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Biological synthesis of silver nanoparticles by using leaf extract of *Justicia adhatoda*

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ABSTRACT

Biosynthesis of Silver nanoparticles is the major division in the field of applicable Nanoscience and Nanotechnology. Silver nanoparticles play a major role in the biomedical field and have various applications. In the present research work, cost effective and environmental friendly silver nanoparticles were synthesized from the leaf extract of Justicia adhatoda, as reducing agent. UV-Visible spectroscopy was used to monitor the quantitative formation of silver nanoparticles. The characteristics of the obtained silver nanoparticles were studied using Scanning Electron Microscope (SEM), Energy-Dispersive spectroscopy (EDX), and Fourier Transform Infrared spectroscope (FTIR). The EDX documented the presence of silver.

Keyword: Silver nanoparticles, *Justicia adhatoda*, SEM, FTIR.

INTRODUCTION

The field of nanotechnology is one of the most active researches nowadays in modern material science and technology. Nanoparticles are fundamental building blocks of nanotechnology. In recent years controllable synthesis of metal nanoparticles has attracted much attention due to their potential application in many areas [1]. They have been extensively exploited for use in biomedical areas, such as targeted drug delivery [2], imaging [3], and antimicrobial activity [4-5].

Physical and chemical methods are more popular for nanoparticles synthesis but the use of toxic compounds limits their application economically feasible one [6-7]. In recent years, plant mediated biological synthesis of nanoparticles is gaining importance due to its simplicity and eco-friendliness [8]. *Justicia adhatoda* commonly known in English as Malabar nut, Adulsa, adhatoda, vasa or vasaka belong to Acanthaceae family and is well known in India and neighbouring countries for more than 100 years as one of the most versatile medicinal plant having a wide spectrum of biological and medicinal activity [9-10]. In the present research work, green synthesis of silver nanoparticles was carried out using the leaf extract of *Justicia adhatoda* and the synthesized silver nanoparticles were characterized by using UV-Visible spectroscopy, Scanning Electron Microscope (SEM), Energy-Dispersive spectroscopy (EDX), Fourier Transform Infrared spectroscopy (FTIR).

MATERIALS AND METHODS

1.1 Plant collection

Leaves of fresh plant were collected from the residential area of Coimbatore, Tamilnadu, India.

1.2 Preparation of plant extract

The leaf extract of Justicia adhatoda (100mg) was weighed and taken in a 250 ml beaker along with 100 ml of Millipore water was added to it and then boiling the mixture for 5 minutes before finally decanting it. Further the extract was filtered with Whatman No. 1 filter paper and stored at 4°C and used for further experiments.

1.3 Synthesis of silver nanoparticles

Silver nitrate ($AgNO_3$) of analytical grade and purchased from precision scientific and co, Coimbatore, India. In the typical synthesis of silver nanoparticles, 10ml of the aqueous extract of *Justica adhatoda* was added to 90 ml of 1mM aqueous $AgNO_3$ solution in a conical flask. Then the conical flask incubated for few minutes at room temperature in the dark place. The formation of AgNPs indicates the colour will turn yellow colour to dark drown colour. The extract was stored at 4°C for further use.

1.4 Characterization of silver nanoparticles

a) UV-Visible spectroscopy

The formation and completion of silver nanoparticles was characterized by UV-Visible spectroscopy using JASCO UV Vis NIR V-670.

b) SEM and EDX

Scanning electron microscope (SEM) and Energy dispersive X-ray analysis (EDAX) was done using Hitachi S-340N. Thin films of the sample were prepared on carbon coated copper grid by just dropping a very small amount of the sample on the grid, extra solution was removed using blotting paper and then the film on the SEM grid were allowed to dry putting it under a mercury lamp for 5 minutes.

c) Fourier Transform Infrared spectroscopy (FTIR)

The synthesized silvernanoparticles was used and examined by Infra red spectrum at the spectral range of 500-3500 cm^{-1} by Fourier Transform Infrared Spectroscopy to recognize the functional groups bound to the silver surface.

RESULTS AND DISCUSSION

Reduction of silver ions into silvernanoparticles using leaf extract of *Justicia adhatoda* was evidenced by the visual change of colour from yellow to reddish brown due to excitation of surface Plasmon vibrations [11] in silver nanoparticles as shown in figure 1.

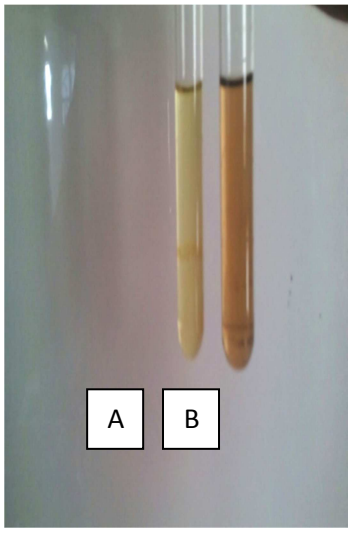

Figure 1: colour change indicating the synthesis of silver nanoparticles
Photographs of (A) aqueous plant leaf extract of *Justicia adhatoda*, (B) after adding 1 mM $AgNO_3$ into the plant leaf extract.

1.5 UV-Visible spectroscopy

UV-Visible spectroscopy is utilized to analyze the size and shape of nanoparticles in aqueous suspensions and the UV-Visible spectra was recorded after few hour incubation of the synthesized silvernanoparticles in dark place. The absorption spectra of the AgNPs have an absorbance peak at 421 nm, and a broadening of the peak indicates that the particles were polydispersed (figure 2).

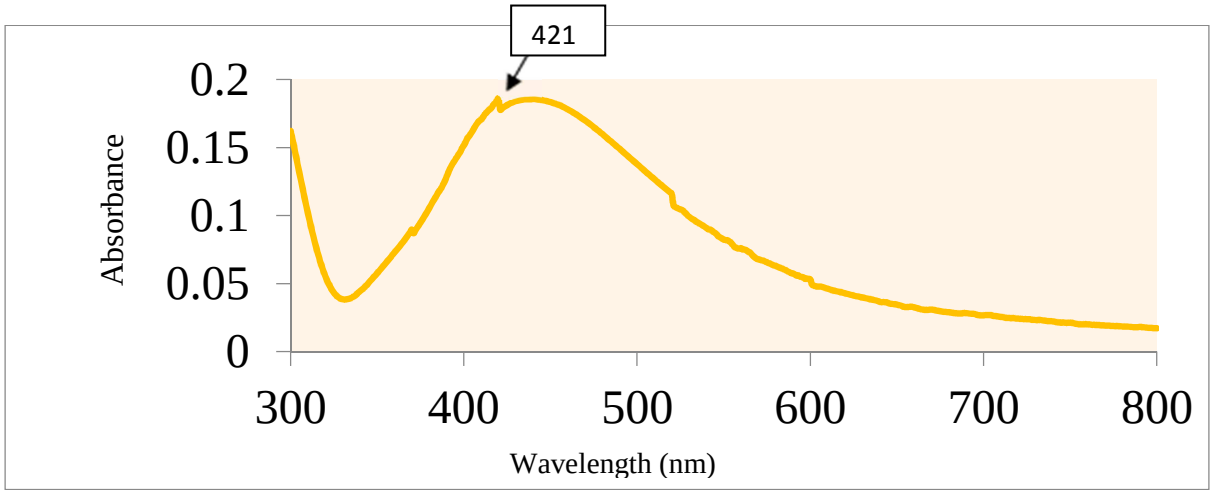

Figure 2: UV-Visible absorption spectra of silver nanoparticles synthesized from *Justicia adhatoda* leaves at 1mM silver nitrate

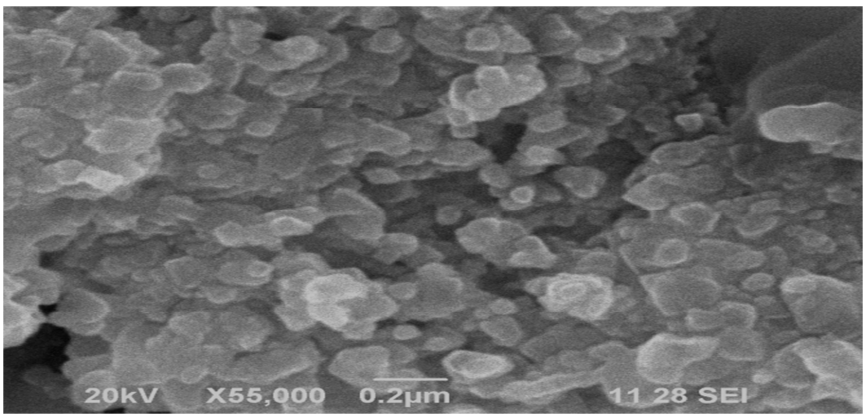

Figure 3: SEM image of AgNPs synthesized from *Justicia adhatoda* leaf extract

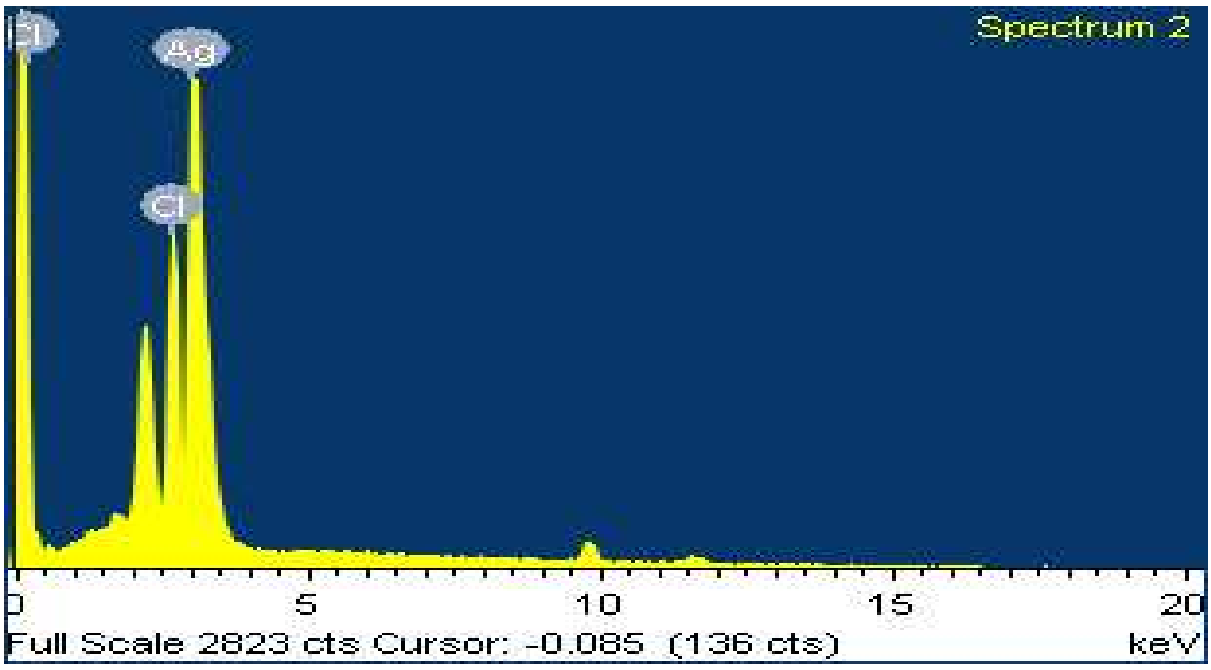

Figure 4: EDX spectra of AgNPs

1.6 SEM and EDX

The morphology and size of the green synthesized AgNPs were studied by SEM. Figure 3 shows the spherical morphology of the nanoparticles, with a size range of 20-40 nm. Further, the elemental composition of the samples

was also determined by EDX. The EDX spectrum showing figure 4, revels the clear elemental composition profile of the green synthesized AgNPs, the intense signal at 3 kV strongly suggests that Ag was the major element, which has an optical absorption in this range due to the surface Plasmon resonance [12]. EDX spectrum also indicates the presence of plant extract (as a capping agent) on the surface of the nanoparticles.

1.7 Fourier Transform Infrared spectroscopy (FTIR)

FTIR measurements of *Justicia adhatoda* aqueous extract and the synthesized silver nanoparticles were carried out to identify the possible biomolecules responsible for the reduction of Ag^+ ions capping of the bioreduced silver nanoparticles synthesized by the leaf extract. FTIR analysis was used for the characterization of the *Justicia adhatoda* leaf extract and the resulting nanoparticles. Absorbance bands were observed at 3331.49, 2114.08, 1637.65, 640.09, 596.56, 554.25 cm^{-1} (Figure 6). FTIR spectra revealed the presence of different functional groups like –C=C-H; C-H stretch Alkynes (terminal), -C=C- stretch alkynes functional group, Aromatic (C=C stretching), Alkyl Halide (C-Cl and C-Br stretching). Whereas the stretch for AgNPs were found around 500-650 cm^{-1} (figure 5). Therefore the synthesized nanoparticles were surrounded by proteins and metabolites such as terpenoids, Flavonoids along with the presence of aromatic carbons and reducing sugars in the solution could be responsible for the reduction of metal ions and formation of the corresponding metal nanoparticles [13-14].

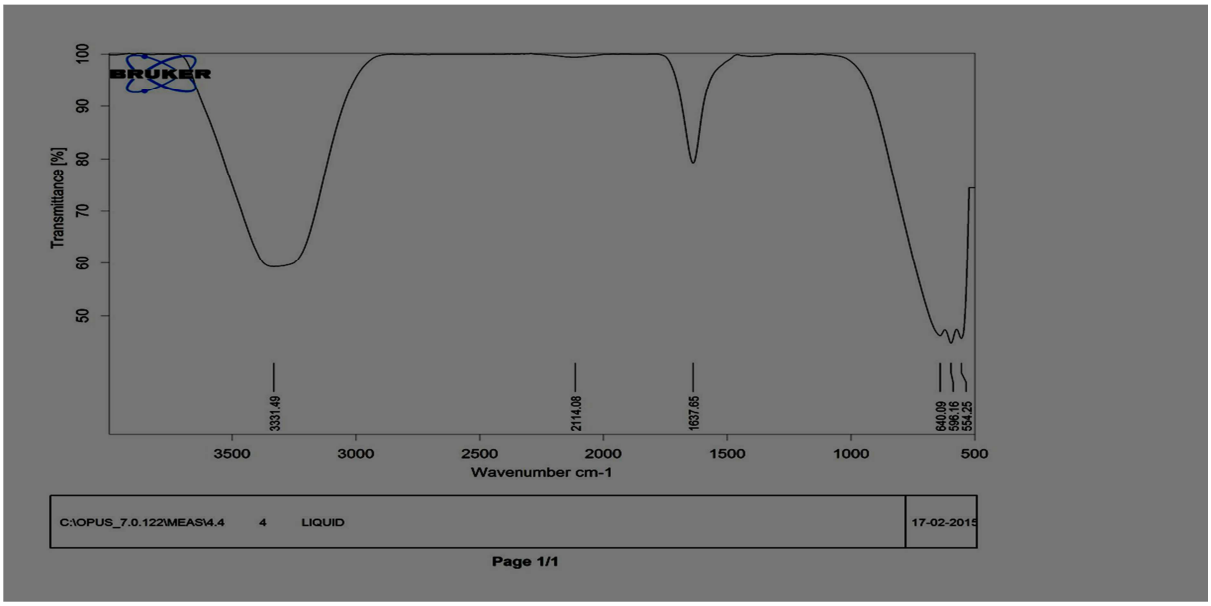

Figure 5: FTIR analysis of silver nanoparticles

CONCLUSION

Synthesis of silver nanoparticles from the leaf of *Justicia adhatoda* was confirmed by colour change from yellow to dark brown. This indicates the formation of silver nanoparticles. The characteristics of the obtained silver nanoparticles were studied using UV-Vis, SEM, EDX, FTIR techniques. The results confirmed the reduction of silver nitrate to silver nanoparticles with high stability and without any impurity.

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