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Review Article

A REVIEW ON GREEN SYNTHESIS OF SILVER NANOPARTICLES

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ABSTRACT

This review focuses on the green synthesis of silver nanoparticles using various plant sources. A detailed study on the reduction of silver ions to silver nanoparticles mediated through plant leaves extract were demonstrated with a brief experimental procedure. Characterization of the synthesized nanoparticles performed through UV spectroscopy, Fourier Transform Infra Red spectroscopy analysis, X-Ray Diffraction analysis, Scanning Electron Microscopy and High Resolution Transmission Electron Microscopy were comparatively analysed for their absorbance, stabilization of bonds, particle sizes in terms of nanometer and the particle shapes contributing configuration respectively. Besides, optimization of the molar concentration of the substrate, silver nitrate and the required volume of the extract added were compared for the appearance of brown colour, which is an indication of the silver nanoparticle formation, whose relative absorbance was found to be in between 425 nm to 435 nm was justified. Also, the clinical significance of the silver nanoparticle conferring the antimicrobial activity was studied with the zone of clearance produced by some pathogenic gram positive and gram negative bacteria and some pathogenic fungus respectively.

Keywords: Antibacterial agents, Antifungal activity, UV- absorption spectra, FTIR analysis, SEM analysis.

INTRODUCTION

Due to rapid industrialization and urbanization, our environment is undergoing great damage and a large amount of hazardous and unwanted chemical, gases or substances are released, and so now it is our need to learn about the secrets that are present in the Nature and its products which leads to the growth of advancements in the synthesis processes of nanoparticles. Nanotechnology applications are highly suitable for biological molecules, because of their exclusive properties. The biological molecules undergo highly controlled assembly for making them suitable for the metal nanoparticle synthesis which was found to be reliable and eco friendly [1]. The synthesis of metal and semiconductor nanoparticles is a vast area of research due to its potential applications which was implemented in the development of novel technologies [2]. The field of nanotechnology is one of the upcoming areas of research in the modern field of material science. Nanoparticle show completely new or improved properties, such as size, distribution and morphology of the particles etc... Novel applications of nanoparticles and nanomaterials are emerging rapidly on various fields [3].

Most of the chemical methods used for the synthesis of nanoparticles are too expensive and also involve the use of toxic, hazardous chemicals that are responsible for various biological risks. This enhances the growing need to develop environmentally friendly processes through green synthesis and other biological approaches. Sometimes the synthesis of nanoparticles using various plants and their extracts can be advantageous over other biological synthesis processes which involve the very complex procedures of maintaining microbial cultures [4], [5]. Many such experiments have already been started such as the synthesis of various metal nanoparticles using fungi like *Fusarium oxysporum* [6], *Penicillium* sp. [7] and using some bacteria such as *Bacillus subtilis* etc… [8], [9]. But, synthesis of nanoparticles using plant extracts is the most adopted method of green, eco-friendly production of nanoparticles and also has a special advantage that the plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites. [10]. There has also been several experiments performed on the synthesis of silver nanoparticles using medicinal plants such as *Oryza sativa, Helianthus annus*, *Saccharum officinarum*, *Sorghum bicolour*, *Zea mays*, *Basella alba, Aloe vera Capsicum annuum*, *Magnolia kobus*, *Medicago sativa* (Alfalfa), Ci*namomum camphora* and *Geranium* sp. in the field of pharmaceutical applications and biological industries. Besides, green synthesis of silver nanoparticles using a methanolic extract of *Eucalyptus hybrida* was also investigated [11].

In the recent days, silver nanoparticles have been synthesized from the naturally occurring sources and their products like green tea (*Camellia sinensis)*, Neem (*Azadirachta indica)* , leguminous shrub (*Sesbania drummondii*) , various leaf broth, natural rubber, starch , *Aloe vera* plant extract , lemongrass leaves extract, etc….[12]. With respect to the microbes, the silver nanoparticles get attached to the cell wall, thereby disturbing the permeability of cell wall and cellular respiration. The nanoparticles may also penetrate deep inside the cell wall, thus causing cellular damage by interacting with phosphorus and sulfur containing compounds, such as DNA and protein, present inside the cell. The bacteriocidal properties of silver nanoparticles are due to the release of silver ions from the particles, which confers the antimicrobial activity [13]. Besides, the potency of the antibacterial effects corresponds to the size of the nanoparticle. The smaller particles have higher antibacterial activities due to the equivalent silver mass content. With respect to the clinical applications of nanoparticle, microorganisms including diatoms, fungi, bacteria and yeast producing inorganic materials through biological synthesis either intra or extracellularly made nanoparticles more biocompatible [14].

Experimental procedures involved in the synthesis of silver nanoparticles using plant extract

10 g of Nelumbo lucifera leaves were boiled in 100ml of distilled water contained in the conical flask. The resulting filterate (12ml) was taken and treated with 88ml of aqueous 1 mM AgNO3 solution and incubated in dark condition, at room temperature. Appearance of brownish yellow coloured solution indicates the formation of AgNPs [15]. 5 ml of seed extract was added to 20 ml of 10^{-3}M aqueous silver nitrate solution, the mixture was heated at 80 °C and after 15 min of heating, the resulting solution become reddish in colour indicating the formation of silver nanoparticles [16]. 5mL, 10ml and 15ml of the leaf extract was added to 25 mL of the aqueous solution of $AgNO_3$ (10^{-3} M) and stirred vigorously for 5 min. Reduction takes place slowly at 300 K and get completed in 30 min by stable light brown colour formation, depending on the intensity of colour formation, respectively to the volume of the extract added. Besides, at 373 K, silver nanoparticle was obtained by adding 25 mL of the extract to 100 mL $AgNO_3$ (10^{-3} M).Also, by adding 5 mL of the extract to 25 mL of $AgNO_3$ solution,the silver nanoparticles were synthesized by rapid reduction at 300 K at a pH of 8,which was found to be intense brown in colour [17].

O. tenuiflorum, *S. tricobatum*, *S. cumini*, *C. asiatica* leaves each of 1.5 g and peels of *C. sinensis* were boiled in 100ml of de-ionized water. 2.5 ml of ammonium solution was added to 5 ml of 1 mM $AgNO_3$ solution, followed by the addition of plants extract from 1ml – 10 ml consequetively. The dark brown indicates the presence of silver nanoparticle formation [18]. By dissolving 10g of dried powder in 100mL of distilled water contained in the 500 mL of Erlenmeyer

flask and then boiling for 10 minutes produces the plant extract. By mixing 10 mL of the plant extract with 90 mL of mM aqueous AgNO3, the reduction of Ag ions kes place which was observed by a color change [19]. 50mL of 10^{-3} M AgNO3 aqueous solution was added to the leaf extract (1mL) and was kept at room temperature for 10 minutes. Under continuous stirring conditions, the yellow colour of the silver nitrate solution gradually changes to brownish yellow, which indicates the formation of silver nanoparticles [20].

Weighed biomass was added to 50 ml of 1 mM aqueous AgNO3 solution placed in the 100ml conical flask in the dark at room temperature for the synthesis of silver nanoparticles using Methanolic Extract of *Eucalyptus hybrida* leaves [21]. 5 ml of mangosteen leaf extract was added into 95 ml of aqueous solution of 1 mM silver nitrate .The leaf extract (1.5 ml) was added to 30 ml of 10^{-3} M $AgNO_3$ aqueous solution. It is then heated on water bath at 75 °C for 60 min. The color change from colorless to brown indicates the reduction of silver nitrate to silver ions [22]. For the reduction of Ag+ ions, by taking two test tubes, 1mL of leaf broth was added to 9 mL of 1mM aqueous AgNO3 solution in the first test tube. In the second test tube no leaf broth was added which serve as control.The test tubes were kept for 24hrs of incubation at room temperature. After incubation, the so formed silver nanoparticle solution was subjected to repeated centrifugation at 15,000 rpm for 20 min. The pellet so obtained was redispersed in the deionized water [23].

12 ml of the aqueous extract of *A. indica* was added to 88 ml of 1 mM (10^{-3} M) solution of silver nitrate. The reaction was performed in dark at room temperature [24]. Aqueous solution of 10^{-3} M and 10^{-4} M silver nitrate (AgNO3) and 10^{-2} M concentration of D-sorbitol were prepared. 3 mL of the Polyalthia longifolia leaves extract and 1 mL of D- sorbitol were added to 40 mL of AgNO3 solution and incubated at room temperature at 25°C and 60°C respectively .Dark brown colour formation inducatesthe appearance silver nanoparticles.

Fine powder of *Boswellia ovalifoliolata* stem bark was added to 1 mM silver nitrate solution and centrifuged at 18,000 rpm for 25 min. The collected pellet was stored at - 40°C.The supernatant was heated at 500° C to 950° C. During the heating process, a change in the color of solution was observed [25].

Characterization

UV Spectrometry analysis

The Extracellular synthesis of silver nanoparticles using leaves of *Euphorbia hirta* involves the reduction of pure Ag+ ions was measured by the UV-Vis spectrum of the reaction medium at 5 hours by using UV-VIS spectrophotometer UV-2450 (Shimadzu). Colloidal silver nanoparticles from *Hevea brasiliensis* has the characteristic surface plasmonic absorption band around 435 nm and is given by UV–Vis spectra . Decreased particle size is due to lower $AgNO_3$ concentration. The silver nanoparticles are spherical shape with diameters ranging from 2 nm to 100 nm . UV–vis absorption spectra of the colloidal dispersions were recorded using the Ultrospec 2100 spectrophotometer. The distribution of the particle size was measured by Zeta-Sizer system (Malvern Instruments). The biosynthesized silver nanoparticles from Mangosteen leaf has a resolution of 1 nm between 300 and 700 nm and possess a scanning speed of 300 nm/min was determined by UV–visible absorption spectrophotometer and the maximum absorbance was found to be at 438 nm. Synthesis of silver nanoparticles from plant extract shows a maximum absorbance occurs at 430 nm which increases as a function of reaction time. While using Magnolia leaf broth, the final absorption intensities at 430 nm will be get increased upto 1.5 Angstorm unit, when compared with the Neem leaf broth,whose intensity only get increased upto 0.5 Angstorm unit [26]. There is no evidence of absorbance the UV-vis spectra range between 400nm - 800nm for the pure solanum torvum plant extract, but when the plant extract gets exposed to AgNO3 solutions, maximum absorbance was found at 434 nm, due to the formation of nanoparticles.

The bioreduction of Ag+ions using Eucalyptus hybrid extract was carried out by sampling of aliquots (0.2 ml) of the suspension, then diluting the samples with 2 ml of deionized water and measuring the UV– Vis spectra of the resulting diluents. The resulting UV–vis spectroscopy analysis was carried out at room temperature on ELICO UV spectrophotometers at a resolution of 1 nm. It is observed that the resonance band occurs at 412 nm and steadily increases without any shift in the peak wavelength. Formation of stable silver nanoparticles using the seed extract of Jatropha curcas in aqueous colloidal solution are confirmed using UV–vis spectral analysis. Characteristic surface plasmon absorption bands are observed at 425 nm for silvernanoparticles synthesized from 10^{-3}(M) $AgNO_3$, for the fixed volume fraction ($f = 0.2$) of aqueous seed extract. By increasing the concentration of silver nitrate solution, Surface Plasmon Resonanace band shifted to the red was observed from 10^{-3} to 10^{-2} (M) concentration and the colour changes from reddish yellow to deep red.

Fourier Transform Infra Red Spectroscopy

The selected area electron diffraction (SAED) patterns from *Hevea brasiliensis* shows that the silver nanoparticles have face ammonia facilitate reduction of the silver ions showed by FTIR. The data has angle of (90°) and f wavelength of (633 nm He–Ne laser). By dropping the solutions onto a silicon plate with Bomem MB 100 spectrometer obtains a film Fourier-transform infrared spectra (FTIR) in the region between 4000 and 400 cm^{-1}. The purified suspension from Mangosteen leaf was freeze dried to obtain dry powder and hence the dried nanoparticles were analyzed by FTIR-JASCO 4100 spectrophotometer.

The FTIR spectrum of the *S. torvum* leaf extract shows peaks at at 1648, 1535, 1450 and 1019 cm^{-1}. The peak at 1450cm^{-1}(-COO-) of carboxylate ions is responsible for stabilizing the silver nanoparticles. Selected area electron diffraction (SAED) pattern using seed extract of Jatropha curcas suggests the polycrystalline nature of the present synthesized silver nanoparticles.It is observed that the silver nanoparticles solution is extremely stable for nearly 65 days with only a little aggregation of particles in solution. FTIR spectroscopy measurements show the presence of three bands 1744, 1650, 1550 and 1454 cm^{-1}. The strong absorption at 1744 cm^{-1} is due carbonyl stretching vibration of the acid groups present in the extract. The bands at 1650 and 1550 cm^{-1} are characteristic of amide I and II bands respectively. The amide band I is due to the stretch mode of the (-CO) carbonyl group coupled to the (-NH) amide linkage while the amide II band is due to the N–H stretching modes of vibration in the amide linkage.

FTIR absorption spectra of *Dioscorea bulbifera* tuber extract shows a strong peak at 3300 cm−1 representing O–H bond. But after bioreduction it is not seen in the extracts of *D. bulbifera.* The absorbance bands at 2931 cm−1, 1625 cm−1, 1404 cm−1, and 1143 cm−1 are associated with respect to the stretch vibrations of alkyl C–C, conjugated C–C with a benzene ring, bending of C–O–H and C–O stretch in saturated tertiary or secondary highly symmetric alcohol in *D. bulbifera.* The presence of peaks at 3749 cm−1 and 1523 cm−1 indicate the –NH2 symmetric stretching and N–O bonds in nitro compounds [27].

The AgNPs was synthesized using *A. spicifera* Shows Intense FTIR bands were observed at 3351.28 cm-1, 2633.71 cm-1, 2083.50 cm-1, 1637.18 cm-1, 1082.87 cm-1 and 712.34 cm-1 . The major FTIR bands were absorbed at 3351.20 cm-1, 2633.74 cm-1 and 712.34 cm-1 .They indicates the presence of alcohols and phenols (O-H), carboxylic acids and its derivatives (C=O) and Chloroalkanes (CX) respectively [28].

FTIR measurements for Gliricidia sepium shows the absorption peak at around 1020 cm-1 can be assigned as absorption peaks of -C-O-C- or –C-O- . The absorption spectra at about 1638 cm-1 result from stretching of vibration of -C=C- . The peak at around 1640 cm-1 indicates the amide I bonds of proteins. The bonds or functional groups such as -C-O-C-, –C-O- and -C=C- are derived from heterocyclic compounds. The amides I bond derived from the proteins are the capping ligands of the nanoparticles [29].

X ray diffraction analysis

Biologically synthesized silver nanoparticles from Eucalyptus hybrida shows X-ray diffraction (XRD) analysis. It is obtained using

an X'Pert Pro X-ray diffractometer operated at a voltage of 40 kV and 30 mA current with Cu Kα radiation. Silver nanoparticles synthesised from aqueous leaves extract of *A. indica* were coated on XRD grid and is used for XRD studies. The spectra were analysed by using Philips PW 1830 X-ray generator. It operates at 30 mA current and 40 kV voltage with Cu Kα1 radiation. XRD analysis shows three distinct diffraction peaks of 38.1°, 44.3° and 64.4° at 2θ values indexed to (1 1 1), (2 0 0) and (2 2 0) the crystalline planes of the face centered cubic structure of metallic silver. In the bioreduction process,the average grain size of the AgNPs formed is estimated to be 24 nm.

The XRD patterns of silver nanoparticles synthesized from seed extract of *Jatropha curcas has a* number of Bragg reflections with 2θ values of 38.03°, 46.18°, 63.43° and 77.18° corresponding sets of lattice planes to the (1 1 1), (2 0 0), (2 2 0) and (3 1 1) were observed. They are indexed as the band for face centered cubic structures of silver. The XRD pattern shows that the formed silver nanoparticles are crystalline in nature. The X- ray diffraction patterns for *S. torvum* leaf extract shows the presence of intense peaks of silver nanoparticles whose average size was calculated as 14 nm.

Dried silver nanoparticles from Nelumbo nucifera leaf extract were coated on XRD grid.The corresponding spectra were recorded by using Phillips PW 1830 instrument which operates at a voltage of 40 kV and a current of 30 mA with CuKα1 radiation. The average size of the silver nanoparticles was calculated as 45 nm . The XRD patterns for silver nanoparticles synthesized using Neem leaf broth has a number of Bragg reflections which corresponds to the (111), (200), (220), (311), and (222) sets of lattice planes. Thus it clearly shows that the silver nanoparticles are formed by the reduction of Ag^+ ions, which are crystalline in nature [30].

Formation of silver nano particles from papaya fruit extract shows three intense peaks which ranges from 10° to 80°. The Average size of the particles was measured as 15nm [31]. The XRD patterns of Ag/*Vitex negundo* indicate the face-centered cubic (fcc) structure of silver nanoparticles [32]. The silver nanoparticles shows XRD peaks at 38.17°, 44.31°, 64.44°, 77.34° and 81.33° corresponding to the face-centered cubic (fcc) planes (111, 200, 220, 311 and 222) of the silver crystals ,respectively [33].

The X-ray diffraction (XRD) pattern for plant-mediated synthesis of silver nanoparticles has photons of energies, in the range of 100 eV–100 keV. A short-wavelength X-rays (hard X-rays) which ranges in between 1–120 keV were used for diffraction applications [34].The X-ray diffraction (XRD) pattern of dry silver nanoparticle using Chenopodium album leaf extract exhibit diffraction peaks at 38.13°, 44.21°, 64.47°, 77.37°, 81.47°, 98.01°, 110.56° and 114.80° .

Scanning ElectronMicroscopy

The formation of spherical shaped silver nanoparticle extracted through *Syzygium aromaticum*, whose size ranging in between 20 nm to 149 nm was confirmed by scanning electron microscopy. Scanning Electron Microscopic (SEM) analysis was done using Hitachi S-4500 SEM machine. Silver nanoparticle synthesized within 10 minutes has an absorbance at 430 nm and the broadening of the peak indicates indicates the polydispersion of the particle. The SEM shows that spherical shape nanoparticle formed with a diameter range 40-50 nm.

The high density silver nanoparticles synthesized by the A. *paniculata shows* SEM image which was done by using SEM (JEOL-MODEL 6390). The average size was from 35-55nm with inter-particle distance and the shape were proved to be spherical. The aggregation of the nanoparticles indicates that they were in the direct contact, but were stabilized by a capping agent [35]. The silver nanoparticles synthesized by Novel *Pseudomonas* sp shows the sharpening of the peaks which indicates that the particles are in the nanoregime. The average size of the silver nanoparticles from 20nm - 100nm. SEM observations were performed on an H-600 electron microscope which operates at an accelerating voltage of 120 kV. The shape of the silver nanoparticles was spherical and gets aggregated into larger irregular structure with no well-defined morphology [36].

Green Synthesis of Silver Nanoparticles from *Cleome Viscosa* was analyzed by SEM. SEM observations were done by using ZEISS EVO 40 EP Electron microscope. SEM analysis shows silver nanoparticles are uniformly distributed on the surface of the cells. But it does not indicate that all the nanoparticles are bound to the surface of the cells.This may be the particles dispersed im the solution may also be deposited onto the surface of the cells [37].

High Resolution Transmission Electron Microscopy

Colloidal silver nanoparticles from *Hevea brasiliensis* were analysed using JEOL-JEM-100 CXII instrument,the morphology of the silver nanoparticles were studied by transmission electron microscopy (TEM), by drying a drop of the washed colloidal dispersion onto a copper grid covered with a conductive polymer. The size and shape of Ag nanoparticles synthesized using mangosteen leaf was visualized using 200 kV Ultra High Resolution TEM (JEOL-2010). TEM grids were prepared and the residual solution of 100 ml after reaction was centrifuged at 5000 rpm for 10 min. The resulting suspension was redispersed in sterile distilled water of 10 ml and centrifugation process was repeated for three times. Biologically synthesized silver nanoparticles on *Bacopa monnieri* uses 25 µl of sample and sputter it on a coated copper stub using HRTEM (JEOL-3010) for electron microscopic study. Dried nanoparticles were coated on XRD grid and the spectra were recorded by using Philips PW 1830 X-ray generator.It operated at a voltage of 40 kV and a current of 30 mA with Cu Kα1 radiation. Atomic absorption spectrophotometer (AAS) was used to assay Concentration of silver.

HRTEM analysis clearly shows that the size of the AgNPs ranges from 2 to 50 nm and also shows that they were well dispersed. The shape was almost spherical to cubic. By using Scherer's formula t = 0.9l/ B cos, an average crystal size (t) of the silver nanoparticles can be estimated from the X- ray wavelength of the Cu Kα radiation (l=1.54Ao), the Bragg angle , and the width of the peak at half height in radians. The average size of the silver nanoparticles from solanum torvum is calculated as 14 nm. The result is comparable with TEM image of the reduction of AgNO3 by *S .torvum* extract. High Resolution Transmission Electron Microscopy (HRTEM) shows that the silver nanoparticles are spherical in structure. Using HR-TEM images, the average size of silver nanoparticles was obtained as14 nm.

HRTEM analysis of biogenic Ag nanoparticles prepared by *Ulva lactuca* extract shows that the size measurement of the particle was found to 20 – 30 nm in diameter [38]. Formation and stability of silver nanoparticles using seed extract of Jatropha curcas in aqueous colloidal solution shows that, by increasing concentration of silver nitrate SPR band shifted to the red from 10^{-3} to 10^{-2} (M) and the colour changes are observed from reddish yellow to deep red. HRTEM shows that the particles are spherical with diameter ranges from 15 to 25 nm. Larger and uneven shaped particles with diameter 30–50 nm. Sizes of the particle at two different $AgNO_3$ concentrations are in agreement with the observed surface plasmon resonance (SPR) band i.e., at 425 and 452 nm respectively.

Applications

Antimicrobial activity

It is a well known fact, that silver ions and nanoparticles are highly toxic and hazardous to microorganisms. It is found out that the silver nanoparticles have many inhibitory and bactericidal effects and so its application is extended as an antibacterial agent. The antibacterial activity of silver nanoparticles is estimated by the zone of inhibition. Many different studies have shown that silver nanoparticles can affect the membrane permeability and respiratory function by attaching to cell surface. Another possibility is that silver nanoparticles not only interact with the surface of the membrane, but can also penetrate deep inside the bacteria. Another observation explains that the silver nanoparticles have relatively higher anti-bacterial activity against gram negative bacteria than gram positive bacteria,which may be due to the thinner peptidoglycan layer and presence of beta barrel proteins called porins.

Very recently, nanoparticles have gained significance in the field of Biomedicine. The most significant and distinguishing property of

nanoparticles is that they exhibit larger surface area to volume ratio. Surface area corresponds to the various properties such as the catalytic reactivity, antimicrobial activity etc… When surface area of the nanoparticles gets increased, their surface energy will get increased and hence their biological effectiveness will also increase [39]. Smaller nanoparticles with a larger surface area to volume ratio provide a more effective antibacterial activity even at a very lower concentration. Silver nanoparticles of many different shapes (spherical, rod-shaped, truncated, triangular nanoplates) were developed by various synthetic routes. Truncated triangular silver nanoplates were found to show the strongest anti-bacterial activity. This property could be due to their larger surface area to volume ratios and their crystallographic surface structures.

Nanosilver is a much effective and a fast-acting fungicide against a broad spectrum of common fungi including genera such as Aspergillus, Candida and Saccharomyces [40]. Standard well diffusion method was used to assay the antibacterial activity against human pathogenic bacteria such as Escherichia coli, Pseudomonas aeroginosa, Bacillus subtilis and Klebsiella pneumonia [41]. In vitro antibacterial activity of the prepared nanoparticles was studied using the Kirby-Bauer technique, which confirmed the recommended standards of the National Committee for Clinical Laboratory Standards (NCCLS) (now known as Clinical and Laboratory Standards Institute CLSI.The agar well diffusion method was used to assess the antibacterial activity of the synthesized Ag nanoparticles. The zone of inhibition produced by various antibiotics were compared with the inhibitory zone produced by the silver nanoparticles, were also demonstrated [42].Besides, the antibacterial assays were performed on human pathogenic bacteria like *Escherichia coli* and *Pseudomonas aeruginosa* by standard disc diffusion method. Briefly, Luria Bertani (LB) broth/agar medium was used to cultivate bacteria. Basically, nanoparticle has antimicrobial (including antibacterial and antifungal) applications. The silver or gold nanoparticles that are produced extracellularly from *Fusarium oxysporum* can be used in several of materials like clothes. Such type of clothes is sterile and is used in hospitals to prevent or to minimize the infection with pathogenic bacteria like Staphylococcus aureus. The average zones of inhibition expressing a profound inhibitory effect was represented as 35mm in *P.aerogenosa* , 30mm in *K. pneumonia*, 36mm in *S. aureus*, 40 mm in *S. typhi*, 38mm in *S. epidermis* and 34 mm in *E.coli* [43].

For the concentration of 20 µg, 40 µg, 60 µg and 80 µg of the nanoparticle, *Staphylococcus aureus* exhibited characteriestic inhibitory zones 14mm, 16mm, 18mm and 20mm diameter, where as Enterococcus *faecalis* exhibited 11mm, 13mm, 14mm and 17mm diameter of zone of inhibiton respectively [44]. Rather, nanoparticle are also used in biological detection, controlled drug delivery, optical filters, sensor design etc. With respect to diagnosis, Silver nanoparticles interact with HIV–1Virus via preferential binding to the gp 120 glycoprotein knobs.

Plants and plant extracts can be effectively used in the synthesis of gold and silver nanoparticles as a greener route. Shape and size control of nanoparticles is easily understood with the use of plants. The nanoparticles extracted from plants are used in many applications for benefit of humans. However, the nanoparticle synthesis mechanism by plants is quite complex to understand. Only some rough ideas are available in their synthesis, such as the reducing agent, proteins and phenolic precipitation. The most promising area of research includes the elucidation of the mechanism of plant-mediated synthesis of silver nanoparticles.

The green synthesis of silver nanoparticles was also carried out using leaf extract of Euphorbia hirta. Further, the silver nanoparticle revealed to possess an effective antifungal property against *Candida albicans*, *C.kefyr*, *A.niger*. The extracts of *Lantana camara* are used as a reducing agent for the synthesis of silver nanoparticles from silver nitrate. The approximate size of nanoparticles was found out to be 39 - 60 nm from the SEM results. This plant can be grown easily and found in all the regions in India as a decorative plant. Also, synthesis of silver nanoparticles reducing silver ions using the extract of Mentha Piperita leaves was reported. The so obtained nanoparticles were found to be highly dense and stable with an average size range from 7 nm to 50 nm [45]. Using the fruit extract of papaya plant, the bio-reduction of aqueous Ag+ ions has been demonstrated. These nanoparticles are so eco-friendly and have various applications in wound healing. This makes this method exclusively applicable for the large-scale synthesis of other inorganic materials (nanomaterials).

CONCLUSION

From this summary, it was concluded that plant mediated synthesis of silver nanoparticles possess potential antimicrobial applications. The characterization analysis proved that the particle so produced in nanodimensions would be equally effective as that of antibiotics and other drugs in pharmaceutical applications. The use of silver nanoparticles in drug delivery systems might be the future thrust in the field of medicine.

REFERNCES

1. Harekrishna Bar, Dipak Kr Bhumi, Gobinda sahoo P, priyanka Sarkar, Sankar PD. Green synthesis of silvernanoparticles using latex of Jatropha curcas. *Colliod surface A* 2009; 39(3):134-139.
2. Cassandra D, Nguyen N, Jodi H, Linfeng G, Tan, Li, et al. Green synthesis of gold and silver nanoparticles from plant extracts.
3. Kaviya S, Santhanalakshmi J, Viswanathan B. Green Synthesis of silver nanoparticles using Polyalthia longifolia Leaf extract along with D-Sorbitol. *Journal of nanotechnology* 2011:1-5.
4. Sastry M, Ahmad A, Islam NI, Kumar R. Biosynthesis of metal nanoparticles using fungi and actinomycetes. *Current Sc*. 2003;85(2):162-170.
5. Sastry M, Ahmad A, Khan MI, Kumar R. Microbial nanoparticle production in *Nanobiotechnology* 2003;85(2):163-169.
6. Nelson D, Priscyla DM, Oswaldo LA, Gabriel IHDS, Elisa E. Mechanical aspects of biosynthesis of silver nanoparticles by several Fusarium oxysporum strains. *Journal of Nanobiotechnology* 2005;3
7. Hemanth NKS, Kumar G, Karthik L, Bhaskara RKV. Extracellular biosynthesis of silver nanoparticles using the filamentous fungus Penicillium sp. *Arch Appl Sci Res* 2010;2(6):161-167.
8. Natarajan K, Subbalaxmi SV, Ramchandra M. Microbial production of silver nanoparticles. *Dig J Nanomat Bios* 2010;5(1):135-140.
9. Elumalai EK, Prasad TNVKV, Hemachandran J, Vivivan Therasa S, Thirumalai T, David E. Extracellular synthesis of silver nanoparticles using leaves of Euphorbia hirta and their antibacterial activities. *J Phram Sci* 2010;2(9):549-554.
10. Ankamwar B, Damle C, Ahmad A, Sastry M. Biosynthesis of gold and silver nanoparticles using Emblics Officinalis Fruit extract and their Phase Transfer and Transmetallation in an Organic Solution. *J nanosci nanotechnol* 2005;5(10):1665-1671.
11. Kasthuri J, Kathiravan K, Rajendran N. Phyllanthin assisted biosynthesis of silver and gold nanoarticles a novel biological approach. *J Nanopart Res* 2009; 11:1075-1085.
12. Vijayaraghavan K, Kamala Nalini SP, Udaya Prakash N, Madhankumar D. Biomimetic synthesis of silver nanoparticles by aqueous extract of Syzygium aromaticum.2012;75:33-35.
13. Amarendra DD, Krishna G. Biosynthesis of silver and gold nonoparticles using Chenopodium album leaf extract. *Colloid Surface A* 2010;369(3):27-33.
14. Guidelli EJ, Ramos ME, Zaniquelli D, Baffa O. Green synthesis of colloidal silver nanoparticles using natural rubber latex extracted from Hevea brasiliensis. *Mol Biomol Spectrosc* 2011:82(1):140-145.
15. Thirunavukkarasu S, Abdul AR, Govindasamy R, Sampath M, Asokan B, Chidambaram J, Abdul AZ, Gandhi E, Chinnaperumal K. Synthesis of silver nanoparticles using Nelumbo nucifera leaf extract and its larvicidal activity against malaria and filariasis vectors. *Parasitol Res* 2011;108(3):693-702.
16. Harekrishna B, Dipak KB, Gobinda P, Priyanka S, Sankar PD, Santanu P, Ajay M. Green synthesis of silvernanoparticles using seed of Jatropha curcas. *Colliod surface A* 2009:348(3):212-216.
17. Daizy Philip. Green Synthesis of gold and silver nanoparticles using Hibiscus rosasinensis. *Low dimen sys nanostruct* 2010:42(5):1417-1424.

18. Peter L, Sivagnanam S, Jayanthi A. Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property. 2012:
19. Mukunthan KS, Elumalai EK, Trupti Patel N, Ramachandra Murty V. Catharanthus roseus a natural source for the synthesis of silver nanoparticles. *Asian Pac J TropBiomed* 2011:1(4):270-274.
20. Govindaraju K, Tamilselvan S, Kiruthiga V, Singaravelu G. Biogenic silver nanopar ticles by Solanum torvum and their promising antimicrobial activity. *J Biopest* 2010:3(1):349-399.
21. Manis D, Seema B, Kushwah BS. Green synthesis of nanoparticles from extract of Eucalyptus Hybrida (Safeda) leaf. *Dig J Nanomater Bios* 2009:4(3):537-543.
22. Ravichandran V, Tiah ZX, Subashini G, Terence FWX, Eddy FCY , Nelson J, Sokkalingam AD. Biosynthesis of silver nanoparticles using mangosteen leaf extract and evaluation of their antimicrobial activities. *J Saudi Chem Soc* 2010:15(2):113-120
23. Thirumurugan A, Neethu AT, Hema PK, Prakash P. Biological synthesis of silver nanoparticles by Lantana camara leaf extracts. *Int J Nanomat Biostruc* 2011:1(2):22-24.
24. Krishnaraj C, Jagan EG, Ramachandran R, Abirami SM, Mohan N, Kalaichelvan PT. Effect of biologically synthesized silver nanoparticles on Bacopa monnieri (Linn) Wettst plant growth metabolism. *Process Biochem* 2011:47(4):651-658.
25. Ankanna S, Prasad TNVKV, Elumalai EK, Savithramma S. Production of Biogenic Silver nanoparticles using Boswellia Ovalifolita stem bark. *Dig J Nanomater Bios* 2011:5(2):369-372.
26. Song JY, Kim BS. Rapid Biological synthesis using plant leaf extracts. *Bioprocess Biosyst Engg* 2009:32(1):79-84.
27. Sougata G, Sumersing P, et al. Synthesis of silver nanoparticles using Dioscorea bulbifera tuber extract and evaluation of its synergistic potential in combination with antimicrobial agent. *Int J Nanomed* 2012;483-496.
28. Kumar P, Senthamilselvi S, Lakshmipraba A, Premkumar K, Muthukumaran R, et al. Efficacy of bio-synthesized silver nanoparticles using Acanthophora spicifera to encumber biofilm formation. *Dig J Nanomat Biostruc* 2012;2:511-522.
29. Raut RW, Lakkakula JR, Kolekar NS, Mendhulkar VD, Kashid SB. Photosynthesis of silver nanoparticle using Gliricidia sepium. *Curr Nanosci* 2009;117-122.
30. Shiv Shankar S, Akhilesh Rai, Absar Ahamad, Murali Sastry. Rapid systhesis of Au, Ag, and bimetallic Au core-AG shell nanoparticles using Neem (Azadirachta indica) leaf broth. *J Colloid Interf Sci* 2004;275(2):496-502.
31. Devendra J, Hemant KD, Sumitha K, Kothari SL. Synthesis of Plant-Mediated Silver nanoparticles using Papaya Fruit Extract and Evaluation of their Anti Microbial Activities. *Dig J Nanomat Bios* 2009; 4(4):723-727.
32. Amal KM, Sanjukta M, Sumana S, Sudebi M. Synthesis of ecofriendly silver nanoparticles from plant latex used as an important taxonomic tool for Phylogenetic Interrelationship. *Adv Biores* 2011; 2(1): 122-133.
33. Mohzen Z, Azizah AH, Fatima AB, Mariana NS, Kamyar S, Fatemah J, et al. Green synthesis and antibacterial effect of silver nanoparticles using *Vitex Negundo* L. *Molecules* 2011; 16(8): 6667-6676.
34. Vineet K, Sudesh KY. Plant-mediated synthesis of silver and gold nanoparticles and their applications, *J Chem Technol Biot* 2009; 84(2): 151-157.
35. Panneerselvam C, Ponarulselvam S, Murugan K. Potential Anti-plasmodial activity of synthesized silver nanoparticles using Andrographis paniculata Nees (Acanthaceae). *Journal of Ecobiotechnology* 2011;3:24-28.
36. Muthukannan R, Karuppiah B, Rapid synthesis and characterization of silver nanoparticles by novel Pseudomonas sp. "ram bt-1", Microbial Biotechnology.
37. Bharathi RS, Suriya J, Sekar V, Rajasekaran R. Biomimetic of silver nanoparticles by *Ulva lactuca* seaweed and evaluation of its antibacterial activity. *Int J Pharm Pharm Sci* 2012;4(3): 139 – 143.
38. Yamini S et al. Green synthesis of silver nanoparticles from Cleome Viscosa : Synthesis and antimicrobial activity. *International conference on Bioscience , Biochemistry and Bioinformatics* 2011;5:334 – 337.
39. Srivastava AA, Kulkarni AP, Harpale PM, Zunjarrao RS. Plant mediated synthesis of silver nanoparticles using a bryophyte: Fissidens minutus and its antimicrobial activity. *Int J Eng Sci Tech* 2011; 3(12):8342-8347.
40. Ramya M, Sylvia SM. Green synthesis of silver nanoparticles. *Int J Pharm Med Biol Sci* 2012; 1(1).
41. Aditi PK, Ankita AS, Pravin MH, Rajendra SZ. Plant mediated synthesis of silver nanoparticles- tapping the unexploited sources. *J Nat Prod Plant Resour* 2011; 1(4): 100-107.
42. Geoprincy G, Saravanan P, Nagendra GN, Renganathan S. A novel approach of studying the combined antimicrobial effects of silver nanoparticles and antibiotics through agar over layer method and dicc diffusion method. *Dig J Nanomat Bios* 2011; 6(4): 1557-1565.
43. Shirley AD, Sreedhar B, Syed GD. Antimicrobial activity of silver nanopaarticles synthesized from novel Streptomyces species. *Dig J Nanomat Bios* 2010; 5(2): 447-451.
44. Karthick RNS, Ganesh S, Avimanyu. Evaluation of anti bacterial activity of silver nanoparticles synthesized from Candida glabrata and Fusarium oxysporum. *Int J Med Res* 2011; 1(3):131-136.
45. Upendra KP, Preeti Saxena S, Anchal S. Bioinspired synthesis of silver nanoparticles. *Dig J Nanomat Bios* 2009;4(1): 159-166.