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Article

Eco-friendly Synthesis of Silver Nanoparticles Using *Plumeria obtusa* Plant Leaves Extract - A Spectral Study and Antibacterial Activity

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ABSTRACT

In the course of the most recent couple of years, the green synthesis of nanoparticles (NPs) using plant parts has developed as a promising procedure for the manufacture of metallic NPs (particularly gold, silver [Ag], zinc oxide, and copper NPs) as it includes a simple, quick, low cost, and ecofriendly. Formation of AgNPs was characterized by ultraviolet (UV)-visible spectroscopy, X-ray diffraction (XRD), energy dispersive X-ray, transmission electron microscopy, and X-ray photoelectron spectroscopy. The biosynthesis of *Plumeria obtusa* AgNPs (PO-AgNPs) was confirmed utilizing UV-visible spectrophotometer which showed maximum absorbance at 445 nm wavelength. The spherical and face-centered cubic crystalline nature of PO-SNPs was investigated with transmission electronic microscopy and XRD. Biosynthesized AgNPs inhibit the growth of the Gram-positive and Gram-negative bacterial strains.

Key words: Green synthesis, Plant extract, *Plumeria obtusa*-silver nanoparticles, Antibacterial activity, X-ray photoelectron spectroscopy.

1. INTRODUCTION

Amid the most recent decade, as the most encouraging technological advancement in the nanotechnology, material science has essentially changed human life and got much more interest [1]. NPs are play a key role for the construction of nanotechnology because of their significant properties due to its morphology, size, and distribution [2]. Different methods have been used to synthesize NPs includes photochemical [3], electrochemical [4], chemical reduction [5], and physical method such as physical vapor condensation [6]. During the biosynthesis of metal nanoparticles (MNPs) mainly involves the reduction of concern metal ion salt solution, there are three regions of chance to take part in green synthesis; (i) selection of solvent, (ii) reducing agent involves in nucleation, and (iii) capping agent utilized for phase growth and produce NPs [7-9]. NPs are produced by plant extracts influenced by the different parameters such as time of reaction, pH factor, concentration, and temperature [10]. Noble MNPs can be synthesized by one-pot technique attracted most of the researchers, particularly this area is affordable, less energy utilization, time saving, and viable to produce eco-friendly materials that are used in different fields than their traditional methods such as physical and chemical as well as accumulate less harmful substances toward human beings and environment [11,12]. Diminishing the measure of any material to nanoscale may change its characteristic properties. In this way, the properties of a nanostructured material can be very divergent from those of the bulk material, making it appropriates for various applications. Specifically, MNPs such as Ag and copper NPs have been connected in a wide range of applications including bioengineering, agriculture, and medicine [13-17]. Nanomaterials are known as a wonder of present-day pharmaceutical. It is expressed that antiinfection agents kills maybe about six distinctive ailments causing microorganisms, but nanomaterials can slaughter about around 650 cells [18]. Among the NPs, AgNPs have been considered by most specialists with incredible medicinal and pharmaceutical applications, an account of its astounding properties such as catalytic properties, biologic effects, as well as high surface to volume ratio [19,20]. More examinations have demonstrated great capability of AgNPs as anticancer and antibacterial agent. AgNPs destroy the mitochondria as well as DNA ultimately it leads to death of the cancer cells. Likewise, AgNPs devastate the bacterial cell film and thusly the cell is lysed [21,22]. AgNPs show the efficient antibacterial activity compared to other salts due to their large surface area, which gives better contact with microorganisms [23]. Fabrication of AgNPs by using different plant species such as Syzygium Cumini [24], Achyranthes Aspera [25], Limonia acidissima [26], Terminalia Chebula [27], Euphorbia antiquorum latex [28], Soybean seeds [29]. *Plumeria obtusa* (PO) is commonly known as devaganneru in Andhra Pradesh. This plant parts can be used for the treatment of anthelmintic, mellitus, diabetes, constipation, asthma, gonorrhea, expectorant, and contraceptive because of their medicinal values [30-32]. In the present study, synthesis of AgNPs was done by the PO plant leaves extract.

1.1. Preparation of Plant Extract

PO plant leaves were collected from Rajeev Gandhi Memorial College of Engineering and Technology, Nandyal, India. Plant leaves collected

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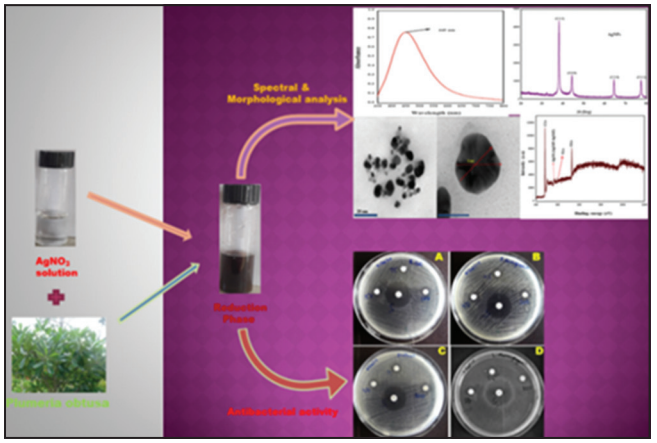
during early sunshine initially washed with running tap water and later on clean with double distilled water for the removal of any dust particles on it, and clean leaves were allowed to shade dried and powdered at room temperature. 10 g leaf extract power was placed in 100 ml double distilled water and boiled at 50°C–60°C stirred on magnetic stirrer around 10 min and filtered through Whatman No. 1 filter paper. The filtrate was stored in refrigerator at 4°C for further use.

1.2. Synthesis of PO-AgNPs

About 50 mM aqueous solution of Ag nitrate ($AgNO_3$) was arranged and utilized for the synthesis of AgNPs. 10 ml of PO extract was included into 90 ml of 50 mM solution of $AgNO_3$ for conversion of Ag^+ to PO-AgNPs.



Graphical Abstract: Green synthesis of *Plumeria obtusa*-AgNPs- spectral studies and antibacterial activity.

1.3. Characterization

Preliminary confirmation of PO-AgNPs was scanned by the in ultraviolet (UV)-visible spectrophotometer (Shimadzu-2600, Tokyo, Japan). Transmission electron microscopy (TEM) measurements were carried out on JEOL model instrument 1200 EX instrument on copper grids with an accelerating voltage of 80 kV. X-ray diffraction (XRD) analysis was carried out for PO-AgNPs with PAN analytical X'PERT PRO model XRD operated at 30 kv, 45 mA with Cu X-ray tube as a radiation source for the PO-AgNPs to record the crystalline nature. Surface chemical characterization of AgNPs was analyzed using X-ray photoelectron spectroscopy (XPS) with auger electron spectroscopy module (model/supplier: PHI 5000 Versa Prob II, FEI Inc.) with the power of Al anode was set at 150 W and operated at pass energy 20 eV for all high-resolution measurements.

2. RESULTS AND DISCUSSION

2.1. UV-Visible Analysis

Initially, 50 mM $AgNO_3$ solution was colorless by the addition of light green color of the 10% of plant extract which allows reduction of Ag^+ to Ag^0 visually observed color changes into dark brown within seconds of the reaction which indicated that the formation of PO-AgNPs. Preliminary confirmation for the formation of PO-AgNPs was monitor by the UV-visible spectrophotometer technique in the range of 300-800 nm. Figure 1 showed surface plasmon resonance peak due to the shifting of electrons from valence band to conduction band. SPR for the prepared PO-AgNPs was observed at 445 nm from the spectrum. SPR band position in the UV-visible spectra was concern to shape, size of the particle, and interaction of the particles with medium, moreover, refractive index property, and transfer of the charge in between medium and particles [33].

2.2. XRD Analysis

Crystalline nature of green synthesized PO-AgNPs was examined by XRD analysis. Figure 2 related to X-ray diffractogram peaks were relevant to the face-centered cubic with Miller indices (1 1 1), (2 0 0), (2 2 0), and (3 1 1) at 2θ angle 38.26°, 44.32°, 64.55°, and 77.45°. The narrow peaks from spectra demonstrate the crystalline NPs. The average size of AgNPs was assessed by the utilization of full width at half maxima (FWHM) with Scherrer equation k λ/β cos θ. FWHM value is inversely proportional to the size of NPs. The average crystallite size was estimated to be 8.06 nm. Table 1 summarizes that different parameters were calculated with XRD analysis of PO-AgNPs.

2.3. TEM Analysis

TEM micrograph gives clear information about morphology, shape and size of the PO-AgNPs synthesized by green route. Figure 3 revealed that PO-AgNPs showed spherical shape without any aggregates. Prepared PO-AgNPs suggested that size range of the particles around 6–10 nm and with an average size 8 nm which is consistent to average size of the PO-AgNPs from XRD 8.06 nm.

2.4. Energy Dispersive X-ray (EDX) Analysis

Figure 4 EDX spectroscopy technique was used to analyze the elemental composition of the sample. The peak around at 3 keV confirmed the

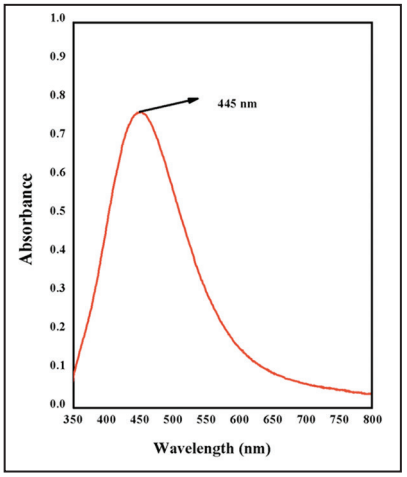


Figure 1: Ultraviolet-visible spectra of *Plumeria obtusa* (PO)-silver nanoparticles obtained using leaves extract of PO

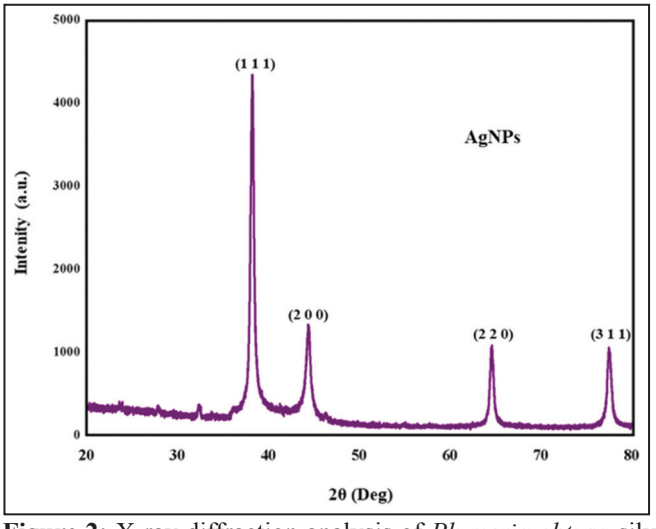


Figure 2: X-ray diffraction analysis of *Plumeria obtusa*-silver nanoparticles

presence of Ag particle from the EDX profile of PO-AgNPs sample. In general, C and O come from the organic molecules present in the plant extract used for the PO-AgNPs preparation act as capping agent. In addition to that Cu signal corresponds to the sample was treated with the copper grid.

Table 1: Different parameters of the XRD analysis of PO-AgNPs

2θ	FWHM	Diffraction plane (hk1)	Crystallite size (nm)	Interplanar spacing "d"
38.2626	1.4209	1 1 1	06.19	1.2449
44.3279	1.1841	2 0 0	07.60	1.1034
64.5501	1.0594	2 2 0	09.35	0.8537
77.4538	1.1715	3 1 1	09.10	0.7897

PO-AgNPs: *Plumeria obtusa*-silver nanoparticles, XRD: X-ray diffraction, FWHM: Full width at half maxima

Table 2: Antibacterial activity of prepared PO-AgNPs by PO

Bacterial strains	Zone of inhibition (mm)			
	50 µl	75 µl	100 µl	*Gentamycin*
E. coli	12	14	15	27
Pseudomonas aeruginosa	09	10	11	25
Proteus	11	12	13	24
Listeria monocytogenes	12	13	14	25

PO-AgNPs: *Plumeria obtusa*-silver nanoparticles

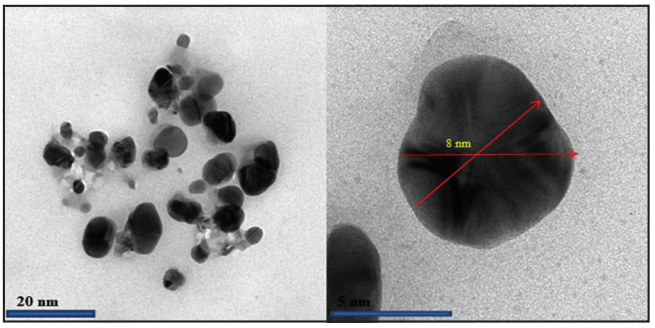


Figure 3: Transmission electron microscopic images of *Plumeria obtusa* (PO) leaves extract-mediated PO-AgNPs at different magnifications

2.5. XPS Analysis

Capped PO-AgNPs were analyzed by XPS is sophisticated extremely powerful analytical tool investigate the interface in between biomolecules-metal and stability of ligand [34]. Figure 5 is relevant to the elements present in the spectrum C-1s, Ag-3d (Ag-3d5 Ag-3d3), N-1s, and O-1s and their concern binding energies are 283.09, 371.51, 399.06, and 531.70. The peaks of C and O clearly indicate that their presence significant for the formation of PO-AgNPs.

2.6. Antibacterial Activity of PO-AgNPs

Antibacterial activity of prepared powder PO-AgNPs has been tested by the disc diffusion method to pathogenic bacterial strains of Gram positive (ve^+) and Gram negative (ve^-), namely Escherichia coli, *Pseudomonas aeruginosa*, *Proteus,* and *Listeria monocytogenes*. Figure 6 shows the zone of inhibition for the PO-AgNPs against above-mentioned bacterial strains and their zone of inhibition. Table 2, relevant to PO-AgNPs, shows the significant antibacterial activity against the pathogenic bacterial strains made in various appositeness of antibacterial activity with the concentration of 100 µl, 75 µl, and 50 µl compared with the standard (*Gentamycin*).

3. CONCLUSION

In the present study, we are reported one-pot synthesis of reliable AgNPs using PO plant leaves extract. AgNPs were effectively biosynthesized by this efficient method, basic, quick, and cost-effective, without involving any external reducing and capping agent. Several compounds present in the leave extract, which can diminish the Ag^+ ion to PO-AgNPs with spherical shape and average size of the particles around 8 nm was confirmed by the XRD and TEM analysis. Our outcomes additionally demonstrate that the synthesized AgNPs showed good physical properties and antibacterial activity.

4. ACKNOWLEDGMENTS

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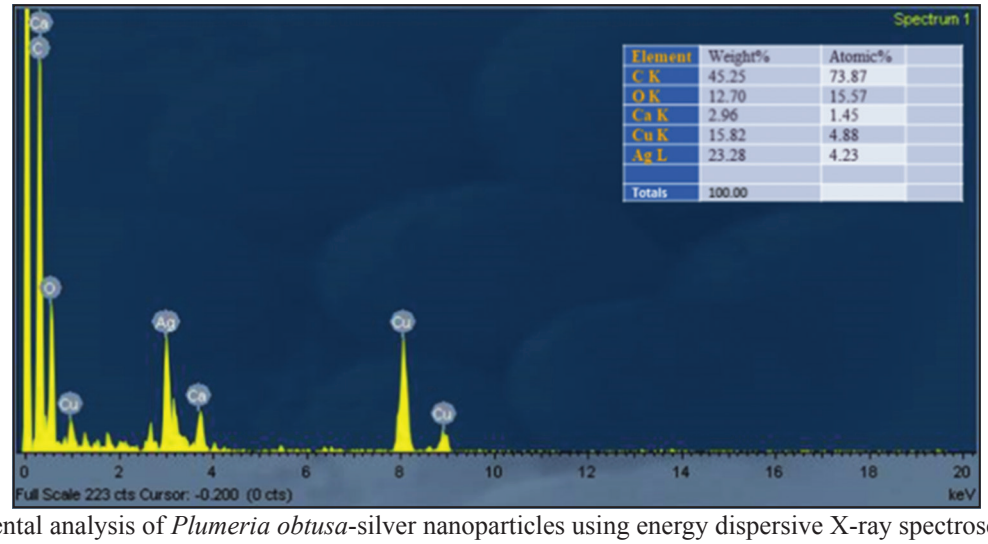

Figure 4: Elemental analysis of *Plumeria obtusa*-silver nanoparticles using energy dispersive X-ray spectroscopy

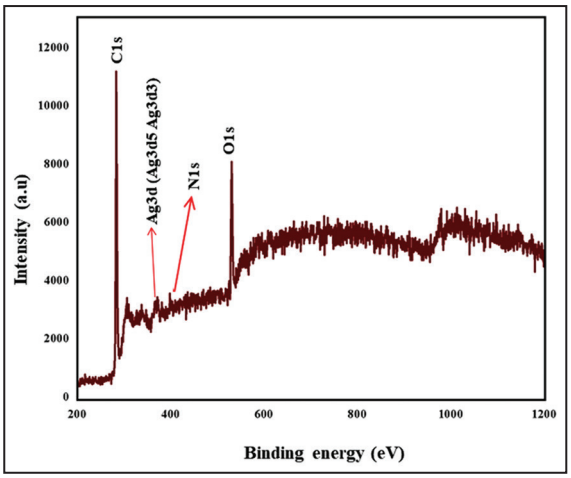

Figure 5: Surface analysis of *Plumeria obtusa*-silver nanoparticles by XPS analyzer

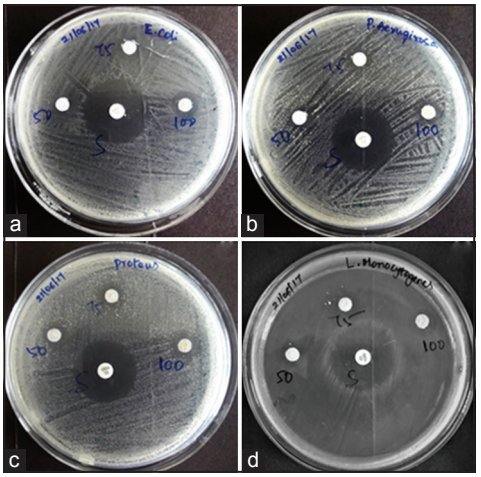

Figure 6: Antibacterial activity of Plumeria obtusa-Ag nanoparticles prepared by Plumeria obtusa leaf extract against (a) *Escherichia coli* (b) *Pseudomonas aeruginosa* (c) *Proteus* (d) *Listeria monocytogenes*

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****Bibliographical Sketch***

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