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Green Synthesis of Silver Oxide Nanoparticles by using *Clerodendrum bracteatum* Leaf Extract and Their Antibacterial Activity

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Abstract: Plant-mediated nanoparticle production is fast, simple, environmentally friendly, and inexpensive. This study synthesised silver nanoparticles using *Clerodendrum bracteatum* leaf extract. FT-IR, SEM, XRD, and Zeta potential were used to characterise silver nanoparticles. FT-IR was utilised to determine the functional groups responsible for reducing silver nitrate and capping agents in the leaf extract. Using Zeta potential, silver nanoparticles' stability was measured. Silver nanoparticles' 18.3 mV negative Zeta potential showed durability. Silver nanoparticles show antibacterial action against *Staphylococcus aureus*, *Micrococcus luteus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, which might help create novel antibacterial medicines.

Keywords: *Clerodendrum bracteatum*, Silver nanoparticles, FT-IR, SEM, XRD, Zeta potential, Antibacterial, Flavonoids, Alkaloids

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Introduction

Green chemicals have been used to synthesise metallic nanoparticles without contaminating the environment (Amin *et al*., 2012). As a reducing and capping agent in green route-mediated metallic nanoparticle synthesis, plant extracts are used. Noble metal silver maintains a major place in nanomaterial research owing to its diverse characteristics (Dong *et al*., 2017). Nanotechnology helps understand molecular, supramolecular, and atomic properties. Chemical approaches to generate nanoparticles are costly, time-consuming, and toxic (Ahmad *et al*., 2011). Nanoparticle manufacturing must be quick, cheap, and environmentally friendly. Earlier studies focused on simple synthesis, not production. In this investigation, we made silver nanoparticles from *Clerodendrum bracteatum* leaf extract (Lee *et al*., 2013).

Clerodendrum is a genus of small tropical trees, shrubs, and perennial plants found in Africa and southern Asia. South America, northern Australia, and eastern Asia have some species (Patel *et al*., 2015). Traditional uses include treating bleeding, rheumatism, haemorrhoids, and lung cancer. Previous phytochemical studies on this genus isolated flavonoid compounds, phenylpropanoid glycosides, sesquiterpenoids, diterpenoids, triterpenoids, alkaloids, and others with antioxidant, antitumor, antibacterial, and anti-inflammatory properties (Zhang *et al*., 2018; Hu *et al*., 2018). This study synthesised silver nanoparticles using *Clerodendrum bracteatum* leaf extract. FT-IR, SEM, XRD, and Zeta potential were used to characterise silver nanoparticles. FT-IR was utilised to determine the functional groups responsible for reducing silver nitrate and capping agents in the leaf extract. Using Zeta potential, silver nanoparticles' stability was measured.

Materials and Methods

Clerodendrum bracteatum leaf extract synthesises of Ag_2O NPs:

30 g of *Clerodendrum bracteatum* leaves were extracted with 70% ethanol. 10 ml of extract and 90 ml of 1 mM silver nitrate solution were mixed in 250 ml Erlenmeyer flasks. The extract produced Ag_2O NPs. The reaction mixture turns from yellow to brown, indicating silver nanoparticle production. Then it was stirred for 5 h at 36°C. The precipitate was rinsed with deionized water and ethanol before drying for 5 h at 80°C. *Clerodendrum bracteatum*-assisted Ag_2O NPs were generated by calcining dried samples at 350°C for 3 h.

Characterization:

Functional groups in 4000-400 cm^{-1} were determined using Perkin-Elmer FTIR spectra. XRD (Philips X'pert diffractometer with Cu K) was utilised to determine the Ag_2O NPs' crystal structure. Zeta potential measured particle sizes. High resolution scanning electron microscopy (HR-SEM) images were taken using a Philips XL30 ESEM with energy dispersive X-ray spectroscopy to examine surface morphology and chemical analysis.

Antimicrobial activity:

Staphylococcus aureus, *Micrococcus luteus*, *Escherichia coli*, and *Pseudomonas aeruginosa* were cultivated on nutritional agar. Bacteria were cultured overnight in nutritious broth at 37 °C, then centrifuged for 5 min at 10,000 rpm and suspended in double distilled water. Cell density (A610 nm) was standardised Spectrophotometrically. Pure Ag_2O NPs were tested using the well diffusion technique following reconstitution with saline (Haq *et al*., 2021; Aravind *et al*., 2021). Hi-Media ruler was used to measure the inhibitory zone in millimetres. Three sets per test were examined.

Results and Discussion

FT-IR studies:

Figure 1 shows Ag_2O nanoparticle FT-IR spectra. The 3405 and 2924 cm^{-1} peaks are due to H_2O's OH stretching vibration in Ag-O-Ag. AgO's 610 cm^{-1} peak (Chuntonov *et al*., 2014).

XRD Analysis:

Figure 2 shows the XRD pattern of Ag_2O with *Clerodendrum bracteatum* leaf extracts, confirming NPS. XRD spectra were compared to Ag_2O (JCPDS no. 00-012-0793). Sharp and strong diffraction peaks indicated good crystallisation. Debye-Scherrer formula computed average crystallite size. Ag_2O crystallites average 25 and 20 nm. Ag_2O's XRD structure is wurtzite. Bragg reflection peaks were detected at 32.06°, 40.03°, 65.03°, and 79.84°, corresponding to the 111, 200, 220, and 311 planes of pure Ag_2O NPs. Using PANalytical X'Pert High Score Plus, Version 3.0.3, XRD confirmed biosynthesized Ag_2O NPs' FCC shape.

Sizing Particles:

DLS measurements were utilised to calculate SNP size. Figure 3 shows the SNPs' particle size dispersion. Particle diameters were 100.12 nm. Size difference between biggest and smallest

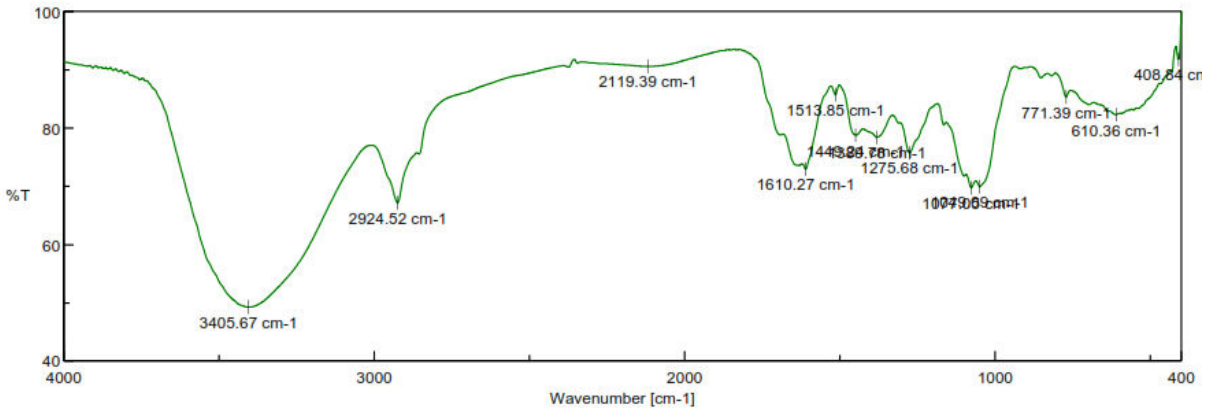

Fig. 1: FT-IR data of Ag_2O NPs with *Clerodendrum bracteatum* leaves extracts.

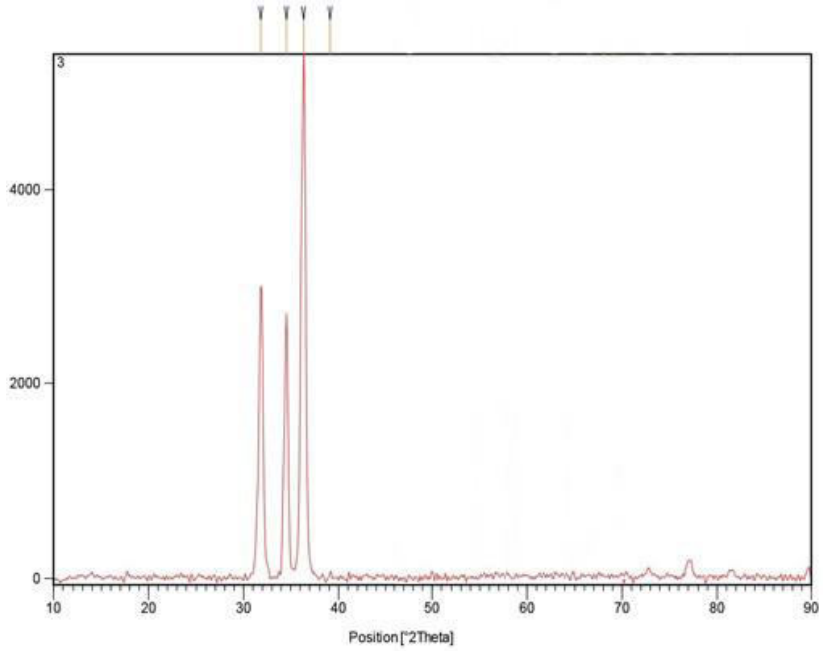

Fig. 2: XRD pattern of Ag_2O NPs with *Clerodendrum bracteatum* leaves extracts.

nanoparticles showed limited SNP dispersion. The nanoparticle zeta potential was 18.3 mV.

SEM Exam:

SEM examination revealed Ag_2O NPs' shape. Figure 4 shows Ag_2O SEM micrographs. Spherical, evenly-distributed particles were found. Ag_2O NPs featured grainy nanosheets stacked vertically. All samples averaged 50-65 nm particle size. Increased Ag_2O NPs matrix reduced average particle size. Formation of Ag-O-Ag on doped nanoparticle surfaces prevented crystal grain growth and particle separation, reducing particle size (Jaishetty *et al*., 2016; Nagadeep *et al*., 2019; Jaishetty *et al*., 2019).

Antibacterial:

We employed good diffusion to compare Ag2O NPs with *Clerodendrum bracteatum* leaf extracts (Fig 5). *S. aureus*, *M. luteus*, *E. coli*, and *P. aeruginosa* were investigated for antibacterial efficacy against Ag_2O NPs. At 100 µl, the zone of inhibition (mm) was measured three times. The Ag_2O NPs improvement % was obvious. Ag_2O NPs inhibited *S. aureus*, *M. luteus*, *E. coli*, and *P. aeruginosa*. The inhibitory zone (%) was found at

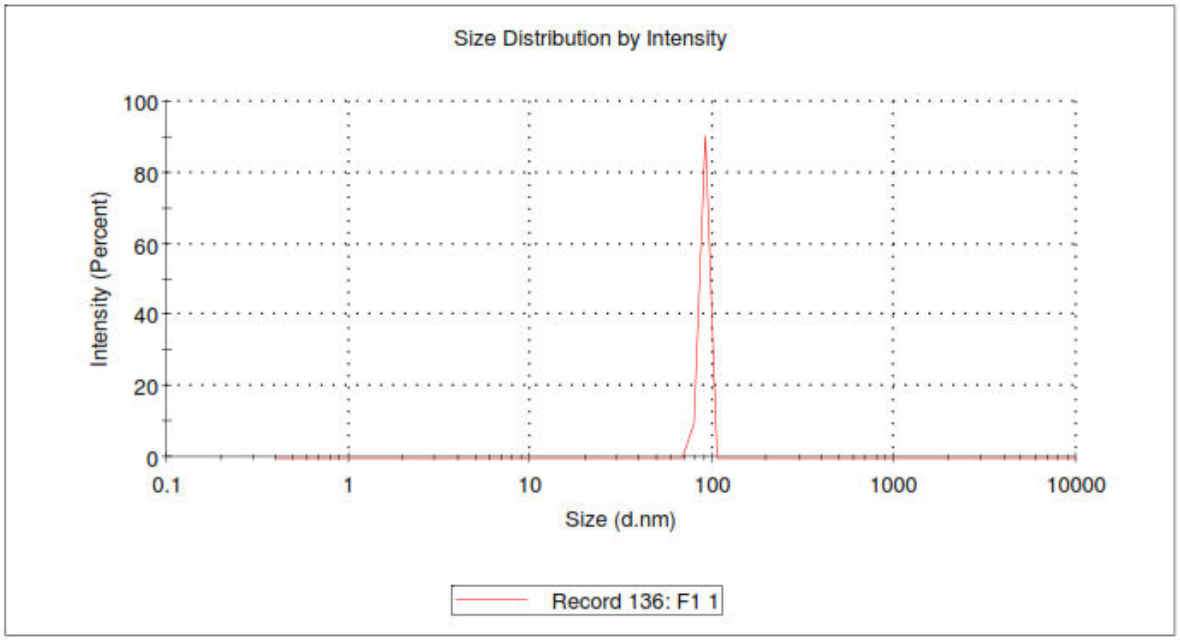

Fig. 3: Particle size analysis of the Ag_2O NPs with *Clerodendrum bracteatum* leaves extracts.

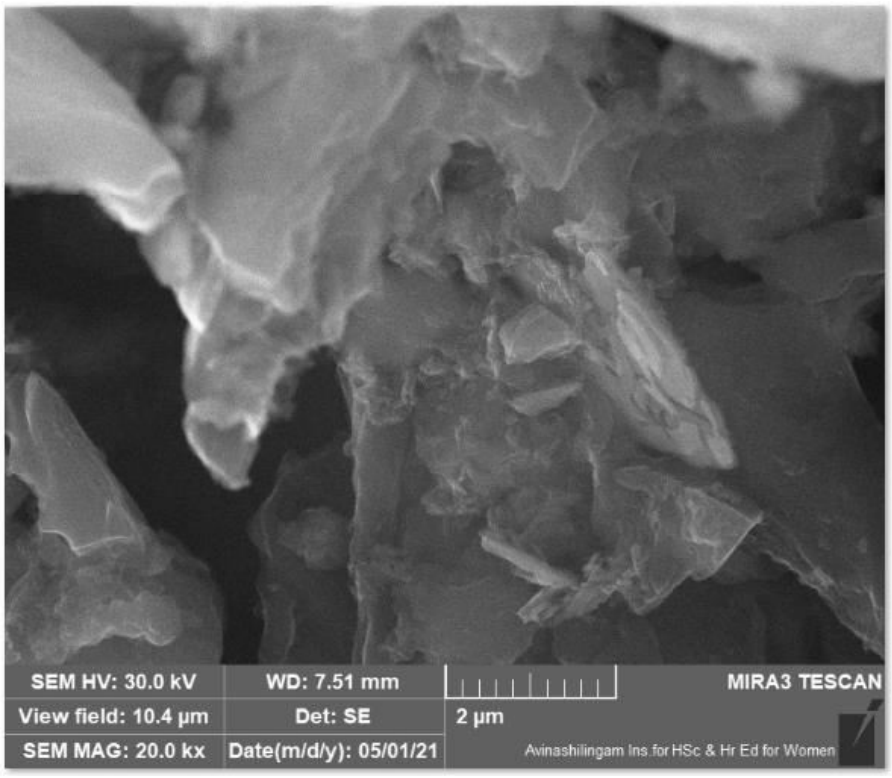

Fig. 4: SEM images of Ag_2O NPs with *Clerodendrum bracteatum* leaves extracts.

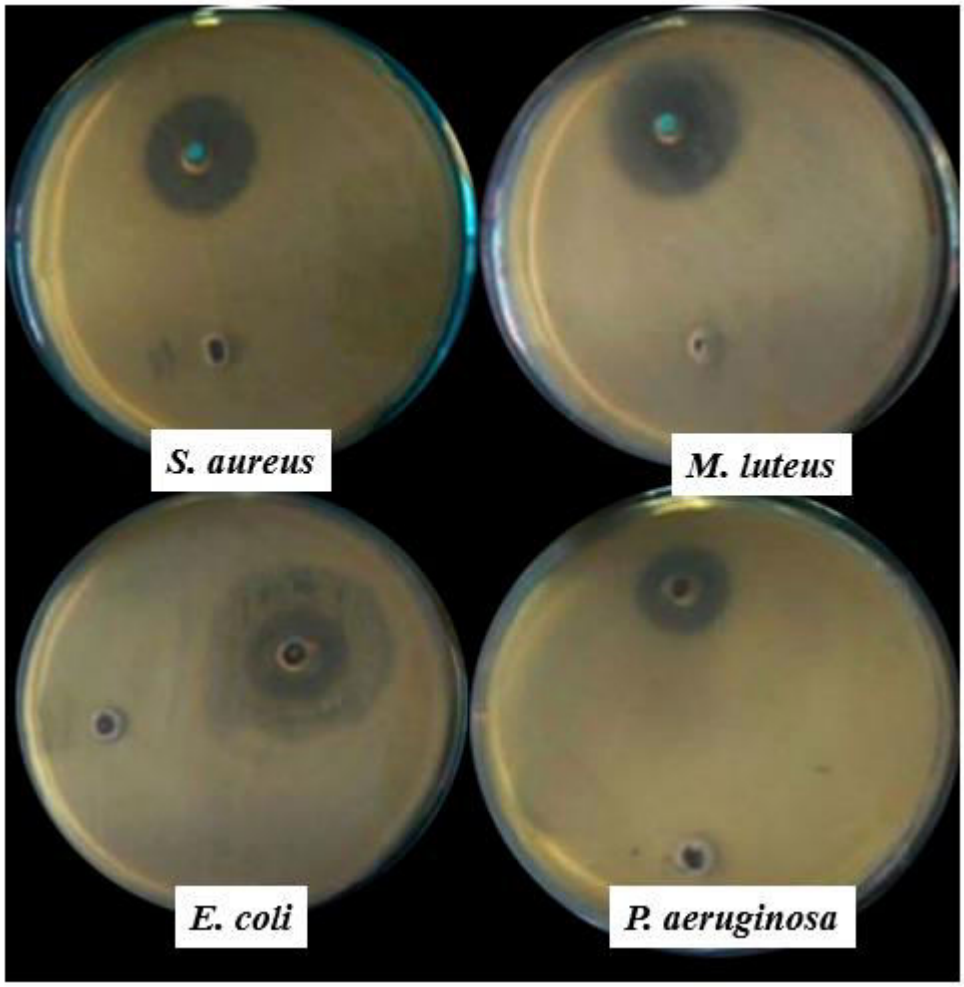

Fig. 5: Antimicrobial efficacy of Ag_2O NPs with *Clerodendrum bracteatum* leaves extracts.

100 µl. Antimicrobial effectiveness of Ag_2O NPs with *Clerodendrum bracteatum* leaves was noticed.

Conclusion

We synthesised Ag_2O NPs from *Clerodendrum bracteatum* leaf extracts. It is an easy, green way to create safe nanoparticles. The nanoparticles' sizes were 100.12 nm. Nanoparticles were bigger because they were surrounded by a thin layer of proteins and metabolites such as terpenoids with functional groups of amines, alcohols, ketones, aldehydes, and other amines, alcohols, ketones, and aldehydes were identified using SEM, XRD, and FT-IR methods. All of these theories say that the ratio of plant extract to metal ion determines nanoparticle shape. Nanoparticles at higher concentrations appeared sheet-like, whereas those in lower concentrations were spherical. 100 µl Ag_2O NPs were bactericidal against *S. aureus*, *M. luteus*, *E. coli*, and *P. aeruginosa*. The investigations found that employing plant extracts to synthesise Ag_2O NPs is more cost-effective, energy-efficient, low-cost, and ecologically benign than using biohazardous chemicals.

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