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# Green Synthesis and Characterization of Silver Nanoparticles Using *Rivea hypocrateriformis* Leaves Extract

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## ABSTRACT

This investigation delves into the eco-friendly production of silver nanoparticles utilizing an extract derived from *Rivea hypocrateriformis* leaves, serving as both a reducing and stabilizing agent. The commencement of the procedure involved validating visual assessments, showcasing the transformation in color of the reaction mixture from a light yellow hue to brown, ultimately culminating in a blackish-brown shade, serving as a clear indicator of the successful formation of nanoparticles. Characterization of the synthesized silver nanoparticles through UV-Visible spectrophotometry revealed a distinct surface plasmon resonance (SPR) band at 450 nm, confirming their metallic nature. Fourier Transform Infrared Spectroscopy (FTIR) analysis identified functional groups in both the plant extract and silver nanoparticles, providing insights into their roles in reduction and stabilization. Scanning Electron Microscopy (SEM) displayed well-separated, spherical nanoparticles with an average size ranging from 15 to 60 nm. This study establishes *R. hypocrateriformis* as a promising source for environmentally friendly synthesis of silver nanoparticles, opening avenues for applications in various fields, including medicine and industry.

**Keywords:** *Rivea hypocrateriformis*, FTIR, SEM, etc.

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## INTRODUCTION

In recent times, the field of green production of metallic nanoparticles has emerged as a novel and promising area of research. The development of green nanoparticles has experienced significant growth in recent years, owing to numerous advantages. These include ease of scalability for large-scale synthesis, cost-effectiveness, high stability of the resulting nanoparticles, and the generation of non-toxic byproducts[1]. When compared to conventional chemical or physical processes, green synthesis offers several benefits, such as the requirement for mild reaction conditions, the use of fewer toxic components, cost-effectiveness, and environmental friendliness. The green synthesis method eliminates the necessity for high pressure, elevated energy, extreme temperatures, or toxic chemicals, making it an economical approach for producing beneficial nanoparticles[2].

The utilization of green synthesis has garnered attention for the production of various metal and metal oxide nanoparticles, primarily because chemical synthesis techniques often result in the presence of harmful chemical species adsorbed on the nanoparticle surfaces. As a result, green synthesis approaches are considered more reliable and economically viable methods for synthesizing these metal nanoparticles[3].

Nanotechnology revolves around processes occurring on the nanometer scale, typically ranging from 1 to 100 nm[4]. Nanoparticles find applications in various fields, including therapeutics, industry, and biology. The traditional methods of chemical and physical nanoparticle creation demand high pressure, energy, temperature, and involve toxic substances. In response to the increasing demand for environmentally friendly nanoparticles, researchers are turning to green technologies. Biosynthesis using plant extracts has proven to be both cost-effective and environmentally benign[5]. Green technologies, particularly the use of plant extracts, serve as reducing and capping agents in nanoparticle synthesis. This approach offers advantages over traditional methods such as photochemical reduction, heat evaporation, electrochemical reduction, and chemical reduction procedures[6].

Plants, known sources of medicinal substances, have contributed significantly to the development of plant-derived medicines. Integrating traditional wisdom and scientific studies is crucial for enhancing regulatory procedures related to herbal medicines, encompassing prescription medications, over-the-counter products, traditional remedies, and dietary supplements. Currently, plant-derived medicine serves as the primary form of basic healthcare for approximately 80 percent of the global population[7]. Harmonizing regulatory regimes is essential, combining traditional knowledge with scientific advancements[8].

Biological catalyst enzymes, also known as biologically active proteins, play a vital role in accelerating metabolic processes in living organisms. These enzymes can be isolated from cells and utilized to catalyze a diverse range of essential industrial products[9]. *Rivea hypocrateriformis* (Desr.) Choisy, a deciduous climbing shrub belonging to the Convolvulaceae family, is widely distributed in regions spanning India, Nepal, Sri Lanka, Pakistan, Bangladesh, Myanmar, and Thailand10. This plant boasts a significant presence in traditional medicine, where various parts like bark, stems, and leaves have been historically employed to address a range of health issues, including malaria, cancer, mental disorders, and pain relief. Notably, in the Tharparkar region of Pakistan, local communities specifically employ *R. hypocrateriformis* for the treatment of malaria and the alleviation of pain.

The plant has attracted attention due to its diverse biological properties, encompassing antioxidant, anti-implantation, antimicrobial, pregnancy interruption, anticancer, and antiarthritic attributes[11,12]. Additionally, *R. hypocrateriformis* plays a vital role in Ayurvedic practices, being a crucial component in the formulation known as "Rasa panchaka," utilized for asthma treatment[13]. Similar to other varieties within the related genus, such as *Rivea corymbosa* Hall and Ipomea violacea L. found in Mexico, *R. hypocrateriformis* is also employed as a hallucinogenic substance in India and as a psychoactive medicine in Pakistan[14]. The objective of the current study was to synthesize and characterize the silver nanoparticles from *R. hypocrateriformis* leaves extract.

## MATERIALS AND METHOD

### Collection and Authentication of Plant Material

*R. hypocrateriformis* leaves were collected from out skirt area of Chail Chowk, Mandi, Himachal Pradesh (H.P.). The plant was identified, authenticated and certified (HIMCOSTE/HPSBB/7098) by Dr. Pankaj Sharma, Senior Scientist, Himachal Pradesh State Biodiversity Board, Shimla, India.

### Preparation of Plant Extract

To create the ethanolic extract of *Rivea hypocrateriformis*, 10 g of leaves powder was mixed with 100 ml of ethanol in a 250 ml Erlenmeyer flask. The mixture underwent heating on a hot plate at 60 °C for a duration of 20 minutes. Following this, the solution was first filtered through regular filter paper mesh to remove undesirable materials. Subsequently, the extract was further filtered using Whatman filter paper No. 1. The resulting filtered extract served as the crucial reducing and stabilizing agent in the synthesis of nanoparticles.

### Green Synthesis of Silver Nanoparticles

A 10 mM silver nitrate solution was meticulously prepared in an Erlenmeyer flask using double distilled water. Subsequently, 400 ml of leaves extract was introduced into 100 ml of the 10 mM silver nitrate solution, and the volume was adjusted to 1000 ml with double distilled water. The resulting mixture underwent stirring for a duration of 2 hours at 45 °C, employing the hot plate method along with a magnetic stirrer15. The reduction of silver ions (Ag+) to silver nanoparticles (Ag0) was verified by the observable color transformation of the solution, shifting from colorless to brown, as illustrated in Figure 1.


**Figure 1 Green Synthesis of Silver Nanoparticles using Ethanolic Extract of *R. hypocrateriformis leaves***

**Characterization of Synthesized Silver Nanoparticles**

Following the nanoparticle synthesis, the reaction mixture underwent centrifugation for 20 minutes at 4000 rpm, leading to the formation of a precipitate. This precipitate was subjected to washing with water and subsequent centrifugation. The resulting pellet was carefully collected and subjected to drying in a hot air oven, maintaining a temperature range of 35-40 °C. The dried nanoparticles were then gathered for further characterization and application studies. Characterizing nanoparticles typically involves investigating their size, shape, and surface area. Homogeneity in these properties is crucial for advancing the applications of nanoparticles. The characterization of silver nanoparticles specifically was conducted using various instrumental techniques, as outlined in reference[16].

**UV-Visible Spectrophotometer**

The reduction of silver ions to silver nanoparticles was characterized using a double-beam UV-visible spectrophotometer within the wavelength range of 300 nm to 700 nm. This analytical procedure was executed using a Perkin Elmer Spectrophotometer in Singapore, featuring a resolution of 1 nm. The recorded data included the determination of maximum absorption peaks for both *Rivea hypocrateriformis* leaves extracts and silver nanoparticles synthesized through green methods.

**Fourier Transform Infrared Spectroscopy (FTIR)**

The infrared (IR) spectrum analysis of Rivea hypocrateriformis leaves powder and green-synthesized silver nanoparticles was conducted using Fourier Transform Infrared

Spectroscopy (FTIR) with a SHIMADZU instrument. The samples were ground into KBr pellets and subjected to scanning within the FTIR spectrum range of 4000 – 400 cm-1.

**Scanning Electron Microscope (SEM)**

Morphological characteristics of green-synthesized Silver Nanoparticles were analyzed using Scanning Electron Microscopy (SEM) with a ZEISS instrument. In this electron microscopic study, the sample underwent preparation as thin films by being placed on carbon-coated copper grids, and the resulting images were recorded for analysis.

## RESULTS AND DISCUSSION

**Synthesis of Silver Nanoparticles (SNPs) Using *R. hypocrateriformis***

The green synthesis of silver nanoparticles utilizing Rivea hypocrateriformis leaves extract was initially verified through visual observation. The formation of silver nanoparticles occurred upon the addition of silver nitrate solution to the leaves extract. Initially, the reaction mixture exhibited a pale yellow color, transitioning to brown, indicating the successful formation of silver nanoparticles (Figure 2). After one hour, the color evolved to dark brown, culminating in a blackish-brown shade, signifying the completion of the silver ion reduction process. The diverse colors of the silver nanoparticles can be attributed to the excitation effect of surface plasmon resonance in the reaction mixture. Notably, the prepared nanoparticles demonstrated non-aggregation. Various research findings have indicated that the stability of these nanoparticles persisted for more than a week.

**(a) (b) (c)**

**Figure 2: Visual Observation of R. hypocrateriformis leaves Extract Mediated Silver Nanoparticles Synthesis (a) Leaves Extract (b) Silver Nitrate Solution (c) Silver Nanoparticles (SNPs)**

**Characterization of Synthesized Silver Nanoparticles**

**UV-Visible Absorption Spectrum**

The UV-visible absorption spectral analysis of *Rivea hypocrateriformis* leaves extract was explored and is illustrated in Figure 4. The UV-visible spectrum of the leaves extract was examined within the range of 250-300 nm in the UV-visible regions, revealing a small absorption peak around 280 nm. This region is attributed to C=C bond, carbonyl bond, and aromatic compounds. These phytochemicals play a significant role in the reduction of silver ions to silver nanoparticles (SNPs). The UV-visible spectrophotometer serves as an intriguing tool for determining the optical properties of silver nanoparticles. The UV-visible spectrum of silver nanoparticles was characterized within the range of 400-540 nm.

The UV-visible spectrum depicts the surface plasmon resonance (SPR) band centered at 450 nm, a characteristic peak indicative of silver nanoparticles (Figure 3). This observation signifies the reduction of silver ions (Ag+) to metallic silver nanoparticles.

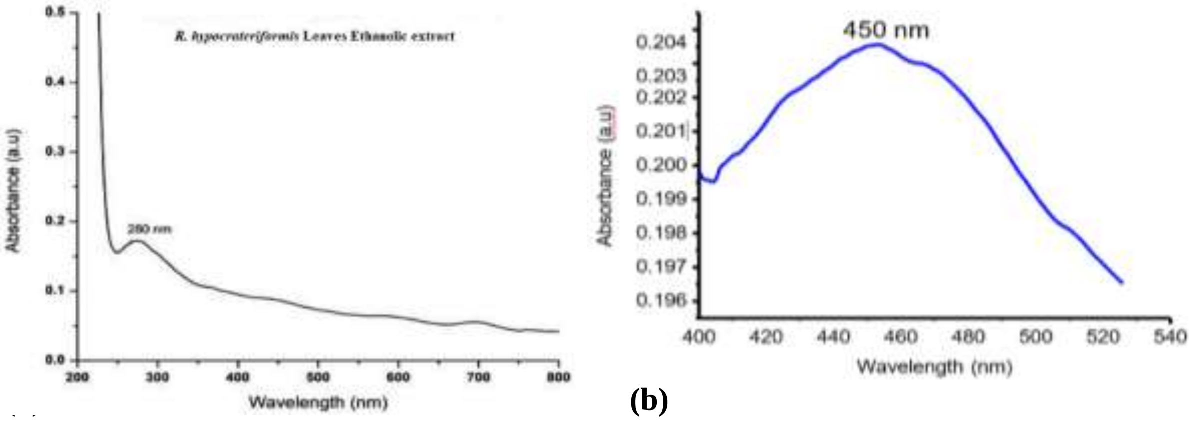


**Figure 3: (a) UV-Visible Spectrum of Ethanolic Extract of *R. hypocrateriformis* (b) UV-Visible Spectrum of Green Synthesized Silver Nanoparticles**

The formation of the SPR band occurred due to the excitation of free electrons present in the silver nanoparticles during the absorption of visible light. The observation of a single peak suggests the formation of spherical-shaped nanoparticles. The broadened peak indicates the presence of poly-dispersed silver nanoparticles, signifying variations in particle size within the sample.

**FTIR analysis of synthesized silver nanoparticles**

The ethanolic extract of leaves exhibited a broad peak at 3314.06 cm-1, which shifted to 3317.95 cm-1 in silver nanoparticles, indicating O-H stretching of carboxylic acids. In the silver nanoparticles, two weak bands emerged at 2923.10 cm-1 and 2854.04 cm-1, corresponding to C–H stretching in alkanes. A narrow band at 1639.72 cm-1, assigned to C-C aromatic compounds and N-H primary amines in the plant extract, slightly broadened to 1600.26 cm-1.

A new peak at 1541.44 cm-1 indicated the presence of N–O asymmetric stretch in nitro compounds. The absorption band at 1400 cm-1 shifted to 1405.59 cm-1, attributed to C–C stretch (in–ring) aromatics. A weak band disappeared, giving rise to a new peak at 1319.62 cm-1, corresponding to C-O stretching in alcohols and carboxylic acids. Additionally, a new broad band at 1077.89 cm-1 was observed, related to C–N stretching in the aliphatic amine group.

The FTIR results confirmed the presence of carboxyl, alcohol, amine, and amide groups in the leaves' extract. These groups are likely involved in the reduction of silver ions to silver nanoparticles. Minor changes between the leaves' extract and silver nanoparticles peaks suggest that these functional groups play a crucial role in both reducing and stabilizing the silver nanoparticles.

**Scanning Electron Microscopy**

The average particle size calculated using diffraction planes are 15 to 60 nm., spherical in shape. Figure 4 indicates that the synthesized silver nanoparticles are well separated showing no agglomeration.

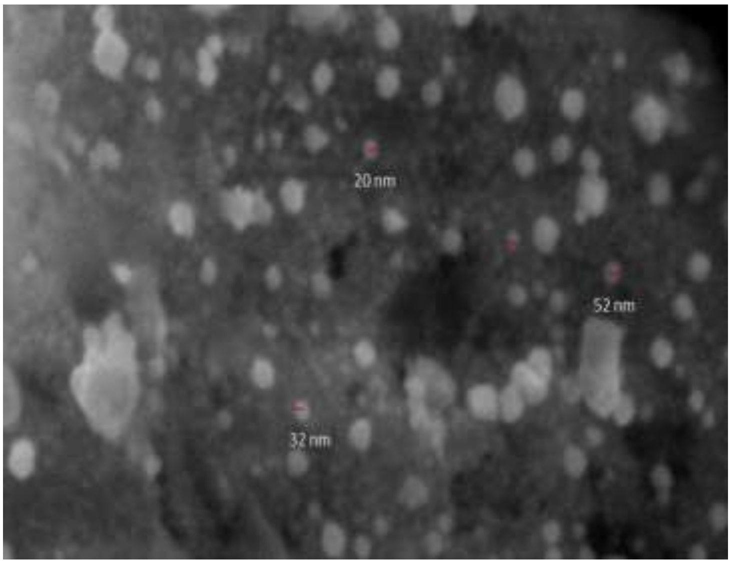


**Figure 4: SEM Image of Silver Nanoparticles**

## CONCLUSION

This study successfully demonstrated the green synthesis of silver nanoparticles using *Rivea hypocrateriformis* leaves extract. The utilization of plant extracts, particularly from medicinal plants like *R. hypocrateriformis*, presents an eco-friendly and cost-effective method for silver nanoparticle synthesis. Visual observation confirmed the formation of silver nanoparticles, evident through the color transition of the reaction mixture from pale yellow to brown and finally to blackish brown. UV-Visible spectrophotometry characterization revealed a surface plasmon resonance (SPR) band centered at 450 nm, a characteristic feature of silver nanoparticles. FTIR analysis highlighted the presence of functional groups, including carboxyl, alcohol, amine, and amide, in both the plant extract and silver nanoparticles, indicating their role in the reduction and stabilization of silver ions. SEM displayed well-separated, spherical silver nanoparticles with an average size ranging from 15 to 60 nm. In conclusion, this research underscores the potential of *R. hypocrateriformis* as a green synthesis source for silver nanoparticles, showcasing applications in diverse fields such as medicine and industry.

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