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Orginal Research Article

Green synthesis of silver nanoparticles using root extracts of *Cassia toral L*. and its antimicrobial activities

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ABSTRACT

Applying environmentally benign materials such as plant extracts used to synthesize silver nanoparticles (Ag-NPs) offers numerous benefits i.e. being eco-friendly and having compatibility for pharmaceutical and other biomedical applications. Metallic nanoparticles are used in different applications including; in electronics, catalysis, and in photonic. Silver metal has a great toxicity against a wide range of microorganisms, particularly silver nanoparticle which has promising antimicrobial properties. Silver nanoparticles are found to be effective as possessing anti-inflammatory, anti-angiogenesis, antiviral, and anti-platelet activities against cancer cells. The synthesized Ag-NPs of *Cassia tora L.* roots were characterized using UV-vis spectra, FT-IR, TEM, and XRD analysis. The antimicrobial activities were assessed by disc diffusion method. The Ag-NPs were also examined against the fresh cultures of one Gram-positive and three Gram-negative bacteria.

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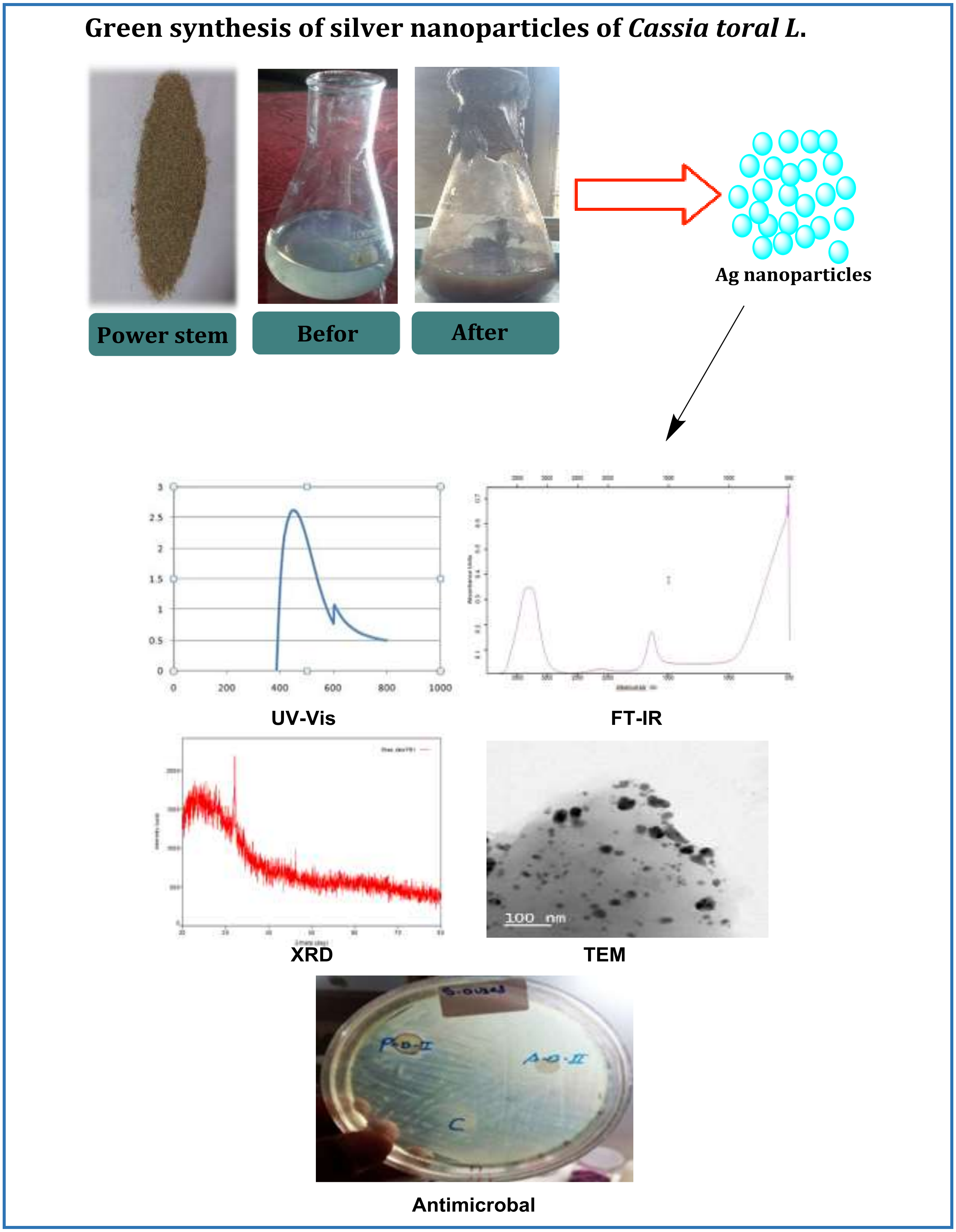
Graphical Abstract



Introduction

Recently, metal nanoparticles have gained a great deal of attention due to their unique chemical, optical, magnetic, mechanical, and electric magnetic properties. Thus, metallic nanoparticles have been used in various applications such as in electronics, catalysis, and photonic [1].

Nanotechnology is growing significantly due to its application in various fields including, medicine; biotechnology, and energy consumption [2]. "Green Synthesis" from plant extract is easy, relevant, efficient, and fast as compared to other chemical and physical methods [3]. Nanotechnology is a field that is burgeoning day by day, making an impact in all spheres of human life. New applications of nanoparticles and nanomaterials are emerging rapidly [4–6].

Nanocrystaline silver particles have found tremendous applications in biomolecular detection and diagnostics [7], antimicrobials and therapeutics [8, 9], catalysis [10], and micro-electronics [11]. Ag-NPs are known to have electrical conducting, magnetic, catalytic, sensing and optical properties [12–14]. They can also be used in coating or embedding for medical purposes [15] and found to be effective as antibacterial, antiviral, anti-inflammatory, anti-angiogenesis, and anti-platelet activities [16, 17]. In addition to their medical uses, Ag-NPs are also used in clothing, catalysis, biosensing, bio-labeling, food industry, paints, optics, electronics, imaging, and water treatment, selective coatings for solar energy absorption, sunscreens and cosmetics [18–26].

"Green chemistry" approach to synthesizing biocompatible nanoparticles has gained attention in recent years. Plant extracts and other natural resources has been found to be an excellent alternative method for green synthesis of nanoparticle due to the fact that this method does not use any toxic chemicals and also has numerous benefits; including, environmental friendliness, and suitability for pharmaceutical and biomedical applications [27, 28].

In this work silver nanoparitcles are synthesized using green, cost effective, fast, and an easy method by the aqueous root extract of *Cassia tora L*. which acts as a reducing and capping agent reducing the silver ion to silver nanoparticles. The Ag-NPs of *Cassia tora L*. root extract was characterized using UV-vis specta, FT-IR, TEM, XRD analysis and antimicrobial activities against Gram-positive and Gram-negative bacteria.

Experimental

Materials and methods

The plant of *Cassia tora L.* was collected from campus of G.V.I.S.H. Amravati, Maharashtra state, India. Throughout the experiment de-ionized water was used (Figure 1).

Preparation of plant extract

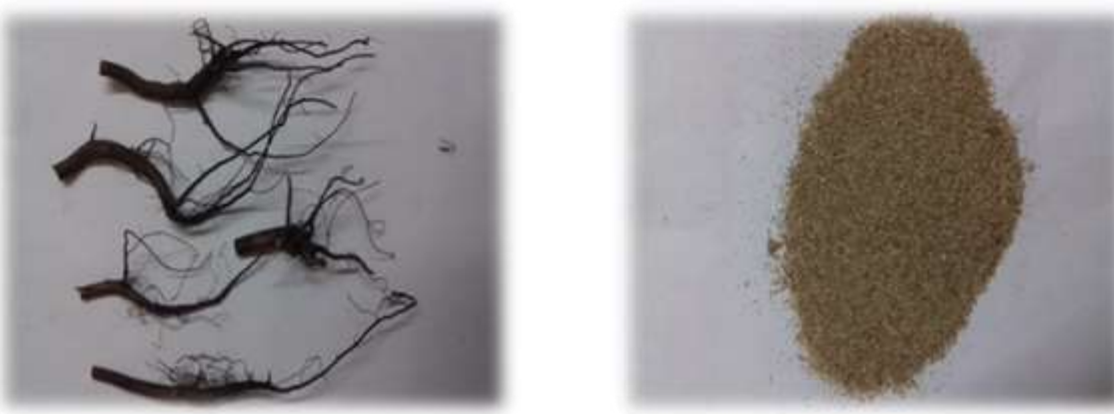
The root of *Cassia tora L.* was first separated from the plant and, then, washed with de-ionized water and dried for 1–2 week at room temperature. The dried roots were crushed into fine powder. Afterwards, 10 g of dried root powder of *Cassia tora L.* was mixed with 100 mL of de-ionized water. The mixture was stirred for 3 hours. Aqueous extract was separated by whatman filter paper no. 1.

Synthesis of silver nanoparticles

5 mL of fresh root extract of *Cassia tora* L. was added to a conical flask containing 40 mL of 1 mM $AgNo_3$ solution under the exposure of sunlight. The silver ions were reduced to silver nanoparticles within few minutes by *Cassia tora* L. root extract. The quick change of solution color showed the formation of silver nanoparticles (Figure 2). The color of solution changed from yellow to light brown and, then, from light brown to dark brown.

Characterization of silver nanoparticles

The reduction of pure Ag^+ ions was monitored by measuring the UV-vis spectrum of the reaction medium after diluting a small aliquot of the root extract of *Cassia tora L.* into deionized water. UV-vis spectral analysis was done using Shimadzu UV-1800 spectrophotometer at room temperature between the range of 190–800 nm. The size and morphology of the synthesized nanospeheres were characterized by transmission electron microscopy (TEM), on conventional carbon-coated copper grids. The size distribution of the Ag-NPs was calculated from the TEM images and the composition and crystal structure of the synthesized nanoparticles were determined by an X-ray diffractometer (XRD) at an ambient temperature. The characterization of the functional groups present in the silver nanoparticles was investigated by FT-IR spectrophotometer (FT-IR analysis was done with KBr pellets and recorded in the range of 500-3500 cm^{-1}).



A B

Figure 1. a) dried root, b) powdered root

Figure 2. c) before 3h, d) after 3 h

Antimicrobial analysis

Ag-NPs synthesized from *Cassia tora L.* root extract were tested for antimicrobial activity against pathogens like *P. seudomonas, E. coli, S. typhy and S. aureus* using disc diffusion method. The fresh cultures were taken on Muller-Hinton agar. The culture was incubated at 37 °C for 24 hours. The diameter of inhibition zones around Ag-NPs were measured and compared to the diameter of inhibition zone. In this sense, silver is effective against more than 650 pathogens having a broad spectrum of activity. But, when it is used in the formation of silver nanoparticles, it enhances the property allowing its use in a wide range of application.

Results and discussion

Nowadays, nanomaterials are at the primary stage of fast developing nanotechnology phase. Nanoparticles are facilitating modern technology to deal with non-sized objects, their unique properties especially, especially size-dependent ones, make them superior materials and essential in different human activities [29]. It has been clarified that silver nanoparticles exhibit yellowish brown color in aqueous solution due to excitation of surface Plasmon vibration in silver nanoparticles [30]. The addition of aqueous root extract of *Cassia tora L.* to the 1 mM solution of silver nitrate in presence of sunlight resulted the formation of silver nanoparticles [31]. Reaction is fast when the addition is done in presence of direct sunlight. The sunlight induces “Green synthesis” of silver nanoparitcles [32].

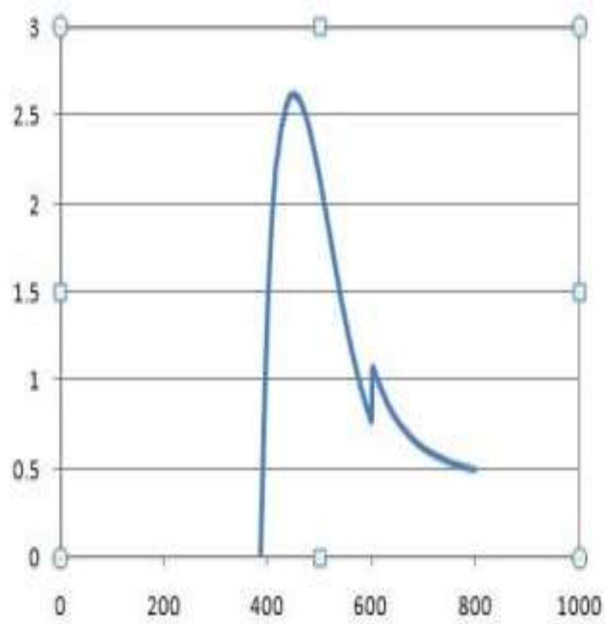
Spectra showing absorbance of synthesized Ag-NPs at different time interval

The reduction of the aqueous Ag^{+} ions during exposure to the root extract of *Cassia tora L*. may be easily followed by UV-vis spectroscopy at different time intervals. Figure 3 shows day 1 to day 4, respectively.

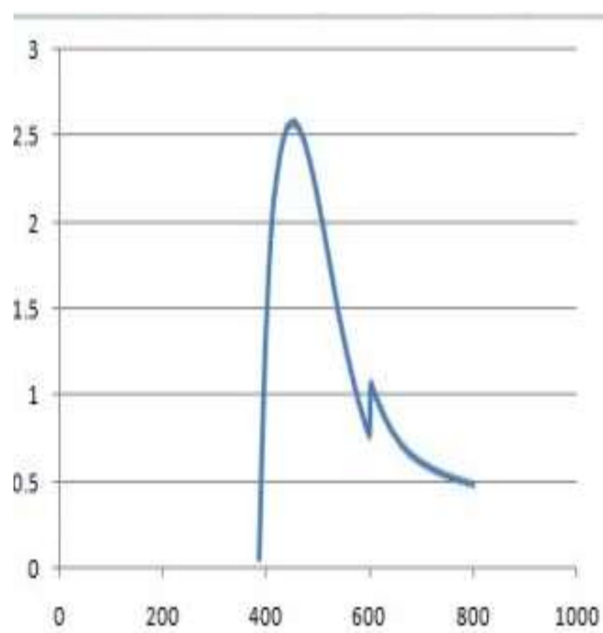
The XRD pattern was used to determine the crystalline nature, peak intensity position and width of silver nanoparticles (Figure 4). The peak appeared at (2θ) 33.70 corresponding to the (111) Planes, respectively. Besides, some studies reported five intense peaks of Ag-NPs at 27.5, 31.99, 45.99, 67.26, 76.46 [33]. The particles are predominantly spherical in shape with a diameter ranging from x nm to y nm. Morphology of the interplanar distance spacing was calculated using Bragg's equation.

$$N\lambda = 2d \sin\theta$$

FT-IR spectra provided information about the interaction of Ag-NPs with aqueous root extract of *Cassia tora L*. The results of the FT-IR analysis showed different stretches at different peaks (Figure 5). The strong peak at 3424 cm^{-1} is due to N–H stretch. The band around 2071 cm^{-1} is due to C≡C, whereas the sharp peak at 1652 cm^{-1} corresponds to amide I arising in accordance to carbonyl stretch in proteins indicating predominant surface capping species which are mainly responsible for stabilization. The broad asymmetric spectra at 2108 cm^{-1} can be assigned to the N–H stretching in the free amino groups of silver nanoparticles [34–40].



Day 1



Day 2

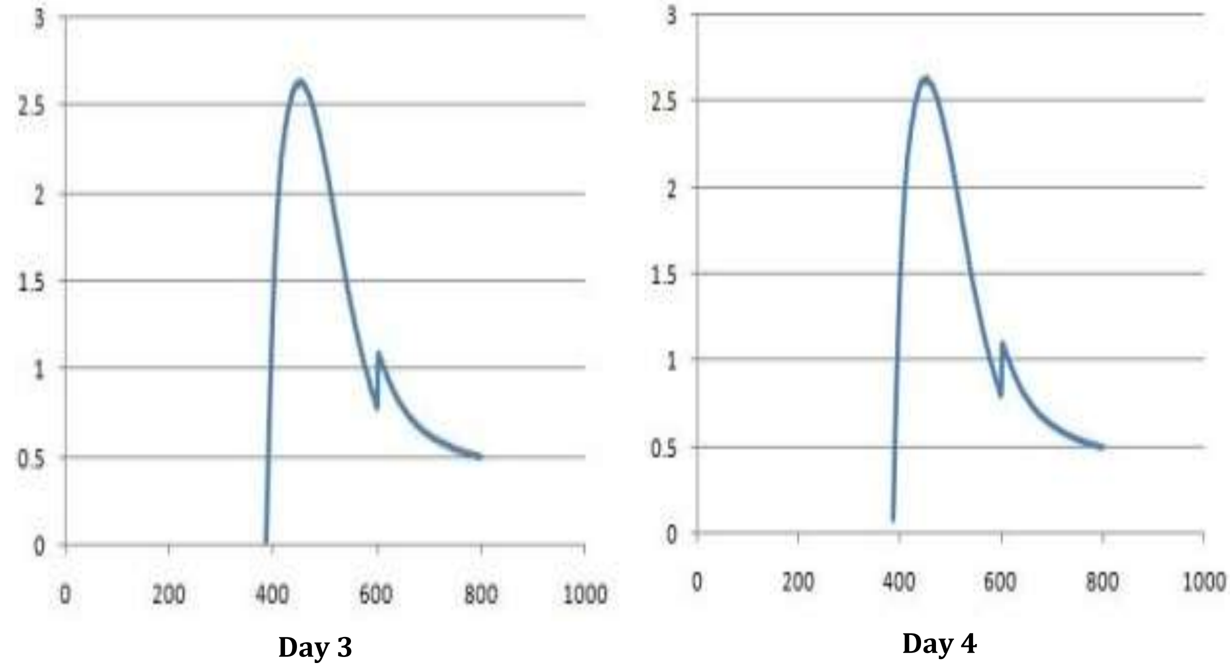


Figure 3. UV-Vis

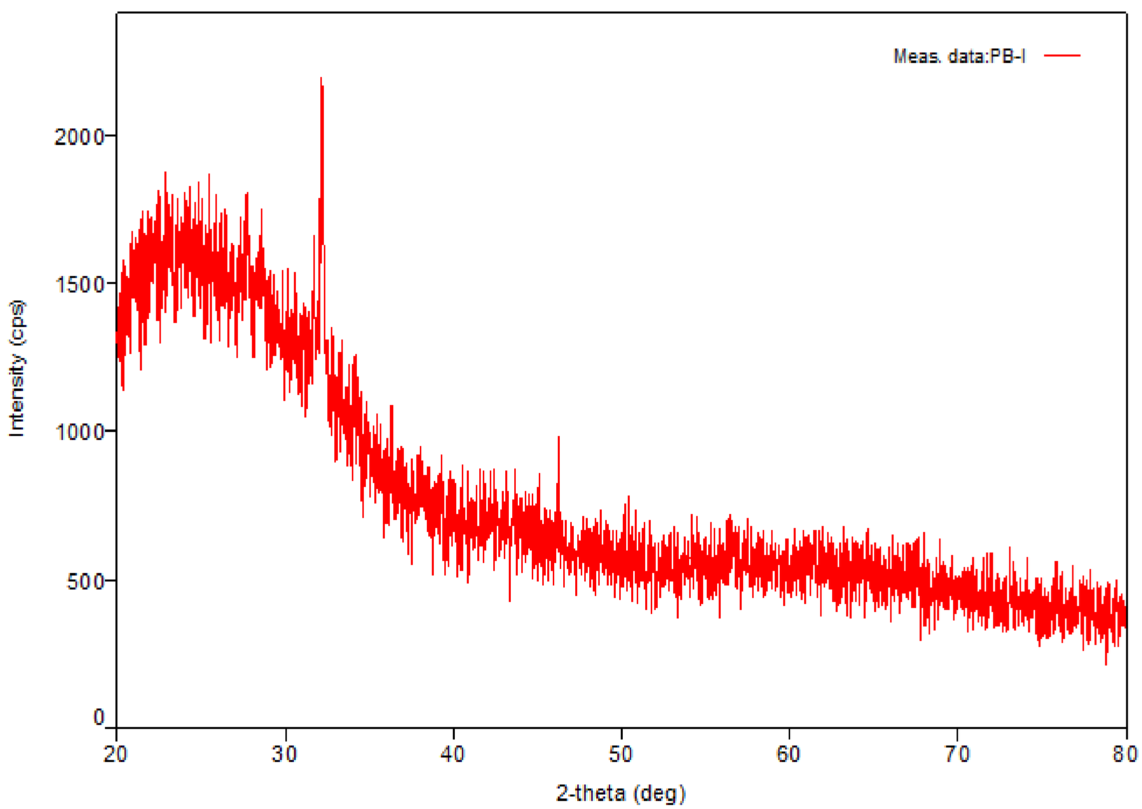


Figure 4. XRD pattern of synthesized silver nanoparticles from root extract of *Cassia tora L*

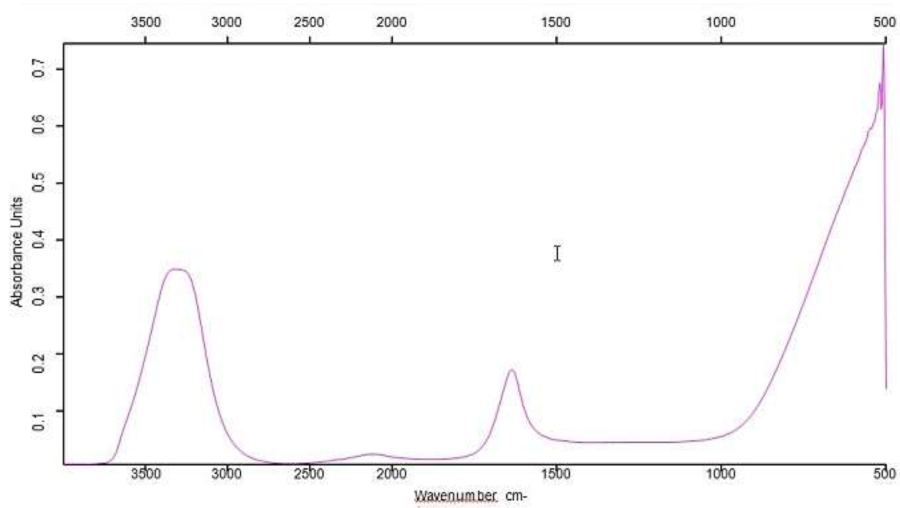
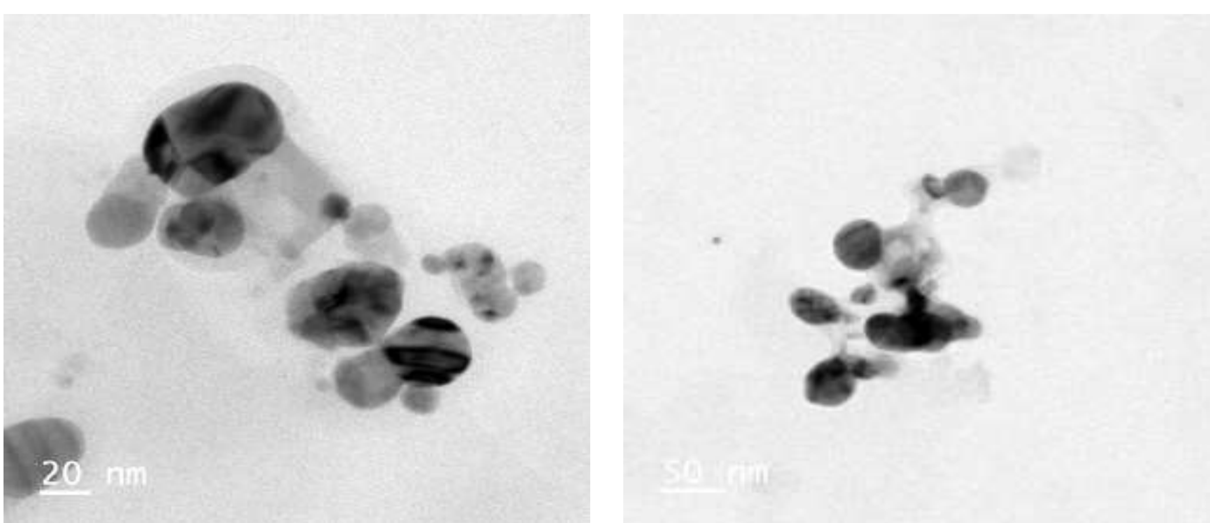


Figure 5. FT-IR spectra of silver nanoparticles

Shape and size of the synthesized silver nanoparticles of *Cassia tora L.* root extract were confirmed by TEM analysis (Figure 6). The TEM micrographs suggested that the synthesized Ag-NPs were of spherical shape [41]. It is used to obtain the measurement of colloidal particle, its distribution and morphology [42].

Synthesized silver nanoparticles were tested against pathogens such as *P. seudomonas, E. coli, S. typhy* and *S. aureus* by disc diffusion method (Figure 7). Among the pathogens, *P. seudomonas* and *S. aureus* were highly sensitive to the synthesized silver nanoparticles. It has been reported that when bacterial cells come to contact with silver nanoparticles, they inhibit the growth and reproduction of bacterial cells [43]. The silver nanoparticles are used in industries, pharmacy and in medicine as they have shown inhibitory activities against various microorganisms. By considering the antimicrobial activity of silver nanoparticles, they can be used in the treatment of cancer [44–45].



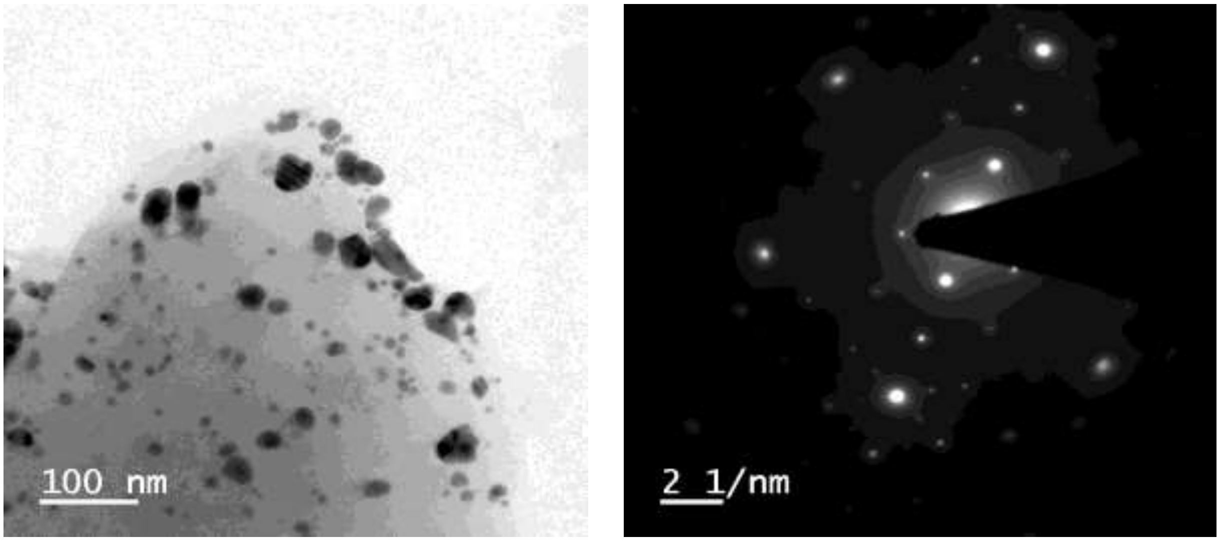


Figure 6. TEM images of syhthesized Ag-NPs at different magnification level

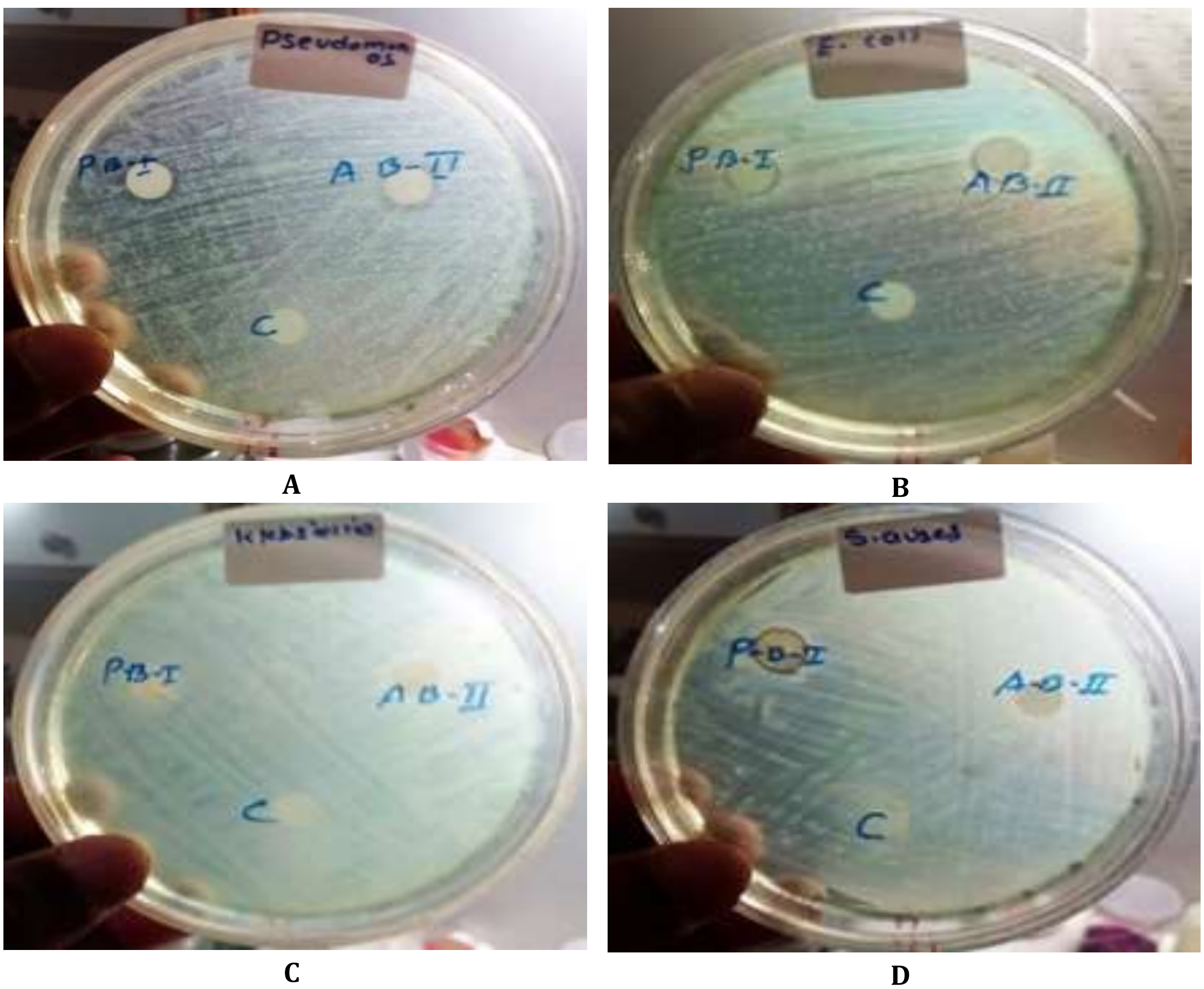


Figure 7. Antimicrobial activity of silver nanoparticles against different bacteria

Conclusion

This research study introduced a procedure for rapid synthesis of Ag-NPs using aq. root extract of *Cassia tora L*. and applying an eco-friendly and convenient method. The green synthesized Ag-NPs were confirmed by various analyses such as UV-Vis, spectrophotometer, XRD, FT-IR, and TEM. The synthesized Ag-NPs were found to be very active against the *P. seudomonas* and *S. typhy.*

Disclosure statement

No potential conflict of interest was reported by the authors.

References

[1]. Vaidyanathan R., Kalishwaralal K., Gopalram S., Gurunathan S. *Biotochenol. Adv.,* 2009, **27**:924

[2]. Bae D.S., Kim E.J., Bang J.H., Kim S.W., Han K.S., Lee J.K., Kim B.I., Adair J.H. *Met. Mater. Int.,* 2005, **11**:291

[3]. Rivas L., Sanchez-Cortes S., Gracia-Ramos J.V., Morcillo G. *Langmuir*, 2001, **17**:574

[4]. Jahn W. *J. Struct. Biol.,* 1999, **127**:106

[5]. Naiwa H.S., Academic Press New York, 2000, p 1

[6]. Murphy C.J. *J. Mater. Chem*., 2008, **18**:2173

[7]. Schultz S., Smith D.R., Mock J.J., Schultz D.A. *Proc. Natl. Acad. Sci.,* 2000, **97**:996

[8]. Rai M., Yadav A., Gade A. *Biotechnol. Adv.,* 2009, **27**:76

[9]. Elechiguerra J.L., Burt J.L., Morones J.R., Camacho-Bragado A., Gao X., Lara H.H., Yacaman M.J. *J. Nanobiotechnol.,* 2005, **3**:6

[10]. Crooks R.M., Lemon B.I., Sun L., Yeung K., Zhao Top M., *Curr. Chem*., 2001, **212**:82

[11]. Gittins D.I., Bethell D., Nichols R.J., Schiffrin D.J. *J. Matter. Chem*., 2000, **10**:79

[12]. Abou El-Nour K.M.M., Eftaiha A., Al-Warthan A., Ammar R.A.A. *Arab. J. Chem.,* 2010, **3**:135

[13]. Krolikowska A., Kudelski A., Michota A., Bukowska J. *Surf. Sci.*, 2003, **532**:227

[14]. Catauro M., Raucci M.G., De Gaetano F.D., Marotta J.A. *Matter. Sci. Matter. Med*., 2004, **15**:831

[15]. Xu X., Yang Q., Bai J., Lu T., Li Y., Jing X. *J. Nanosci. Nanotechnol*., 2008, **8**:5066

[16]. Sotiriou G.A., Pratsinis S.E. *Environ. Sci. Technol*., 2010, **44**:5649

[17]. Safaepour M., Shahverdi A.R., Shahverdi H.R., Khorramizadeh M.R., Gohari A.R. *Avicenna. J. Med. Biotechnol.,* 2009, **1**:111

[18]. Gulrajani M.L., Gupta D., Periyasamy S., Muthu S.G. *J. Appl. Polym. Sci*., 2008, **108**:614

[19]. Vigneshwaran N., Kathe A.A., Varadarajan P.V., Nachane R.P., Balasubramanaya R.H. *J. Nanosci. Nanotechnol,* 2007, **7**:1893

[20]. Kumar A., Vemula P.K., Ajayan P.M., John G. *Nat. Mater.,* 2008, **7**:236

[21]. Bosetti M., Masse A., Tobin E., Cannas M. *Biomaterials*, 2002, **23**:887

[22]. Cho M., Chung H., Choi W., Yoon J. *Appl. Environ. Microbiol*., 2005, **71**:270

[23]. Li Q., Mahendra S., Lyon D.Y., Brunet L., Liga M.V., Li D., Alvarez P.J.J. *Water Res*., 2008, **42**:4591

[24]. Smitha S.L., Nissamudeen K.M., Philip D., Gopchandran K.G. *Spectrochim. Acta A.,* 2008, **71**:186

[25]. Kalimuthu K., Babu R.S., Venkataraman D., Bilal M., Gurunathan S. *Colloid Surf. B*., 2008, **65**:150

[26]. Kowshik M., Ashtaputure S., Kharazi S., Vogel W., Urvan J., Kulkarni S.K., Paknikar K.M. *Nanotechnology*, 2003, **14**:95

[27]. Dahl J.A., Maddux B.L.S., Hutchison J.E. *Chem Rev*., 2007, **107**:2228

[28]. Hutchison J.E. *ACS Nano*., 2008, **2**:395

[29]. Shinkai M., Yanase M., Suzuki M., Honda H., Wakabayashi T., Yoshida J., Kobayashi T. *J. Magn. Magn. Mater.,* 1999, **194**:176

[30]. Shankar S.S., Rai A., Ankamwar B., Singh A., Ahmad A., Sastry M., *Nat. Mater*., 2004, **3**:482

[31]. Sahebrao B.K., Raut R.W., Lakkakula J.R., Mendhulkar V.W., Kolekar N.S. *Curr. Nanoscience*, 2009, **5**:117

[32]. Pathak R.S., Hendre A. *Der Pharmacia letter*, 2015, **7:**313

[33]. Pavani K.V., Gayathramma K., Banerjee A., Shah S. *American J. Nanomater*., 2013, **1**:5

[34]. Sheela N.R., Muthu S., Krishnan S.S. *Asian J. Chem.*, 2010, **22**:5049

[35]. Das S., Das J., Samadder A., Bhattacharyya S.S., Das D., Khuda-Bukhsh A.R. *Colloids and Surfaces B. Biointerfaces,* 2013, **101**:325

[36]. Dinesh S., Karhikeyan S., Arumugam P. *Archives of Applied science Research*, 2012, **4**:178

[37]. Suman T.Y., Rajasree S.R.R., Kanchana A., Elizabeht S.B. *Colloids and surfaces B, Biointerfaces*, 2013, **106**:74

[38]. Vivek R., Thangam R., Muthuchelian K., Gunasekaram P., Kaveri K., Kannan S. *Proc. biochem.*, 2012, **47**:2405

[39]. Naz S., Khaskheli AR., Aljabour A., Kara H., Talpur FN, Sherazi STH., Khaskheli AA., Jawaid S., *Hindawi Publishing Corporation Advances in Chemistry*, 2014, **2014**:6

[40]. Kirthika P., Dheeba B., Sivakumar R., Abdulla S.S. *Int. J. Pharm. Pharm. Sci.*, 2014, **6**:8

[41]. Arun S., Saraswathi U., Singaravelu. *Int. J. Pharm. Sci*., 2014, **3**:54

[42]. Lin P.C., Lin S., Wang P.C., Sridhar R. *Biotechnol. Adv*., 2016, **32**:711

[43]. Kim S.H., Lee S.H., Ryu D.S., Choi S.J., Lee D.S. *Korean J. Microbiol. Biotechnol*., 2011, **39**:77

[44]. Patil S., Sivaraj R., Venckatesh R., Vanathi P., Rajiv P. *Int. J. Curr. Res*., 2015, **7**:21539

[45]. Kim J.S., Kuk E., Yu K.N., Kim J.H., Park S.J., Lee H.J., Kim S.H., Park Y.K., Park Y.H., Hwang C.Y., Kim Y.K., Lee Y.S., Jeong D.H., Cho M.H. *Nanomedicine*, 2007, **3**:95

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