



Biosynthesis And Characterization Of Silver Nanoparticles Using An Extract Of *Azadirachta Indica* Leaves

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Article History

Volume 6, Issue 2, 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi: [10.48047/AFJBS.6.2.2024.2737-2743](https://doi.org/10.48047/AFJBS.6.2.2024.2737-2743)

Abstract

The silver nanoparticles (Ag NPs) show a very interesting optical property of surface plasmon resonance in the visible region due to which they find application in photovoltaics for enhancing the efficiency of solar cells. For this the synthesized Ag NPs need to be stable and pure. The present work reports the green synthesized Ag NPs from an extract of *Azadirachta Indica* (Neem) leaves as reducing/stabilizing and capping agent. The morphology and stability of the biosynthesized Ag NPs were investigated by SEM, FTIR and UV-Visible spectroscopy. The SEM images confirmed the formation of spherical silver nanoparticles uniformly distributed throughout the solution. Visual perception confirmed the formation of the Ag NPs after the addition of the leaf extract the same was confirmed using the UV-Vis spectroscopy absorption peak at 420-430 nm. The FTIR spectroscopy confirmed the functional groups responsible for the bioreduction of Ag⁺ to Ag NPs. The synthesized Ag NPs were stable for a long period of time.

Key Words: Green synthesis, Silver Nanoparticles, Surface Plasmon Resonance, Leaf extract.

1. Introduction

In the recent years there has been increasing demand for the production of metal nanoparticles especially noble metals because they exhibit novel chemical and physical properties owing to their small physical dimensions. Due to their size, shape and large surface area these metal nanoparticles show unique magnetic, electronic, mechanical and chemical properties which are different from their bulk counterpart. For these extraordinary properties the metallic nanoparticles have found wide applications in catalysis, electronics, photonics, optoelectronics, biosensors, information storage, energy conversion [1-7]. For all these applications, synthesising nanoparticles of adequate size and morphology is very important. Among the metal nanoparticles the silver nanoparticles (Ag NPs) are widely studied because of their superior performance over the other metals. In particular, Ag NPs show an interesting optical behaviour known as surface plasmon resonance (SPR) in the visible region as the nanoparticles diameter becomes comparable with, or smaller than the wavelength of incident light. This behaviour depends upon the size, shape as well as dielectric environment of metal nanoparticles [8]. This optical property of the Ag NPs has been harnessed in the field of photovoltaics for enhancing the efficiency of the solar cells [9]. There are different methods of synthesis of Ag NPs including laser ablation [10], chemical reduction [11], thermal decomposition [12], electron beam irradiation [13]. Polyol [14], *in situ* chemical synthetic route [15]. Many of these synthesis methods

involve the use of hazardous chemicals or high energy and require the purification process due to which the synthesis cost goes high. Conversely, the green synthesis of nanoparticles using enzymes [16], microorganisms [17] and plant extract [18,19] offer many advantages over the conventional methods. These biological methods are eco-friendly, economic and easily scaled up for large synthesis and don't use any toxic chemicals, high temperature or energy and more importantly the synthesized nanoparticles are stable for a longer time.

The Green Synthesized Ag NPs have wide applications such as, catalysts in chemical reactions, as spectrally selective coatings for solar energy absorption and intercalation material for solar energy batteries, biolabelling, as optical receptors and as antimicrobial agents [20,21]. There are reports where stable Ag NPs were synthesized using the leaf extract. Ajitha et al. synthesized Ag NPs using *Lantana camara* leaf extract to study the antibacterial activity [22]. Kharat et al. synthesized the Ag NPs using the *Elephantopus scabe* leaf extract to study the antioxidant activity of Ag NPs [23]. Giri et al. Ag NPs from fully expanded leaves of *Eugenia roxburghii* DC., to test their effectiveness in inhibiting biofilm production [24]. Here we report the green synthesis of Ag NPs using *Azadirachta indica* (neem) leaf extract as a source of nanoparticle formation. The green synthesized Ag NPs were characterised using UV-Visible spectrophotometry, Fourier transform infrared (FT-IR) spectroscopy and Scanning electron microscopy (SEM). The surface plasmon resonance of the synthesized Ag NPs are studied in detail which helps to foresee its energy harvesting property.

2. Experimental

2.1 Preparation of Plant Extract

Azadirachta indica (neem) plant extract was used for the synthesis of silver nanoparticles. Fresh leaves of *Azadirachta indica* were collected, they were surface cleaned with running tap water to remove debris and other contaminated organic contents, followed by double distilled water and air dried at room temperature. About 15gm of finely cut leaves were taken in a beaker containing 200 ml double distilled water and boiled at 70°C for 40 minutes using magnetic stirrer until the colour changes to green. The green plant extract was cooled, filtered with Whatman filter paper no. 1, covered with aluminium foil and stored at room temperature for the synthesis of Ag NPs.

2.2 Synthesis of Silver Nanoparticles

For synthesis of silver nanoparticles, 10mg Silver nitrate GR salt is dissolved in 50 ml Double distilled water at room temperature. Now the magnetic stirrer is set at a temperature of 70°C. Using a burette 0.5 ml, 1 ml and 1.5 ml of green plant extract was added drop-wise to the silver nitrate solution very slowly until the pale yellow colour changes to bright yellow and then dark brown colour. Three samples of the solution were collected. Sample A (0.5 ml of green plant extract), Sample B (1 ml of green plant extract), Sample C (1.5 ml of green plant extract). All the prepared samples were characterised using UV-VIS spectrophotometry in the visible range 200–800nm. The reduction of Ag ions to Ag NPs and the uniformity of the synthesised Cu NPs were confirmed by SEM images. The chemical binding of the synthesised Ag NPs were analysed using FT-IR spectrometer. All the characterizations were performed at Central facilities for research and development, Osmania University, Hyderabad.

3. Results and Discussion

3.1 UV-Visible Analysis

The UV-Visible spectra of the green synthesized Ag NPs is shown in Figure 1. In all experiments, addition of plant extract of *Azadirachta indica* into the conical flask containing aqueous solution of

silver nitrate led to the change in the colour of the solution from pale to bright yellow and then to dark brown within reaction duration due to excitation of surface plasmon vibrations in silver nanoparticles as a first visual confirmation of Ag NPs synthesis (25).

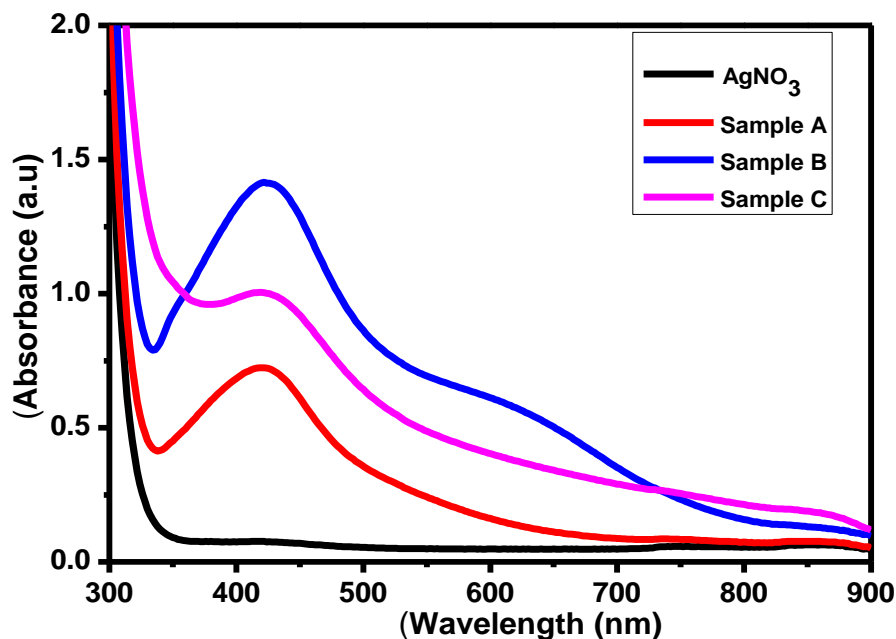


Fig. 1. UV-Visible Spectra of green synthesized Ag NPs collected for different concentrations of the plant extract.

On addition of different concentrations of natural plant extracts 0.5 ml, 1 ml, 1.5 ml to aqueous silver nitrate solution keeping its concentration constant, the colour of the solution changed from pale yellow to bright yellow and finally to dark brown indicating formation of silver nanoparticles. The Silver nanoparticles synthesized at different concentrations of leaf extract were analysed by UV spectra of Plasmon resonance band observed at 420–430 nm similar to those Resonance (SPR), typical of silver nanoparticles having absorbance values which were reported earlier in the visible range of 430 nm (26). According to Mie's theory spherical metal NPs can only give single SPR band, while anisotropic particles could give two or more SPR bands depending upon shape of the NPs [27]. There is increase in intensity of absorption peaks with increase in the concentration of the plant extract. It is observed that the intensity of the absorption peak for 0.5 ml and 1 ml is maximum may be due to less agglomeration and small particle size. As the quantity of leaf extract increases the size of the Ag NPs increases due to which they agglomerate and intensity of the peak is reduced. The UV-vis spectra recorded, implied that most rapid bioreduction was achieved using *A. indica* leaf extract as reducing agent and the formation of silver nanoparticles occurred rapidly within 15 min.

3.2 SEM Analysis

Scanning electron microscopy (SEM), was carried out to evaluate the surface morphology and uniformity of the green synthesised Ag NPs. Figure 2 represent the typical beautiful SEM images of as prepared Ag nanoparticles with different concentrations of the plant extract at room temperature with two different magnifications

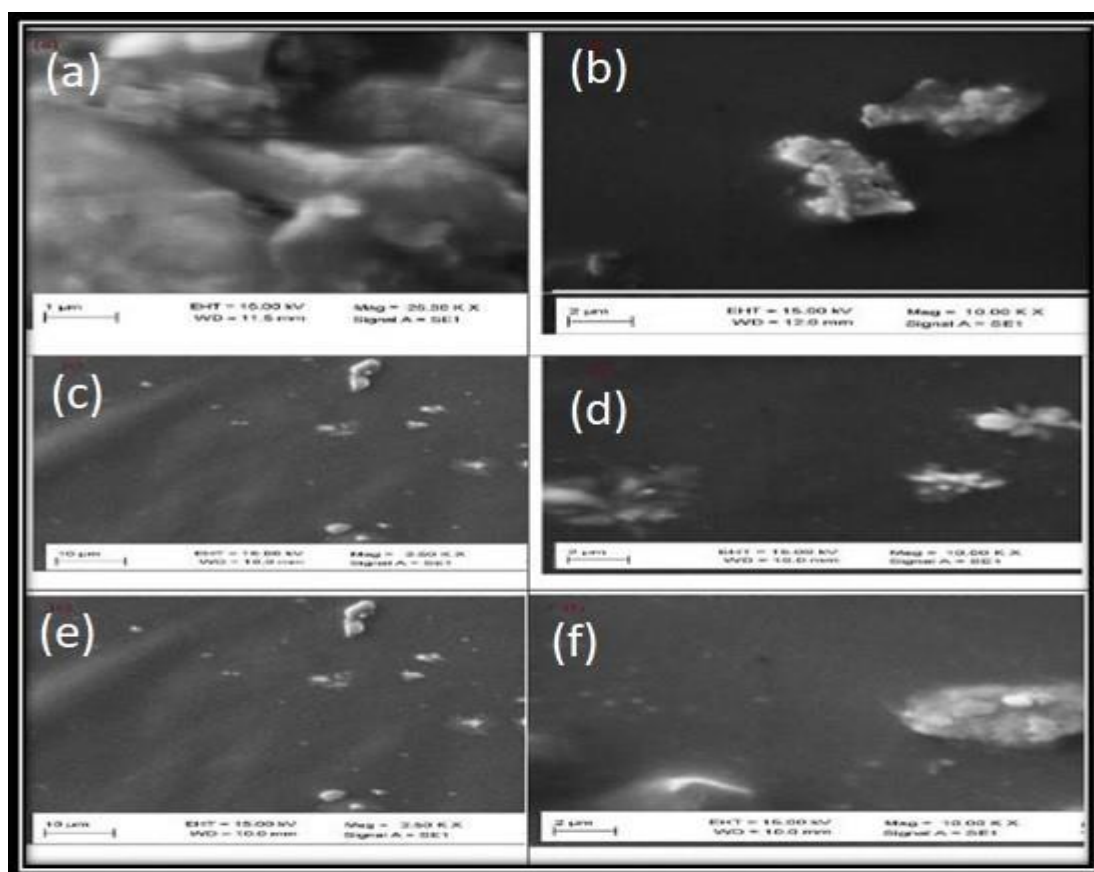


Fig. 2. SEM Images of the green synthesized Ag NPs with (a, b) 0.5 ml, (c, d) 1 ml and (e, f) 1.5 ml plant extract at different magnifications.

The SEM images confirmed the formation of silver nanoparticles in the aqueous solution of silver nitrate with different concentrations of the plant extract. The silver nanoparticles are uniformly distributed throughout the solution and are spherical in nature. The silver nanoparticles are well defined and uniform in size.

3.3 FT-IR Spectroscopy

FTIR measurements were carried out in order to identify the presence of various functional groups in biomolecules responsible for the bioreduction of Ag^+ to Ag^0 nanoparticles and capping/stabilization of silver nanoparticles. The observed intense bands were compared with standard values to identify the functional groups. Figure 3 shows the FTIR spectra of the green synthesized Ag NPs. The strong and broad band at 3334 cm^{-1} is due to O-H stretching vibration indicating the presence of alcohol and phenol. The band at 1743 cm^{-1} was assigned to the carboxyl group ($-\text{C}=\text{O}$) stretching vibration. The band at 1633 cm^{-1} in the spectra corresponds to C-N and C-C stretching indicating the presence of proteins [28]. The band at 1450 cm^{-1} was assigned for N-H stretch vibration present in the amide linkages of the proteins. These functional groups have role in stability/capping of Ag NPs as reported in many studies [29].

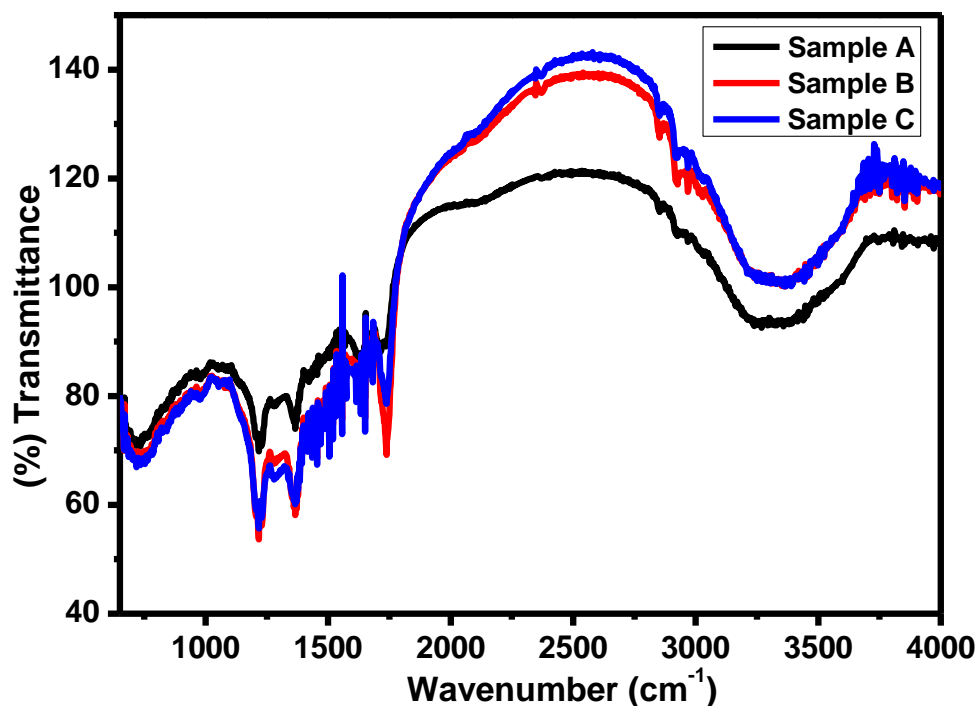


Fig.3 FTIR Spectra of green synthesized Ag NPs collected for different concentrations of the plant extract.

The band at 1377 cm^{-1} exemplifies the N=O symmetry stretching typical of the nitro compound. The band at 1240 cm^{-1} corresponds to C-N stretching of amines. The observed peaks are mainly attributed to flavonoids and terpenoids excessively present in plants extract. The wide and strong peak with maximum intensity at 720 cm^{-1} C-Br stretching, which is characteristic of alkyl halides [30]. From FTIR results, it can be concluded that some of the bioorganics compounds from *Azadirachta indica* extract formed a strong coating/capping on the nanoparticles.

4. Conclusion

A simple, cost effective green synthesis of stable spherical Ag NPs was demonstrated using the *Azadirachta indica* leaf extract which acts as both reducing/stabilising and capping agent at room temperature. The leaf extract quantity in the aqueous silver nitrate solution effects the size of the nanoparticles. Visual perception confirmed the formation of the Ag NPs after the addition of the leaf extract the same was confirmed using the UV-Vis spectroscopy absorption peak at 420–430 nm. The FTIR spectroscopy confirmed the functional groups responsible for the bioreduction of Ag^+ to Ag NPs. This green synthesis of Ag NPs could be a competitive alternative to other conventional chemical/physical methods and can be utilized for photovoltaic, sensing, optoelectronic devices in future.

References

- 1] M.C. Daniel, D. Astruc, "Gold nanoparticles: assembly, supramolecular chemistry, quantum-size-related properties, and applications toward biology, catalysis, and nanotechnology", *Chem. Rev.* **104**, 2004, 293–346.
- 2] Y. Tian, T. Tatsuma, "Plasmon-induced photoelectrochemistry at metal nanoparticles supported on nanoporous TiO_2 ", *Chem. Commun.* 2004, 1810–1811.
- 3] S.B. Kalidindi, U. Sanyal, B.R. Jagirdar, "Nanostructured Cu and Cu@Cu₂O core shell catalysts for hydrogen generation from ammonia-borane", *Phys. Chem. Chem. Phys.* **10**, 2008, 5870–5874.

- 4] M. Grzelczak, J.P. Juste, P. Mulvaney, L.M.L. Marzan, "Shape control in gold nanoparticle synthesis", *Chem. Soc. Rev.* **37**, 2008, 1783–1791.
- 5] C. B. Murray, S. Sun, H. Doyle, T. Betley, "Monodisperse 3d transition–metal (Co, Ni, Fe) nanoparticles and their assembly in to nanoparticle superlattices", *Mater. Res. Soc. Bull.*, **26** 2001, 985.
- 6] E. E. Elemike, D. C. Onwudiwe, L.Wei, L. Chaogang, Z. Zhiwei, "Noble metal–semiconductor nanocomposites for optical, energy and electronics applications" *Solar Ener. Mater. Solar Cells*, **201**, 2019, 110106.
- 7] S. P. Lim, A. Pandikumar, H. N. Lim, R. Ramaraj, N. M. Huang, "Boosting photovoltaic performance of dye sensitized solar cells using silver nanoparticle–decorated N,S–co–doped–TiO₂ photoanode", *Scientific Reports*, **5**, 2015, 11922.
- 8] K.L. Kelly, E. Coronado, L.L. Zhao, G.C. Schatz, "The optical properties of metal nanoparticles: the influence of size, shape, and dielectric environment", *J. Phys. Chem. B*, **107**, 2003, 668–677.
- 9] H.A. Atwater, A. Polman, "Plasmonics for improved photovoltaic devices", *Nat. Mater.* **9**, 2010, 205–213.
- 10] T. Tsuji, D. H. Thang, Y. Okazaki, M. Nakanishi, Y. Tsuboi, M. Tsuji, "Preparation of silver nanoparticles by laser ablation in polyvinylpyrrolidone solutions," *Appl. Surf. Sci.*, **254 (16)**, 2008, 5224–5230.
- 11] M. M. Kemp, A. Kumar, S. Mousa, T. J. Park, P. Ajayan, N. Kubotera, S. A. Mousa, R. J. Linhardt, "Synthesis of gold and silver nanoparticles stabilized with glycosaminoglycans having distinctive biological activities," *Biomacromolecules*, **10(3)**, 2009, 589–595.
- 12] H. Gao, L. Liu, Y.–F. Luo, D.–M. Jia, "In–situ preparation of epoxy/silver nanocomposites by thermal decomposition of silver–imidazole complex," *Mater. Lett.*, **65(23–24)**, 2011, 3529–3532.
- 13] K. A. Bogle, S. D. Dhole, and V. N. Bhoraskar, "Silver nanoparticles: synthesis and size control by electron irradiation," *Nanotechnology*, **17(13)**, article no. 021, 2006, 3204–3208.
- 14] J. B. Wolf, T. M. Stawski, G. J. Smales, A. F. Thunemann, F. Emmerling, "Towards automation of the polyol process for the synthesis of silver nanoparticles", *Scientific Reports*, **12**, 2022, 5769.
- 15] M. Z. Kassae, M. Mohammadkhani, A. Akhavan, R. Mohammadi, "In situ formation of silver nanoparticles in PMMA via reduction of silver ions by butylated hydroxytoluene", *Structural Chem.*, **22**, 2011, 11–15.
- 16] H. Schneidewind, T. Schuler, K.K. Strelau, K. Weber, D. Cialla, M. Diegel, "The morphology of silver nanoparticles prepared by enzyme–induced reduction", *Beilstein J. Nanotechnol.* **3**, 2012, 404–414.
- 17] K.B. Narayanan, N. Sakthivel, "Biological synthesis of metal nanoparticles by microbes", *Adv. Colloid Interf. Sci.* **156**, 2010, 1–13.
- 18] G.M. Sulaiman, W.H. Mohammed, T.R. Marzoog, A.A. Al–Amiery, A.A. Kadhum, A.B. Mohamad, G. Bagnati, "Green synthesis, antimicrobial and cytotoxic effects of silver nanoparticles using Eucalyptus chapmaniana leaves extract", *Asian Pac. J. Trop Biomed.* **3**, 2013, 58–63.
- 19] A.B. Vimalanathan, V. Tyagi, A. Rajesh, P. Devanand, M.G. Tyagi, "Biosynthesis of silver nanoparticles using Chinese white ginseng plant root Panax ginseng", *World J. Pharm. Pharm. Sci.* **2**, 2013, 2716–2725.
- 20] N. Duran, P.D. Marcato, O.L. Alves, G. Souza, G.I.H. De Souza, E. Esposito, "Mechanistic aspects of biosynthesis of silver nanoparticles by several Fusarium oxysporum strains", *J Nanobiotechnol.* **3**, 2005, 8–14.

- 21] M. Kowshik, S. Ashtaputre, S. Kharrazi, W. Vogel, J. Urban, S.K. Kulkarni, K.M. Paknikar, "Extracellular synthesis of silver nanoparticles by a silver-tolerant yeast strain MKY3", *Nanotechnology*, **14**, 2003, 95-100.
- 22] B. Ajitha, Y. A. Reddy, P. S. Reddy, "Green synthesis and characterization of silver nanoparticles using Lantana camara leaf extract" *Mater. Sci. Engi. C*, **49**, 2015, 373-381.
- 23] S. N. Kharat, V. D. Mendhulkar, "Synthesis, characterization and studies on antioxidant activity of silver nanoparticles using Elephantopus scaber leaf extract", *Mater. Sci. Engi. C*, **62**, 2016, 719-724.
- 24] A. K. Giri, B. Jena, B. Biswal, A. K. Pradhan, M. Arakha, S. Acharya, L. Acharya, "Green synthesis and characterization of silver nanoparticles using Eugenia roxburghii DC. extract and activity against biofilm-producing bacteria", *Sci. Reports.*, **12**, 2022, Article No. 8383.
- 25] A.Y. Obaid, S.A. Al-Thabaiti, L.M. Al-Harbi and Z. Khan, "Extracellular bio-synthesis of silver nanoparticles", *Global Adv. Res. J Microbio.*, **3(8)**, 2015, 119-126.
- 26] A.R.V. Nestor, V.S. Mendieta, M.A. CLopez, R.M.G. Espinosa, M.A.C. Lopez, J.A.A. Alatorre, "Solventless synthesis and optical properties of Au and Ag nanoparticles using camellia sinensis extract", *Mater. Lett.* **62**, 2008, 3103-3105.
- 27] K. G. Stamplecoskie, J. C. Scaiano, "Light emitting diode can control the morphology and optical properties of silver nanoparticles", *J. Am. Chem. Soc.* **132**, 2010, 1825-1827.
- 28] P. Prakash, P. Gnanaprakasam, R. Emmanuel, S. Arokiyaraj, M. Saravanan, "Green synthesis of silver nanoparticles from leaf extract of *Mimusops elengi*, Linn. for enhanced antibacterial activity against multi drug resistant clinical isolates", *Colloids and Surfaces B: Biointerfaces*, **108**, 2013, 255-259.
- 29] K. L. Niraimathi, V. Sudha, R. Lavanya, P. Brindha, "Biosynthesis of silver nanoparticles using *Alternanthera sessilis* (Linn.) extract and their antimicrobial, antioxidant activities" *Colloids and Surfaces B: Biointerfaces*, **102**, 2013, 288-291.
- 30] S. Mahdi, M. Taghdiri, V. Makari, M. Rahimi-Nasrabadi, "Procedure optimization for green synthesis of silver nanoparticles by aqueous extract of *Eucalyptus oleos*" *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, **136**, 2015, 1249-1254.