# Green fabrication of barium oxide nanoparticles using Dodonaea viscosa root Extract, their characterization and biological assessment.

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**Research Article**

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# Green fabrication of barium oxide nanoparticles using Dodonaea viscosa root Extract, their characterization and biological assessment.

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**Abstract**

Barium oxide nanoparticles (BaO NPs) were successfully synthesized using an eco-friendly green method with *Dodonaea viscosa* L. root extract as a reducing and stabilizing agent. The synthesized nanoparticles were characterized by SEM, XRD, and FTIR techniques. SEM analysis showed irregular, agglomerated nanoparticles with with an average size of ~50 nm. XRD confirmed the crystalline nature and phase purity of BaO nanoparticles, while FTIR indicated the presence of plant-derived functional groups and characteristic Ba–O vibrations. The BaO nanoparticles exhibited strong antibacterial activity against *Escherichia coli* (90.6%) and *Staphylococcus aureus* (85.30%), and notable antifungal activity against *Candida glabrata* (87%), *Candida albicans* (85%), and *Aspergillus fumigatus* (83%). These results demonstrate that green-synthesized BaO nanoparticles possess promising antimicrobial potential.

**Keywords:** Green synthesis, Barium oxide nanoparticles, *Dodonaea viscosa*, Characterization, Antibacterial activity, Antifungal activity

## INTRODUCTION

The rapid growth of Nano-based technologies from 2005 to 2010 reflects the superior and unique properties of nanoparticles compared to bulk materials [1]. Nanotechnology, a field named by Norio Taniguchi and inspired by Richard Feynman's 1959 vision, involves manipulating matter at the molecular scale to create nanoparticles with at least one dimension below 100 nm, which can exist in various structural forms such as 0D, 1D, 2D, or 3D [2, 3]. Nanoparticles exhibit distinctive physical and chemical properties due to their small size and large surface area; however, stable heavy metal nanoparticles can cause environmental toxicity, while engineered gold nanoparticles are widely applied because of their superior mechanical, electrical, thermal, chemical, and optical properties compared to bulk gold [4, 5]. Nanoparticles can act as targeted "magic bullets" in agriculture by delivering agrochemicals or genes to specific plant organelles, and advances in synthesis and characterization have significantly expanded research and applications of nanostructured materials with enhanced properties [6, 7].Green chemistry plays a vital role in nanotechnology by enabling the eco-friendly synthesis of safe nanoparticles, with green methods offering greater efficiency, lower cost, and easier characterization than conventional approaches [8, 9]. *Dodonaea viscosa* L. is a hardy evergreen shrub widely distributed across diverse regions worldwide, including Pakistan, where it commonly grows in low hilly scrub vegetation and has historical and commercial significance [10, 15]. *Dodonaea viscosa* L., a woody perennial shrub or small tree of the Sapindaceae family, includes multiple species, grows up to 7 m tall, and is named after botanist Rembert Dodoens, with "viscosa" referring to its sticky nature [11, 14]. *Dodonaea viscosa* L., a drought-resistant shrub introduced to southern China in the 1980s to combat desertification, shows superior drought survival in karst regions, and its flower extracts have potential antibacterial and anticancer properties [12, 13].

## Material and Methods

## Preparation of Plant Extract

The study describes the collection and preparation of *Dodonaea viscosa* L. roots from Nagri Payeen, Pakistan, for the green synthesis of BaO nanoparticles, including botanical identification, voucher preservation, cleaning, drying, aqueous extraction, incubation, and filtration to ensure research accuracy and reproducibility [16, 17].

## Chemicals and other materials

In the present study, barium chloride, sodium hydroxide, and distilled water were used as chemical reagents. All chemicals were of analytical grade and high purity.

## Synthesis of Barium Oxide Nanoparticles

Barium acetate (0.5 M) was mixed with 10 mL of *Dodonaea viscosa* L. root extract to a total volume of 100 mL and stirred at room temperature for five hours. The resulting mixture was centrifuged at 3000 rpm for 20 minutes, after which the supernatant was discarded, and the particles were washed with distilled water two to three times [18].

## Characterization of BaO nanoparticles

## SEM Analysis of Extract

Scanning electron microscopy (SEM) was used to examine barium oxide nanoparticles synthesized from *Dodonaea viscosa* L. extract, with gold coating for conductivity and a 20 kV voltage to observe their morphology, size, and surface structure [19].

## XRD Analysis

X-ray diffraction (XRD) was employed to study the structure of barium oxide nanoparticles, using X-ray radiation from a cathode ray tube and a diffractometer to generate the sample's structural spectrum. [20].

### FTIR Analysis

Fourier Transform Infrared Spectroscopy (FTIR) characterizes green-synthesized nanoparticles by identifying functional groups through infrared absorption, with spectrum peaks indicating successful nanoparticle formation [21, 22].

# Bioassays

## Antibacterial Assay

Antibacterial agents, including plant-derived antibiotics, are used to inhibit or eliminate microbial growth and treat diseases. In a study with five bacterial strains, the disc diffusion method was applied to assess their effectiveness [23].

*Bacillus subtilis*, a Gram-positive bacterium found in soil and mammal stomachs, aids digestion and survives cooking but can cause diseases in labs and animals [24]. *Escherichia coli*, a Gram-negative bacterium normally harmless in warm-blooded animals, can include harmful strains like STEC that cause serious illness. Both bacteria are used in laboratories, requiring strict hygiene to prevent infection. [25].

## Antifungal Assay

Antifungal assays detect and control harmful fungi that can affect humans, plants, and food. Synthesized BaO nanoparticles were tested for antifungal activity using the agar tube dilution method [26]. *Trichophyton rubrum*, a dermatophyte discovered in 1845, infects skin, hair, and nails, causing conditions like athlete's foot and ringworm, usually treatable with topical or oral antifungals [27]. ***Aspergillus fumigatus,*** discovered in 1863, can cause respiratory issues in immunocompromised individuals, highlighting the importance of early detection and antifungal treatment. [28].

# RESULT AND DISCUSSION

## Synthesis of Barium Oxide Nanoparticles

Barium acetate was dissolved in a 0.5 M solution, and 10 mL of *Dodonaea viscosa* L. root extract was added to 90 mL of this solution to make 100 mL. The mixture was kept at room temperature for five hours, and then centrifuged at 3000 rpm for 20 minutes. The supernatant was discarded, and the precipitate was washed several times with distilled water [29].

## SEM Analysis

SEM analysis revealed that the synthesized BaO nanoparticles are irregular in shape and highly agglomerated, forming clustered structures due to strong interparticle interactions. The particles are in the nanometer range with an estimated size of 50 nm, and their rough, non-uniform morphology confirms the successful formation of BaO nanoparticles [30].

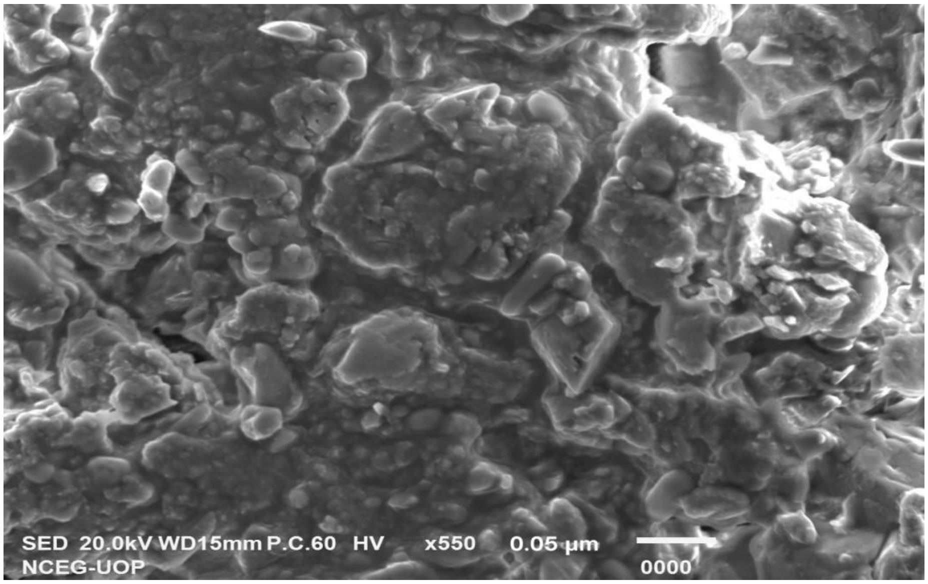


**Figure 3.1: SEM image of BaO nanoparticle**

## XRD Analysis

The XRD pattern confirms the crystalline nature of BaO nanoparticles, showing characteristic peaks at 2θ ≈ 5.25°, 16.14°, 19.95°, 26.14°, 29.29°, and 35.15°. Peak broadening indicates Nano scale crystallite size, while the absence of impurity peaks suggests good phase purity [31].

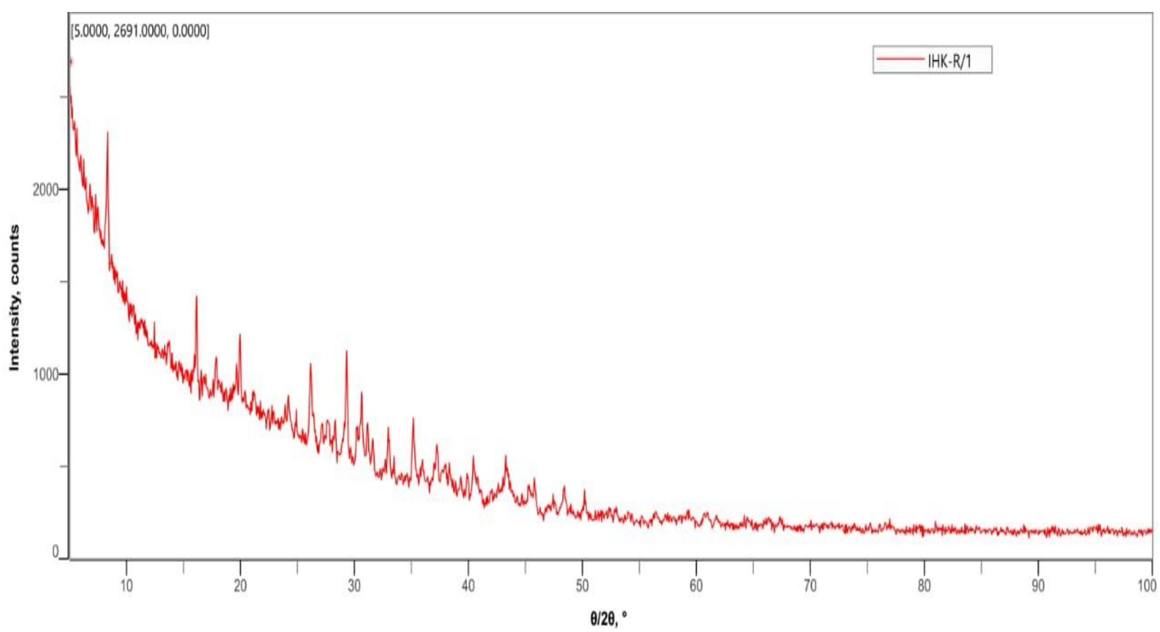


**Figure 3.2: X-Rays Diffraction Analysis of BaO nanoparticle**

## Fourier-Transform Infrared Spectroscopy (FTIR)

The FTIR spectrum confirms the successful synthesis of BaO nanoparticles. The broad band at ~3332 cm⁻¹ indicates O–H stretching from surface hydroxyl groups or adsorbed moisture, while weak features near 2516 cm⁻¹ are related to hydrogen-bonded O–H or $CO_2$ interactions. Peaks at ~1789 and 1632 cm⁻¹ correspond to C=O stretching and H–O–H bending/C=C vibrations, suggesting the presence of organic residues from the green synthesis acting as capping agents. The band at ~1405 cm⁻¹ is attributed to carbonate groups formed due to surface carbonation, and the peak near 1080 cm⁻¹ indicates C–O stretching. Characteristic Ba–O vibrations observed at ~872, 711, and 525 cm⁻¹ confirm the formation of barium oxide nanoparticles [32].

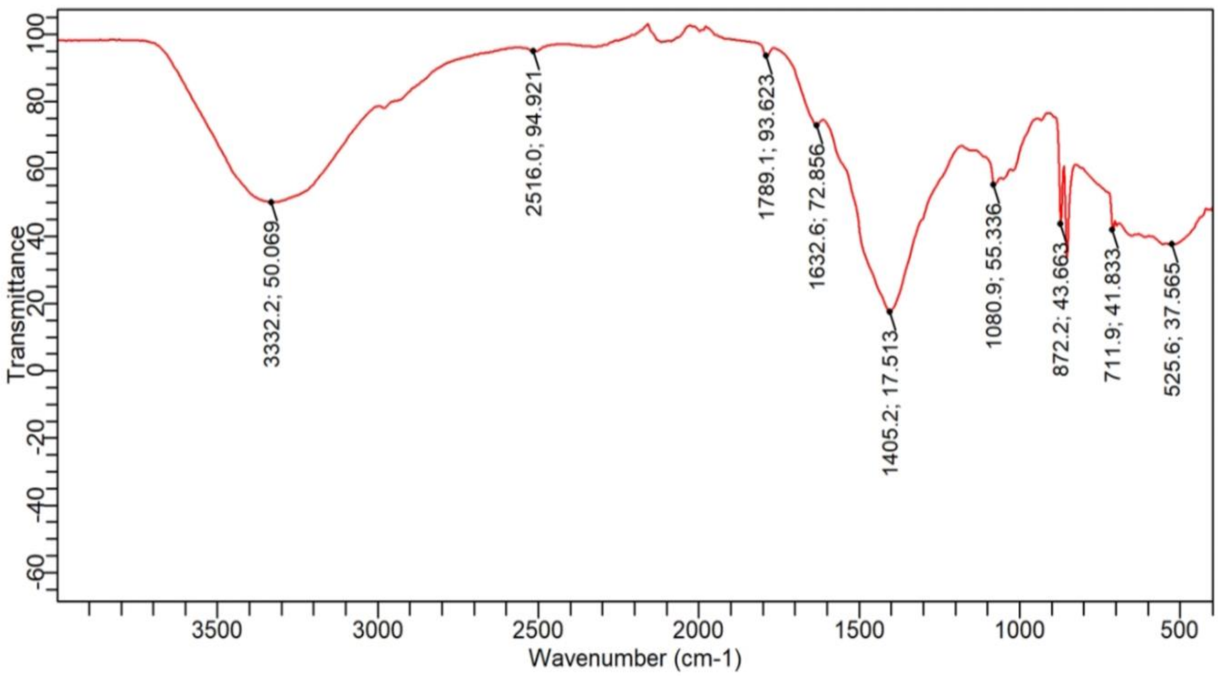


**Figure 3.3: FTIR Analysis of a mixture of BaO nanoparticles**

## Biological Assessment of Synthesized Nanoparticles

## Antibacterial Assay

The antibacterial activity of BaO nanoparticles synthesized from *Dodonaea viscosa* L. extract was tested using the disc diffusion method on five bacterial strains. The nanoparticles showed the highest inhibition against E. coli (90.26%), followed by *S. aureus* (85.30%) and S. typhi (10%), while *P. aeruginosa* and *B. subtilis* showed no inhibition, compared to the positive control, Ofloxacin.

**Table3.2: Antibacterial activities of BaO nanoparticles**

| Name of Bacteria | Percent Inhibition of (Sample) | Percent Inhibition of Drug (Oflaxacin) |
|---|---|---|
| ***E. coli*** *ATCC25922* | 90.6 % | 93% |
| ***B. subtilis*** *ATCC 23857* | No inhibition | 85% |
| ***S. aureus*** *NCTC 6571* | 85.30 % | 79% |
| ***P. auriginosa*** *ATCC 10145* | N0 inhibition | 92 % |
| ***S. typhi*** *ATCC 14028* | 10 % | 88 % |

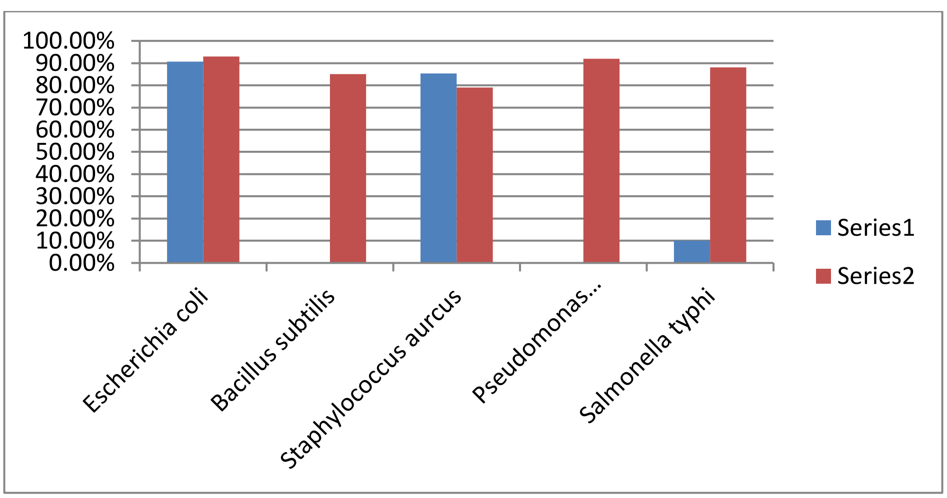


**Figure 3.5: Antibacterial activities of BaO Nps**

## Antifungal Assay

Antifungal activity of BaO nanoparticles synthesized from *Dodonaea viscosa* L. extract was tested against several fungal strains. The nanoparticles showed inhibition of 83% against *Aspergillus fumigatus*, 65% against *Trichophyton rubrum*, 85% against *Candida albicans*, 81% against *Aspergillus niger*, 74% against *Microsporum canis*, 87% against *Candida glabrata*, and 78% against *Fusarium lini*, with Macnazole and Amphotericin-B as negative controls.

**Table 3.1: Antifungal activities of BaO nanoparticles**

| Name of Fungus | Linear Growth (mm) | | Percent Inhibition | Drug |
|---|---|---|---|---|
| | Sample | Control | | |
| ***Trichophyton rubrum*** | 35 mm | 100 mm | 65 % | Miconazole |
| ***Candida albicans*** | 15 mm | 100 mm | 85 % | Miconazole |
| ***Aspergillus niger*** | 19 mm | 100 mm | 81 % | Amphotericin-B |
| ***Microsporum canis*** | 26 mm | 100 mm | 74 % | Miconazole |
| ***Fusarium lini*** | 22 mm | 100 mm | 78 % | Miconazole |
| ***Candida glabirata*** | 13 mm | 100 mm | 87 % | Miconazole |
| ***Aspergillus fumigatus*** | 17 mm | 100 mm | 83 % | Miconazole |

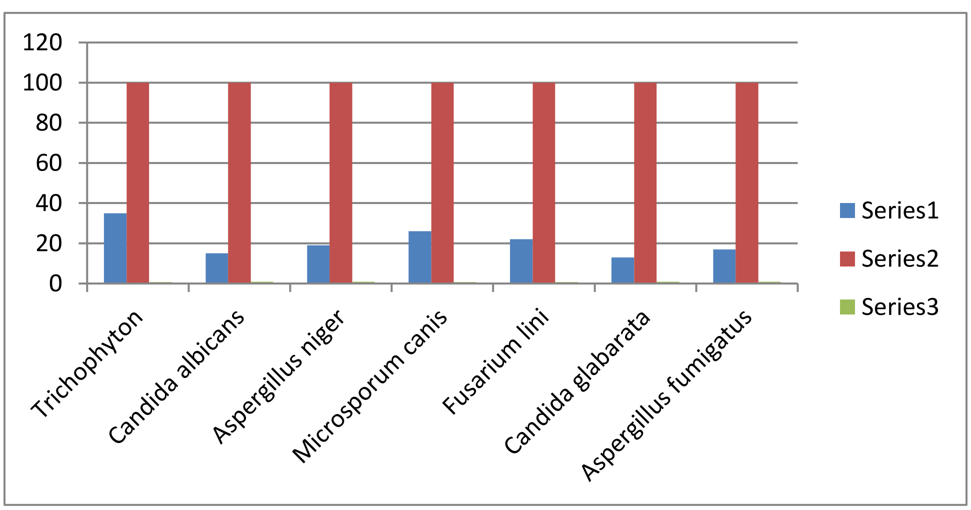

**Figure 3.4: Antifungal activities of BaO nanoparticle**

# Conclusion

The present work confirms the successful green synthesis of barium oxide nanoparticles using *Dodonaea viscosa* L. root extract through an environmentally friendly and cost-effective approach. Structural and morphological characterization verified the formation of crystalline, nanosized BaO particles with irregular and agglomerated morphology. The synthesized nanoparticles demonstrated remarkable antimicrobial activity, particularly against *E. coli*, *S. aureus*, *Candida glabrata*, and *Aspergillus fumigatus*. Overall, the results suggest that plant-mediated BaO nanoparticles possess strong antimicrobial potential and may serve as promising candidates for future biomedical and environmental applications.

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