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Communication

Green Synthesis of Silver Nanoparticles from a Novel Medicinal Plant Source Roots Extract of *Mukia maderaspatana*

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Abstract: This letters informs the novel work on aqueous extract of *Mukia maderaspatana* used for the biotransformation of metallic silver ion into zerovalent silver nanoparticles. This medicinal plant contains medicinal valuable compounds such as polyphenols, flavonoids, Vitamin C, E, proteins and polysaccharides. These medicinal compounds are responsible for the bioreduction of $AgNO_3$ into silver nanoparticles (AgNPs). The synthesised AgNPs were characterized by UV-vis spectroscopy, FTIR, XRD, SEM and TEM analysis. The biosynthesised silver nanoparticle has potential applications in biomedical and biosensor field.

Keywords: Silver Nanoparticles, $AgNO_3$, *Mukia maderaspatana*

1. Introduction

There are so many methods available for the synthesis of silver nanoparticles such as photochemical, chemical synthesis route, gamma-irradiation and thermal decomposition. Plants are exclusively used for the synthesis of AgNPs from $AgNO_3$ [1-5]. Chemical methods are utilized by using various reducing chemicals such as citrate, borohydride and organic compounds. These chemical compounds and their by products are harmful to living organisms, hence green synthesis methods are used to overcome these problems [11], [12]. *Mukia maderaspatana* was used as traditional tamilian medicinal plant for cough, cold, asthma and lung related problems. It contains unique polyphenols medicinal compounds such as flavanoids, terpinoides, poly unsaturated fatty acids, Vitamin C and E, carotenoids, small amount of proteins and carbohydrates. AgNps are potential against several harmful bacterial, fungus, virus pathogens [6], [7], [8] and also have intrinsic cytotoxicity effect on cancer cells [9], [10]. The biogenic of nanosilver, bioreduction of aqueous $AgNO_3$ by aqueous extract of medicinal plant *Mukia maderaspatana* and stabilization of AgNps was obtained due to the presence of alcohol, tannins, aldehyde and protein present in the plant extract. Drug resistance of cancer cells are demanding vicinity for the researchers to develop effective therapeutic bioactive compounds. Cytotoxicity effect of green synthesized nanosilver was established. But, there is lack of information available on cancer cells and their cell signalling inhibitory mechanisms. AgNps possess very good cytotoxicity activity. Many plants were used for the synthesis of AgNPs and their potency on cytotoxicity effect was previously reported. But no work has been established for the synthesis of AgNps using the medicinal plant available as plenty in Tamilnadu, India. In this present investigation, the *Mukia maderaspatana* was used as a medicinal plant for the synthesis of AgNPs as the first time. Synthesized AgNps were analyzed using UV-Vis spectroscopy, FTIR, XRD, SEM and TEM.

2. Methods and Materials

2.1. Materials

$AgNO_3$ and Whatman no. 1 filter paper were purchased

from Glaxo India Ltd., Mumbai. Plants were collected from Mannargudi, Tamilnadu, India. Double distilled water was obtained from Balaji chemicals Ltd., Chennai, India.

2.2. Mukia maderaspatana Plant Extracts Preparation

Mukia maderaspatana plant root was collected from the Mannargudi delta areas and it was shade dried and powdered. 10 g of plant powder was soaked in 100 ml double distilled water for 10 h and boiled for 30 min with continuous stirring. The boiled plant extract was brought into room temperature and filtered in Whatman No.1 filter paper. This plant extract was used for further process and stored at 4°C.

2.3. Synthesis of Silver Nanoparticles

1mM of $AgNO_3$ was mixed with 100 ml of double distilled water. The aqueous $AgNO_3$ was added to 10 ml of freshly prepared plant extract and stirred at 60°C for an hour. When the white silver nitrate solution was turned into brown, the characteristic change of silver nanoparticles from $AgNO_3$ was observed.

2.4. Characterization of Ag Nanoparticles

Several experimental methods are available to characterize the synthesized silver nanoparticles. Synthesized silver nanoparticles were analyzed by standard protocols such as UV–Visible spectra (Elico-SL210 spectrophotometer), FTIR analysis (Shimadzu spectrophotometer FTIR 8400), XRD analysis (D8 Advanced Brucker instrument), SEM (SEM (TESCAN VEGA3 SBU) and TEM Hitachi H7650, 120 KV TEM.

2.5. UV-Visible Spectroscopy and FTIR Analysis

Green synthesis of silver nanoparticles was initially characterized by UV-Vis spectroscopy. In this method, the amount of light was absorbed and scattered by the sample in the range of 100 to 800 nm. The UV-analysis was achieved by Elico-SL 210, UV- Double beam spectrophotometer (from 200 nm to 900 nm). FTIR analysis was done using Perkin Elmer FTIR spectrometer. Centrifuged and dried silver nanoparticles (sample) and dried plant extract were ground with KBr and then made into pellets. These pellets were subjected for Fourier infra red wavelength varying from 500 to 4000 cm^{-1}.

2.6. XRD (X-Ray Diffraction)

X-Ray diffraction analysis method was used to characterize the formation of silver nanoparticles and crystalline nature of silver nanoparticles. AgNps were placed on glass plate and analyzed for Bragg's angle θ at 2° which was determined by Philips PW 1830 XRD.

2.7. SEM and TEM

Centrifuged silver nanoparticles were dispersed in double distilled water and the morphology of nanoparticles was characterized by SEM (Scanning Electron Microscope). In order to dry the liquid sample, it was placed on the metal disc with vacuum pressure (TESCAN VEGA3 SBU). For the TEM (Transmission Electron Microscope) analysis, centrifuged sample was redistributed in double distilled water with 1:10 volume ratio. The diluted samples were placed on the copper grid (coated with carbon layer) and allowed to dry at room temperature. The dried nanoparticles characterization was performed in Hitachi H7650, 120 kv TEM.

3. Results and Discussion

3.1. UV-Vis Spectroscopy

Few metal nanoparticles were shown specific Surface Plasmon Resonance (SPR) peak at UV-Visible region. Colloidal silver nanoparticles exhibit SPR effect ranges varying from 390 to 420 nm due to Mie scattering[13]. UV-spectroscopy is the effective method to evaluate the size and shape of the nanoparticles in water. The plant extract was not shown any peaks when compared to silver nanoparticles. It has been reported that the spherical shaped silver nanoparticles absorbed SPR band around 400-420 nm [16], [17]. From the Figure 1, silver nanoparticles shows the peak at 448 nm which is similar to the work reported by the sivakumar et al., (2013) [14]. The dark brown colour was disappeared based on the time difference and aggregation. Due to these reason, the intensity of the SPR was decreased [15]. In the plant extract flavonoids and proteins act as a reducing and stabilizing agent for the formation of silver nanoparticles [18-20]. The SPR intensity was increased with increasing the number of silver nanoparticles formation. Intrusion occurred in the range of 200-380 nm after keeping the solution for an hour, this may be due to the occurrence of capping on the silver nanoparticles with the reduction [22].

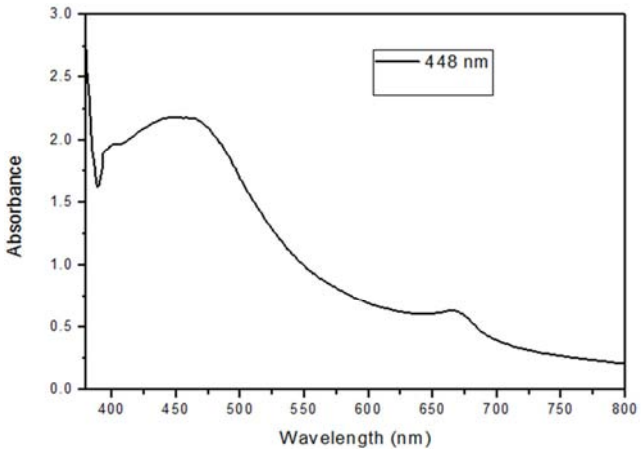

Figure 1. *UV- absorption of green synthesized silver nanoparticles.*

3.2. FTIR

FTIR analysis was used to find out the reduction of silver nanoparticles by biomacro molecules present in the plant extract. These biomacro molecules are responsible for the reduction and stabilization of silver nanoparticles. The bands were observed at 1641 cm^{-1}, 2344 cm^{-1}, 3478 cm^{-1} and 3890

cm^{-1}. The bands at 3478 and 3526 cm^{-1} were responsible for the O-H stretching of alcohol group present in plant extract [21]. Phenolic groups in the plant extract could be the reason for the reduction of silver ions and slight changes in the band at 3890 - 3903 cm^{-1} was due to the involvement of phenolic intermediate compounds. The band at 1631cm^{-1} denotes the presence of amide-I group present in the plant extract. The polyphenolic compounds in the plant extract could be the reason for the reduction of silver nanoparticles and proteins compounds were responsible for the stabilization of AgNps (capping). From the Figure 2, it was observed that the compound corresponding to 2098 cm^{-1} present in the plant extract was responsible for the reduction of $AgNO_3$ into AgNps.

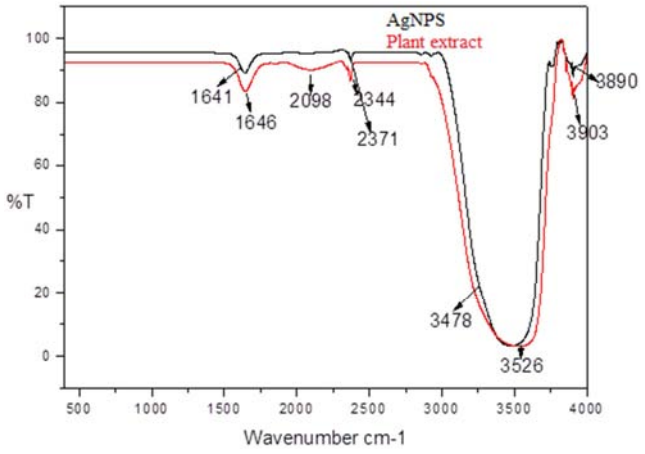

Figure 2. *FTIR analysis of plant extract and green synthesized silver nanoparticles.*

3.3. XRD (X-ray Diffraction)

The XRD analysis of silver nanoparticles shows the low intense peaks at 38° and 43.9° (2θ) which are responsible for (111) and (200) Bragg reflection, respectively and these values were matched with JCPDS file NO. 04-0783. Broadening of XRD peaks was responsible for the decrease in silver metal ion concentration and increase in the formation of silver nanoparticles. The peak at 12° represents the presence of organic molecules in the silver nanoparticles [23]. Based on these result, green synthesized silver nanoparticles could be face centred (fcc) and cubic structured [24]. Figure 3 shows the XRD pattern of the result. It clearly implies that the *Mukia maderaspatana* reduced $AgNO_3$ into AgNps with crystalline in nature. The crystalline nature of the silver nanoparticles was measured by Scherrer's formulae $D = k\lambda/\beta \cos\theta$. Where, D is particles diameter, k is constant equal to 1, λ is X-ray wavelength (1.54 Å) and β is full with half maximum of high intensity peak (FWHM). The average crystalline size of the AgNps was found to be 12 nm. Generally the broadening of XRD peaks represents the particle size with nano range [25]. Mahdieh *et al*., (2012) was also obtained the same result in their investigation of AgNps synthesis from *Spirulina platensis* [26].

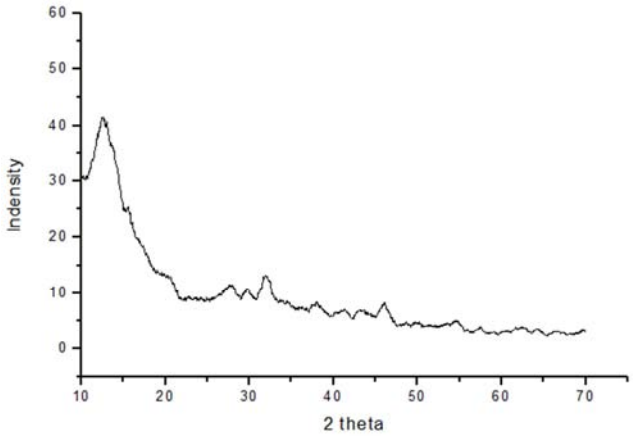

Figure 3. *XRD characterization of Ag^0 nanoparticles. Silver nanoparticles XRD spectrum shows four different 2theta values of the crystalline peaks ranging from 20 -80 theta. The 2theta values 32.11, 37.9, 46.0,6 4.2 and 77.4 corresponding to (311),(111), (100),(220) and (311) indexed values.*

3.4. SEM and TEM

The morphology of synthesized AgNps was analyzed using scanning Electron Microscopy (SEM), it was shown in Figure 4(a). From this Figure 4(a), the AgNps size and shape was found as spherical in shape and nano size. TEM image was shown in Figure 4(b), it was observed that the AgNps were found to be in the range of nano size. Figure 4(b) revealed that the AgNps were in spherical shape and the particles size was observed as 10 ± 30 nm. Most of the particles were obtained as 24 nm. The synthesis of silver nanoparticles is depending upon the nature of the plant extract. When the plant extract concentration increases the nanoparticles size will be decrease [27]. From the SEM and TEM results, the synthesized AgNps average particles size was found as 25 nm.

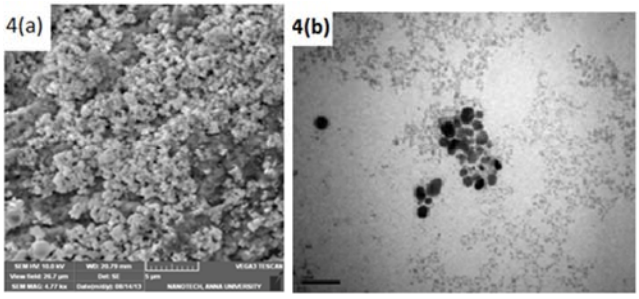

Figure 4. *SEM and TEM images of AgNps.*

4. Conclusion

The stable silver nanoparticles were synthesized with average size of 25 nm from *Mukia maderaspatana* medicinal plant aqueous extract as a reducing and stabilizing agent by green synthesis technique. In the present investigation, the medicinal plant *Mukia maderaspatana* was utilized as a novel source for bioactive compounds to reduce $AgNO_3$ into AgNps. These synthesized silver nanoparticles possess an added benefit for the plant bioactive compounds on its surface. It was clearly observed from FTIR spectrum. The crystalline nature of AgNps was confirmed by XRD. The synthesized silver

nanoparticles may be used for the antibacterial, cytotoxicity, drug delivery and biosensor applications.

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