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Research Article

BIOLOGICAL SYNTHESIS OF SILVER NANOPARTICLES USING THE TUBEROUS ROOT EXTRACT OF *IPOMOEA BATATAS* AND THEIR CHARACTERIZATIONS AND ANTIBACTERIAL ACTIVITY

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ABSTRACT

Objectives: Tuberous root extract based synthesis of silver nanoparticles (AgNPs), characterizations using Fourier-transform infrared spectroscopy (FT-IR), UV-visible, powder X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), energy dispersive X-ray (EDX) techniques, and antibacterial activity of AgNPs against *Staphylococcus aureus, Staphylococcus mutans, Proteus vulgaris,* and *Escherichia coli*.

Methods: Root extract of *Ipomoea batatas* (sweet potato) was prepared by boiling of small cut pieces of root with double distilled water. Added root extract with silver nitrate solution and centrifuged and collect the pellets. After several washing and drying, AgNPs have been preserved for characterizations and antibacterial activity.

Results: The synthesized AgNPs were well characterized by FT-IR, UV-visible, XRD, FESEM, and EDX methods, and significant zones of inhibition observed around the loaded AgNPs on the agar plates. The zones of inhibition have been achieved 36, 40, 46, and 32 mm for *E. coli*, *P. vulgaris*, *S. mutans,* and *S. aureus*.

Conclusion: The characterisation methods such as UV-Visible, FTIR, Powder XRD, FESEM and EDX indicate an efficient formation of AgNPs using root extract of *I. batatas.* The biologically synthesized AgNPs are found good antibacterial agents.

Keywords: Biological synthesis, Silver nanoparticles, Characterization methods, Antibacterial activity.

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INTRODUCTION

Nanotechnology in chemical, biological, and pharmaceutical sciences is the practice of production, working, and applications of materials under nano ranges (1–100 nm). A biological or green synthetic approach used to synthesize nanoparticles has recently emerged a new field of research. The chemical methods used to synthesize different nanoparticles are suffered from the use of hazardous chemicals, low efficiency, high cost, and not environmentally friendly [1]. A green synthetic process has many advantages over the conventional methods such as very low cost, minimization of harmful chemicals, eco-friendly, no additional cost on instrumentations, and highly efficient. Metal nanoparticles such as gold (Au), silver (Ag), palladium (Pd), copper (Cu), and platinum (Pt) have been synthesized extensively due to their importance in pharmaceutical and other industries [2-4]. These metal nanoparticles exhibited very unique physical and chemical properties and are useful in electronics, photonics, catalysis, and biomedical fields [5-8]. Among these metal nanoparticles, AgNPs have recognized one of the important metal nanoparticles used in pharmaceutics, air filtration, water detoxification, agriculture, textiles, and oxidation reactions [7-10]. After synthesis of nanoparticles using any biomaterials, suitable characterization methods are required to explore the physicochemical properties of nanoparticles. The characterization methods such as Fourier-transform infrared spectroscopy (FT-IR), field emission scanning electron microscopy (FESEM), UV-visible, powder X-ray diffraction (XRD), and energy dispersive X-ray (EDX) are generally used to analyze the silver nanoparticles (AgNPs). It is necessary to all health-care industries to characterize nanomaterials using the above-mentioned techniques before applications [11-13].

The biological activities of AgNPs are based on the shape, size, morphology, composition of particles, dissolution rate, surface phenomena, and nature of reducing agents used in the synthetic methods [5,13-16]. In the purposed work, we have used the tuberous root extract of *Ipomoea batatas* (sweet potato) to synthesize AgNPs. The edible roots of plant were collected from the local vegetable market near Uttaranchal University, Dehradun (India). Sweet potato or *I. batatas* is a starchy, and root vegetable has a sweet taste; it belongs to the family *Convolvulaceae*. The bulky tubers contain starch, vitamins, and sugary substances, and a tuber is highly nutritive that is also used as raw materials for distilleries. Medicinally, *I. batatas* is used as an antiasthmatic, antitumor, antidiabetic, anti-inflammatory, aphrodisiac, and anti-convalescent agents [17,18].

METHODS

All the chemicals used in experimental work were of analytical grade (AR) and the glassware washed with 10% HNO_3 and double distilled water and then dried in tray dryer. The necessary solutions or mixtures were prepared in double distilled water.

Preparation of tuberous root extract

A tuber of *I. batatas* was peeled and cut into small possible pieces and then dried for 2–3 h at room temperature, and then, the cut pieces of tuber washed with double distilled water for removing all water soluble impurities. Take 2 g of washed pieces of the plant with 100 ml of double distilled water in 250 ml Erlenmeyer flask. Boil the content for 25–30 min at 60°C under controlled conditions and cooled the content and filter it. The filtrate was used as an extract to synthesize AgNPs and preserved at 4°C [1].

Synthesis of silver nanoparticles

100 ml of 0.01 M silver nitrate ($AgNO_3$) solution was prepared by dissolving an adequate amount of the salt in double distilled water. Now, added 10 ml of extract in 100 ml of $AgNO_3$ solution with a continuous shake. The formation of nanoparticles was indicated by a color change from colorless to silvery brown. The solution was now centrifuged with a constant rpm 10,000 for 15 min, and the nanoparticles settled dawn. The

pellets of nanoparticles have been washed with double distilled water and again centrifuged. Finally, the synthesized nanoparticles were heated at 60°C–65°C for 1 h under controlled conditions at hot air oven and preserved in airtight bottles for characterizations and further studies [8,9].

Characterizations

The characterization techniques such as FT-IR, powder XRD, FESEM, UV-visible, and EDX have been used to analyze AgNPs [2,9,11].

Antibacterial activity

The antimicrobial activity of AgNPs was tested using well-diffusion method. The plates containing Muller–Hinton agar were prepared by introducing 15 ml of liquid media on sterile Petri dishes. The AgNPs have been loaded in the wells and then incubated for 24 h at 37°C; a zone of inhibitions obtained and measured around the nanoparticles for *Staphylococcus aureus, Streptococcus mutans, Proteus vulgaris,* and *Escherichia coli* [19-21].

RESULTS

Fourier-transform infrared spectroscopy (FT-IR)

FT-IR is used to detect the presence of bonds on the substances. FT-IR is rapid, economical, and non-destructive technique with high sensitivity and precisions. An interference-based spectroscopy explains the type of functional groups on the materials [22]. Broad peaks are obtained at 3852, 3744, 3416, 1627, 1383, 1016, and 571 cm^{-1} (Fig. 1), respectively.

Ultraviolet (UV)-visible

UV-visible spectroscopy is also very low cost, rapid, and very simple method of characterization. It can be used in a qualitative as well as quantitative analysis of nanomaterials. It is associated with the excitation of electrons from lower to higher energy levels; light with the precise amount of energy can cause transitions from one energy level to another. The UV-visible spectra of AgNPs have been obtained in the range of 360-800 nm (Fig. 2).

Field emission scanning electron microscope (FESEM)

The FESEM technique is basically used to observe the morphological behavior of nanoparticles. In this technique, electrons are released from a source of field emission and accelerated in a high electrical field gradient, and at a high vacuum, these electrons are centered and deflected by electronic lenses, and the FESEM images of AgNPs are represented in Fig. 3.

Energy dispersive X-ray (EDX)

EDX analysis with FESEM is used to elemental composition of nanomaterials and also a non-destructive technique. The peaks of EDX spectra are related to the true composition of the sample being analyzed; EDX detectors measure the relative abundance of X-rays against energy. The EDX spectra of AgNPs are shown in Fig. 4 (peaks possibly omitted: 2.145, 9.717, and 11.460 keV).

Powder X-ray diffraction (XRD)

Powder XRD is diffraction based analytical method and related to the diffraction of X-rays from nanoparticles. A diffraction pattern is obtained from the curve, intensity against the angle of detector (2θ), and generally known as diffractogram (Fig. 5); characteristic peaks obtained at 9θ, 38θ, 44θ, 64θ, 77θ, and 82θ.

Antibacterial activity

Nanomaterials have gained an important role in the research fields of nanomedicine, nanotoxicology, and nanobiotechnology. In nanoform, silver is very effective to inhibit different microorganisms such as bacteria and fungi. Zones of inhibition were found 42, 36, 32, and 36 mm for *S. mutans, P. vulgaris, S. aureus,* and *E. coli* at initial dosage of AgNPs (2.5 mg/ml).

DISCUSSION

The broad FT-IR peaks obtained at 3852, 3744, 3416, 1627, 1383, 1016, and 571 cm^{-1} (Fig. 1) indicate the presence of–OH,-SH,-NH,-C=O,-C-O,-C-N,-C-S,-C-C-, Ag-O, Ag-N, and Ag-C bonds on the surface of biologically synthesized AgNPs. The formation of AgNPs using root extract of *I. batatas* is observed at 375 nm and 390 nm after only 10 min. The FESEM images indicated that the AgNPs are roughly spherical in shape, agglomerated, and uniformly distributed. The characteristic XRD peaks obtained at 9θ, 38θ, 44θ, 64θ, 77θ, and 82θ. These peaks are corresponding to 111, 200, 220, 311, and 222 planes, respectively. The other unassigned peaks indicate that the crystallisation of bioorganic phase on the surface of AgNPs. The EDX spectra shows that the biological formation of AgNPs with other carbon and oxygen atoms (Table 1).

A review of literature [19-21,24,-26] reveals that the AgNPs are very effective antimicrobial agent as over other nanoparticles. AgNPs can enter easily into the cells of microorganisms and then show a potential inhibition mechanism inside the cells which cause distortions and destroys the cell membranes; finally, it causes death of the microbial cells. Different amount of AgNPs was loaded on the agar plates, and after incubation period (24 h at 37°C), a significant zone of inhibitions has been obtained for *E. coli*, *P. vulgaris*, *S. mutans,* and *S. aureus*. The antibacterial activity of AgNPs increased with increase of its dosage for all bacterial species, and the dosage variation was done from 2.5 mg/ml

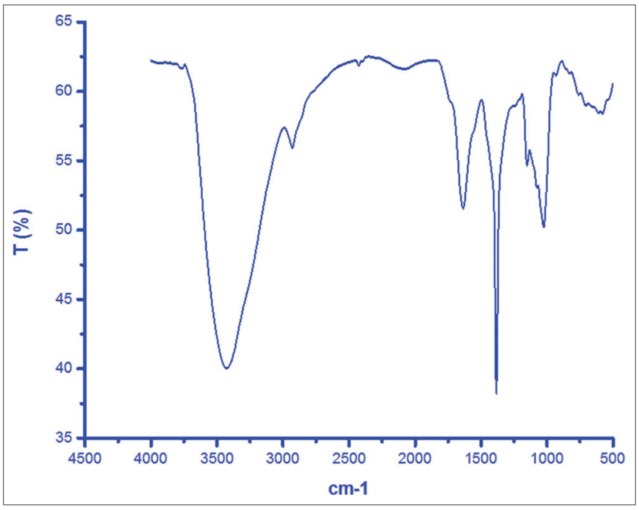

Fig. 1: Fourier-transform infrared spectroscopy spectra of silver nanoparticles synthesized using extract of *Ipomoea batatas*

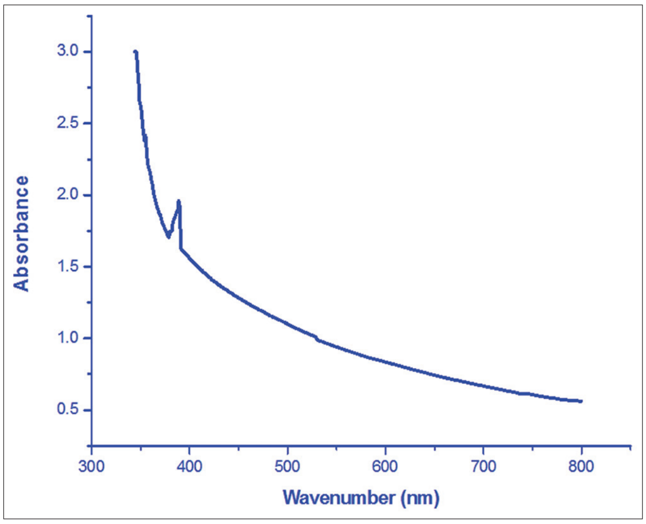

Fig. 2: Ultraviolet-visible spectra of silver nanoparticles synthesized using extract of *Ipomoea batatas*

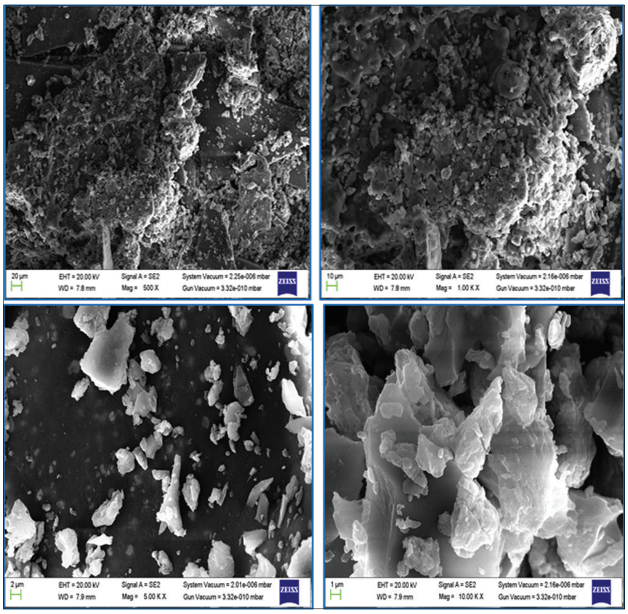

Fig. 3: Field emission scanning electron microscopy (FESEM) images of silver nanoparticles (AgNPs) synthesized using extract of *Ipomoea batatas*

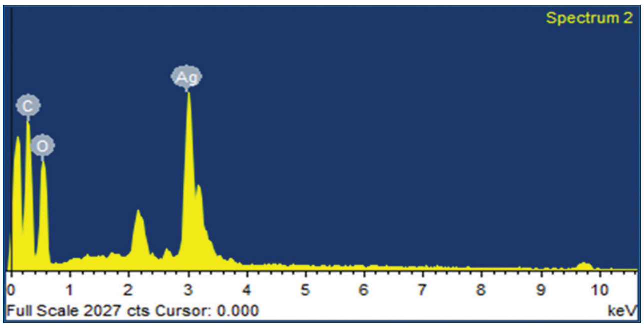

Fig. 4: Energy dispersive X-ray spectra of silver nanoparticles

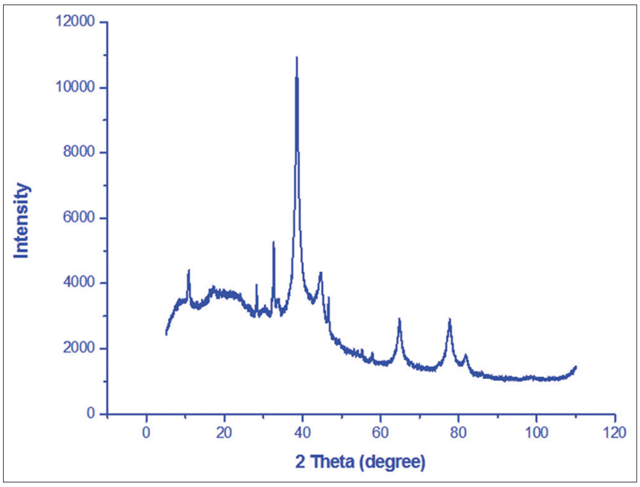

Fig. 5: Energy dispersive X-ray pattern of silver nanoparticles synthesized using extract of *Ipomoea batatas*

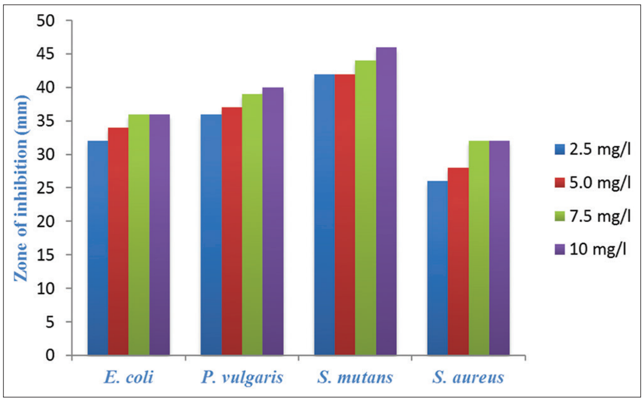

Fig. 6: Zone of inhibition for bacterial species at different amount of silver nanoparticles

to 10 mg/l (Fig. 6). At 10 mg/ml dosage of AgNPs, the zone of inhibitions has been achieved 36, 40, 46, and 32 mm for *E. coli*, *P. vulgaris*, *S. mutans*, and *S. aureus*.

CONCLUSIONS

The biologically synthesized AgNPs using the root extract of *I. batatas* as reducing reagent have been recognized as good antibacterial agents for *S. aureus, S. mutans, P. vulgaris,* and *E. coli*. The AgNPs were well characterized using different analytical methods such as UV-visible, FT-IR, XRD, FESEM, and EDX. The synthetic method was found highly efficient, low cost, eco-friendly, and specific.

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CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

The ideas of this research work, characterizations, and antibacterial activity of AgNPs are mainly concerned with the corresponding author Dr. Naveen Chandra Joshi. The experimental work has performed by Mrs Juhi Chhabra in the advanced chemistry laboratory of Uttaranchal University, Dehradun (India), with the assessment of corresponding author.

Table 1: Energy dispersive X-ray composition

Element	Weight (%)	Atomic (%)
C, K	26.89	42.31
O, K	44.61	52.70
Ag, L	28.51	4.99
Totals	100.00	

Ag: Silver, C: Carbon, K and L: Energy terms related to principle of EDX spectroscopy, O: Oxygen

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