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RESEARCH ARTICLE

Plant mediated Synthesis of Silver nanoparticles using leaves of *Odina wodier* Roxb.

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Abstract

The present study deals with the synthesis of silver nanoparticles using the leaf broth of *Odina wodier* Roxb. (Family: *Anacardiaceae*). The leaf broth was prepared and resuspended in aqueous solution of silver nitrate and it is known as Reaction medium. This reaction medium was kept in an incubator cum shaker (Orbitek) with 250rpm at 27^0C for 24 hours to reduce the silver nitrate in to silver nanoparticles. The observation of colour change in reaction medium from pale yellow to dark brown indicates the formation of silver nanoparticles and they were characterized by UV-Visible Spectroscopy, Fourier Transform Infra-Red (FT-IR) Spectroscopy, Transmission Electron Microscopy (TEM) and X-ray diffraction (XRD) analyses. It is evident that the synthesized silver nanoparticles are capped by biomolecules which are responsible for reduction of silver ions. Energy Dispersive X-Ray (EDX) analysis and Scanning Electron Microscopy (SEM) confirmed the presence of silver nanoparticles. This type of plant mediated synthesis appears to be cost effective, eco-friendly and easy alternative green synthesis to conventional, physical and chemical methods to the synthesis of silver nanoparticles.

Introduction

Nanotechnology deals with the processes that are in nanometer scale with a size of up to 100 nm and they are composed of specific characteristics on morphology (ie., Shape and Size) and distribution (Ankanna *et al.,* 2010). Nanotechnology has wide application in the areas of Medicine, Energy, Electronics, Catalysis and Chemistry (Vineet and Sudesh, 2009). Nanocrystalline silver is a known metal that has come into use before Neolithic periodic, even Greeks used it for cooking and to save the water from contaminants. The synthesis of silver nanoparticles using several methods have been reported, they are Chemical Reduction (Santos and Marzan, 1999), Thermal decomposition (Plante *et al.*, 2010), Phytochemical (Bera *et al.,* 2010), Reverse Micelles (Lim *et al.,* 2004), Radiation Assisted (Cheng *et al.*, 2011), Electrochemical (Hirsch *et al.,* 2005), Sonochemical (Korotchenkov *et al.,* 2006), Microwave assisted (Nadagouda *et al.*, 2011) and recently *via* Green chemistry method (Raveendran *et al.*, 2003). Mostly, these methods are very expensive and the toxic and hazardous chemicals were used which cause Environmental, Human and Biological risks (Forough *et al.,* 2010). To overcome this, the eco-friendly method for the synthesis of silver nanoparticles using Plants (Parashar *et al.,* 2009), Fungi (Saifuddin *et al.*, 2009), Bacteria (Bhansa *et al.*, 2006) and Enzymes (Willner *et al.*, 2007) have been reported, this is a single step, time reducing and cost effective method for the synthesis of Silver nanoparticles. Silver nanoparticles have several applications in the field of Detection and Diagnostics, Antimicrobial, Therapeutics, Optoelectronics, Diagnostic biological probes and Display devices (Annamalai *et al.*, 2011; Sarkar *et al.,* 2010 and Rai *et al.,* 2009). The synthesis of silver nanoparticles using plant has been reported as in *Merremia tridendata* (Ganesan *et al.,* 2013), *Phyllanthus amarus* (Annamalai *et al.,* 2011), *Diopyros kaki* (Vyom *et al.*, 2009) and *Jatropa curcas* (Harekrishna *et al.*, 2009). The present study is also aimed for the plant mediated synthesis of silver nanoparticles using leaf extract of *Odina wodier*, Roxb. and the silver nanoparticles were characterized using UV- Visible spectroscopy, FT-IR (Fourier Transform Infrared) spectroscopy, XRD (X- ray Diffraction), SEM (Scanning Electron Microscopy), EDX (Energy Dispersive X-ray spectroscopy), TEM (Transmission Electron Microscopy) and AAS (Atomic Absorption Spectroscopy) analyses.

Material and Methods

Biological Synthesis of silver nanoparticles:
All the reagents used in the present study were obtained from Himedia Laboratories Pvt Ltd (Mumbai, India). *Odina wodier* Roxb. (Fig 1) belongs to *Anacardiaceae* were collected from the Botanical garden of Ayya Nadar Janaki Ammal College, Sivakasi, Tamilnadu, India.

Fig 1. *Odina wodier,* Roxb. leaves

The collected leaf samples were thoroughly washed with tap water followed by distilled water to remove the surface contaminants and dried for 48 hours under the shade. The dried leaves were taken and ground to make fine powder using a mixer and sieved using 20 mesh sieve to get uniform size range. 10g of sieved leaf powder was added to 100ml of distilled water and boiled at 70 °C for 10 minutes to prepare the leaf broth (Sathishkumar *et al.,* 2009). 10 ml of freshly prepared leaf broth was resuspended in 190ml of an aqueous solution of silver nitrate and this mixture is used as reaction medium (Muyabi *et al.*, 2012).
This medium was kept in an Incubator cum shaker (Orbitek-Model) with 250 rpm at 27°C for 24 hours. For this reaction medium a small aliquot of the sample was used to characterize the presence of silver nanoparticles synthesized during the above reaction. The characterization was performed through the following analyses: UV- Visible spectroscopy (UV-Vis), Fourier Transform Infrared spectroscopy (FT-IR), X-ray Diffraction (XRD) analysis. Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Analyses (EDX) and Transmission Electron Microscopy (TEM). The quantity of Silver nanoparticles synthesized by leaf tissue was estimated using Atomic Absorption Spectroscopy (AAS) in accordance with the following equation (Dias *et al.,* 2002).

$$q = [(C_0 - C) / X]$$

Where: q (mg of metal nanoparticles synthesized by one gram of leaf tissue) is the metal specific uptake, C_0 is the initial metal concentration (mg l^{-1}), C is the residual metal concentration (mg l^{-1}) and X is the biomass concentration of the leaf tissue (g).

Result and Discussion

UV- Visible spectrum of silver nanoparticles:
UV-Visible spectroscopy analysis was carried out on a Labomed (Model UV- D3200) UV-Visible spectrophotometer. The leaf broth reduced aqueous silver nitrate into silver ions and formed into silver nanoparticles. The leaf broth had brown color before the addition of silver nitrate solution which was colorless (Fig 2). After the addition of aqueous silver nitrate in to the leaf broth (reaction medium) gradually changed into dark brown color within 24 hours of reaction (Fig 2). It indicates that the silver nitrate is rapidly reduced into silver ions within 24 hrs. UV- Visible spectra of the reaction media taken at different time intervals explicit that the Surface Plasmon Resonance (SPR) vibrations are found between 410nm and 480nm with the λ_{max} at 450 nm which is blue shifted (Fig 3). The λ_{max} in SPR bands of silver nanoparticles varies with the substrate or an organism by which they are synthesized. For example the λ_{max} in SPR band is at 430 nm by *Bacillus cereus* (Anuradha *et al.,* 2011); 440 nm by *Trichoderma harzianum* (Prashant and Balaji, 2011); 412nm by leaves of *Allium cepa* (Antariksh *et al.,* 2010); 405nm and 480nm by leaves of *Enicostema hysopifolium* and *Rauvolfia tetraphylla* respectively (Veena *et al.,* 2011). In the present study, the absorbance of the reaction medium increases up to 0.8 a.u. at 450nm in 24 hrs of reaction. This may be due to the capping agents like secondary metabolites or enzymes present in the leaf broth reduce the aqueous silver nitrate rapidly. The absorbance gradually decreases after 24 hrs, this may be ascribed to the saturation of capping agents in the reaction medium after 24 hrs which started to decrease in the reduction process of silver nitrate into silver ions. The time taken for the change in color of the reaction medium varies from plant to plant. Interestingly, the leaf extract of *Trianthema decandra* made the color change within four hrs (Geethalakshmi and Sarada,

2010). The leaf extract of *Merrimia tridendata* and *Sesuvium portulacastrum* reduced the silver nitrate and observed this color change within 24 hrs (Ganesan *et al.*, 2013; Asmathunisha *et al.*, 2010). λ_{max} of *Odina wodier,* Roxb. which is blue shifted at 450 nm. The decrease in the particle size is related to a Blue shift and the red shift due to the increased size of silver nanoparticles (Mulvaney, 1996).

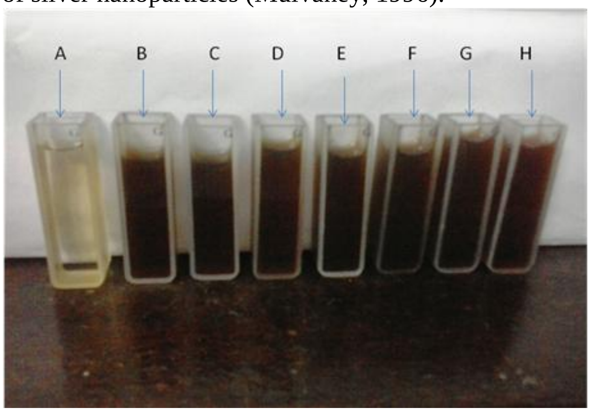

Fig 2. Colour change of the reaction medium (leaf broth of *Odina wodier,* Roxb. and 1mM aqueous silver nitrate during the biological synthesis of silver nanoparticles). A- Control (Aqueous silver nitrate), B- leaf broth of *Odina wodier,* Roxb. C, D, E, F, G and H are the reaction media at different time intervals of reaction such as 10 minutes, 30 minutes, one hour, three hours, 6 hours and 24 hours respectively.

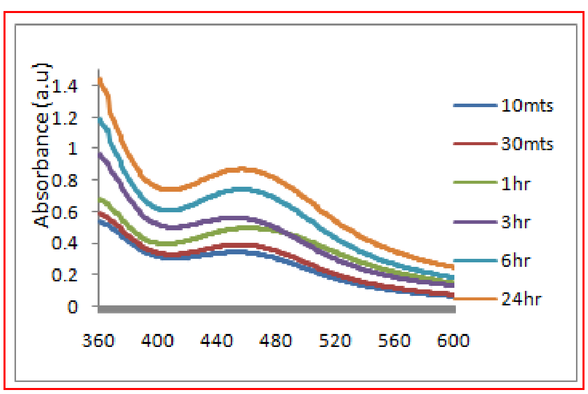

Figure 3: UV-Visible spectra of silver nanoparticles synthesized by leaf aqueous extract of *Odina wodier,* Roxb. as a function of time

FT-IR Spectroscopic Analysis:

FT-IR measurements (Shimadzu FTIR spectrophotometer, using KBr pellet method) identified the biomolecules in the leaf broth of *Odina wodier,* Roxb. which were responsible for reducing silver nitrate and the synthesized silver nanoparticles. The nature of chemical bonds present in the reaction medium was characterized. The FTIR spectrum of leaf broth before reaction, showed several absorption peaks at 601, 653, 680, 1118, 1193,1384, 1458, 1544, 1622, 1666, 2854, 2925, 3220, 3384, 3419 and 3525 cm^{-1} (Fig 4a). The FT-IR spectrum of purified and dried reaction medium with silver nanoparticles (Fig 4b) shows the absorbance peak at 606, 653, 752, 808, 1112, 1267, 1336, 1400, 1454, 1670, 2108, 2268, 2883 and 3313 cm^{-1}. The strong absorbance band at 1386 cm^{-1} was associated with the stretch of functional groups such as –C-O-C-, -C=O-, -C=C, -C=O- (Elavazhagan and Arunachalam, 2011). The absorbance bands are known to be associated with the stretching vibrations for -C-C-O, -C-C-, -C=C-, C=O (esters, ethers) and C-O (polyols) respectively (Bar *et al.*, 2009). The total disappearance of the bands at 680, 1193, 1622, 1544, 1622, 2854, 2925, 3220, 3419 and 3525 cm^{-1}after bio-reduction may be ascribed to the reduction of silver ions into silver nanoparticles, leading to unsaturated carbonyl groups with a broad peak at 1666 cm^{-1}.

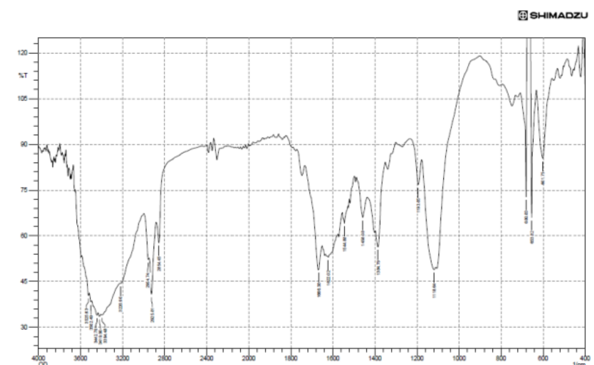

Fig 4a. FT-IR spectrum of leaf broth of *Odina wodier,* Roxb.

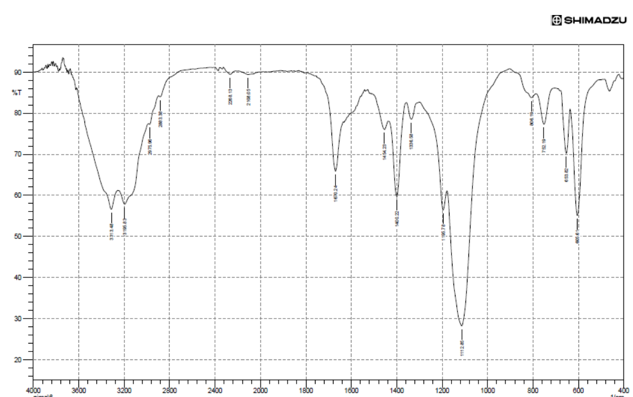

Fig 4b. FT-IR spectrum of silver nanoparticles using leaf extracts of *Odina wodier,* Roxb.

XRD Analysis:

Crystalline metallic silver nanoparticles were examined by X-ray diffractometer Shimadzu (XRD 6000)). Fig 5 shows the X-ray diffraction peak obtained for the synthesized silver nanoparticles using *Odina wodier*, Roxb. leaf extract. The Full-Width Half Maximum (FWHM) values measured for the plane of reflection were measured using Debye-Scherrer's equation, $t=0.9\lambda/\beta Cos\theta$ (Narashima *et al.*, 2011). The mean size of the nanoparticles was estimated as 13nm using the observed XRD pattern at 2θ= 38° marked within (111), 49.1° marked within (200), 67.0° marked within (220) and 78.5° marked within (311). The XRD pattern revealed that the silver nanoparticles formed are face centered cubic (fcc) structures (Mohsen *et al.*, 2011). The XRD pattern thus showed that the silver nanoparticles formed are crystalline in nature (Dubey *et al.*, 2009). This also suggested that the crystallization of bio-organic phase occurred on the surface of silver nanoparticles (Sathyavathi *et al.*, 2010).

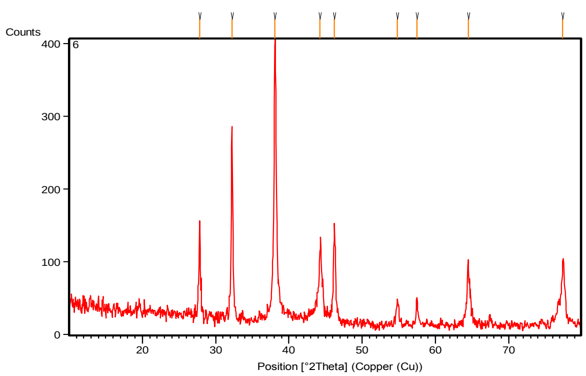

Fig 5. XRD pattern of silver nanoparticles formed after reaction of leaf broth of *Odina wodier,* Roxb.

SEM and EDAX Analyses:

Scanning electron microscopy (SEM) analysis of silver nanoparticles was done using Hitachi S-4500 Scanning Electron Microscopy. The surface morphology (ie. shape and size) of the silver nanoparticles was shown in Fig 6. The uniform spherical shape nanoparticles were obtained with the sized ranging from 5-30nm (~). Similarly, the spherical shaped silver nanoparticles with a diameter ranging from 30-40nm were synthesized using *Boswellia ovalifoliolata* (Savithramma *et al.*, 2011); 30-50nm using *Merremia tridendata* (Ganesan *et al.*, 2013); Plant extracts of *Elaeagnus latifolia* (Probin *et al.*, 2012); *Carcia papaya* (Jain *et al.*, 2009) and *Emblica officinalis* (Ankamvar *et al.*, 2005). The strong silver peak in the EDX- spectrum (Fig 7) confirms the presence of elemental silver. Metallic silver nanoparticles generally show typical optical absorption peaks approximately at 3KV due to Surface Plasmon Resonance (Magudapathi *et al.*, 2001). The EDX peak of Ag along with Cl, K and Mg as the mixed components present in the reaction medium. The strong elemental signal along with weak oxygen that may be originated from the biomolecules bound to the surface of the nanoparticles (Elumalai *et al.*, 2010).

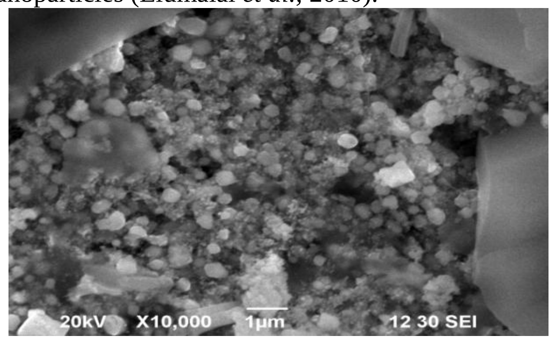

Fig 6. SEM images of silver nanoparticles synthesized using *Odina wodier,* Roxb. leaf broth (at 10000X magnification).

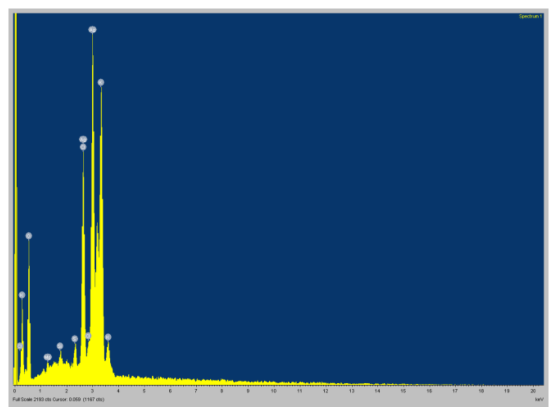

Fig 7. EDX image of silver nanoparticles synthesized using *Odina wodier,* Roxb. leaf broth

TEM Analysis:

Transmission electron microscopy (TEM) analysis of the sample was carried out using Philips-Techno 10 instrument operated at an acceleration voltage of 200KV with resolution of 0.3nm. A drop of leaf broth was placed on carbon coated copper grid and exposed to infrared light for solvent evaporation. Fig. 8a shows the TEM image at high resolution of silver nanoparticles that are well dispersed with sizes ranging from 5 to 30 nm (~).The size distribution of silver nanoparticles which ranges between 5 and 40 is shown in Fig. 8b. However, the size of the silver nanoparticles synthesized using *Sesuvium portulacastrum* was found to range from 5 to 20 nm (Asmathunisha *et al.*, 2010). Interestingly, the mean size of the silver nanoparticles synthesized using *Moringa oleifera* was 57 nm and spherical in morphology was reported (Prasad and Elumalai, 2011).

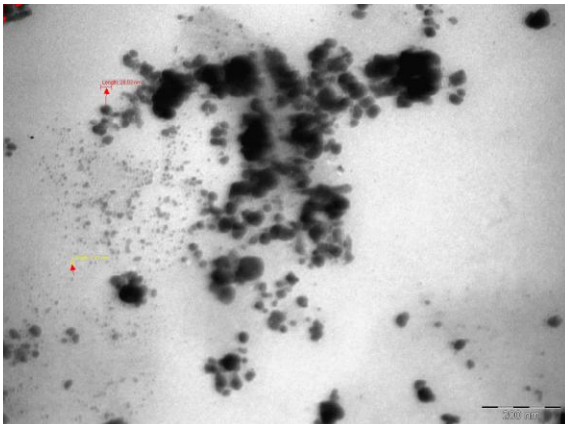

Fig 8a. TEM image of silver nanoparticles synthesized from the *Odina wodier,* Roxb. leaf

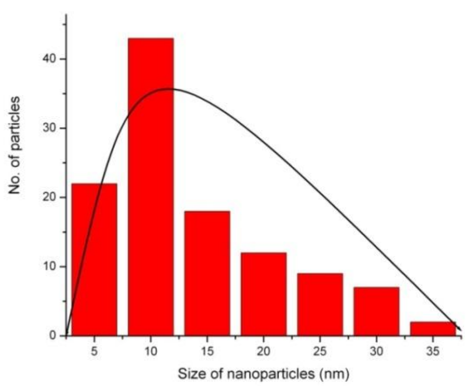

Fig. 8b. Histogram of silver nanoparticles synthesized from *Odina wodier*, Roxb. leaf

Atomic Absorption Spectroscopy:
The amount of silver nanoparticles synthesized was analyzed with Atomic Absorption Spectroscopy (Schimadzu AAS 6300) after termination of the reduction of silver nitrate in order to find out residual concentration of silver. Interestingly, in this eco-friendly and cost effective method one gram dry weight of *Odina wodier,* Roxb. leaves could synthesize 1.50 mg of silver nanoparticles synthesized from. Moreover, in this method the rapid reduction of silver nitrate within 24 hours has been noticed. So this is an alternate and simple method for the synthesis of silver nanoparticles using plants.

Conclusion

Thus the present study, the synthesis of silver nanoparticles using leaf broth of *Odina wodier,* Roxb. has been achieved with the rapid reduction of silver nitrate into silver nanoparticles. Interestingly, the reaction medium changed its colour from pale yellow to dark brown within 24 hrs of reaction. The UV-Visible spectrum of the reaction medium with silver nanoparticles synthesized using *Odina wodier,* Roxb. has λ_{max} at 450 nm and absorbance was raised upto 0.8 a.u. The FTIR spectrum showed the total disappearance of the bands at 680, 1193, 1622, 1544, 1622, 2854, 2925, 3220, 3419 and 3525 cm^{-1} after bio-reduction may be ascribed to the reduction of silver nitrate into silver nanoparticles, leading to unsaturated carbonyl groups with broad peak at 1666 cm^{-1}. The SEM images obtained in the present study elucidate the existence of very small and uniformly spherical nanoparticles with size ranging from 5-30 nm. The XRD and TEM analyses determine the average size of the nanoparticles is of 13 nm. The strong silver peak obtained from the EDX spectrum confirms the significant presence of elemental silver. Finally the Atomic Absorption Spectroscopy analysis of the silver nanoparticles synthesized by the leaf tissue of *Odina wodier,* Roxb. brings out the ability of one gram of dry weight of *Odina wodier,* Roxb.. leaves to synthesize 1.50 mg of silver nanoparticles. Thus the silver nanoparticles are synthesized using a green resource, *Odina wodier* Roxb. which is an alternate method to physical and chemical syntheses due to its cost effective and eco-friendly nature.

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References

Ankanna, S., Prasad, T.N.V.K.V., Elumalai, E. K. and Savithramma, N. (2010): Production of Biogenic Silver nanoparticles using *Boswellia ovalifoliolata* stem bark. Digest Journal of Nanomaterials and Biostructures., 5(2): 369-372.

Ankamwar, B., Chaudhary, M. and Sastry, M. (2005): Gold nanotriangles biologically synthesized using tamarind leaf extract and potential application in vapor sensing. Synthesis Reaction Inorganic Metal Organic Nanotechnology Metal Chemistry. 35: 19-26

Annamalai, A., Sarah, T.B., Jose, N.A., Sudha, D. and Christina, V.L. (2011): Biosynthesis and characterization of silver and gold nanoparticles using aqueous leaf extraction of *Phyllanthus amarus* Schum. & Thonn. World Applied Sciences Journal., 13 (8): 1833- 1840.

Anuradha, P., Seema, S., Naheed, A., Ashok, G. and Preety, S.(2011): Synthesis of AgNPs by *Bacillus cereus* bacteria and their Antimicrobial potential. Journal of Biomaterials and Nanobiotechnology., 2: 156- 162.

Antariksh, S., Tripathi, R.M. and Singh, R.P. (2010): Biological synthesis of silver nanoparticles using onion (*Allium cepa*) extract and their Antibacterial activity. Digest Journal of Nanomaterials and Biostructures., 5(2): 427-432.

Asmathunisha, N., Kathiresan, K., Anburaj, R., Nabeel, M.A. (2010): Synthesis of Antimicrobial silver nanoparticles by callus and leaf extracts from salt marsh plant, *Sesuvium portulacastrum* L. Colloids and Surfaces B: Biointerfaces., 79: 488-493.

Bar, H., Bhui, D.K., Sahoo, G.P., Sarkar, P., Pyne, S. and Misra, A. (2009): Green synthesis of silver nanoparticles using seed extract of *Jatropha curcas.* Surface Analytical Physicochemical Engineering Aspects. 348: 212-216.

Bera, R.K., Das, A.K. and Raj, C.R. (2010): Scope of network polysilanes in the synthesis of fluorescent silver and gold nanoparticles/ nanoclusters-modulations of their optical properties in the presence of Hg (II) ions. Chemical Materials., 22: 4505-4511.

Bhansa, K.C. and D' Souza, S.F. (2006): Extracellular biosynthesis of silver nanoparticles using the fungus *Aspergillus fumigates*. Colloids and Surfaces B: Biointerfaces., 47: 160-164.

Cheng, Y., Yin, L., Lin, S., Wiesner, M., Bernhardt, E. and Liu, J, (2011): Toxicity reduction of polymer stabilized silver nanoparticles by sunlight. Journal of Physical Chemistry Colloids., 115: 4425-4432.

Dias, M.A., Lacerda, I.C.A., Pimentel, P.F., Castro, H.F. and Rosa, C.A. (2002): Removal of heavy metals by *Aspergillus terrus* strain immobilized in a polyurethane matrix. Letters in Applied Microbiology., 34: 46-50.

Dubey, M., Bhadauria, S. and Kushwah, B.S. (2009): Green synthesis of nanosilver particles from extract of *Eucalyptus hyrida* (safeda) leaf. Digest .Journal of Nanomaterials and Biostructructure.4: 537-543.

Elavazhagan, T., and Arunachalam, K.D. (2011): *Memecylon edule* leaf extract mediated green synthesis of silver and gold nanoparticles. International Journal of Nanomedicine. 6: 1265-1278.

Elumalai, E.K., Prasad, T.N.V.K.V., Hemachandran, J., Viviyantherasa, S., Thirumalai, T. and David, E. (2010): Extracellular synthesis of silver nanoparticles using leaves of *Euphorbia hirta* and the antibacterial activities. Journal of Pharmaceutical Science and Research. 2: 549- 557

Forough, M. and Farhadi, K (2010): Biological and Green synthesis of silver nanoparticles. Turkish Journal of Engineering Environmental Science., 34: 281-287.

Ganesan, V., Astalakshmi, A., Nima, P. and Arunkumar, C. (2013): Synthesis and characterization of silver nanoparticles using *Merremia tridentata* (L.) Hall.f. International Journal of Current Science., 6: 87-93

Geethalakshmi, R. and Sarada, D.V.L. (2010): Synthesis of plant-mediated silver nanoparticles using *Trianthema decandra* extract and evaluation of their antimicrobial activities. International Journal of Engineering Science and Technology., 2(5): 970-975.

Harekrishna, B., Dipak, K.R., Priyanka, S., Sankar, P. and Ajay, M. (2009): Green synthesis of Silver nanoparticles using latex of *Jatropa curcas*. Colloids and Surfaces A: Physicochemical Engineering Aspects. 339:134-141.

Hirsch, T., Zharnikov, M., Shaporenko, A., Stahl, J., Weiss, D. and Wolfbeis, O.S. (2005): Size controlled electrochemical synthesis of metal nanoparticles on monomolecular template. Angew Chemical International Edition., 44: 6775-6778.

Jain, D., Daima, H.K., Kachnwaha, S. and Kothari, S.L. (2009): Synthesis of plant mediated silver nanoparticles using Papaya fruit extract and evaluation of their antimicrobial activities. Digest Journal of Nanomaterials and Biostructures. 4: 723-727.

Korotchenkov, O.A., Cantarero, A., Shpak, A.P., Kunitskii, Y.A., Senkevich, A.I. and Borovoy, M.O. (2006): Doped ZnS: Mn nanoparticles obtained by sonochemical synthesis. Nanotechnology., 16: 2033-2036.

Lim, K.T., Hwang, H.S., Ryoo, W. and Johnston, K.P. (2004): Synthesis of Tio_2 nanoparticles utilizing hydrated reverse micelles in Co_2. Langmuir., 20: 2466-2471.

Magudapathi, P., Gangopadhyay, P., Panigrahi, E.K., Nair, K.G.M. and Dhara, S. (2001): Electrical transport studies of silver nanoclusters embedded in glass matrix. Physical B. 299: 142-146

Mohsen, Z., Azizah, A.H., Fatima, A.B., Mariana, N.S., Kamyar, S., Fatemeh, J. and Farah, F. (2011): Green synthesis and Antibacterial Effect of silver nanoparticles using *Vitex negundo* L.. Molecules. 16: 6667-6676

Mubayi, A., Chatterji, S., Raj, P.K. and Watal, G. (2012): Evidence based green synthesis of nanoparticles. VBRI Press., doi: 10.5185/amlett. Incnano.353.

Mulvaney, P. (1996): Surface Plasmon Spectroscopy of nanosized metal particles, Langmuir. 12: 788-800.

Nadagouda, M.N., Spet, T.F. and Varma, R.S. (2011): Microwave- assisted green synthesis of silver nanostructures. Accounts Chemical Research., 44: 469-478.

Narasimha, G., Praveen, B., Mallikarjuna, K. and Raju, B.D.P. (2011): Mushrooms (*Agariscus bisporus*) mediated biosynthesis of silver nanoparticles, characterization and their antimicrobial activity. International .Journal of Nanotechnology Dimensions. 2: 29-36.

Parashar, V., Prashar, R., Sharma, B. and Pandey, A.C. (2009): *Parthenium* leaf extract mediated synthesis of silver nanoparticles: a novel approach towards weed utilization. Digest Journal of Nanomaterials and Biostructures., 4(1): 45-50.

Plante, I.J.L., Zeid, T.W., Yangab, P. and Mokari, T. (2010): Synthesis of metal sulfide nanomaterials via thermal decomposistion of single-source precursors. Journal of Material chemistry., 20: 6612-6617.

Prasad, T.N.V.K.V. and Elumalai, E.K. (2011): Biofabrication Ag nanoparticles using *Moringa oleifera* leaf extract and their Antimicrobial activity. Asian Pacific Journal of Tropical Biomedicine., 11: 439-442.

Prashant, S and Balaji, R. (2011): Biological synthesis and characterization of Silver nanoparticles using the fungus *Trichoderma harzianum*. Asian Journal of Experimental Biological Science., 2(4): 600- 605.

Probin, P., Azmin, S., Himakshi, S., Jahnabi, R., Kongkana, G. and Pitambar, B. (2012): Plant-Mediated synthesis of Silver nanoparticles using *Elaeagnus latilfolia* leaf extrat. Digest Journal of Nanomaterials and Biostructures. 7(3): 1117-1123.

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

Raveendran, P., Fu, J. and Wallen, S.L. (2003): Complete green synthesis and stabilization of metal nanoparticles. Journal of American Chemical Society., 125: 13940-13941.

Saifuddin, N., Wong, C.W. and Yasimura, A.N. (2009): Rapid Biosynthesis of silver nanoparticles using culture supernatant of bacterial with microwave irradiation. E- journal of Chemistry., 6(1): 61-70.

Santos, I.P. and Marzan, L.M.L. (1999): Formation of PVP- Protected metal nanoparticles in DMF. Langmuir., 15: 948-951.

Sarkar, R., Kumabhakar, P. and Mitra, A.K. (2010): Green synthesis of silver nanoparticles and its optical properties. Digest Journal of Nanomaterials and Biostructures., 5: 491-496.

Sathishkumar, M., Sneha, K., Won, S.W., Cho, C.W., Kim, S. and Yun, Y.S. (2009): *Cinnamon zeylanicum* bark extract and powder mediated green synthesis of nano-crystalline silver particles and its bactericidal activity. Colloids Surface B. 73:332–338.

Sathyavathi, R., Balamurali, K.M., Venugopal, R.S., Saritha, R. and Narayana, R.D. (2010): Biosynthesis of silver nanoparticles using *Coriandrum sativum* leaf extract and their application in nonlinear optics. Advance Science Letters. 3: 1-6.

Savithramma, N., Rao, M.L. and Suvarnalatha Devi, P. (2011): Evaluation of Antibacterial efficacy of biologically synthesized silver nanoparticles using stem barks of *Boswellia ovalifoliolata* Bal. and Henry and *Shorea tumbuggaia* Ruxb. Journal of Biological Science., 11: 39-45.

Song, J.Y., Jang, K.H. and Kim, B.S. (2009): Biological synthesis of gold nanoparticles using *Magnolia kobus* and *Diopyros kaki* leaf extracts. Process Biochemistry. 44:1133-1138

Veena, K., Nima, P. and Ganesan, V. (2011): Green synthesis of silver nanoparticles using two different higher plants. Advanced Biotech., 11(2):06-10.

Vineet, K and Sudesh, K.Y. (2009): Plant mediated synthesis of silver and gold nanoparticles and their applications. Journal of Chemical Technology Biotechnology., 84: 151-157.

Vyom, P., Rashmi, P., Bechan, S. and Avinash, P. (2009): *Parthenium* leaf extract mediated synthesis of silver nanoparticles a novel approach towards weed utilization. Digest Journal of nanomaterials and nanostructures., 4 : 45-53

Willner, B., Basnar, B. and Willner, B. (2007): Nanoparticle- enzyme hybrid systems for nanobiotechnology. FEBS J. 274(2): 302-309.