Journal of Pharmaceutical and Biomedical Analysis Letters
ISSN: 2347-4742 | https://doi.org/10.30904/j.jpbmal.2026.5023
J. Pharm, Biomed. A. Lett., 2026; 14(2): 33-37

Biosynthesis of silver nano particles of herbal plant extracts and characterisation by using UV and FTIR analysis

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Keywords
Green synthesis**,**
Silver nanoparticles,
Zingiber officinale,
Carica papaya,
Camellia sinensis,
Antioxidant,

Received 20-03-2026
Revised 12-04-2026
Accepted 14-05-2026
Published 20-06-2026

ABSTRACT
The present study explores the green synthesis of silver nanoparticles (AgNPs) using aqueous extracts of Zingiber officinale (ginger rhizome), Carica papaya (papaya seeds), and Camellia sinensis (green tea leaves). Extracts were subjected to phytochemical screening, total phenolic content (TPC) estimation, and characterization of AgNPs by UV–Vis and FTIR. Their biological efficacy was evaluated through catalytic degradation of methylene blue, antioxidant activity (DPPH assay), and antimicrobial studies. Ginger showed the highest TPC (75.65 mg GAE/mg), efficient AgNP formation, and strong antioxidant, antimicrobial, and catalytic activities. Papaya seeds, with lower TPC (13.7 mg GAE/mg), produced AgNPs with moderate antioxidant and antimicrobial effects, particularly against E. coli. Green tea (36.64 mg GAE/mg) yielded stable AgNPs with significant antioxidant, catalytic, and antibacterial activity. These findings highlight plant-mediated AgNPs as eco-friendly nanomaterials with biomedical and environmental potential, with ginger demonstrating the strongest overall performance.

INTRODUCTION

Nanotechnology is the study of creating functional systems at the molecular level. The top-down method (physical processes) and the bottom-up approach (chemical and biological processes) are the two main steps in calculating the development of nanotechnology. In the bottom-up and top-down techniques, respectively, the materials and devices are constructed by the molecular components themselves utilizing the molecular recognition principle and developed from larger entities without control of the atomic level [1-6]. The two main approaches of nanotechnology, leading to the progression are shown in Fig.1. Researchers today are increasingly focusing on synthesizing nanomaterials because of their versatile properties and widespread applications in fields as diverse as nanoelectronics, nanomechanics, nanophotonics, nanoionics, food technologies, non-linear optics, environmental health, drug delivery systems, cosmetics, and personal care products [7]. These fields had been evolved during the last few decades by providing a basic scientific foundation for the expansion of nanotechnology. The properties of NMTs are changed by decreasing their size due to statistical and quantum mechanical effects. The interface and colloidal science produced number of materials like NPs, nanorods, which are very much useful in nanotechnology to produce variety of NMTs with fast ion transport, related to nanoelectronics and nanoionics. The NPs or NMTs with their diversified utilization have been considered for increasing of economy in different fields such as energy, pharmaceutical, agriculture and transportation etc., [8,9] for improving quality of life and making it simpler. The development of metal nanoparticles (MNPs) is another breakthrough in nanotechnology; these MNPs, with their micro size and enormous surface area, have crucial physical and chemical features.

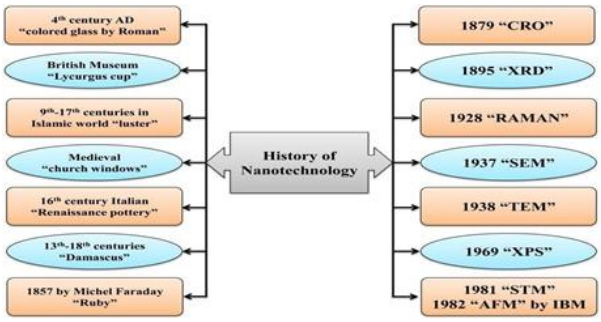

Fig.1: Historical background of Nanotechnology

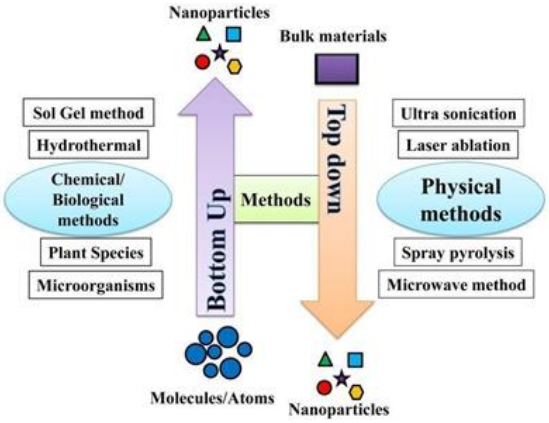

Fig.2: Synthetic methods of MNPs

MATERIALS AND METHODS

Synthesis of Silver Nanoparticles

At room temperature, an equal quantity of aqueous extracts of dried rhizome of Zingiber Officinale, dried seeds of Carica papaya and dried leaves of Camellia sinensis were added drop-wise to a conical flask containing 100ml 1mM silver nitrate solution while constantly mixing. Three types of particles are prepared by using three extracts. To avoid silver auto-oxidation, we maintained the solution in the dark. 20 ml of 0.1M sodium carbonate is added, to increase the reducing potentials of extract until pale yellow, brown and olive green colour formation and centrifugation is carried out with resulting solution at 10000 rpm for 15min, removed the supernatant to produce AgNPs [10].

Fig.3: Synthesis of AgNPs by using Rhizome extract of Zingiber Officinale

Fig.4: Sequence of formation of AgNPs by using Rhizome extract of Zingiber officinale

Fig.5: Synthesis of AgNPs by using Seeds extract of Carica papaya

Fig.6: Sequence of formation of AgNPs by using Seeds extract of Carica papaya

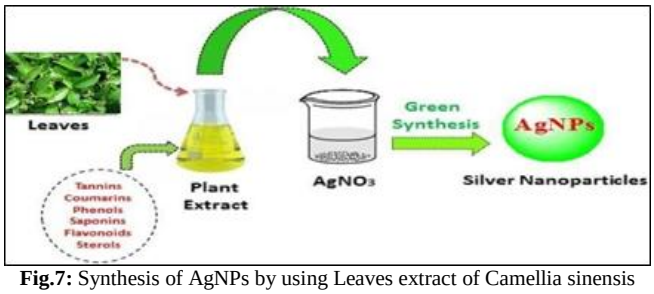

Fig.7: Synthesis of AgNPs by using Leaves extract of Camellia sinensis

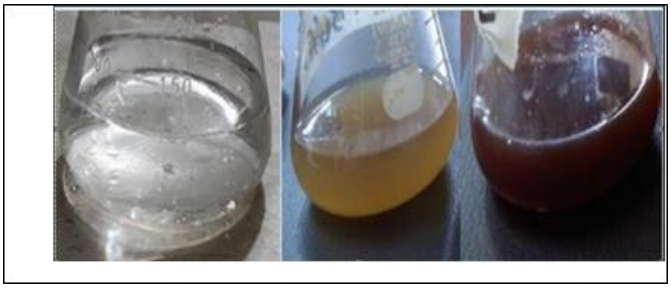

Fig.8: Sequence of formation of AgNPs by using Leaves extract of Camellia sinensis

Catalytic Reduction of Methylene blue during AgNPs Synthesis: The absorption value of methylene blue is used for the effective catalytic reduction of chemical dyes. It is demonstrated using different volumes of aqueous extracts containing 15 ml of aqueous extract. After 30 minutes and 60 minutes of incubation, response is monitored at room temperature. In addition, 1ml methylene was added to the different aliquots of generated AgNPs, and the response after 30 and 60 min of incubation. When compared to methylene blue, the absorption values at 670 nm were the greatest [11].

Characterization techniques

A brief description of principle, working and instrumentation of the spectrophotometers employed for characterization of synthesized AgNPs. The instruments utilized for confirmation of prepared AgNPs and to verify their properties area.

Ultraviolet-visible spectroscopy (UV-Vis spectroscopy)

Spectral analysis of the fractions of rhizome, seeds and leaves extracts was performed to determine their λmax by using UV-Vis spectroscopy (Lab India 3000+) at wavelength range of 200 – 800 nm. The respective eluents used for separation of fraction in column chromatography were used as blank. UV-Vis spectroscopy is to study the interaction of nanoparticles with light. It's particularly useful for analyzing the optical properties of nanoparticles, such as their plasmon resonance. Procedure: A sample of the synthesized nanoparticles is prepared in solution. The UV- Vis spectrophotometer measures the absorbance of light by the nanoparticles at various wavelengths. The resulting

spectrum can reveal the absorption peak, which corresponds to the plasmon resonance of the nanoparticles. This peak's location and magnitude reveal details on the size, shape, and concentration of the nanoparticles[12].

Fourier Transform Infrared Spectroscopy (FTIR)

In order to identify the functional groups with antioxidant properties present in the selected fractions of rhizome, seeds and leaves extracts, IR spectrum (Bruker 8400, Shimadzu) was recorded at wave number range of 4000 – 400 cm-1. Sample preparation was done by Potassium Bromide (KBr) pressed pellet method. FTIR is used to study functional groups and chemical composition of nanoparticles by analyzing the absorption of infrared light[13].

Procedure:

A sample of the nanoparticles is mixed with an infrared-transparent material (such as KBr) to form a pellet or placed in a suitable liquid cell. The FTIR spectrometer measures the interaction of infrared light with the sample. The resulting spectrum shows absorption peaks at specific wavenumbers, corresponding to vibrations of chemical bonds in the nanoparticles. FTIR analysis can identify functional groups on the nanoparticle surface and reveal potential interactions between the nanoparticles and the plant extracts used in the synthesis[14].

Determination of Antioxidant Activity

Free Radical Scavenging Activity by Using DPPH (1,1-Diphenyl-2- picrylhydrazyl (DPPH) 2,2-Diphenyl-1 picrylhydrazyl (DPPH) was used to measure free radical scavenging to establish antioxidant activity. A 0.1 mM DPPH solution was first diluted in 82% ethanol. 1mg/ml stock solutions of each AgNPs of aqueous extract of rhizome of Zingiber, seeds of Carica papaya and leaves of camellia sinensis and series of concentration of 50-350µg/ml were prepared and 2ml of DPPH (0.1mM) is taken and the absorbances of the solutions were taken at 517 nm in triplicate after 30 minutes of incubation. A "blank" test was performed, in which water was used in lieu of the sample [15]. To calculate radical scavenging activity, the following equation was used.

% Radical scavenging activity = A0 - A1/A0 × 100 Where A0=The absorbance of blank

A1= The absorbance of the sample.

Antimicrobial Activity of Zi-AgNPs,Cp-AgNPs & Cs-AgNPs

The biogenic AgNPs antibacterial efficacy against gram-negative bacteria. The Escherichia coli (ATCC 10798) organisms based on their human infections and gram positive bacteria such as Staphylococcus aurues. (ATCC 6538) The inhibitory effects of silver nanoparticles on bacterial growth was assessed using following method.

Preparation of media

The medium was prepared per the instructions provided by the maker. After adding 38 grams of Mueller Hinton Agar to 1000 ml of distilled water in a flask, the mixture was heated very slowly until the agar was fully dissolved. For 15 minutes at 1210C, the medium was autoclaved to ensure its sterility. After cooling to between 45 and 50 0C, around 25 ml of the sterilized medium was aseptically placed onto sterilized Petri dishes with a 90 mm diameter, and the dishes were allowed to dry until any leftover moisture from the surface of the agar was gone. The sterility of the manufactured medium was determined by incubating a selection of plates at 37 0C for 24 hours.

Preparation of disc

Absorbent filter paper (Whatman no.1) was used to make 6mm diameter diffusion discs, which were then sterilized at 12000C for 1hour and dried in oven. The discs were then soaked aseptically with 30µl of each crude extract of plant at a concentration of 100 mg/ml using a sterile digital micro pipette, air-dried for 15 minutes at room temperature, and then kept at 40C until use.

Disc diffusion method for Antimicrobial activity

Screening and assessing synthesized AgNPs for their antibacterial properties is often done using the disc diffusion technique. Various bacterial strains, including G+ve Staphylococcus aureus and G-ve Escherichia coli, were used to test the antibacterial efficacy of the synthesized AgNPs. Nutrient agar is the go-to medium for cultivating bacteria in the disc diffusion technique. Beef extract, agar, starch, and casein hydrolysate are the main components. The nutritional agar is first dissolved in sterile water and the PH is neutralized at room temperature. The nutritional agar medium is autoclaved for 15 minutes at 15 pounds of pressure and 120 0C. Each sterilized and dried glass petri dish gets around 15-20 ml of autoclaved nutritional agar material. After 20 minutes, the petri dishes are dried and replaced with test microorganisms. Then, we placed the 6mm sample discs on top of it. The petri dishes were kept in an incubator at 37 °C for 24 hours. The resulting zone of inhibition is hand- calculated using a ruler [16].

RESULTS AND DISCUSSION

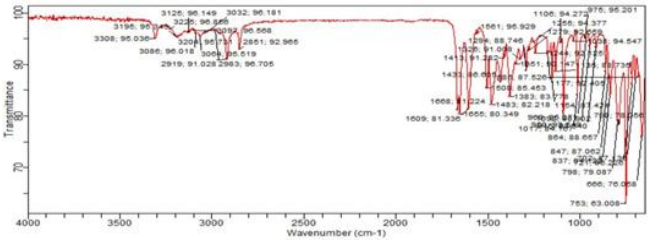

Fig.9: FTIR analysis of AgNPs

FTIR analysis

The FTIR spectra of dried Cs-AgNPs are shown. Absorption band analysis was used to determine the chemicals involved in the reduction and capping of Cs- AgNPs by photochemistry. There were many peaks in the infrared spectrum of green tea extract, including ones at 3308 cm-1, 2983 cm-1, 2851 cm-1, 1655 cm-1, 1383 cm-1, 1106cm-1, 1038cm^{-1}, and 969 cm-1. O-H stretching of alcohol in polyphenols and N-H stretching of amines are responsible for the wide band at 3308 cm-1. C-H stretching in alkanes and OH stretching in carboxylic acids produce the wide bands at 2983 cm-1 and 2851 cm-1 respectively. C-O-C stretching is shown by the 1106 cm-1 and 1038 cm-1 peaks, whereas C=C bending is seen by the 969 cm-1 peak. In addition to proteins, flavonoids, saponins, and glycosides, phytochemical examination of Cs-AgNPs indicates the presence of polyphenols such as gallic acid (GA), gallo-catechin (GC), Catechin(CE), epigallocatechin, and gallic acid. The FTIR spectra of Cs-AgNPs show that they have peaks at 2919 cm-1, 1609 cm-1, 1244 cm-1, 1017 cm-1, and 753 cm-1. C- H stretching and N-H bending are shown by the peaks at

2919 cm-1 and 1609 cm-1 respectively. The FTIR spectra of Cs-AgNPs may be compared to one another to reveal differences in their chemical composition. C-O stretching and C=O ketone stretching account for the peaks at 1244 cm-1 and 1017 cm-1 whereas C-H bending is responsible for the peak at 753cm-1 [17].

Catalytic Reduction of Cs-AgNPs

Methylene blue decrease by nanoparticles mediated by plants is widely established. The maximum absorption is 670 nm of Pure Methylene Blue. We added the green tea leaves extracts thirty minutes after the teal; the absorption reduced progressively and increased to a higher wavelength[18-20]. The decrease in absorption shows that the green tea leaves extract can destroy the methylene blue. The dye-containing reaction combination of Cs-AgNPs and the extract exhibited a greater absorbance rate after 30 minutes than Green tea leaves extract. However, a significant reduction in the absorption of Methylene blue occurred during the 70% reaction mix.

Characterization of Cs-AgNPs

UV- Vis Spectroscopy

Observing the surface phenomena of metallic nanoparticles using a UV-Vis spectrometer is a typical way to verify the synthesis of Cs-AgNPs in a colloidal solution. This optical characteristic is very size-, shape-, concentration-, and agglomeration- dependent. Cs-AgNPs are formed, as indicated, when the color shifts from yellow to brown. A Gaussian-shaped peak at 354nm was seen in the UV spectrum of the Cs- AgNPs solution.

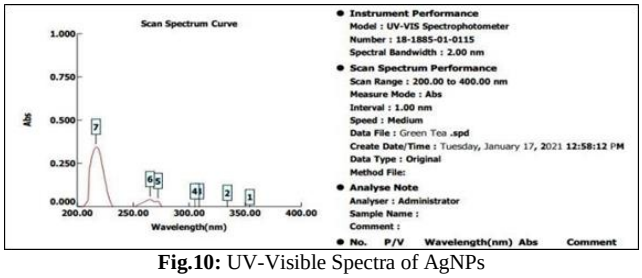

Fig.10: UV-Visible Spectra of AgNPs

Table.1: UV-Vis Spectrum of Cs-AgNPs

S. No.	Peak	Area	%Area
1	Peak-1	354	-0.066
2	Peak-2	334	-0.040
3	Peak-3	309	-0.032
4	Peak-4	305	-0.032
5	Peak-5	272	0.031
6	Peak-6	265	0.040
7	Peak-7	217	0.344

Evaluation of Biological Activity

Free Radical Scavenging Activity by Using DPPH

The Cs-AgNps IC50 (Inhibitory Concentration) was calculated by contrasting it with the ascorbic acid standard value. The results of the DPPH test used to measure the antioxidant activity of Cs-AgNPs reveal that the concentration of the sample is directly related to the amount of free radicals present [Fig 12]. It implies that the amount of free radicals in the Cs-AgNPs would increase with concentration. The % of radical scavenging activity of the Cs-AgNps at various concentrations as % of DPPH scavenging activity is shown in Table 3. According to the findings, DPPH scavenging activity has greater radical inhibition activity that is equivalent to that of regular ascorbic acid.

Table.2: The % scavenging activity of Cs-AgNPs by DPPH Method

Conc(µg/ml)	% of DPPH Scavenging Activity	IC 50 Values
50	40.23	103.5
100	51.28	416
150	56.59	728.5
200	65.98	1041
250	74.45	1353.5
300	80.56	1666
350	89.63	1978.5

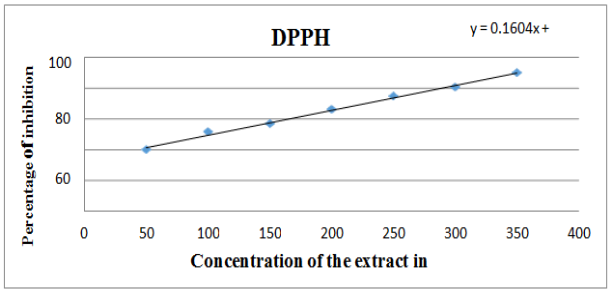

Fig. 11: Graphical representation of DPPH radical scavenging activity of Cs-AgNPs Values are expressed. Ascorbic acid was used as a standard

Antimicrobial activity

Both gram-negative Escherichia coli and gram-positive Staphylococcus aureus were utilized to test the antibacterial properties of AgNPs made from two different concentrations of Cs-AgNPs. the comparative inhibitory zones of sterile water, a common antibiotic, 50 µg/ml of AgNPs, and 100 µg/ml of Cs-AgNPs. Silver nanoparticles of varying Cs-AgNPs have been shown to have a considerable antibacterial effect on the two isolated bacterial strains. Results were compared to a control group exposed to the common antibiotic ampicillin. The zone formed by 100 µg/ml of AgNPs is larger than that formed by 50 µg/ml. The concentration of AgNPs in the reaction mixture has been shown to have a significant impact on their antibacterial activity. Gram-negative bacteria are more effective in killing other bacteria than gram- positive bacteria are, regardless of concentration [21-22].

(A) Escherichia coli, (B) Staphylococcus aurues

Fig.12: Antimicrobial Activity of the Produced Silver Nanoparticles against (A) Escherichia coli, (B) Staphylococcus aurues as Displayed on Microtiter Plates

Table.3: Zone of inhibition of Cs-AgNPs

Name	S.aureus	E.coli	Control
Zone of Inhibition (mm)	7.8	7.2	11.2

DISCUSSION

The green tea extract may create silver nanoparticles in this investigation. IR Spectroscopy have confirmed the authenticity of these Cs-AgNPs. Catalytic reduction of methylene blue solution allowed us to track and verify the production of Cs-

AgNPs. Free radical scavenging ability was measured using the DPPH method, and antimicrobial efficacy was determined using the disc diffusion technique. Zingiber officinale (Ginger): High phenolic content (75.65mg GAE/mg), efficient AgNP synthesis, strong antioxidant and antimicrobial activity, and effective methylene blue degradation. Carica papaya (Papaya seeds): Lower phenolic content (13.7mg GAE/mg), successful AgNP formation, dose-dependent antioxidant activity, moderate catalytic and antimicrobial effects, with E. coli more sensitive than S. aureus. Camellia sinensis (Green tea): Moderate phenolic content (36.64 mg GAE/mg), stable AgNP synthesis, good antioxidant and catalytic activity, and antimicrobial efficacy, particularly against E. coli.

CONCLUSION

A Plant-mediated silver nanoparticles (AgNPs) from ginger, papaya, and green tea exhibited significant catalytic, antioxidant, and antimicrobial activities. Ginger showed the strongest overall performance due to its higher phenolic content, while papaya and green tea also demonstrated promising biological potential. These findings highlight the value of green-synthesized AgNPs in biomedical and environmental applications.

CONFLICT OF INTERESTS

The authors declare no conflict of interest

FUNDING: This study received no specific funding from public, commercial, or not for profit funding agencies.

AI TOOL DECLARATION

The authors declare that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

REFERENCES

[1] Pike Bettina F, Laszlo Brassai, A reason to eat healthy The role of meaning in life in maintaining homeostasis in modern society, Health psychology 3(1) (2016) 134-139.

[2] Leonti M, Traditional medicines and globalization Current and future perspectives in ethnopharmacology. Frontiers in pharmacology. 4 (92) (2013).

[3] Willis KJ, State of the World's Plants, Royal Botanic Gardens, Kew, (2017).

[4] Traditional Medicine Strategy 2002-2005. World Health Organization. (2002).

[5] Rodrigues T, Reker D, Schneider P, Schneider G. Counting on natural products for drug design, Natural Chemistry, 8(2) (2016) 531-541.

[6] Ekor Martins, The growing use of herbal medicines issues relating to adverse reactions and challenges in monitoring safety, Frontiers in pharmacology 4(2) (2014) 177.

[7] S. Gurunathan, K. Kalishwaralal, R. Vaidyanathan, D. Venkataraman, S.R.K. Pandian, J. Muniyandi, N. Hariharan, S.H. Eom, Biosynthesis, purification and characterization of silver nanoparticles using Escherichia coli, Coll. Surf B: Biointer. 74 (2009) 328-335.

[8] D. Philip, Green synthesis of gold and silver nanoparticles using Hibiscus rosa sinensis, Phy E: Low-Dimen. Sys. Nanostr. 42 (2010) 1417-1424.

[9] E. Castro-Longoria, A.R. Vilchis-Nestor, M. Avalos-Borja, Biosynthesis of silver, gold and bimetallic nanoparticles using the filamentous fungus Neurospora crassa. Coll. surf B: Biointer. 83 (2011) 42-48.

[10] K. Indira, U.K. Mudali, N. Rajendran, Corrosion behavior of electrochemically assembled nanoporous titania for biomedical applications, Ceram. Int. 39 (2013) 959-967.

[11] [K. Indira, S. Ningshen, U. KamachiMudali, N. Rajendran, Structuralfeatures of self- organized TiO2 nanopore arrays formed by electrochemical anodization oftitanium, J. Electrochem. Soc. Ind. 60 (2011) 145-147.

[12] A.H. Shah, E. Manikandan, M.B. Ahamed, D.A. Mir, S.A. Mir, Antibacterial and Blue shift investigations in sol–gel synthesized CrxZn1− xO Nanostructures, J. luminescence. 145 (2014) 944-950.

[13] Y. Wang, N. Herron, Nanometer-sized semiconductor clusters: materials synthesis, quantum size effects, and photophysical properties, J. Phy. Chem. 95 (1991) 525-532.

[14] T.V. Mathew, S. Kuriakose, Studies on the antimicrobial properties of colloidal silver nanoparticles stabilized by bovine serum albumin, Coll. Surf B: Biointer. 101 (2013) 14-18.

[15] J. Lai, W. Niu, R. Luque, G. Xu, solvo thermal synthesis of metal nanocrystals and their applications, Nano Today. 10 (2015) 240-267.

[16] . Lai, W. Niu, R. Luque, G. Xu, solvo thermal synthesis of metal nanocrystals and their applications, *Nano Today*. 10 (2015) 240-267.

[17] H. Palza, Antimicrobial polymers with metal nanoparticles, *Int. J. mol. Sci*. 16 (2015) 2099- 2116

[18] Z.H. Dhoondia, H. Chakraborty, Lactobacillus mediated synthesis of silver oxide nanoparticles, *Nano mat. Nanotech*. 2 (2012) 15-20.

[19] X. Li, S. Chen, W. Hu, S. Shi, W. Shen, X. Zhang, H. Wang, *In situ* synthesis of CdS nanoparticles on bacterial cellulose nanofibers, *Carbohydr. Polym*. 76 (2009) 509-512.

[20] J. Gallo, A. Panacek, R. Prucek, E. Kriegova, S. Hradilova, M. Hobza, M. Holinka, Silver nanocoating technology in the prevention of prosthetic joint infection, *Mat*. 9 (2016) 337- 341.

[21] Singh, A, Jain D, Upadhyay MK, Khandelwal N, Verma HN, Green synthesis of silver nanoparticles using Argemone Mexicana leaf extract and evaluation of their antimicrobial activity, Dig. J. Nanomater. Biostruct., 5(2), 2010, 483−489.

[22] S. Ahmed, M. Ahmad, B.L. Swami, S. Ikram, A review on plants extract mediated synthesis of silver nanopaarticles for antimicrobial applications: A green expertise, J.Adv. Res. 7(2016) 17-28.