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Green Synthesis of Silver nano particles using the plant extracts from some members of family Bignoniaceae

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Abstract

Silver nanoparticles (AgNPs) are among the most significant nanometals due to their widespread use in biotechnology and biomedicine. Bacteria, fungus, enzymes, and plant extracts are some of the resources available for green AgNP production. Plants and microbes are widely used for the green manufacture of metallic nanoparticles. Using plants to synthesize nanoparticles is emerging and beneficial compared to microbes because plants contain a wide range of bio-molecules that can act as capping/stabilizing and reducing agents, increasing the rate of reduction and stabilization of synthesized nanoparticles. Plants appear to be the greatest candidates for biosynthesis of silver nanoparticles, and they are appropriate for large-scale biosynthesis. Interest in using metallic nanoparticles in the food, paint, textile, cosmetic, and medical industries has grown. A reliable and green technique for the synthesis of silver nanoparticles has been developed using plant extracts and characterized by UV-visible spectroscopy and Fourier Transform Infrared Spectroscopy (FTIR). This research presented a simple and effective approach to synthesizing silver nanoparticles. The main aim of the present study is to synthesize and characterize the silver nanoparticles of the Aqueous leaf extracts and Alcoholic leaf extracts of *Tecoma stans, Cresentia cujete and Tabubeia rosea*. The research involved collecting *Cresentia cujete* leaves from Khanvel Silvassa botanical garden, and *Tecoma stans* and *Tabubeia rosea* leaves from Sathaye college campus Mumbai. The leaves were washed, dried and powdered. The dried powder of the leaves were used to prepare the aqueous extracts which were heated at 100°C for 20-30 minutes, filtered, and stored at 4°C. The alcoholic extract was prepared by soaking the dried powder of the leaves into ethanol for about 2-3 hours and stored at 4°C. Silver nitrate ($AgNO3$) was used as a precursor for the synthesis of silver nanoparticles from the leaves. The green synthesis method was used, by adding the aqueous as well as the alcoholic extracts to different beakers and then (AgNO3) extract was added to the plant extract. Plant extracts were prepared from the species of the Bignoniaceae family. In the UV-visible spectra peaks found around 200-350 nm indicated successful synthesis of silver nanoparticles and in the (FTIR) Fourier Transform Infrared Spectroscopy the spectrum of aqueous plant extracts and AgNPs shows the characteristics band which indicated O-H Stretching which correspond to C=O stretching vibrations.

Key Words: - Silver nanoparticles, UV-Vis Spectroscopy, FTIR, Green synthesis, Nanotechnology, Plant extracts, Characterize, Bignoniaceae

Introduction

A major historical turning point has been signaled by the nanotechnology revolution. The manufacturing sector, modifying, and photographing nanostructures of diameters between 1 and 100 nm are all part of nanotechnology. Feynman initially brought up the concept of nanotechnology in 1959. In a number of sectors, including food packaging, electronics, agriculture, medicine, and health care, nanotechnology has opened up new possibilities. Additionally, it is among the most recent advancements in industry. **(Alharbi et al., 2022)**.Nanotechnology has emerged as a key area of study in the fields of electronics, medicine, the environment, textiles, and more in recent decades. This is caused by a material's unique characteristics at the nanoscale level. To neutralize pathogenic organisms, a variety of nanomaterials, including copper, zinc, titanium, magnesium, gold, alginate, and silver, were employed.**(Mahadevan et al., 2017)**

The term "nanotechnology" refers to the production, representation, manipulation, and use of structures through nanoscale shape and size control. The most prominent field of material science research is nanotechnology, and the production of nanoparticles (NPs) is expanding dramatically globally. **(Rafique et al., 2017)** Specifically, the use of metallic nanoparticles in the food, paint, textile, cosmetics, and medical industries has garnered interest. The use of nanoparticles (NPs) in the administration of cancer medications has gained support in recent years. NPs may be used as therapeutic carriers to exclusively target cancer cells because of their smaller particle size. The manufacturing of NPs using chemicals is very costly and detrimental to the environment. **(Deepak et al., 2019)**

Nanomedicine is a new multidisciplinary discipline that combines medical research with nanoscale technologies, resulting in a wide range of uses for nanoparticles in healthcare. Medicine is no longer solely the purview of doctors; nanoscale technology and its parts are employed as instruments for disease detection, management, and pain relief as well as for overall health, preservation, and progress. Understanding living cells and molecular interactions can be improved with the use of nanotechnology.**(Gohil et al., 2024)**Utilizing plants to synthesis NPs may be beneficial over other environmentally acceptable biological techniques since it eliminates the need for the laborious process of maintaining cell cultures. Making NPs extracellularly from plants or their extracts in a controlled manner that takes into account their size, dispersity, and shape would be more advantageous for biosynthetic processes.**("A Review on Green Synthesis of Silver Nanoparticles (SNPs) Using Plant Extracts," 2025)**

Silver nanoparticles are synthesized using a variety of techniques, including heat evaporation, photochemical reduction, electrochemical reduction, and biological. According to published research, these techniques are highly costly and involve the use of dangerous chemicals that pose threats to human health and the environment. The manufacture of silver nanoparticles from plant extract is currently gaining more interest due to its environmentally beneficial properties.**(Asif et al., 2022)**In view of their unique and adjustable characteristics as well as their use in biomedicine for drug delivery and tissue and tumor imaging, silver nanoparticles have been investigated as a significant study topic. To determine these nanoparticles' antibacterial activity in cell lines and animal models, more research can be done.**(Shumail et al., 2021)**

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Materials and Methods

Sample Collection

The *Cresentia cujete* leaves were collected from the botanical garden of Khanvel Silvassa and the leaves of *Tecoma stans and Tabubeia rosea* were collected from the Sathaye college campus Mumbai. The leaves were washed with tap water four to five times before detached from the shoots. Then leaves were shade dried for 48 hours at room temperature and fine powder was made out of it.

Aqueous Extract

Cresentia cujete Leaf Extract Preparation

For extract preparation 10 g fine powder of *Cresentia cujete* leaves was added into 100 mL deionized water. Then it was heated at 100°C for 20 to 30 minutes. The obtain extract was filtered using filter paper (Whatman no. 1) and stored at 4°C for further use.

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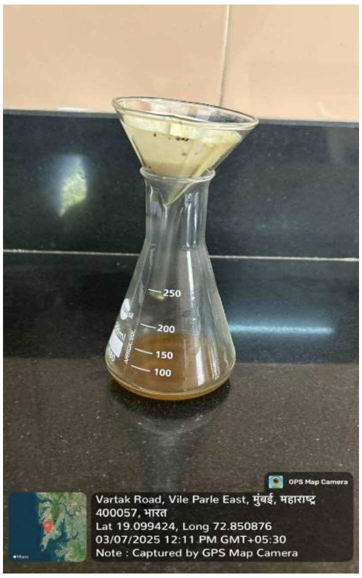
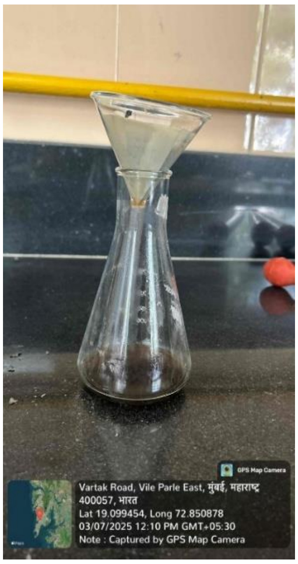
Tecoma stans Leaf Extract Preparation

For extract preparation 10 g fine powder of *Tecoma stans* leaves was added into 100 mL deionized water. Then it was heated at 100°C for 20 to 30 minutes. The obtain extract was filtered using filter paper (Whatman no. 1) and stored at 4°C for further use.



Tabubeia rosea Leaf Extract Preparation

For extract preparation 10 g fine powder of *Tabubeia rosea* leaves was added into 100 mL deionized water. Then it was heated at 100°C for 20 to 30 minutes. The obtain extract was filtered using filter paper (Whatman no. 1) and stored at 4°C for further use.



Alcholic Extract

Cresentia cujete Leaf Extract Preparation

For extract preparation 5 g fine powder of *Cresentia cujete* leaves was added into 50 mL Ethanol. and it was left for 2-3 hours at room temperature. The obtain extract was filtered using filter paper (Whatman no. 1). The filtered extract was taken in the of 10 mL and the volume was adjusted to 100 mL with Ethanol.

Tecoma stans Leaf Extract Preparation

For extract preparation 5 g fine powder of *Tecoma stans* leaves was added into 50 mL Ethanol. and it was left for 2-3 hours at room temperature. The obtain extract was filtered using filter paper (Whatman no. 1). The filtered extract was taken in the of 10 mL and the volume was adjusted to 100 mL with Ethanol.

Tabubeia rosea Leaf Extract Preparation

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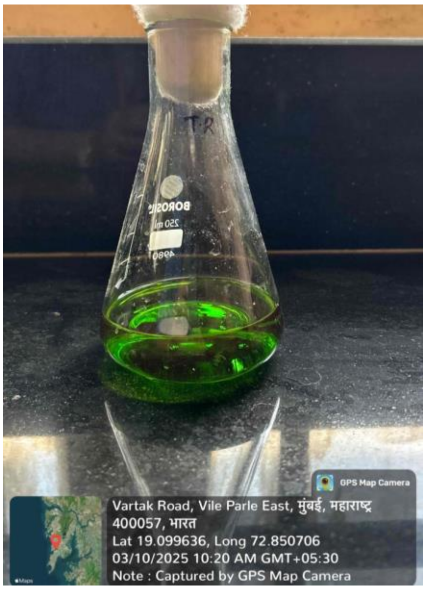
For extract preparation 5 g fine powder of *Tabube*ia *rosea* was added into 50 mL Ethanol. and it was left for 2-3 hours at room temperature. The obtain extract was filtered using filter paper (Whatman no. 1). The filtered extract was taken in the of 10 mL and the volume was adjusted to 100 mL with Ethanol.



Precursor Preparation

Silver nitrate ($AgNO_3$) was used as precursor for the synthesis of silver nanoparticles from the *Cresentia cujete*, *Tecoma stans* and *Tabubeia rosea* leaves extract. 2 mM solution of silver nitrate was prepared using double distilled water and stored at 4°C in refrigerator.

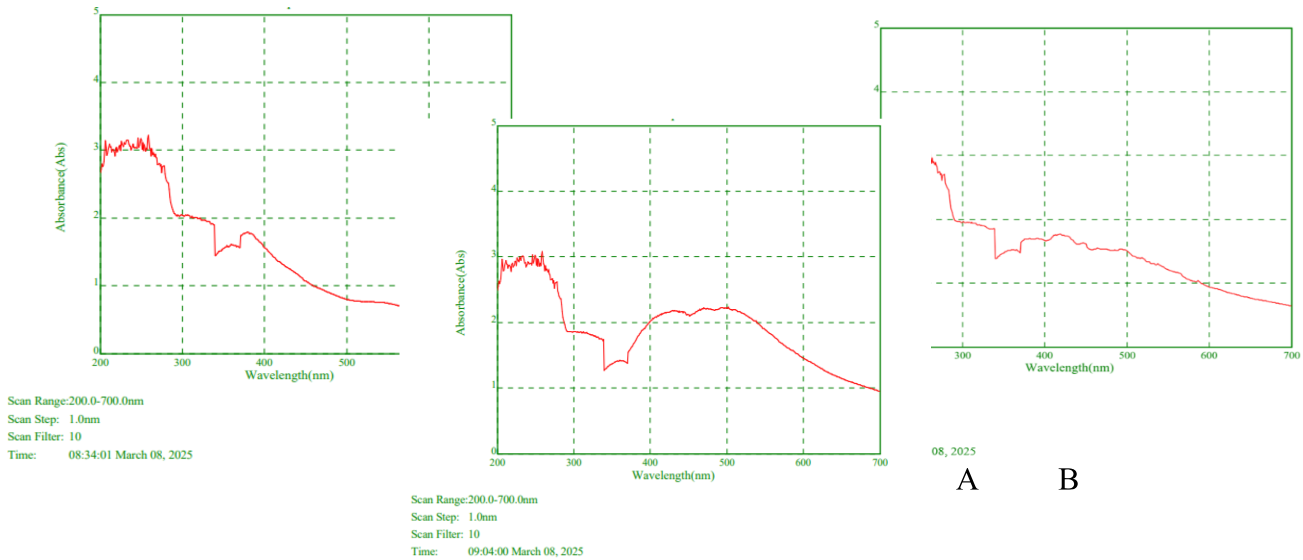
Biosynthesis of Silver Nanoparticles

The green synthesis method was followed for the synthesis of silver nanoparticles. For the reduction of Ag^{+} ions, 5 mL leaves extracts of *Cresentia cujete*, *Tecoma stans* and *Tabubeia rosea* was added in different beakers and then 10 ml aqueous extract of Ag NO^3 was added to the plant extract in their respective beakers.

Result and Discussion

Data Analysis of UV-VIS Spectrophotometer

1. ***Tecoma stans*** **aqueous extract**



A B

C

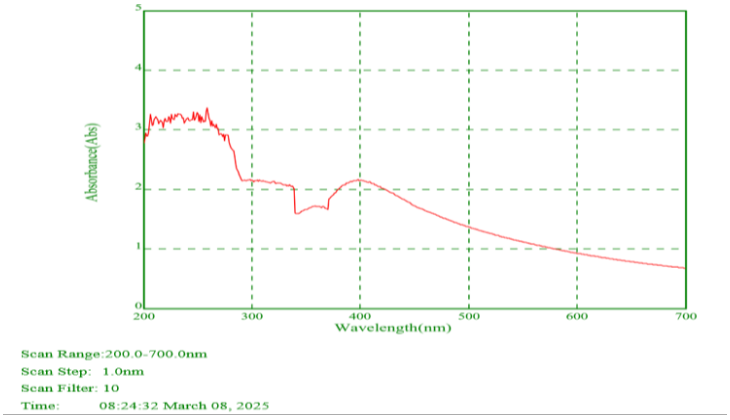
A- Aqueous extract *Tecoma stans* 0 Min, B- Aqueous extract *Tecoma stans* 15 Min, C- Aqueous extract *Tecoma stans* 30 Min

In figure A the plant extract of *Tecoma stans* at 0 min with the presence of silver nano particles got investigated under the UV-VIS spectrophotometer, it is found that the nano particles could be observed more efficiently in the ultraviolet region i.e., from the range of 200 – 260 nm which is also observed in the visible range but not efficiently as ultraviolet region.

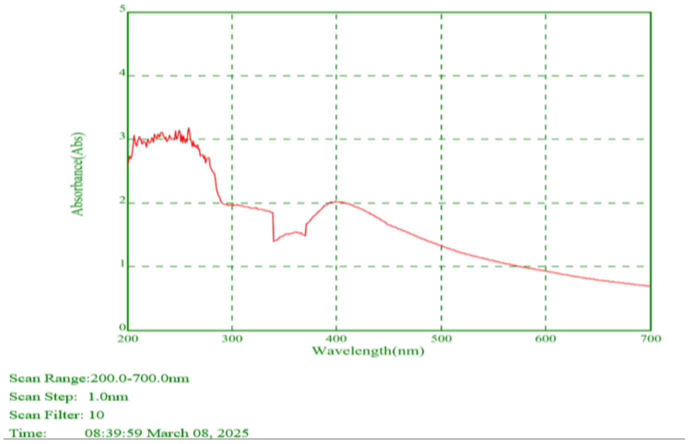
In figure B the plant extract of *Tecoma stans* at the interval of 15 minutes, it was observed that there is a drop in the graph between the range of 290 – 330 nm in the ultra violet range which states that the nano particles have already started to degrade in the solution changing the colour of the solution to brown.

In figure C at the time interval of 30 minute the plant extract with silver nano particle was again investigated under UV-VIS spectrophotometer it was observed that the graph shows peaks from the range of 200-280 nm and there was a slight down fall from 290-320 nm. Then there was a slight peak at the range of 500 nm and then a complete decline which shows that the nano particles completely degraded in the solution.

2. ***Cresentia cujete aqueous extract***



A



B

C

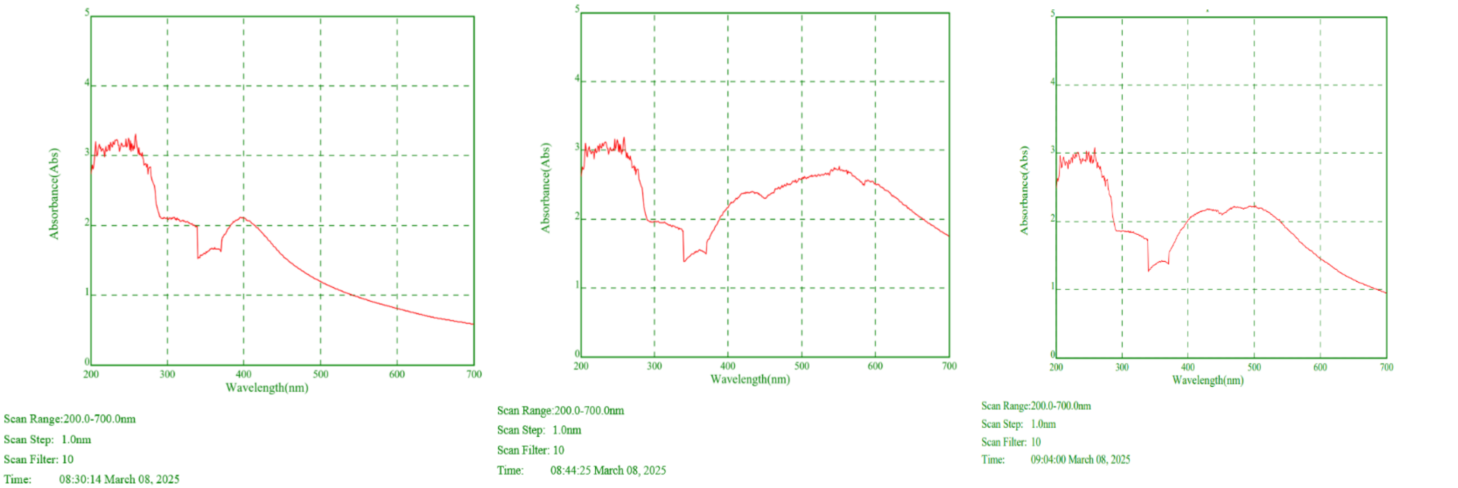
A- *Aqueous extract Cresentia cujete at 0 min, B- Aqueous extract Cresentia cujete at 15 min, C- Aqueous extract Cresentia cujete at 30 min*

In figure A the aqueous plant extract of *Cresentia cujete* at 0 min with the presence of silver nano particles got investigated under the UV-VIS spectrophotometer, it is found that the nano particles could be observed more efficiently in the ultraviolet region i.e., from the range of 200 – 290 nm which is also observed in the visible range but not efficiently as ultraviolet region. The graph shows a rapid decline from 410 nm onwards.

In figure B the aqueous plant extract of *Cresentia cujete* at the interval of 15 minutes, it was observed that there is a drop in the graph between the range of 290 – 340 nm in the ultra violet range which states that the nano particles have already started to degrade in the solution. The graph shows a gentle peak at 400 nm and then a complete drop down till the range of 700 nm.

In figure C the aqueous extract at the 30-minute interval, the combination of plant extract and silver nanoparticles was re-evaluated using a UV-VIS spectrophotometer, showing that the graph reveals peaks in the range of 200-280 nm and a slight reduction from 290-320 nm. Subsequently, a small peak emerged at approximately 410 nm, after which there was a complete decrease, signifying that the nanoparticles had wholly degraded in the solution.

3. ***Tabebuia rosea aqueous extract***



A B C

A- *Aqueous extract Tabebuia rosea at 0 min, B- Aqueous extract Tabebuia rosea at 15 min, C- Aqueous extract Tabebuia rosea at 30 min*

In figure A the presence of silver nanoparticles in the aqueous plant extract of *Tabebuia rosea* was examined using a UV-VIS spectrophotometer. It was discovered that the nanoparticles were more easily detected in the ultraviolet region between 200 and 290 nm, which is also detected in the visible range but less effectively than in the ultraviolet region,

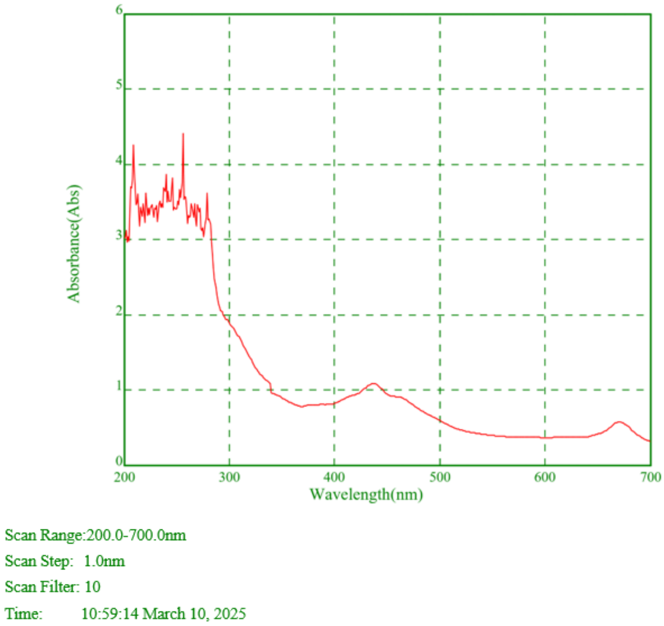
In figure B the aqueous plant-based extract of *Tabebuia rosea* containing silver nanoparticles was examined using a UV-VIS spectrophotometer at 15-minute intervals. It was discovered that the nanoparticles were more easily visible in the ultraviolet region, specifically between 200 and 290 nm.

Additionally, some peaks were discovered between 450 and 590 nm, and the graph indicates a decrease from the 600 nm range.

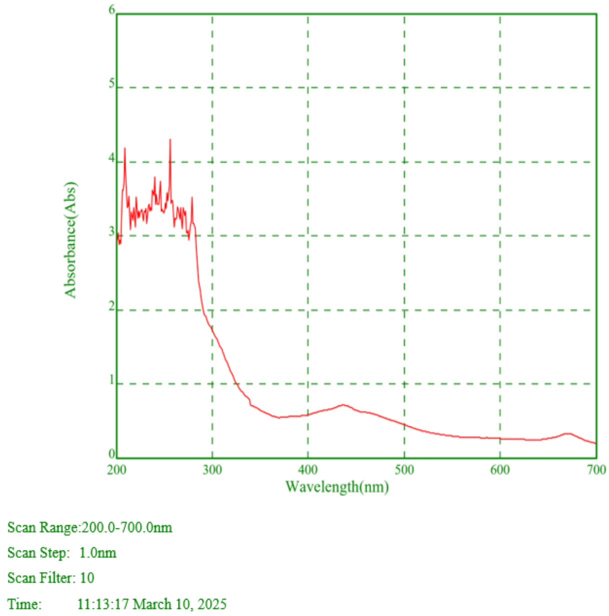
In figure C at the 30-minute interval, the combination of plant extract and silver nanoparticles was re-evaluated using a UV-VIS spectrophotometer, showing that the graph reveals peaks in the range of 200-290 nm and a slight reduction from 290-320 nm and there is sudden drop from 500 nm onwards.

Upon comparing the graphs of the aqueous plant extract of three species of the Bignoniaceae family i.e., *Tecoma stans, Cresentia cujete and Tabubeia rosea* from the UV-VIS spectroscopy it can be said that all the species used in the current study has the potential in production and degradation of silver nano particles. *Cresentia cujete* and *Tecoma stans* examined has the greater potential for production and degradation of silver nano particles than the species i.e.*, Tabubeia rosea.*

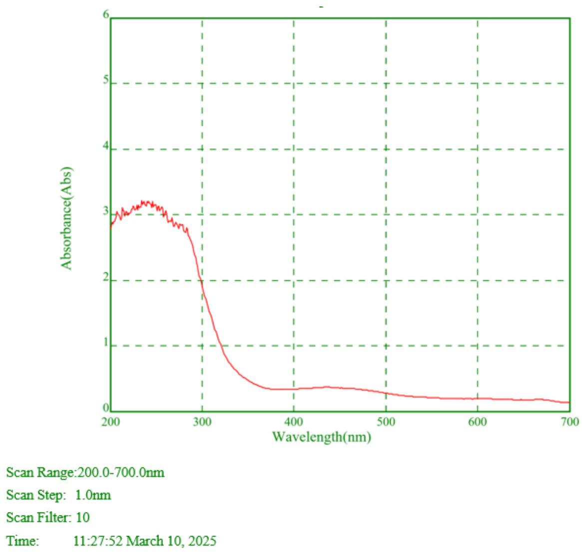
1. ***Tecoma stans* alcoholic extract**



A



B



C

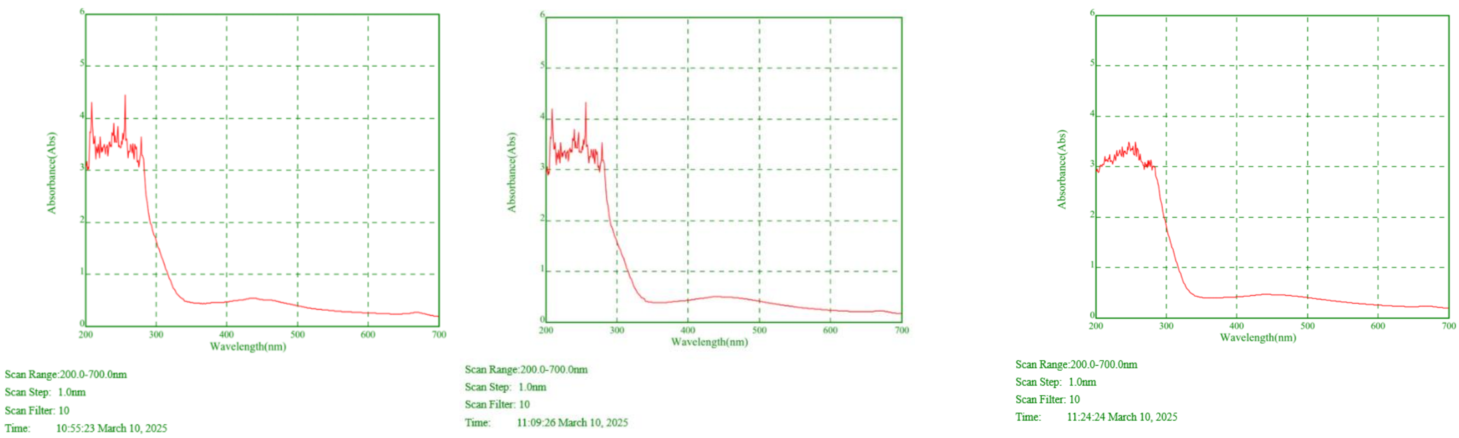
A- Alcoholic extract *Tecoma stans* 0 Min, B- Alcoholic extract *Tecoma stans* 15 Min, C- Alcoholic extract *Tecoma stans* 30 Min

In figure A the Alcoholic plant extract of *Tecoma stans* at 0 min with the presence of silver nano particles got investigated under the UV-VIS spectrophotometer, it is found that the nano particles could be observed more efficiently in the ultraviolet region i.e., from the range of 200 – 280 nm were very sharp peaks were observed in the visible range but not efficiently as ultraviolet region.

In figure B the Alcoholic plant extract of *Tecoma stans* at the interval of 15 minutes, it was observed that there is a drop in the graph between the range of 290 – 330 nm in the ultra violet range which states that the nano particles have already started to degrade in the solution.

In figure C at the time interval of 30 minute the Alcoholic plant extract with silver nano particle was again investigated under UV-VIS spectrophotometer it was observed that the graph shows small peaks from the range of 200-290 nm and there was a complete down fall from 290 nm.

2. ***Cresentia cujete* alcoholic extract**



A B C

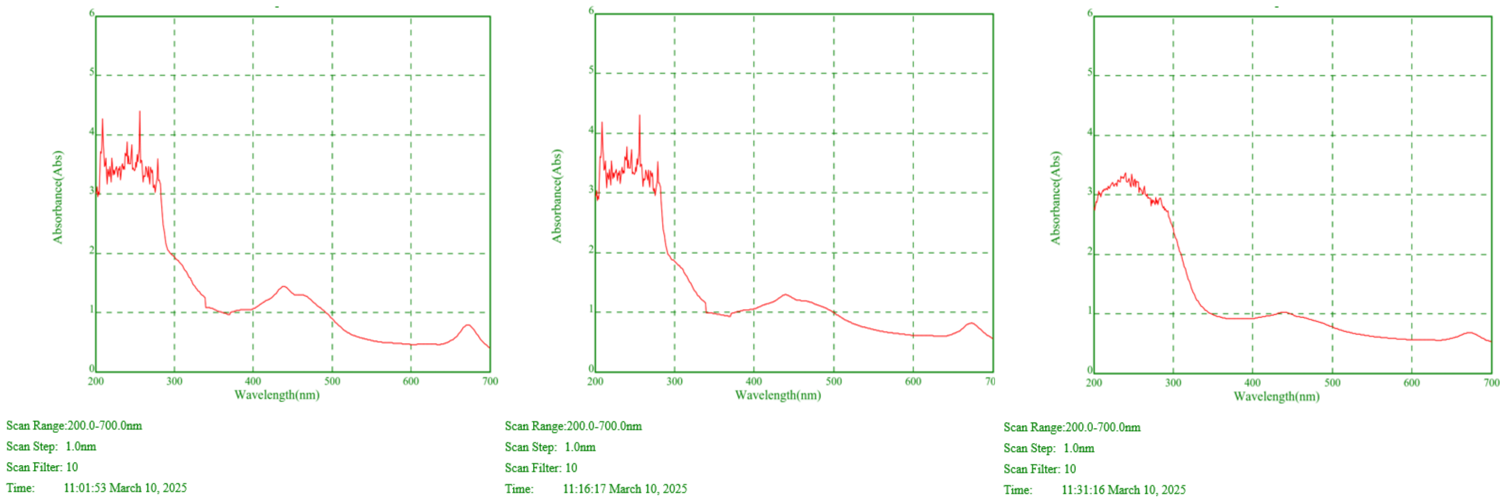
A- *Alcoholic extract Cresentia cujete at 0 min, B- Alcoholic extract Cresentia cujete at 15 min, C- Alcoholic extract Cresentia cujete at 30 min*

In figure A the alcoholic plant extract of *Cresentia cujete* at 0 min with the presence of silver nano particles got investigated under the UV-VIS spectrophotometer, it is found that the nano particles could be observed more efficiently in the ultraviolet region i.e., from the range of 200 – 290 nm very sharp peaks were observed in the visible range but not efficiently as ultraviolet region. The graph shows a rapid decline from 300 nm onwards.

In figure B the alcoholic plant extract of *Cresentia cujete* at the interval of 15 minutes, it was observed that there is a rapid drop in the graph from the range of 290 nm in the ultra violet range which states that the nano particles have already started to degrade in the solution.

In figure C the alcoholic extract at the 30-minute interval, the combination of plant extract and silver nanoparticles was re-evaluated using a UV-VIS spectrophotometer, showing that the graph reveals short peaks in the range of 200-290 nm and from 300 nm, there was a complete decrease, signifying that the nanoparticles had wholly degraded in the solution.

3. ***Tabebuia rosea alcoholic extract***



A **B** **C**

A- Alcoholic extract Tabebuia rosea at 0 min, B- Alcoholic extract Tabebuia rosea at 15 min, C- Alcoholic extract Tabebuia rosea at 30 min

In figure A the presence of silver nanoparticles in the alcoholic plant extract of *Tabebuia rosea* was examined using a UV-VIS spectrophotometer. It was discovered that the nanoparticles were more easily detected in the ultraviolet region between 200 and 290 nm, with very sharp peaks detected in the visible range but less effectively than in the ultraviolet region,

In figure B the alcoholic plant-based extract of *Tabebuia rosea* containing silver nanoparticles was examined using a UV-VIS spectrophotometer at 15-minute intervals. It was discovered that the nanoparticles were more easily visible in the ultraviolet region, specifically between 200 and 290 nm and there was a sudden decline on the graph from the range of 300 nm.

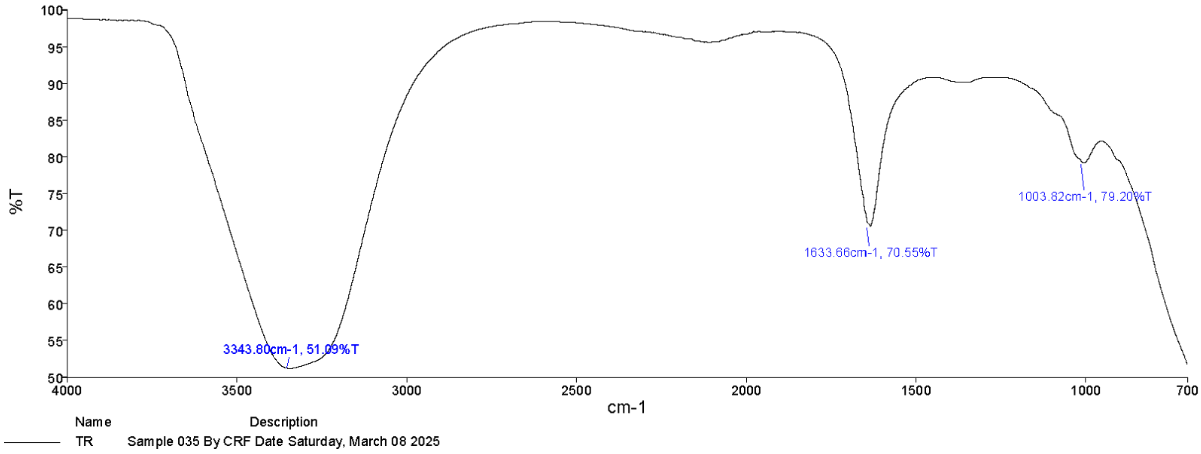
In figure C at the 30-minute interval, the combination of plant extract and silver nanoparticles was re-evaluated using a UV-VIS spectrophotometer, showing that the graph reveals blunt peaks in the range of 200-290 nm and there is a sudden drop from 290 nm onwards.

Upon comparing the graphs of the alcoholic plant extract of three species of the Bignoniaceae family i.e., *Tecoma stans, Cresentia cujete and Tabubeia rosea* from the UV-VIS spectroscopy it can be said that all the species used in the current study has the potential in production and degradation of silver nano particles. *Cresentia cujete* and *Tecoma stans* examined has the greater potential for production and degradation of silver nano particles than the species i.e.*, Tabubeia rosea.*

Data Analysis of FTIR (Fourier Transform Infrared Spectroscopy)

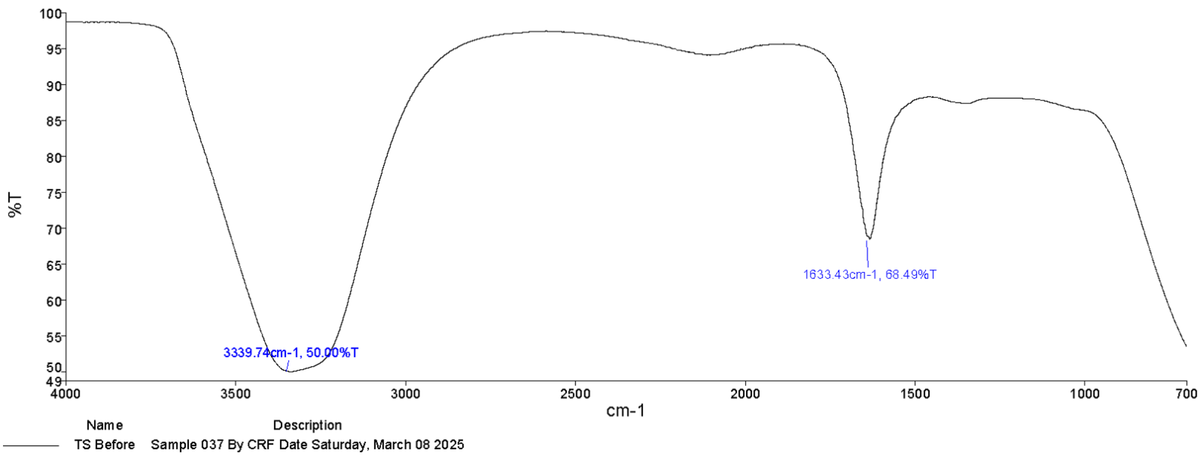
Aqueous plant extract Tabebuia rosea

The FTIR



Spectrum of *Tabebuia rosea* and AgNPs shows the characteristics band at 3343.80cm-1 (51.09%), 1633.66cm-1(70.55%), 1003.82cm-1(79.20%) which correspond to C=O and O-H stretching.

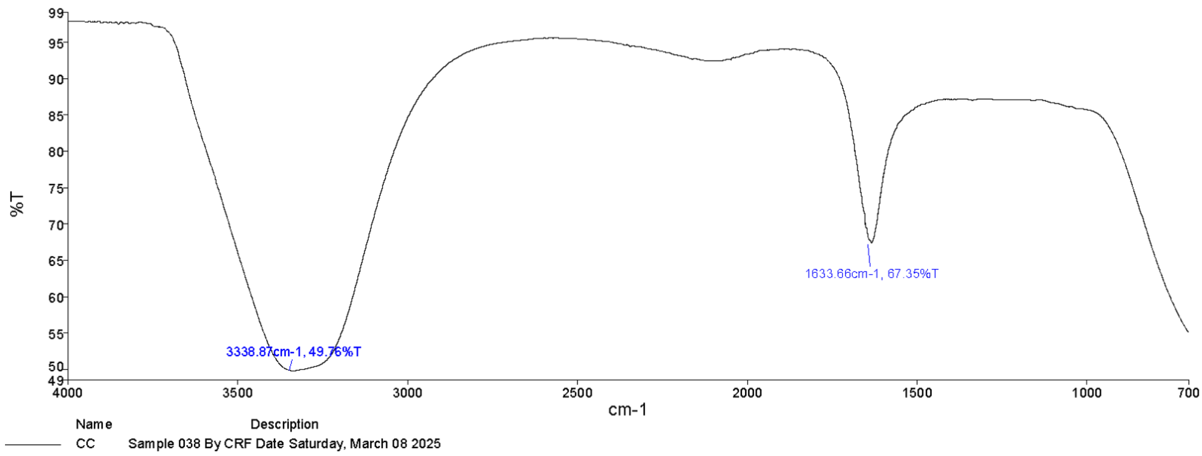
Aqueous plant extract Tecoma stans



The FTIR

Spectrum of *Tecoma stans* and AgNPs shows the characteristics band at 3339.74cm-1 (50.00%) which indicates O-H Stretching and 1633.43cm-1(68.49%) which correspond to C=O stretching vibrations.

Aqueous plant extract Cresentia cujete



The FTIR Spectrum of *Cresentia cujete* and AgNPs shows the characteristics band at 3338.87cm-1 (49.76%) it shows the broad O-H stretching and 1633.66cm-1(67.35%) which correspond to C=O stretching vibrations.

CONCLUSION

The research highlights the effective synthesis and characterization, along with potential uses, of silver nanoparticles (AgNPs). Through the utilization of UV-Vis spectroscopy and FTIR (Fourier Transform Infrared Spectroscopy) the results indicated that silver nanoparticles were formed using the green synthesis approach. The nanoparticles stated have great potential in industrial, environmental, or medicinal domains.

In summary, the research indicated that silver nanoparticles are potential for a number of scientific and industrial breakthroughs due to their simple synthesis and controlled features. Optimizing synthesis techniques, investigating long-term stability, and looking into new applications might be the main areas of future research.

FUTURE SCOPE

Green synthesis of silver nanoparticles has a bright future due to developments in sustainability, medicinal applications, environmental remediation, and material science. The strategy might transform a number of sectors by providing more sustainable and biocompatible substitutes for conventional techniques, in addition to meeting the increasing need for economical and environmentally friendly nanoparticle manufacturing. To fully achieve the promise of this novel approach, more study into process optimization, scalability, and safety evaluations will be required.

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