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Synthesis and Characterization of Environment Friendly Silver Nanoparticles

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Abstract

In this work, synthesis of silver nanoparticles was achieved by using aqueous extract of Indian medicinal plant such as *Musa balbisiana*, *Azadirachta indica*, and *Ocimum tenuiflorum*. The plants extracts were mixed with 1mM Silver nitrate solution for the synthesis of silver nanoparticles. The synthesized nanoparticles were characterized using UV–Vis absorption spectroscopy, FTIR and SEM. Further the nanoparticles tested for antibacterial activity against human pathogens. In this investigation, nanoparticles from *Musa balbisiana* show reasonable inhibition activity against the tested bacterial pathogens. This is a cost effective and environment friendly technique for green synthesis of silver nanoparticles from $AgNO_3$ solution through the plant extract as reducing as well as capping agent.

Keywords: Silver nanoparticles, green plant, UV–Vis absorption and *Musa balbisiana*.

INTRODUCTION

Silver nanoparticles have high surface area to volume ratio and the unique chemical, physical properties [1, 2]. Nowadays, they have been widely used as an effective bactericidal agent against broad spectrum of bacteria, including antibiotic resistant strains [3]. Hence, researchers are shifting towards nanoparticles in general and silver nanoparticles (AgNPs) in particular to solve the problem of emergence of MDR bacteria [4].

Many techniques of synthesizing silver nanoparticles are there such as chemical reduction of silver ions in aqueous solutions [5], thermal decomposition [6], chemical reduction and photoreduction in reverse micelles [7] and radiation chemical reduction [8]. There is a growing need to develop environmentally friendly processes for nanoparticle synthesis that do not use toxic chemicals. The recent most preferred way is ecofriendly synthesis of nanoparticles. The synthesis of nanoparticles using plants can prove many advantageous over other biological processes by eliminating the elaborate processes of maintaining microbial cultures [9].

The use of environmentally benign materials like plant leaf extract [10], bacteria [11], fungi [12] and enzymes [13] for the synthesis of silver nanoparticles offers numerous benefits of eco-friendliness and compatibility for pharmaceutical and various biomedical applications.

MATERIALS AND METHODS

Plant sample

Three Indian medicinal plants such as *Musa balbisiana* (banana), *Azadirachta indica*, (neem) and *Ocimum tenuiflorum* (black tulsi) were selected for this study. Fresh healthy leaves were collected locally and rinsed thoroughly first with tap water followed by distilled water. Leaves were cut into small pieces, dried at room temperature and then finely ground using electric chopper.

Preparation of aqueous extracts

About 10 g of powdered leaves of each plant was weighed separately and transferred into 250 ml beakers containing 100 ml distilled water. The mixture was boiled for about 20 min and cooled. The extracts were filtered thrice through Whatman No. 1 filter paper and then refrigerated (4°C) until use.

Synthesis of silver nanoparticles

1mM aqueous solution of Silver nitrate (AgNO3) was prepared and used for the synthesis of silver nanoparticles (Ag NPs). 10 ml of each leaf aqueous extract was added into 90 ml Silver nitrate solution in separate 250 ml Erlenmeyer flasks and kept at room temperature for 5 h. All the reactions were carried out in darkness (to avoid photo activation of AgNO3) at room temperature. Complete reduction of $AgNO_3$ to Ag^+ ions was confirmed by the change in color from colorless to colloidal brown.

UV-Vis spectra analysis

The bio reduction of pure Ag^+ ions in aqueous solution was monitored through UV-Vis spectrum analysis by UV-Vis spectrophotometer (Shimadzu) after diluting a small aliquot of the sample with 2 ml of distilled water.

FTIR analysis

FTIR analysis of the dried Ag NPs was carried out through the potassium bromide (KBr) pellet (FTIR grade) method in 1:100 ratio and spectrum was recorded using FTIR-6300 Fourier transform infrared spectrometer equipped with Intone Infrared Microscope using transmittance mode operating at a resolution of 4 cm^{-1}.

SEM analysis

The colloidal solution containing Ag NPs were centrifuged at 4000 rpm for 15 min. The pellets were discarded and the supernatants were again centrifuged and the final pellets were dissolved in 0.1 ml of distilled water. The pellet was mixed properly and carefully placed on a glass cover slip followed by air drying. The cover slip itself was used during scanning electron microscopy (SEM) analysis.

Antibacterial activity

The antibacterial activities of the plant leaf extracts and of the Ag NPs synthesized from the respective extracts were effectively accessed against the bacterial pathogens such as *Bacillus cereus* (G+ve) and *Escherichia coli* (G-ve) by disc diffusion method. Sterile filter paper discs were soaked with plant leaf extracts and synthesized Ag Nps. 24 h broth cultures of the bacterial pathogens were swabbed on the Nutrient agar plates using sterile cotton swab. The dried discs were placed on the plate individually with 2 cm distances. The plates were incubated at 37°C for 24 to 48 h and then, the zones of inhibition were measured.

RESULT AND DISCUSSION

Silver nanoparticles appear yellowish brown in color in aqueous medium as a result of surface plasmon vibrations. After adding different leaf extracts were the color of the solution changed from faint yellowish brown to reddish brown and finally to colloidal brown indicating Ag NP formation.

UV-Vis spectra analysis

The UV-Vis absorption spectra of Ag NPs formed in the reaction media has absorption maxima in the range of 425 to 475 nm due to surface Plasmon resonance of Ag NPs. The UV-Vis spectra recorded, implied that most rapid bio reduction was achieved using *M.balbisiana* leaf extract as reducing agent followed by *O. tenuiflorum* and *A. indica* leaf extracts. This was denoted by broadening of the peak which indicated the formation of poly dispersed large nanoparticles due to slow reduction rates (Figure 1). The UV-vis spectra also revealed that formation of Ag NPs occurred rapidly within the first 15 min only and the AgNPs in solution remained stable even after 24 h of completion of reaction.

FTIR analysis

FTIR analysis carried out to characterize the Ag NPs obtained from each type of plant extract (curve A= *M.balbisiana*, curve B= *A.indica* curve C= *O. tenuiflorum*) is shown in Figure 2. In all three Ag NP solutions, prominent bands of absorbance were observed at around 1,025, 1,074, 1,320, 1,381, 1,610 and 2,263 cm^{-1}. The observed peaks denote -C-OC-, ether linkages, -C-O-, germinal methyl's, -C=C- groups or from aromatic rings and alkynes' bonds, respectively. These bands denote stretching vibration bands responsible for compounds like flavor-noids and terpenoids and so may be held responsible for efficient capping and stabilization of obtained Ag NPs.

SEM analysis

The SEM images of the Ag NPs are shown in Figure 3. It is seen that Ag NPs of different shapes were obtained in case of different leaf extracts being used as reducing and capping agents. *M.balbisiana*, *A. indica* and *O. tenuiflorum* extracts formed approximately spherical, triangular and cubical Ag NPs, respectively. This may be due to availability of different quantity and nature of capping agents present in the different leaf extracts. This is also supported by the shifts and difference in areas of the peaks obtained in the FTIR analysis.

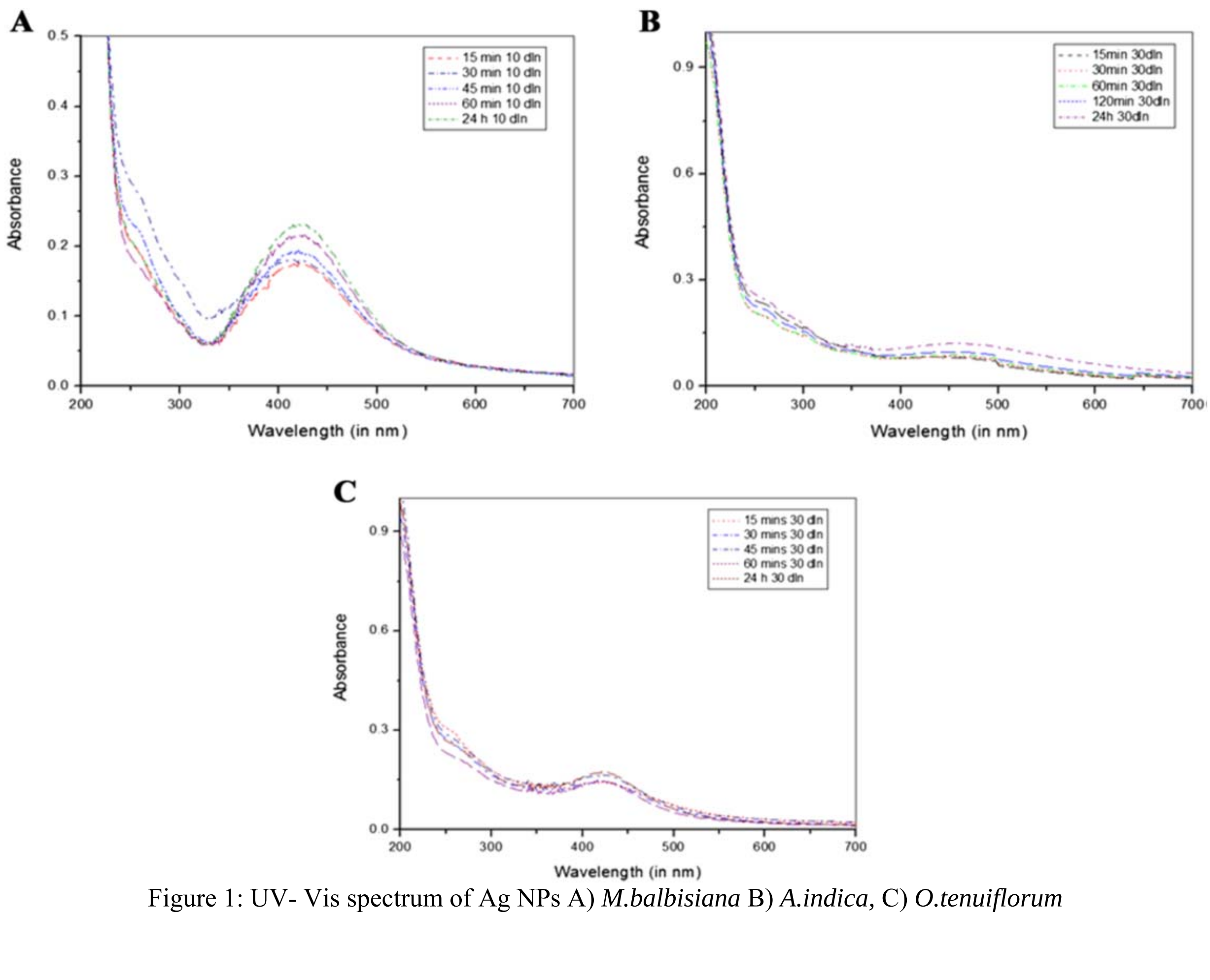

Figure 1: UV- Vis spectrum of Ag NPs A) *M.balbisiana* B) *A.indica,* C) *O.tenuiflorum*

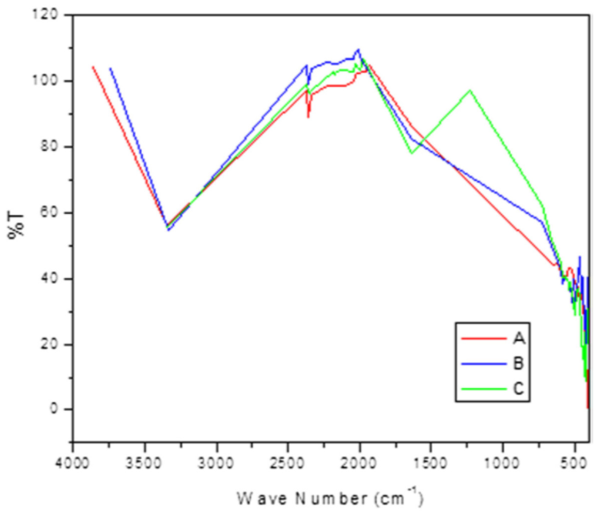

Figure 2: FTIR analysis of Ag NPs A) *M.balbisiana* B) *A. indica*, C) *O. tenuiflorum*

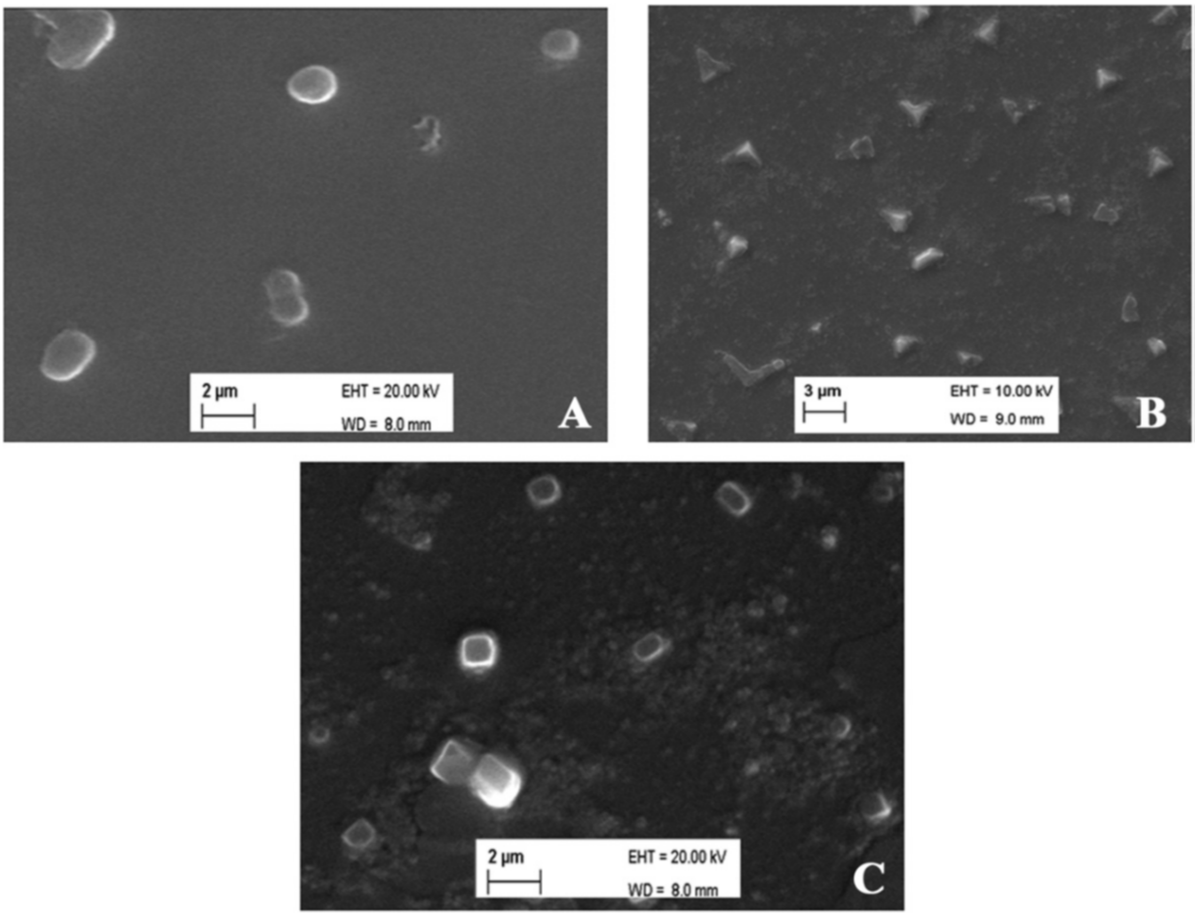

Figure 3: SEM analysis of Ag NPs A) *M.balbisiana* B) *A. indica*, C) *O.tenuiflorum*

Table 1: Antibacterial activity of Ag NPs

Source of sample	**Type of sample**	**Zone of inhibition in mm**	
		B.cereus	*E.coli*
M.balbisiana	Plant extract	9 ± 0.015	9 ± 0.004
	AG NPs	16 ± 0.016	14 ± 0.02
A.indica	Plant extract	9 ± 0.02	9 ± 0.013
	AG NPs	14 ± 0.008	12 ± 0.007
O. tenuiflorum	Plant extract	9 ± 0.007	9 ± 0.02
	AG NPs	14 ± 0.021	14 ± 0.017

Antibacterial activity

Antibacterial activity of the crude leaf extract and Ag NPs results were shown in Table 1 and the values were expressed as Mean ± SD. The zone of inhibition by Ag NPs prepared from *M.balbisiana* leaf extract show maximum inhibition on *B.cereus* and *E.coli* than the other extracts.

CONCLUSION

In conclusion, the bio-reduction of aqueous Ag+ ions by the leaf extract of the three Indian plants has been demonstrated. The reduction of the metal ions through leaf extracts leading to the formation of silver nanoparticles of fairly well-defined dimensions. In the present study, we found that leaf extract of *M.balbisiana* can be used good source for synthesis of silver nanoparticles. This green chemistry approach toward the synthesis of silver nanoparticles has many advantages such as, ease with which the process can be scaled up, economic viability, etc. Applications of such eco-friendly nanoparticles in bactericidal, wound healing and other medical and electronic applications, makes this method potentially exciting for the large scale synthesis of other nano particles.

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