Research Article

Nature inspired fabrication and evaluation of Silver nanoparticles (AgNPs) from *Terminalia catappa* extract

Disha M. Dhabarde[1]*, Mansi Kanchanwar[1], Debarshi Kar Mahapatra[2], Manish A. Kamble[3], Ashwini R. Ingole[4]

[1]*Department of Pharmaceutical Chemistry, Kamla Nehru College of Pharmacy, Nagpur 441108, Maharashtra, India*

[2]*Department of Pharmaceutical Chemistry, Dadasaheb Balpande College of Pharmacy, Nagpur 440037, Maharashtra, India*

[3]*Department of Pharmacognosy, Kamla Nehru College of Pharmacy, Nagpur 441108, Maharashtra, India*

[4]*Department of Pharmaceutics, Kamla Nehru College of Pharmacy, Nagpur 441108, Maharashtra, India*

Received: 31 October 2018 Revised: 23 November 2018 Accepted: 25 December 2018

Abstract

Objectives: The present research involved the synthesis of AgNPs employing fruit extract of *Terminalia catappa* (FETC) which will lay the foundation for the environmentally friendly production of nanomaterials. **Materials and Methods:** The AgNPs were fabricated from silver nitrate and characterized by Ultraviolet-Visible (UV-Vis) spectroscopy and Scanning Electron Microscope (SEM). An anti-bacterial study for the synthesized AgNPs was performed on *Staphylococcus aureus* (*S. aureus*). **Results:** The reduced sample displayed an optical absorption band peak at 259 nm, which was due to absorption attributes of metallic Ag as a result of Surface Plasmon Resonance (SPR). The fruit extract of *T. catappa* exhibited preparation of AgNPs of range 15-45 nm which were bacilli-like long, somewhat elliptical, and double-stacked morphology. It was noted that a lighter image has been seen primarily at the edges of the particles than the centre, which may be due to the capping of the AgNPs by the capping biomolecules (proteins, alkaloids, etc.). The bactericidal potential screening against *S. aureus* demonstrated noteworthy activity (ZOI of 25.3±1.14 mm at MIC of 25μg/mL) as compared with the standard drug, ciprofloxacin (33.4±1.03 mm ZOI at MIC of 6.25μg/mL). **Conclusion:** This study will certainly promote the use of plant extract mediated synthesis of nanomaterials, which will be more eco-friendly, least generation of by-products and exert less toxicity. Thereby, the research opened the avenues for greener fabricating technologies and restricting the use of older chemical technologies which severely affect the environment.

Keywords: *Terminalia catappa*, silver, nanoparticle, extract, anti-bacterial, synthesis.

Introduction

Nanomaterials of 1-100 nm range have revolutionized this era with its diverse applications in the field of medicine, clinical treatment, drug delivery, imaging, theranostics, and diagnosis (Khalandi et al., 2017). The modified physicochemical characteristics of these metallic nanoparticles of a high ratio of surface area to mass as compared to that of bulk material have revealed numerous promising, interesting, and emerging applications (Marin et al., 2015). Generally, these nanomaterials are conjugated with a variety of functionalized biomolecules and find application in treating, targeting, and delivering the drug in various ailments (Parhi et al., 2012). The nanocomposite products and technologies have stronghold significance in pharmaceutical sciences.

Silver nanoparticles (AgNPs) have been expansively applied for drug delivery, biomedical sciences, catalysis, etc. AgNPs have gained citadel fame for millenniums as anti-bacterial owing to their cumulative toxic effect on bacterial proteins (Wei et al., 2015). The interaction of AgNPs with the bacteria involved several well-known mechanism(s) for exerting activity, such as generation of reactive oxygen species, disrupt biochemical process, damage to the cell wall, loss of respiratory activity, membrane permeability modulation, decreased enzymatic activity, nitrosylation of metal centers,

****Address for Corresponding Author:***
Disha M. Dhabarde, PhD
Assistant Professor,
Department of Pharmaceutical Chemistry,
Kamla Nehru College of Pharmacy, Nagpur 441108, Maharashtra, India
E-mail: dishamandave@gmail.com

DOI: https://doi.org/10.31024/ajpp.2019.5.3.4

physical damage to components, peroxidation of the polyunsaturated phospholipids, nitrosation of protein thiols, reduced NADPH production, etc (Rai et al., 2009).

As the time flies, the need of nanomaterial raised several folds than expected. To meet the rising demand, the production techniques involve chemical and physical methods, which produce toxic elements (Ahmed et al., 2016). Some of the environmental threat processes involved chemical reduction of metal ions, use of reverse micelles, thermal decomposition in organic solvents, etc. These methods are preferred by the formulator since they proffer controlled particle size, better distribution, more economic, and improved scalability (Mittal et al., 2013).

As the directorates of environmental protection have been enforced, industries are now bound to use safe, pollution-free techniques for the fabrication of nanomaterials (Kumar et al., 2009). The plant extract mediated nanomaterial synthesis remained one of the most widespread techniques. The extracts of fruits, vegetable, spices, and condiment have been in application for preparing nanoparticles, nanocubes, nanotriangles, and nanorods (Mahapatra et al., 2017). This technique received widespread notice amongst the technical group of people due to attributes like better safety, quite economic, non-hazardous to the environment, etc (Sharma et al., 2009). Generally, the synthesis of AgNPs takes place in two major steps: the first step involves catalytic reduction of silver ions into silver nano-size and the second step involves NPs capping. The plant biomass provides phytoconstituents which act as reducing as well as capping agents (Rajan et al., 2015).

Terminalia catappa (Combretaceae) is a plant present in sub-tropical and tropical zones, known as tropical almond. The plant has not been reported for the biosynthesis of AgNPs. The flowers, leaves, fruits, seeds, bark, and roots are the key biomasses that have the potential to reduce the ionic form of silver to elemental form, due to the presence of phytoconstituents (Thomson and Evans, 2006). The present research involved the synthesis of AgNPs employing fruit extract of *Terminalia catappa* (FETC) which will lay the foundation for the environmentally friendly production of nanomaterials.

Materials and methods

Chemicals

Sigma-Aldrich (Germany) remained the chief supplier of silver nitrate. The reagents employed in the study were of analytical grade and purchased from HiMedia (India). Double distilled water was employed during the experiment (Borosil®, India).

Collection of plant material

The fruits of *Terminalia catappa* were collected from the tree present in the Butibori region of Nagpur, Maharashtra, India. The plant was recognized and authenticated by Dr. Dongarwar, Department of Botany, RTM Nagpur University, Nagpur, Maharashtra.

Extraction of plant material

The collected plant material was thoroughly cleaned with water and the flesh was removed carefully for starting the extraction procedure. The fresh flesh of the fruit of *Terminalia cattapa* was collected in the month of March, and dehydrated in the shade for the definite period and powdered consequently. The aqueous fruit extract was prepared by taking 15g of powdered *Terminalia cattapa* fruit in 200 mL of distilled water. The content was heated on a hot plate with continuous stirring at a temperature of 30–40°C for the period of 30 minutes. Then, the formed water extract was filtered through filter paper and the filtrate was concentrated by heating in a boiling water bath. Further, the content was dried and at terminally obtained gummy residue was used for AgNP synthesis.

Preparation of silver nitrate solution

For the study, an aqueous solution of silver nitrate ($AgNO_3$) of 1mM concentration was prepared. This was accomplished by dissolving 0.01698g of $AgNO_3$ in 100 mL of double distilled water.

Synthesis of silver nanoparticles

The fabrication of the silver nanomaterials involved a reaction of fresh fruit flesh extract (1 mL) with 9 mL of 1mM aqueous solution of $AgNO_3$ and further incubation of the content for 24 hours at 37°C. The change in the color of the mixture was checked, since it is an indicator of nanoparticles formation.

Characterization of silver nanoparticles

UV-Vis spectroscopic study

The UV-Vis spectrophotometer (Shimadzu® UV-1800, Kyoto) was employed in studying the reduction of pure silver ions. For this study, the samples (pure $AgNO_3$ solution and the prepared AgNP solution) in small aliquots with double distilled water were scanned in the wavelength range of 200-800 nm after 24 hours (Mahapatra et al., 2018).

Scanning electron microscopic study

The scanning electron microscopy (SEM) technique (JOEL-JSM 6390 SEM) was employed in comprehensively studying the morphology of the prepared nanomaterial. The samples were analyzed by initially sprinkling the content over the double tape hold to the aluminum stub, followed by installing in the SEM chamber and subsequently scanning at the acceleration voltage of 10 kV. The scanned photomicrographs were recorded and saved (Dangre et al., 2016).

Antibacterial activity

The potential of the fabricated silver nanoparticles in exhibiting bactericidal activity against pathogenic *Staphylococcus aureus* (*S. aureus*, MTCC 3160) were evaluated suitably. The *in-vitro* antibacterial was executed by disc diffusion method using the Muller Hinton Agar medium. Initially, the microbes were cultured in the nutrient broth and further incubated at 37±1°C for 24 hr. Subsequently, the cultured cells were multiplied in the Muller Hinton agar plates. The AgNPs containing discs were screened against *S. aureus* and compared with ciprofloxacin (positive control). The zone of inhibition (ZOI) was measured in millimeters (mm). The experiment was performed in triplicate manner. The minimum inhibitory concentration (MIC) was performed by the agar streak dilution method. The MIC value was determined and the average was taken (Telrandhe et al., 2017).

Results and discussion

The study revealed that with the addition of plant extract to the aqueous silver nitrate solution, a change in color of the content was observed after few hours. This certainly indicated the formation of AgNPs in the medium by the reduction of ionic silver to elemental silver form.

UV-Vis spectroscopic study

The reduced sample displayed an optical absorption band peak at 259 nm, which was due to absorption attributes of metallic Ag as a result of Surface Plasmon Resonance (SPR). An increase in intensity was noticed which may be due to the formation of AgNPs in a time-dependent manner. The absorption peak at 200 nm reflects that abundant organic molecules interacted with the silver ions in the solution. In contrast, the absorption band at 250 to 300 nm specified that capping occurred after the formation of AgNPs. Figure 1 depicts the UV spectra of *Terminalia catappa* mediated synthesized AgNP sample.

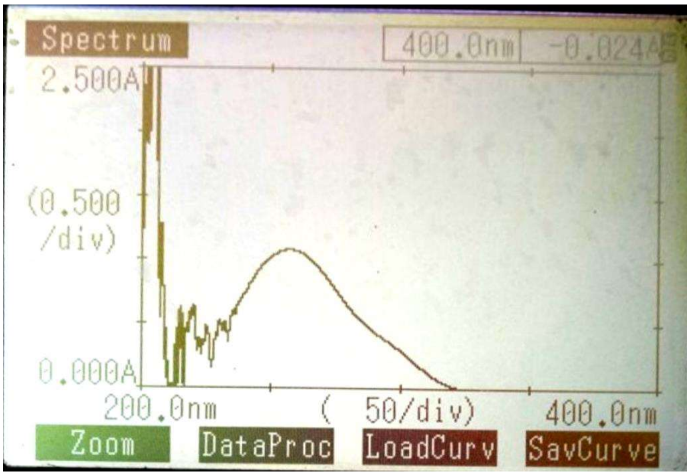

Figure 1. UV spectra of synthesized nanoparticles

Scanning electron microscopic study

The observed morphology was quite interesting. A bacilli-like long, somewhat elliptical, and double-stacked morphology was seen predominantly in the photomicrograph. No such oval or round shaped nanoparticles have been observed. The obtained photomicrograph was seen to be a very infrequent phenomenon. Most of the particles were in the size of 15-45 nm. From the figure 2, it was clear that the largest morphology frequency lies at approximately 15-25 nm where this particle sizes range comprises 70% of the total AgNPs observed. It was noted that a lighter image has been seen primarily at the edges of the particles than the centre, which may be due to the capping of the AgNPs by the capping biomolecules (proteins, alkaloids, etc.).

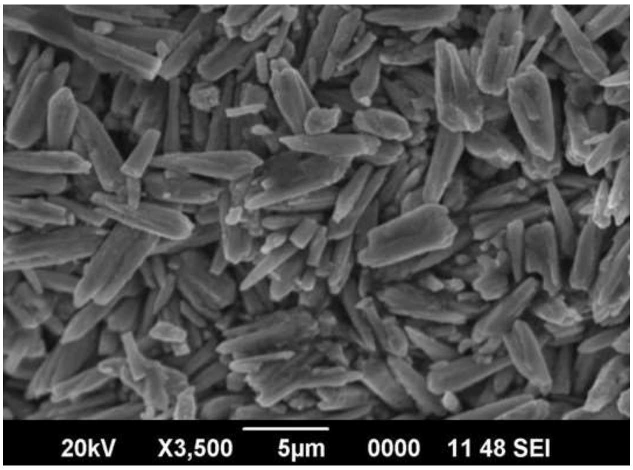

Figure 2. SEM micropictograph of fabricated silver nanoparticles

Anti-microbial activity

The formed AgNPs exhibited tremendous anti-microbial activity against *S. aureus* where it displayed a noteworthy ZOI of 25.3±1.14 mm at MIC of 25μg/mL. In contrast to the standard drug ciprofloxacin, which demonstrated 33.4±1.03 mm ZOI at MIC of 6.25μg/mL, it may be concluded that the fabricated AgNPs have striking bactericidal potentials.

Conclusion

The present research is a milestone in the history of nature inspired silver nanomaterial synthesis. *Terminalia catappa*, a plant of Indian origin remained a prime member for the fabrication of the nanomaterials. The fruit extract of *T. catappa* exhibited preparation of AgNPs of range 15-45 nm which were bacilli-like long, somewhat elliptical, and double-stacked morphology. The UV-spectral studies also confirmed the formation of the silver nanomaterials from the plant extract by the optical absorption band peak at 259 nm. The bactericidal potential screening against *S. aureus* demonstrated noteworthy activity (ZOI of 25.3±1.14 mm at MIC of 25μg/mL) as compared with the standard drug, ciprofloxacin. This study will certainly promote the use of plant extract mediated synthesis of nanomaterials, which will be more eco-friendly, least generation of by-products and exert less toxicity. Thereby, the research opened the avenues for greener fabricating technologies and restricting the use of older chemical technologies which severely affect the environment.

Conflict of interest

There is no conflict of interest regarding the publication of the article.

References

Ahmed S, Ahmad M, Swami BL, Ikram S. 2016. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: a green expertise. Journal of Advanced Research, 7(1):17-28.

Dangre PV, Godbole MD, Ingle PV, Mahapatra DK. 2016. Improved Dissolution and Bioavailability of Eprosartan Mesylate Formulated as Solid Dispersions using Conventional Methods. Indian Journal of Pharmaceutical Education and Research, 50(3):S209-S217.

Khalandi B, Asadi N, Milani M, Davaran S, Abadi AJ, Abasi E, Akbarzadeh A. 2017. A Review on Potential Role of Silver Nanoparticles and Possible Mechanisms of their Actions on Bacteria. Drug Research, 67 (02): 70-76.

Kumar V, Yadav SK. 2009. Plant-mediated synthesis of silver and gold nanoparticles and their applications. Journal of Chemical Technology and Biotechnology, 84(2):151-7.

Mahapatra DK, Bharti SK, Asati V. 2017. Nature inspired green fabrication technology for silver nanoparticles. Current Nanomedicine, 7(1):5-24.

Mahapatra DK, Tijare LK, Gundimeda V, Mahajan NM. 2018. Rapid Biosynthesis of Silver Nanoparticles of Flower-like Morphology from the Root Extract of *Saussurea lappa*. Research & Reviews A Journal of Pharmacognosy, 5(1): 20-24.

Marin S, Mihail Vlasceanu G, Elena Tiplea R, Raluca Bucur I, Lemnaru M, Minodora Marin M, Mihai Grumezescu A. 2015. Applications and toxicity of silver nanoparticles: a recent review. Current Topics in Medicinal Chemistry, 15(16):1596-1604.

Mittal AK, Chisti Y, Banerjee UC. 2013. Synthesis of metallic nanoparticles using plant extracts. Biotechnology Advances, 31(2):346-56.

Parhi P, Mohanty C, Sahoo SK. 2012. Nanotechnology-based combinational drug delivery: an emerging approach for cancer therapy. Drug Discovery Today, 17(17-18):1044-1052.

Rai M, Yadav A, Gade A. 2009. Silver nanoparticles as a new generation of antimicrobials. Biotechnology Advances, 27(1):76-83.

Rajan R, Chandran K, Harper SL, Yun SI, Kalaichelvan PT. 2015. Plant extract synthesized silver nanoparticles: an ongoing source of novel biocompatible materials. Industrial Crops and Products, 70:356-73.

Sharma VK, Yngard RA, Lin Y. 2009. Silver nanoparticles: green synthesis and their antimicrobial activities. Advances in Colloid and Interface Science, 145(1-2):83-96.

Telrandhe R, Mahapatra DK, Kamble MA. 2017. Bombax ceiba thorn extract mediated synthesis of silver nanoparticles: Evaluation of anti-Staphylococcus aureus activity. International Journal of Pharmaceutics and Drug Analysis, 5(9):376-379.

Thomson LA, Evans B. 2006. Terminalia catappa (tropical almond). Species Profiles for Pacific Island Agroforestry, 2:1-20.

Wei L, Lu J, Xu H, Patel A, Chen ZS, Chen G. 2015. Silver nanoparticles: synthesis, properties, and therapeutic applications. Drug Discovery Today, 20(5):595-601.