https://doi.org/10.30799/jnst.246.19050402
J. Nanosci. Tech. - Volume 5 Issue 4 (2019) 751–753

ISSN: 2455-0191

Share Your Innovations through JACS Directory

Journal of Nanoscience and Technology

Visit Journal at http://www.jacsdirectory.com/jnst

Eco-Friendly Microwave Assisted Green Synthesis, Characterization and Antibacterial Activity of Silver Nanoparticles

Devendra Kumar*, Akanksha Tiwari, Neelam

Department of Chemistry, Institute of Basic sciences, Dr. Bhimrao Ambedkar University, Khandari Campus, Agra – 282 002, Uttar Pradesh, India.

ARTICLE DETAILS

Article history:
Received 05 May 2019
Accepted 27 May 2019
Available online 11 June 2019

Keywords:
Nanoparticles
Microwave Irradiation
Antibacterial Activity

ABSTRACT

This paper deals a novel method for the synthesis of silver nanoparticles (AgNPs) by microwave assisted approach using silver nitrate and trisodium citrate. The formation of nanoparticles was confirmed by UV-visible spectral studies. Particle size and morphology was determined by P-XRD and HR-TEM studies which revealed the average particle size of synthesized nanoparticles 21.49 and 20.08 nm respectively with spherical shape. The synthesized nanoparticles were screened for antibacterial activity in *vitro* against gram-positive bacteria *Staphylococcus aureus* and *Bacillus subtilis* and gram-negative bacteria *Escherichia coli* and *Klebsiella pneumoniae* by adopting disk diffusion method. The results of antibacterial studies exhibited that AgNPs were potential antibacterial agent.

1. Introduction

In modern materials science the field of nanotechnology is one of the most important active areas of research. Nanoparticles showed entirely novel or better properties based on specific characteristics like size, distribution and morphology [1]. Metallic nanoparticles are unique and can significantly modify physical, chemical and biological properties compared to bulk material of same composition because of their surface-to-volume ratio. So, these nanoparticles have been utilized for a variety of applications [2-5]. Silver nanoparticles (AgNPs) paying attention to the researchers due to their attractive optical [6], electronic [7] and excellent catalytic activities [8, 9]. The biological activity of silver nanoparticles depends on numerous factors including size, shape dependent distribution, composition of particles, particles reactivity in solution, morphology, effectiveness of ion liberates, type of cell and the nature of reducing agents used for the synthesis of AgNPs [10]. The advantage of AgNPs over bulk metal or salts is due to the slow and regular release of silver from nanoparticles, in that way causing permanent protection against bacteria [11-13]. Previous literature reported anticancer activity of chloroquine-based silver nanoparticles against neuroblastoma cells [14]. A number of methods are used for the preparation of nanoparticles such as reduction method [15], reversed micelles [16], chemical co-precipitation [17], spray pyrolysis [18], sol-gel [19], laser ablation [20], plasma polymerization [21]. However, these methods are non-eco-friendly since they frequently need large amounts of toxic chemicals and high temperature processing conditions. Recently, microwave assisted method has fascinated broad attention in material science which helps to enhance the nucleation rate, minimize the synthesis time and provide the small particles with fine particle size and high purity [22]. With the increasing awareness towards the environmental safety people are ready to begin the eco-friendly approach for the synthesis of nanoparticles. In continuation [23] of our previous work the purpose of the present work is to extend an easy, rapid and completely green method for synthesizing AgNPs using trisodium citrate as reducing and stabilizing agent in aqueous medium by microwave irradiation. The prepared silver nanoparticles have been screened for their antibacterial activity in *vitro* against gram +ve bacteria *Staphylococcus aureus* and *Bacillus subtilis* and gram –ve bacteria *Escherichia coli* and *Klebsiella pneumoniae* by adopting disk diffusion method.

2. Experimental Methods

2.1 Synthesis of Silver Nanoparticles

0.8 g silver nitrate ($AgNO_3$) was dissolved in 25 mL deionised water in a 100 mL round bottom flask. 25 mL aqueous solution of trisodium citrate (1.25 g) was added drop wise to the above solution under vigorous stirring at 110 W in 20 min by maintaining the temperature 70 °C in a microwave synthesizer. The obtained precipitate was separated by using centrifugation and washed with deionised water for several times. Finally, it was dried at 150 °C for 1 h to get the silver nanoparticles.

2.2 Characterization

Microwave synthesizer Discover Lab Mate with Intelli-Vent Pressure, 240 V/50 Hz was used to synthesize nanoparticles. UV-visible spectrum of silver nanoparticles was recorded by UV–visible spectrophotometer Shimadzu 1800$^+$ in DMSO at room temperature. The P-XRD spectra of nanoparticles have been recorded on XPERT-PRO X-ray diffractometer manages at a voltage of 45 kV and a current of 40 mA with Cu Kα radiation in a θ–2θ configuration. The transmission electron microscopic measurements of synthesized nanoparticles have been performed by using JEOL model JEM 2100.

2.3 Antibacterial Activity

The antibacterial activity of the synthesized nanoparticles has been screened on two gram-positive *Staphylococcus aureus* and *Bacillus subtilis* and two gram-negative *Escherichia coli* and *Klebsiella pneumoniae* microorganisms by using disk diffusion method [24]. The culture media was sterilized by moist heat sterilization method in an autoclave at 121°C temperature at 15 pounds pressure for about 30 minutes. Now well sterilized culture media was spread homogeneously on each petri plates. The culture media was then allowed to solidify. After solidification a sterilized swab of cotton was dipped in the bacterial culture broth and applied carefully on the entire surface of the petri plate. The petri plates were incubated at 37 °C for 24 h and then sterilised discs of 6 mm have been loaded at different places on the solidified culture plates. Five different concentrations (50, 25, 12.5, 6.25 and 3.12 µg/mL) of silver nanoparticles and 3.12 µg/mL for standard antibiotic amikacin, were prepared in ethanol. From the above solutions 20 µL solution of each concentration was pipette out by using micropipette and loaded to different sterile discs separately. The petri plates have been subjected for incubation at 37 °C for 24 h. After 24 h the zone of inhibition values in diameter (in mm) was measured with the help of a ruler.

---

*Corresponding Author:devendrakumar131@gmail.com(Devendra Kumar)

https://doi.org/10.30799/jnst.246.19050402

Cite this Article as: Devendra Kumar, Akanksha Tiwari, Neelam, Eco-friendly microwave assisted green synthesis, characterization and antibacterial activity of silver nanoparticles, J. Nanosci. Tech. 5(4) (2019) 751–753.

3. Results and Discussion

3.1 UV-Visible Spectral Studies

The UV-visible absorption spectrum (Fig. 1) of synthesized silver nanoparticles [25] exhibited a strong absorption peak at 420 nm which confirmed the formation of silver nanoparticles.

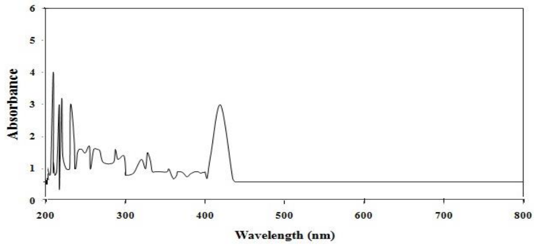

Fig. 1 UV-Visible absorption spectrum of silver nanoparticles

3.2 P-XRD Studies

The structure and composition of synthesized silver nanoparicles was determined by X-ray diffraction technique. The P-XRD spectra of nanoparticles showed that particles were crystalline in nature. The crystalline size of nanoparticles has been calculated by using the width of X- ray peaks supposing they are free from non-uniform strains using Debye-Scherrer's formula, D = kλ/βcosθ, where D = Mean crystallite domain size, at right angles to the reflecting planes, k = Constant equals to unity, λ = x-ray wavelength, β =Full width at half of the maximum intensity (FWHM) and θ =Diffraction angle. Full width at half maximum has been used to find the size distribution of nanoparticles. It has been observed that the broader is the peak, broader is the size distribution of nanoparticles. On applying Debye Scherrer formula on different peaks of P-XRD graph of silver nanoparticles (Fig. 2). It has been found that the synthesized nanoparticles have different size like 23.36, 7.35, 29.24, 38.84, 1.74, 21.24, 21.62, 15.08, 26.15 and 27.34 nm. The average particle size of synthesized silver nanoparticles has been found to be 21.49 nm.

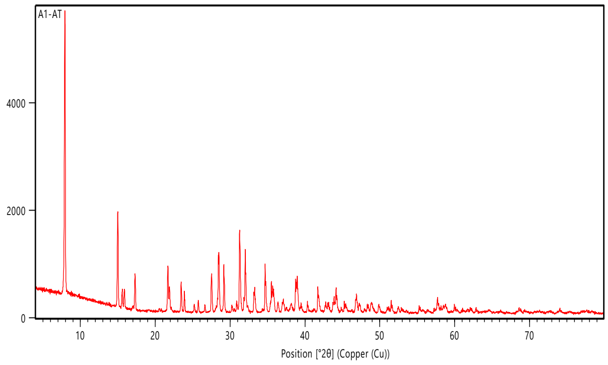

Fig. 2 P-XRD graph of silver nanoparticles

3.3 Transmission Electron Microscopic Studies

The transmission electron microscopic (TEM) images indicated that the particle size of synthesized silver nanoparticles lies in the range of 11.05 to 38.63 nm. The average size of silver nanoparticles was 20.08 nm. TEM images of silver nanoparticles indicated spherical shape of the nanoparticles. The TEM images of silver nanoparticles have been shown in Fig. 3.

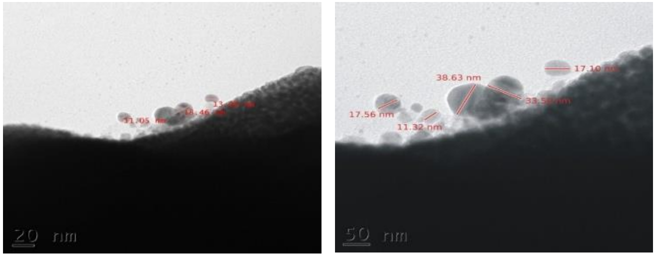

Fig. 3 TEM images of synthesized silver nanoparticles

3.4 Antibacterial Activity

The antibacterial activity of the synthesized silver nanoparticles was measured against two gram-positive *Staphylococcus aureus* and *Bacillus subtilis* and two gram-negative *Escherichia coli* and *Klebsiella pneumoniae* bacteria in diameter (in mm). The zone of inhibition (Fig. 4, Table 1) was found 24, 19, 16, 14 and 8 mm corresponding to the concentration 50, 25,12.5, 6.25 and 3.12 μg/mL against the bacteria *Staphylococcus aureus*. The zone of inhibition (Fig. 4, Table 1) was found 19, 16, 14, 12 and 7 mm with respect to the concentration 50, 25, 12.5, 6.25 and 3.12 μg/mL against the bacteria *Bacillus subtilis*. However, zone of inhibition for standard drug Amikacin was observed 13 mm and 11 mm at the concentration 3.12 μg/mL against *Staphylococcus aureus* and *Bacillus subtilis* respectively. Synthesized silver nanoparticles exhibited the zone of inhibition (Fig. 5, Table 2) at 22, 16, 13, 12 and 9 mm corresponding to the concentration 50, 25, 12.5, 6.25, 3.12 μg/mL against the bacteria *Escherichia coli*. The zone of inhibition (Fig. 5, Table 2) was found 20, 14, 12, 9 and 7 mm with respect to the concentration 50, 25, 12.5, 6.25 and 3.12 μg/mL against the bacteria *Klebsiella pneumoniae.* However, zone of inhibition for standard drug Amikacin was found at 12 mm and 8 mm at 3.12 μg/mL concentration against *Escherichia coli* and *Klebsiella pneumoniae* respectively. From the antibacterial studies it has been found that the silver nanoparticles were potential active on the microorganisms exploring the further research on this noble metal.

Table 1 Maximum zone of inhibition values (in mm) for silver nanoparticles against gram-positive micro-organisms

S. No.	Test conc. (μg/mL)	*Staphylococcus aureus*	*Bacillus subtilis*
1.	50	24	19
2	25	19	16
3	12.5	16	14
4	6.25	14	12
5	3.12	8	7
STD Amikacin	3.12	13	11

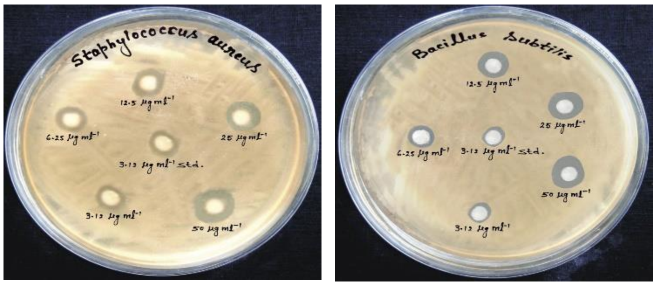

Fig. 4 Petri plates showing zone of inhibition against *Staphylococcus aureus* and *Bacillus subtilis*

Table 2 Maximum zone of inhibition values (in mm) for silver nanoparticles against gram-negative micro-organisms

S. No.	Test conc. (μg/mL)	*Escherichia coli*	*Klebsiella pneumoniae*
1.	50	22	20
2	25	16	14
3	12.5	13	12
4	6.25	12	9
5	3.12	9	7
STD Amikacin	3.12	12	8

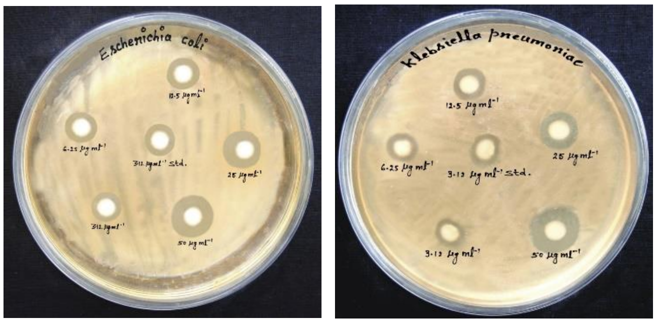

Fig. 5 Petri plates showing zone of inhibition against *Escherichia coli* and *Klebsiella pneumoniae*

4. Conclusion

In the present paper ecofriendly microwave assisted synthesis method has been used for the synthesis of silver nanoparticles. This method is a novel and cost effective and less energy consuming. The results of P-XRD and HR-TEM studies revealed that the average particle size of synthesized nanoparticles was 21.49 and 20.08 nm respectively with spherical shape. The synthesized nanoparticles were screened for antibacterial activity in

https://doi.org/10.30799/jnst.246.19050402

Cite this Article as: Devendra Kumar, Akanksha Tiwari, Neelam, Eco-friendly microwave assisted green synthesis, characterization and antibacterial activity of silver nanoparticles, J. Nanosci. Tech. 5(4) (2019) 751–753.

vitro against two gram +ve bacteria *Staphylococcus aureus* and *Bacillus subtilis* and two gram -ve bacteria *Escherichia coli* and *Klebsiella pneumoniae* bacteria by adopting disk diffusion method. The results of antibacterial studies exhibited that AgNPs were potential antibacterial agent. AgNPs may be used as bound dressing ointments, lotions, emulsions to control the bacterial growth.

Acknowledgements

Authors are grateful to Head, Department of Pharmacy, Dr. Bhimrao Ambedkar University, Agra, for providing UV-visible analysis, Sophisticated Analytical Instrumental Facility, Punjab University, Chandigarh for P-XRD analysis, SAIF, Cochin for Transmission Electron Microscopic analysis. Authors are also thankful to Dr. Ajay Singh, Ajay Diagnostic centre Jay Hospital, Agra for antibacterial activities.

References

[1] D. Jain, H.K. Daima, S. Kachhwaha, S.L. Kothari, Synthesis of plant-mediated silver nanoparticles using papaya fruit extract and evaluation of their anti-microbial activities, Dig. J. Nanomater. Biostruct. 4(3) (2009) 557-563.

[2] V.K. Sharma, R.A. Yngard, Y. Lin, Silver nanoparticles: green synthesis and their antimicrobial activities, Adv. Colloid Interf. Sci. 145 (2009) 83-96.

[3] V. Ravichandran, S. Vasanthi, S. Shalini, S.A.A. Shah, R. Harish, Green synthesis of silver nanoparticles using *Atrocarpus altilis* leaf extract and the study of their antimicrobial and antioxidant activity, Mater. Lett. 180 (2016) 264-267.

[4] B. Ajitha, Y.A.K. Reddy, P.S. Reddy, Y. Suneetha, H.J. Jeon, C.W. Ahn, *Lantana camara* leaf extract mediated silver nanoparticles: antibacterial, green catalyst, J. Mol. Liq. 219 (2016) 84-92.

[5] M. Behravan, A.H. Panahi, A.I. Naghizadeh, M. Ziaee, R. Mahdavi, A. Mirzapour, Facile green synthesis of silver nanoparticles using *Berberis vulgaris* leaf and root aqueous extract and its antibacterial activity, Int. J. Biol. Macromol. 124 (2019) 148-154.

[6] J. Xu, X. Han, H. Liu, Y. Hu, Synthesis and optical properties of silver nanoparticles stabilized by Gemini surfactant, Colloids Surf. A Physicochem. Eng. Asp. 273(1-3) (2006) 179-183.

[7] D. Chen, X. Qiao, X. Qiu, J. Chen, Synthesis and electrical properties of uniform silver nanoparticles for electronic applications, J. Mater. Sci. 44(4) (2009) 1076-1081.

[8] K. Muthu**,** S. Priya, Green synthesis, characterization and catalytic activity of silver nanoparticles using *Cassia auriculata* flower extract separated fraction, Spectrochim. Acta A Mol. Biomol. Spectrosc. 179 (2017) 66-72.

[9] R. Sarada, R. Sarada, V. Jagannadharao, M. Padma, B.S. Sundar, Catalytic application of synthesized capped silver nanoparticles for reduction of p-nitroaniline, Asian J. Chem*.* 29(1) (2017) 62-64.

[10] C. Carlson, S.M. Hussain, A.M. Schrand, L.K. Braydich-Stolle, K.L. Hess, et al., Unique cellular interaction of silver nanoparticles: size-dependent generation of reactive oxygen species, J. Phys. Chem. B 112 (2008) 13608-13619.

[11] X. Zhao, Y. Xia, Q. Li, X. Ma, F. Quan, et al., Microwave-assisted synthesis of silver nanoparticles using sodium alginate and their antibacterial activity, Colloids Surf. A. Physicochem. Eng. Asp. 444 (2014) 180-188.

[12] A. Zille, M.M. Fernandes, A. Francesko, T. Tzanov, M. Fernandes, et al., Size and aging effects on antimicrobial efficiency of silver nanoparticles coated on polyamide fabrics activated by atmospheric DBD plasma, ACS Appl. Mater. Interf. *7*(25) (2015) 13731-13744.

[13] P. Totaro, M. Rambaldini, Efficacy of antimicrobial activity of slow release silver nanoparticles dressing in post-cardiac surgery mediastinitis, Interact. Cardiovasc. Thorac. Surg. 8(1) (2009) 153-154.

[14] S.C. Vivekanandhan, M. Chandramohan, P. Selvam, Design synthesis and characterization of biogenic chloroquine silver nanoparticles as potential anticancer agent against neuroblastoma cells, Asian J. Chem. 30(3) (2018) 537-540.

[15] S. Ghazali, M. Jaafar, A. Azizan, Synthesis of silver nanoparticles by chemical reduction method: Effect of reducing agent and surfactant concentration, Int. J. Automot. Mech. Eng. 10(1) (2014) 1920-1927.

[16] C. Taleb, M. Petit, P. Pileni, Synthesis of highly monodisperse silver nanoparticles from AOT reverse micelles: A Way to 2D and 3D self-organization, Chem. Mater. 9(4) (1997) 950-959.

[17] G. Tailor, S. K. Shailesh, J. Chaudhary, S. Afzal, Synthesis, structural and thermal analysis of silver nanoparticles using bakalite composite, Asian J. Chem. 30(3) (2018) 483-486.

[18] K. Pakiyaraj, Annealing effect on Al doped SnO_2 nano structure thin films prepared by spray pyrolysis technique, J. Nanosci. Tech. 4(1) (2018) 317-319.

[19] A. Sharma, R.K. Karn, S.K. Pandiyan, Synthesis of TiO_2 nanoparticles by sol-gel method and their characterization, J. Basic. Appl. Eng. Res. 1(9) (2014) 1-5.

[20] M. Ganjali, M. Ganjali, P. Vahdatkhah, S.M.B. Marashi, Synthesis of Ni nanoparticles by pulsed laser ablation method in liquid phase, Procedia Mater. Sci. 11 (2015) 359-363.

[21] J. Cao, T. Matsoukas, Synthesis of hollow nanoparticles by plasma polymerization, J. Nanopart. Res. 6(5) (2004) 447-455.

[22] A.G. Al-Sehemi, A.S. Al-Shihri, A. Kalam, G. Dud, T. Ahmad, Microwave synthesis, optical properties and surface area studies of NiO nanoparticles, J. Mol. Struct. 1058 (2014) 56-61.

[23] D. Kumar, Neelam, Green chemistry approach: synthesis of silver nanoparticles by using lime juice (*Citrus aurantifolia*) extract and their evaluation as antibacterial agent, J. Ind. Chem. Soc. 91 (2014) 1667-1674**.**

[24] H.G. Aslan, S. Özcan, N. Karacan, The antibacterial activity of some sulfonamides and sulfonyl hydrazones, and 2D-QSAR study of a series of sulfonyl hydrazones, Spectrochim. Acta A Mol. Biomol. 98 (2012) 329-336.

[25] S. Vijayakumar, S. Mahadevan, P. Arulmozhi, S. Sriram, P.K. Praseeth, Green synthesis of zinc oxide nanoparticles using *Atalantia monophylla* leaf extracts: characterization and antimicrobial analysis, Mater. Sci. Semicond. Proces. 82 (2018) 39-45.

https://doi.org/10.30799/jnst.246.19050402

Cite this Article as: Devendra Kumar, Akanksha Tiwari, Neelam, Eco-friendly microwave assisted green synthesis, characterization and antibacterial activity of silver nanoparticles, J. Nanosci. Tech. 5(4) (2019) 751–753.