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Exploring Green Extracts for Silver Nanoparticle Synthesis

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Abstract

This inclusive review explores the synthesis of AgNPs using eco-friendly green methodologies, specifically plant extracts. This environmental friendly approach has emerged as a economical and simple option to conventional chemical process. The synthesis of AgNPs from plant extracts involves a "green" route, emphasizing aqueous extracts from diverse plant sources. In addition to the synthesis process, the potential of these green-synthesized AgNPs are discussed in this review.

The goal of this study was to deliver a inclusive overview of the green synthesis of Ag nano particles using plant extracts, shedding light on potential applications, and paving the way for continued innovation in this eco-friendly and promising field. In this study, various green extraction methods for the synthesis of silver nanoparticles are compared and their effectiveness is discussed. In this review, an exploration of silver nanoparticle synthesis using different plant extracts is presented. The different sizes and structures arising from these extraction methods will be carefully examined and compared. By examining the intricacies of the synthesis processes, this review aims to clarify not only the scientific implications but also the practical applications that may arise from preparing nanoparticles based on plant extract variation.

Keywords: AgNPs; Eco-friendly; Green Synthesis; Plant Extracts; Antibacterial Activity.

Introduction

Silver nanoparticles are tiny particles of silver with dimensions in between 1 to 100 nm. They possess different and chemical properties as they have small size and high surface area. Nano materials are objects that possess optical and electrical properties that mainly depend upon the size and shape of nanoparticles. Various methods are available for synthesizing silver nanoparticles, including chemical reduction, physical methods, and bio synthesis. The choice of method can affect the size, shape, also the properties of the nanoparticles. The green synthesis of silver nanoparticles is essential because it is eco-friendly , minimizes the use of hazardous chemicals, and promotes sustainable practices. Using natural extracts, plants, or microorganisms as reducing agents, this method enhances biocompatibility, reduces energy consumption, and is often cost-effective.

The process preserves the biological activity of the used sources and typically produces fewer toxic by-products, aligning with green chemistry principles. Overall, green synthesis addresses environmental concerns associated with traditional methods, making it a crucial approach

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for the eco-friendly production of silver nanoparticles with contradictory applications in medicine, electronics, and other fields. The synthesis of silver nanoparticles (AgNPs) owns considerable target in the dynamic landscape of nanotechnology because of its diverse applications, ranging from catalysis to antibacterial activity. This review explores green extracts derived from plants as an non-polluting and sustainable path for AgNP synthesis. Motivated by concerns surrounding the toxicity of chemicals in conventional methods, the observed synergistic antibacterial effect underscores the potential of this green-synthesized nanomaterial as an antibacterial alternative. This review aims to unravel the promising developments in green synthesis.

Method and materials

General materials

1. Silver Precursor: Silver nitrate ($AgNO_3$) is usually used.
2. Plant Extracts :A green reducing agent derived from plants, such as leaf or seed extracts, acts as a reducing and stabilizing agent.
3. Solvent: Deionized water or another environmental friendly solvent is typically used.
4. Apparatus for heating : To facilitate and control the synthesis process.
5. Equipment for stirring : To ensure uniform mixing during the synthesis.
6. Sonicator : To disrupt and disperse nano particles using ultrasonic the nanoparticles ,
7. Characterization Tools: UV-Visible spectrophotometer, transmission electron microscopy (TEM) and X-ray diffraction (XRD) are utilized analyzing the size, shape, also the structure of the nanoparticles.
8. PH-modifying Agents: To control the pH of the reaction, basic or acidic solutions are often utilized.

In the virtue of the green synthesis of silver nanoparticles, plant extracts, like neem or aloe vera, serve as non-polluting reducing agents. These extracts accommodate bioactive compounds that involve a important role in converting silver ions into silver nanoparticles. The silver precursor, often silver nitrate, reacts with the bioactive components in the plant extract under specific conditions, leads to the emergence of green silver nanoparticles. These nanoparticles are typically stabilized using agents like polyvinyl alcohol or polyvinylpyrrolidone. The synthesis process may involve heating and stirring, and the resulting nanoparticles can be characterized using techniques like UV-Visible spectroscopy.

Method

(Fig: 1)

Plant Selection

Selection involves a comprehensive consideration of the plant's availability and, ensuring it serves as source of reducing agents for the subsequent synthesis of silver nanoparticles.

Plant Extract Preparation

Extraction methods that are applied with accuracy including the complex procedures of maceration and soxhlet extraction. flavonoids, polyphenols,and terpenoids are just a few of the many phytochemicals that are intended to be captured in this artistic stage . These substances have the potential to be the catalyst for the reduction of silver ions, hence addition of plant extract to precursor solution .

It takes great thought and planning to combine the plant extract with a well-made precursor solution, which frequently contains silver nitrate. It entails the harmonic merging of plant-derived chemicals with silver ions, laying the

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groundwork for a green, long-term reduction process. By utilizing the plant extract's natural lowering ability, this clever integration guarantees an eco-friendly synthesis.

Reduction reaction: plant extract's bioactive ingredients serve as a guide for the carefully watched procedure of starting the reduction reaction. These substances interact with silver ions in a coordinated way, serving as organic reducing agents. The silver ions are reduced as a result of this well planned reaction of chemical components, which makes it simpler for silver nanoparticles to develop simultaneously. The complex interaction between these compounds controls the size and shape of the resultant nanoparticles in addition to affecting reaction kinetics..

Nanoparticle Formation

Watching the silver nanoparticles form slowly is an interesting element of the synthesis. The reduction process causes visible color changes, shifting from the original color of the precursor solution into distinctive colors of brown or reddish-brown. This visual transition is a concrete indicator of the effective creation of nanoparticles, indicating an important step in the synthetic process.

Characterization

Characterization provides the application of sophisticated analytical techniques:

UV-Visible Spectroscopy: This method provides valuable insights into the nanoparticles' size, shape, and concentration by analyzing their absorption spectrum.

X-ray Diffraction: XRD gives the nanoparticles' crystal structure, composition, and purity.

Electron Microscopy (TEM or SEM): At a microscopic level, these techniques allow for the visualization of nanoparticles, offering detailed information about their morphology, size distribution.

Results and Discussion

(Table 1.1)

1. **Limonia acidissima :**

   Size and Shape: Silver nanoparticles were synthesized with size ranging from 25 to 45 nanometer, exhibiting a spherical shape. The plant's purple acid phosphatase apoenzyme played a crucial role in the green synthesis process.[1]

2. **Capparis spinosa L :**

   Size and Shape: The leaf extract of Capparis spinosa L. facilitated the formation of spherical silver nanoparticles accompanied by size in between 5 to30 nanometer.[2]

3. **Banana Peel:**

   Size and Shape: Banana peel extract contributed to the synthesis of spherical silver nanoparticles accompanied by size in the range of 10 to30 nanometer.[3]

4. **Aloe Vera :**

   Size and Shape: A hydrothermal method utilizing Aloe vera plant extract resulted in silver nanoparticles accompanied by size ranging from 20 to 60 nanometer, exhibiting a spherical shape.[4]

5. **Urtica dioica Linn :**

   Size and Shape: The synthesis using Urtica dioica Linn. leaves led to nearly spherical silver nanoparticles size varying from 20 to 40 nanometer.[5]

6. **Clitoria ternatea :**

   Size and Shape: Clitoria ternatea extract contributed to the formation of spherical silver nanoparticles accompanied by size in the range of 2 to 40 nanometer.[6]

7. **Tectona grandis :**

   Size and Shape: The seeds extract of Tectona grandis resulted in silver nanoparticles

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accompanied by size between 10 to 30 nanometer and a predominantly oval and spherical shape.[7]

8. **Neem** :

Size and Shape: Green synthesis using Neem leaves extract yielded nearly spherical silver nanoparticles accompanied by size ranging from 5-20 nanomter.[8]

9. Eucalyptus globulus:

Size and Shape: Eucalyptus globulus leaf extract contributed to the formation of spherical silver nanoparticles accompanied by size in the range of 1.5–25 nanometer.[9]

10. **Oak** :

Size and Shape: Synthesis using oak fruit hull extract resulted in cubic and spherical silver nanoparticles accompanied by an average size of 40 nanometer.[10]

11. **Tea** :

Size and Shape: Tea leaf extract played a role in synthesizing spherical silver nanoparticles with size around 20 nanometer.[11]

12. Cuminum cyminum :

Size and Shape: Cuminum cyminum extract caused to the formation of spherical silver nanoparticles accompanied by size of approximately 12 nanometer.[12]

13. **Hena** :

Size and Shape: Hena extract contributed to nearly spherical silver nanoparticle accompanied by an average size of 50 nanometer.[13]

14. Cinnamomum cassia :

Size and Shape: Cinnamon extract was utilized for synthesizing nearly spherical silver nanoparticles accompanied by size ranging from 2-30 nanometer.[14]

15. Hagenia abyssinica :

Size and Shape: The leaf extract of Hagenia abyssinica facilitated the synthesis of spherical silver nanoparticles accompanied by size in the range of 5-30 nanometer.[15]

16. Datura metel :

Size and Shape: Silver nanoparticles were synthesized using Datura metel extract, resulting in rod-like and spherical shapes.[16]

17. Croton macrostachyus :

Size and Shape: The leaf and bark extracts of Croton macrostachyus led to the formation of spherical silver nanoparticles accompanied by size ranging from 5-20 nanometer.[17]

18. Rice Husk :

Size and Shape: Silver nanoparticles were synthesized using rice husk extract, resulting in nearly spherical shapes accompanied by size varying from 10-20 nanometer.[18]

19. Zingiber officinale and Thymus vulgaris :

Size and Shape: The synthesis using the combined extracts of Zingiber officinale and Thymus vulgaris yielded spherical silver nanoparticles accompanied by size between 5-20 nanometer [19]

Discussion

The diverse plant extracts employed in the green synthesis of silver nanoparticles possess proven effective in generating nanoparticles of varying sizes and shapes. The choice of plant extract involves crucial role in determining the characteristics of the synthesized nanoparticles. The cited references provide valuable insights into the green synthesis process, emphasizing the environmental friendly and sustainable nature of these methodologies. Further investigations into the applications and properties of these nanoparticles could unlock their potential in

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various fields, including medicine, catalysis, and antibacterial agents.

In summary, the green synthesis of silver nanoparticles (AgNPs) using various plant extracts has demonstrated promising results with diffrent sizes and shapes. The effectiveness of each method depends on specific application requirements. Neem and Urtica dioica Linn. extracts produced smaller, nearly spherical nanoparticles (5-20 nm), suitable for biomedical applications. Tectona grandis exhibited a mix of oval and spherical AgNPs (10-30 nm), providing diversity in shape and size for potential applications in agriculture. Aloe Vera yielded larger, spherical AgNPs (20-60 nm), offering possibilities in drug delivery or catalysis. The choice of the most effective method is contingent upon the intended application, showcasing the versatility and potential wide-ranging applications of green-synthesized AgNPs across various fields.

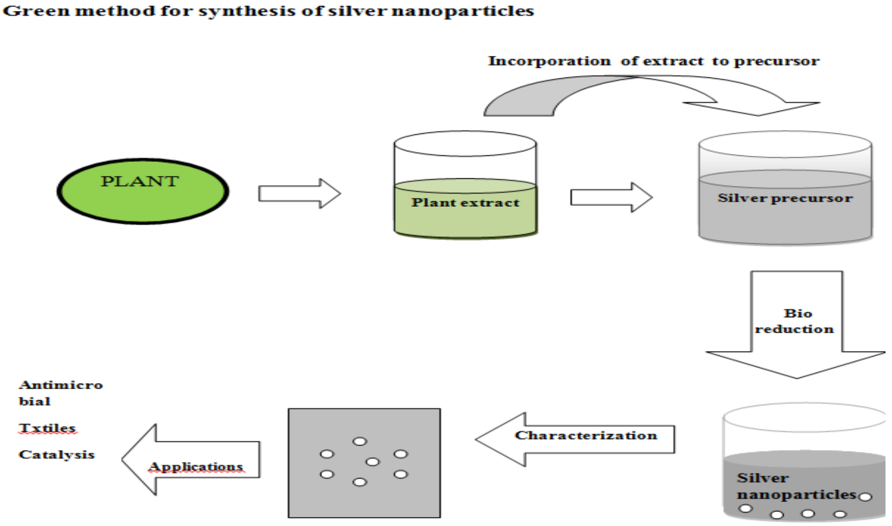

Table 1.1 : Results for Green synthesis of silver nano particles.

Plant\plant extracts	Size(nm)	Shape	References
Limonia acidissima.	25-45	Spherical	[1]
Capparis spinosa L.	5-30	Spherical	[2]
Banana peel.	10-30	Spherical	[3]
Aloe vera	20-60	Spherical	[4]
Urtica dioica Linn	20-40	Spherical	[5]
Clitoria ternatea	20-40	Spherical	[6]
Tectona grandis	10-30	Oval, spherical	[7]
Neem	5-20	Spherical	[8]
Eucalyptus globulus	1.5–25	Spherical	[9]
Oak	40	Cubic, spherical	[10]
Tea	20	Spherical	[11]
Cuminum cyminum	12	Spherical	[12]
Hena	50	Spherical	[13]
Cinnamomum cassia	2-30	Nearly spherical	[14]
Hagenia abyssinica	5-30	Spherical	[15]
Datura metel	5-50	Spherical	[16]
Croton macrostachyus	5-20	Rod like , spherical	[17]

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Rice husk	20	Spherical	[18]
Zingiber officinale and Thymus vulgaris	10-20	Spherical	[19]

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Conclusion

The utilization of a variety of plant extracts in the environmental friendly production of silver nanoparticles has demonstrated efficacy in producing nanoparticles with distinct sizes and forms. An important factor in defining the properties of the produced nanoparticles is the selection of plant extract. The references provided offer insightful explanations of the green synthesis process, highlighting the sustainable and eco-friendly characteristics of these techniques. Additional research on these nanoparticles uses and characteristics may be able to fully realize their promise in a number of industries, such as antibacterial agents, medicine, and catalysis.

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