Eco-Friendly Synthesis of Silver mediated Nanoparticles using the Leaf extracts of *Cipadessa baccifera* (Roth) Miq.

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Nanotechnology is one of the emerging fields of the scientific world. Various physical and chemical methods have been formulated for the synthesis of nanoparticles of desired shape and size. These methods are not eco friendly and economically feasible. In the present study, rapid, simple, eco-friendly approach was applied for synthesis of silver nanoparticles using *Cipadessa baccifera* aqueous leaf extract. The phytosynthesized nanoparticles were characterized by FT-IR, X-RD and SEM analyses. FT- IR used to study the functional group present in the nanoparticles. X-ray diffraction was used to confirm the crystalline nature of the particles. The morphology and crystalline phase of the nanoparticles were determined using scanning electron microscopy (SEM). The results suggested that protocol is simple, rapid, one step, eco-friendly, non-toxic and alternative conventional physical/chemical methods. The formation of brown color at room temperature within a stipulated time takes place without the involvement of any hazardous chemicals.

Keywords: Green synthesis, *Cipadessa baccifera*, Silver nanoparticles, Aqueous extract

Introduction:

Nanotechnology is the field of sciences which deals with production, manipulation and use of materials ranging in nanometers. In recent years various methods followed for synthesis of silver nanoparticles. Among the various methods, phytosynthesised silver nanoparticles in the field of herbal and medicinal plant biology had more attention to nanobiotechnology (Roy and Das, 2015). The 'green' environment friendly processes in chemistry and chemical technologies are becoming increasingly popular and are much needed as a result of worldwide problems associated with environmental concerns (Thuesombat et al., 2014).

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Silver is the one of the most commercialized nano-material with five hundred tons of silver nanoparticles production per year (Larue et al., 2014).The typical application of nanoparticles can be found in many fields like heterogeneous catalysis, semiconductors, microelectronics, information storage, pharmaceuticals, paints and ceramics. Particles with a size between the 1 to 100 nm have the special benefit that physical and chemical properties differ from the bulk material properties and are strongly size dependent (Niemann et al., 2006). Nano scale materials can be made up of numerous ways. A broad classification divides the synthesis methods into either bottom up or top down process (Kelsall et al., 2005).

Many biological approaches for both extracellular and intracellular nanoparticles synthesis have been reported till date using microorganisms including bacteria, fungi and plants (Spring, 1995; Mukherjee, 2001). Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as well as provide natural capping agents. Moreover, the use of plant extracts also reduces the cost of microorganisms isolation and culture media enhancing the cost competitive feasibility over nanoparticles synthesis by microorganisms (Singhal, 2011). *Cipadessa baccifera* plant is from Meliaceae family. It is one of the well-known traditional medicinal plants in India used for the treatment of rheumatoid arthritis, dysentery and pruritus (Roy and Shailendra, 2006), the paste of root, leaf and bark of this plant is applied topically cure psoriasis (Kindo *et al.,* 2014). Its decoction has been utilized to treat dysentery, skin itches and malaria fevers by tribal communities (Liang *et al.,* 1991 and Luo *et al.,* 2000). The methanol and chloroform extracts of leaves were evaluated for antimicrobial, antioxidant, hemolytic and thrombolytic activities (Thirunavukarasu *et al.,* 2014). Based on the enormous medicinal potential of the plant, the present study is designed to investigate the eco-friendly synthesis of silver nanoparticles of *Cipadessa baccifera* using aqueous leaf extract.

Materials and methods:

The plant material selected for the present study is *Cipadessa baccifera* (Roth) Miq. belonging to the family Meliaceae. The plant material was collected from the Western Ghats of South India and identified with the help of herbarium specimens deposited in St. Xavier's College Herbarium (XCH).

Synthesis of Silver Nanoparticles

10 g of fresh leaf was boiled with 100 ml of double distilled water. The extract was filtered through WHATMAN no.1 filter paper. The filtered samples were collected in a conical flask. The obtained extract was used for the synthesis of silver nanoparticles.1 mM silver nitrate solution was prepared by the concentration of 0.0169 gm in 100 ml double distilled water and stored. 90 ml of the silver nitrate solution was taken in a conical flask. To this 10 ml of the extract was added. The color changes of the silver nitrate solution were found from colorless to dark brown. The conical flask was incubated at light for 72 h.

FT-IR spectrophotometer analysis

Fourier Transform Infrared Spectrophotometer (FT-IR) is perhaps the most powerful tool for identifying the types of chemical bonds (functional groups) present in compounds. The wavelength of light absorbed is characteristic of the chemical bond as can be seen in the annotated spectrum. By interpreting the infrared absorption spectrum, the chemical bonds in a molecule can be determined. Dried nanoparticles of the plant material were used for FT-IR analysis. 10 mg of dried nanoparticles was encapsulated in 100 mg of KBr pellets, in order to prepare translucent sample discs. The powdered sample was loaded in FT-IR spectroscope (SJASCO FT-IR 410 spectrophotometer), with a scan range from 400 to 4000 cm with a resolution of 2 cm^{-2}.

XRD analysis

The characterization of purified synthesized silver nanoparticles were freeze dried powered and used for XRD analysis (PANalytical X'Pert Pro Powder X'Celerator Diffractometer) at 40 kv/20 mA using continuous scanning 2 delta mode (Absar, 2003). The silver nanoparticles solution was purified by repeated centrifuges at 5000 rpm for 20 minutes followed by redispersion of the pellet of silver nanoparticles into 10 ml of deionized water.

SEM (Scanning Electron Microscopic) analysis

SEM analysis was done using VEGA3 TESCAN machine. Thin films of the sample were prepared on a carbon coated copper grid by just dropping a very small amount of the sample on the grid, extra solution was removed using a blotting paper and then the film on the SEM grid was allowed to dry by putting in under a mercury lamp for 5 min.

Results and discussion

Synthesis of silver Nanoparticles

When silver salt ($AgNO_3$) is added to aqueous leaf extract of *Cipadessa baccifera* it results into a color change from pale yellow to yellowish - brown and finally to dark - brown color. The reduction of silver ions to metallic silver is due to the presence of reducing agents. It was suggested that compounds like caffeine and theophylline act as reducing agent when *Acalypha indica* leaf extract was used (Krishnaraj *et al.,* 2010). Silver nanoparticles show yellowish - brown color in aqueous solution due to the excitation of surface plasmon vibrations (Shankar *et al.,* 2004). The aqueous silver ions when exposed to plant extracts were reduced and thus resulted in the formation of silver nanoparticle. The leaf extracts were initially pale yellow or brownish yellow in colour. After the addition of aqueous silver nitrate solution, the colour changed to dark brown colour within 5-20 minutes due to excitation of surface plasmon vibrations in silver nanoparticles (Jha *et al.,* 2010). The time duration taken to change in colour can be varies from species to species. Noble metal particles specially silver and gold exhibit a strong absorption band in the visible region and giving specific color to the solution (Ching *et al.,* 2010).

FT-IR Analysis

The FT-IR measurements of green synthesized Silver nanoparticles were executed to identify the possible interaction between protein and Silver nanoparticles. The FT-IR spectrum was used to identify the functional group of the active components based on the peak value in the region of infrared radiation. The peak values detected in the leaf synthesized silver nanoparticles are 537.14, 1045.35, 1072.35, 1283.54, 1384.79, 1606.59, 1720.39, 2360.71, 2851.56, 2920.99 and 3316.37 cm^{-1} (Figure 1). The band at 3316 cm^{-1} in the spectra corresponds to O–H stretching vibration indicating the presence of alcohol and phenol. Bands at 2920.99 and 285.56 cm^{-1} region arising from C–H stretching of aromatic compounds were observed. The peak observed at 1720.39 cm^{-1} indicated the presence of C=O stretching of saturated aldehyde compound. The peaks at 1606.59 and 1384.79 cm−1correspond to C–N stretch vibrations, as well as to the amide I bands of proteins in the leaf extract (Gurunathan *et al.,* 2015). The peak observed at 1283.54 cm−1 indicate the presence of alkyk halide, The band at 1072.35 cm−1 is due to ether linkages and suggest the presence of flavanones adsorbed on the surface of metal nanoparticles (Shankar *et al.,* 2004). The band at 1045.35 cm−1 was assigned for C–N (amines) stretch vibration of the proteins. The band at 537 cm−1 region could be attributed to C–Br stretching, which is characteristic of alkyl halides. The immediate reduction and capping of silver ions into silver nanoparticles in the present investigation might be due to flavonoids and proteins. The flavonoids present in the leaf extract are powerful reducing agents which may be suggestive of the formation of AgNPs by reduction of silver nitrate. The flavonoid compounds in the water extract of M. pendans might be actively involved and responsible for the reduction of Ag+ to Ag0 (Zuas *et al.,* 2014). Another one report also suggested that the involvement of water-soluble flavonoid in the reduction of metal ions using plant extracts (Prabhu *et al.,* 2010).

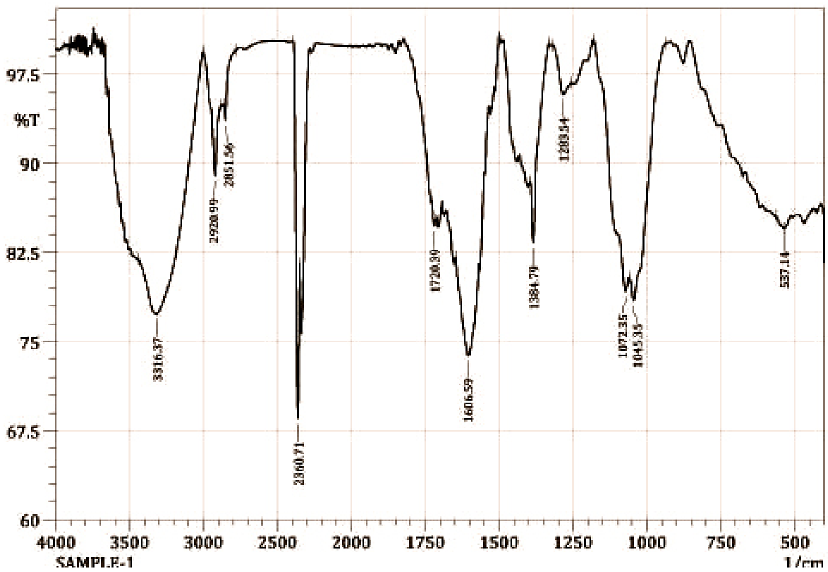

Figure 1. FT-IR Spectrum of nanoparticles of *Cipadessa baccifera*

X-Ray diffraction studies

The biosynthesized silver nanoparticle by employing *Cipadessa baccifera* leaf extracts were further demonstrated and confirmed by the characteristic peaks observed in XRD analysis. Analysis through X-ray diffraction was carried out to confirm the crystalline nature of the silver nanoparticles. A comparison of our XRD spectrum with the standard confirmed that the silver particles formed in our experiments were in the form of nanocrystals, as evidenced by the peak at 2θ value of 28.3751^{o} corresponding to the height of 92.77 for *Cipadessa baccifera*. The corresponding'd' spacing value of Ag nanoparticle is 3.14284 for synthesised leaf nanoparticles (Figure 2). The result indicated that the silver nanoparticle synthesized by leaf extract is crystalline in nature.

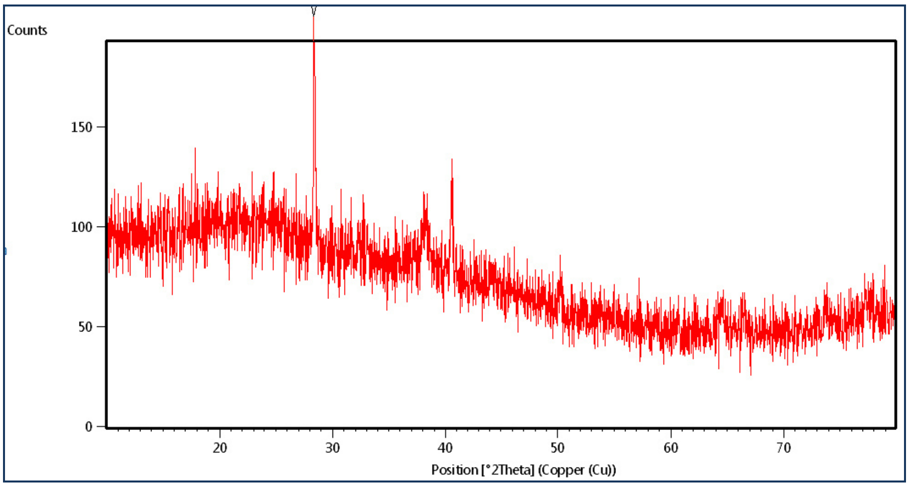

Figure 2. XRD Spectrum of nanoparticles of *Cipadessa baccifera*

SEM analysis of silver nanoparticles

The synthesized silver nanoparticles were further characterized by SEM analysis. SEM determines the surface morphology and size of particles. It was noted that the particles were predominantly spherical in shape. The particles other than the spherical shaped were also present. SEM analysis of *Cipadessa baccifera* showed uniformly distributed silver nanoparticles on the surfaces of the cells (Figure. 3). The silver nanoparticles were spherical in shape with particle sizes range from 20-500 nm. The larger silver particles may be due to the aggregation of the smaller ones, due to the SEM measurements.

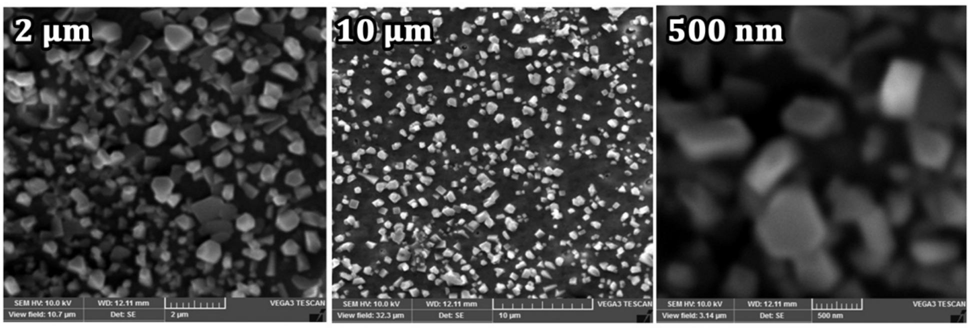

Figure 3. SEM images of *Cipadessa baccifera* synthesized nanoparticles

Conclusions

In the present study the phytosynthesised silver nanoparticles were obtained from the aqueous leaf extract of *Cipadessa baccifera.* The color changes from pale yellow to dark - brown c indicate the presence of nanoparticles and it is further characterized by the FT-IR–spectrum, X-RD and SEM analysis. FT- IR spectra represent the functional group present in the silver nanoparticles. FT - IR showed the structure, the respective bands of the synthesized nanoparticles, and the stretch of bonds. X- RD studies indicate that the particle nature of the nanoparticles. SEM analysis expresses the range of different sizes of nanoparticles present in the plant sample. In future the nanoparticles will be used in different fields of science like drug delivery and other scientific research.

Competing interests

The authors declare that they have no competing interests.

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