transmitted infection. Int J Nanomedicine 7:5007–5018
15. Kang K, Lim DH, Choi IH, Kang T, Lee K, Moon EY, Yang Y, Lee MS, Lim JS (2011) Vascular tube formation and angiogenesis induced by polyvinylpyrrolidone-coated silver nanoparticles. Toxicol Lett 205(3):227–234
16. Lallawmawma H, Sathishkumar G, Sarathbabu S, Ghatak S, Sivaramakrishnan S, Gurusubramanian G, Senthil Kumar N (2015) Synthesis of silver and gold nanoparticles using Jasminum nervosum leaf extract and its larvicidal activity against filarial and arboviral vector Culexquinquefasciatus Say (Diptera: Culicidae). Environ Sci Pollut ResDOI. doi:10.1007/s11356015-5001-x
17. Rathi Sre PR, Reka M, Poovazhagi R, Arul Kumar M, Murugesan K (2015) Antibacterial and cytotoxic effect of biologically synthesized silver nanoparticles using aqueous root extract of Erythrina Indica L. Spectrochim Acta Part A 135:1137–1144
18. M.C. Somasekhara Reddy, L. Sivaramakrishna, A. Varada Reddy, The use of agricultural waste material, jujube seeds for the removal of anionic dye (Congo red) from the aqueous medium, J. Hazard. Mater. 203-204 (2012)118-127.
19. A. Leela, M. Vivekanandan, Tapping the unexploited plant resources for the synthesis of silver nanoparticles, Afr. J. Biotechnol. 7 (2008) 3162–5315
20. O.J. Abayeh, E.A. Aina, C.O. Okuonghae, Oil content, and oil quality characteristics of some Nigerian oil seeds, Jour. Pure Appl. Sci. 1 (1998) 17-23.

ISSN-2394-5125 VOL 7, ISSUE 07, 2020

21. E. Geethalakshmi, D.V. Sarada, Synthesis of plant-mediated silver nanoparticles usingTrianthema decandra extract and evaluation of their anti-microbial activities, Int. J. Eng. Sci. Tech. 2 (2010) 970–975.
22. N. Ahmad, S. Sharma, M.K. Alam, V.N. Singh, S.F. Shamsi, B.R. Mehta, A. Fatma, Rapidsynthesis of silver nanoparticles using dried medicinal plant of basil, Colloids. Surf. B. Biointerf. 81 (2010) 81–86.
23. A. Bankar, B. Joshi, A.R. Kumar, S. Zinjarde, Banana peel extract mediated novel route for thesynthesis of silver nanoparticles, Colloids Surf. A 368 (2010) 58– 63.
24. Murugan K, Senthilkumar B, Senbagam D, Saleh Al S (2014) Biosynthesis of silver nanoparticles using Acacia leucophloea extract and their antibacterial activity. Int J Nanomedicine 9(1):2431– 2438
25. Salema WM, Haridy M, Sayed WF, Hassan NH (2014) Antibacterial activity of silver nanoparticles synthesized from latex and leaf extract of Ficus sycomorus. Ind Crop Prod 62:228– 234
26. Aravinthan A, Govarthanan M, Selvam K, Praburaman L, Selvankumar T, Balamurugan R, Kamala-Kannan S, Jong-Hoon K (2015) Sunroot mediated synthesis and characterization of silver nanoparticles and evaluation of its antibacterial and rat splenocyte cytotoxic effects. Int J Nanomedicine 10:1977–1983
27. Palaniyandi V, Jayabrata D, Raman P, Baskaralingam V, Kannaiyan P (2015) Greener approach for the synthesis of antibacterial silver nanoparticles using an aqueous solution of neem gum (Azadirachta indica L.) Ind Crop Prod 66:103–109
28. Ashish Deep Gupta, Vipin Kumar Bansal, Vikash Babu, Nishi Maithil, Chemistry, the antioxidant and antimicrobial potential of nutmeg (Myristica fragrans Houtt), J. Gen. Eng. Biotechnol. 11 (2013) 25-31
29. Murugan K, Senthilkumar B, Senbagam D, Saleh Al S (2014) Biosynthesis of silver nanoparticles using Acacia leucophloea extract and their antibacterial activity. Int J Nanomedicine 9(1):2431– 2438
30. Sudhakar C, Selvam K, Govarthanan M, Senthilkumar B, Sengottaiyan A, Stalin M, Selvankumar T (2015) Acorus calamus rhizome extract mediated biosynthesis of silver nanoparticles and their bactericidal activity against human pathogens. J Genet Eng Biotechnol 13:93–99
31. Chandana Thummaneni, D.V. Surya Prakash, Ramya Golli, Meena Vangalapati, Green synthesis of silver nanoparticles and characterization of caffeic acid from Myristica fragrans (Nutmeg) against antibacterial activity, Materials Today: Proceedings,Volume 62, Part 6,2022,Pages4001-4005,ISSN 2214-7853