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Green Synthesis Mediated Preparation and Characterization of Metallic Nanoparticles of Cactus *(Opuntia* ficus-indica)

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Abstract: *Metal nanoparticles (MNPs), sized between 1–100 nm, possess unique physical, chemical, and biological properties, making them valuable across fields such as biomedicine, catalysis, electronics, and environmental remediation. This study explores the green synthesis of MNPs using Opuntia ficus-indica (prickly pear cactus) extract, which serves as a natural reducing and stabilizing agent. This eco-friendly method eliminates the need for toxic chemicals, offering a sustainable alternative to conventional synthesis. The biosynthesized nanoparticles show promise in diverse applications including biomedical therapies, water purification, cosmetics, agriculture, and food packaging, highlighting their multifunctional potential in enhancing human health and environmental sustainability..*

Keywords: Preparation and Characterization of Metallic Nanoparticles ,Cactus (Opuntia ficus-indica)

I. INTRODUCTION

Metal nanoparticles(MNPs) have come an innovative instrument across a wide diapason of fields, from biomedicine and catalysis to electronics and environmental pollution remediation. These small patches, which typically range in size from 1- 100 nanometers, own special physical, chemical, and natural parcels making them different from their bulk counter corridor. Having a high face area- to- volume rate, MNPs have an increased reactivity, conductivity, and optic parcels that make them suitable for multitudinous operations. Ranging from targeted medicine delivery and biomedical imaging to catalytic transformers and electronic bias, MNPs are being delved for their capability to revise multitudinous diligence and enhance our quality of life. Opuntia ficus- indica, or the prickly pear cactus, has been a prized resource for centuries, yielding food, fodder, and indigenous drug. In recent times, scientists have set up a new use for this protean factory the biosynthesis of essence nanoparticles. The excerpt of Opuntia ficus- indica has been shown to parade reducing and stabilizing capability and hence a great seeker for the eco-friendly conflation of essence nanoparticles. This new process provides a sustainable means of conflation compared to conventional chemical conflation, which avoids the necessity for poisonous chemicals and minimizing environmental pollution. In this exploration, we probe biosynthesis of essence nanoparticles from Opuntia ficus- indica excerpt, emphasizing the possibility of this approach for nanoparticle product with distinct operation.

APPLICATION

1. Biomedical applications: The nanoparticles have potential uses in biomedical applications, including wound healing, tissue engineering, and anticancer therapy.
2. Water treatment: Antimicrobial and catalytic activity of these nanoparticles make them applicable for water treatment purposes, like purifying pollutants and contaminants from water.
3. Cosmetics and skincare: Due to the antioxidant and antimicrobial nature of these nanoparticles, they are applicable for cosmetics and skincare products, like anti-aging lotions and wound healing creams.

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4. Agricultural applications: The nanoparticles can be used in agriculture, like plant growth stimulation, pest management, and soil purification.
5. Packaging of food: The antimicrobial nature of these nanoparticles renders them appropriate for food packaging purposes, including shelf life extension and spoilage prevention Creams are the topical preparations which can be applied on the skin.

TAXONOMICAL CLASSIFICATION

- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Magnoliopsida
- Family: Cactaceae
- Genus: Opuntia
- Species: Opuntia ficus–indica
- Botanical Name: Opuntia ficus–indica
- Common Name: prickly pear cactus
- Synonym: prickly pear

The prickly pear, whose scientific name is Opuntia ficus Indica is a succulent plant, a cactus of the Cactaceae family spread in the Mediterranean, recognizable by its various fruits, by spiny blades called cladodes, thick and fleshy but over all resistant to failure or in further thirsty areas, similar as in Sicily, where it grows wild. Opuntia ficus Indica represents in the world of cosmetics a real concentrate of important salutary parcels for the skin. From the cladodes it's possible to gain an excerpt rich in gum and pectin that promote the mending of injuries and becks as well as having an emollient and soothing action like the most notorious Aloe. Its fruits, called tuna, in addition to being largely appreciated for their bright colors and organoleptic characteristics, are particularly rich in sugars, amino acids, vitamin C and vitamin E and especially antioxidant factors. Opuntia ficus- indica or prickly pear cactus is largely antimicrobial against several bacteria and fungi. Excerpts of colorful factory corridor, similar as cladodes(stems), fruits, and seed canvases , have inhibited growth of both Gram-positive and Gram-negative bacteria, as well as some fungi.

RATIONALE

1. Renewable and Sustainable Resource Opuntia ficus- indica is a readily available and furnishing a sustainable volition to traditional chemical conflation styles.
2. Eco-Friendly Synthesis system-Employing Opuntia ficus- indica excerpt provides an indispensable system for synthesizing nanoparticles without exercising dangerous chemicals, therefore creating a more environmentally-friendly system of nanoparticle product.
3. Biomedical and Pharmaceutical Applications These nanoparticles have biocompatible accoutrements with antimicrobial and antioxidant parcels, therefore they can be used in the drug and pharmaceutical diligence for crack treatment, towel engineering and indeed cancer curatives.
4. Scalability and Cost- Effectiveness The use of Opuntia ficus- indica excerpt for nanoparticle conflation offers a cost-effective and scalable approach, making it an seductive option for artificial and marketable operations.
5. Interdisciplinary Research openings This exploration area islands the gap between accoutrements wisdom, biology, and drug, furnishing openings for interdisciplinary collaboration and invention.

OBJECTIVES

1. Studying the phytochemical properties of Opuntia ficus-indica extract nanoparticles can be formed with.
2. Illustrate the process of biosynthesis of the metallic nanoparticles and latterly Characterize the patches for size, and stability.
3. probe the implicit uses of these nanoparticles in fields similar as biomedicine, environmental remediation, and catalysis

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4. punctuate the benefits of using factory- grounded conflation over traditional styles, including reduced toxin and environmental impact.
5. Discuss challenges, limitations, and future prospects in the green synthesis of nanoparticles using plant extracts

MATERIALS AND METHODS

Collection Of Materials:

The Opuntia ficus-indica and the other chemicals such as Silver nitrate, Ethanol was taken from Sarojini college of pharmacy from Chemistry laboratory.

Extraction method : Extract was prepared by the soxhlet method.

• Took a Fresh Cladodes of plant then it was be Grinded with the help of mixer grinder until its converted to the mucilage.
• The mucilage of cladode was extracted with Water using a Soxhlet apparatus.
• Then the extract was stored in glass bottle in cool place for further experiment.

Excipients with their role

Ingredients role

1 Opuntia ficus-indica=Reducing and stabilising agent
2 Silver Nitrate= Precursor
3Distilled water= Solvent

Formulation

The preparation of Silver Nanoparticles using Opuntia ficus indica cladodes extract.

1) Preparation of Plant Extract: Obtain an extract from Opuntia ficus-indica by boiling or immersing the plant material in water or a solvent.
2) Silver Salt Solution: Prepare a solution of silver nitrate ($AgNO_3$) or a different silver salt.
3) Reduction Reaction: Combine the extract with the solution of silver salt, so the phytochemicals present in the extract can reduce the silver ions to form silver nanoparticles.
4) Stabilization: Phytochemicals present in the plant extract can also stabilize the resulting nanoparticles to avoid agglomeration.

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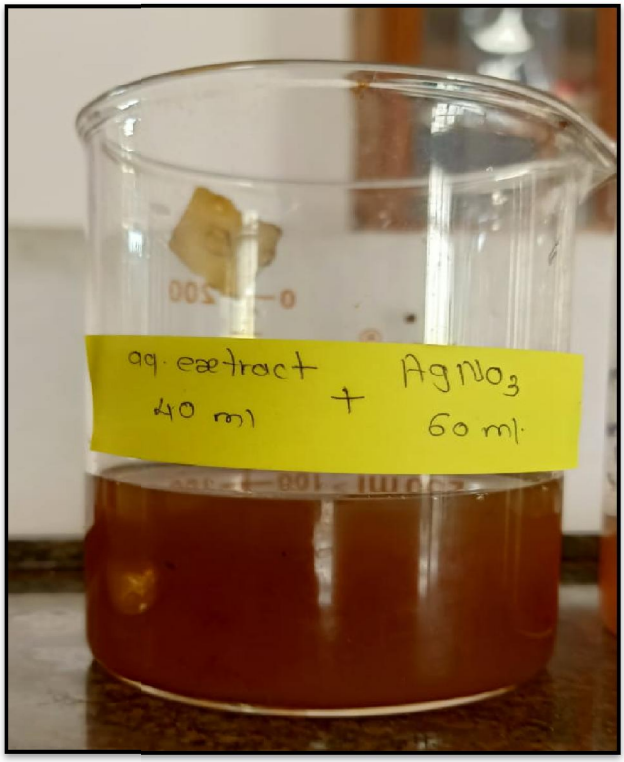
Sr .No	Ingredients	Quantity (%)	Uses
1.	Aqueous extract of Opuntia ficus-indica	40	Anti-microbial
2.	Silver nitrate solution	60	Precursor



Characterization of Nanoparticle:

• UV-Visible Spectroscopy:

Analyzes the interaction between the nanoparticles and light, providing insights into their electronic structure and conforming their formation.

• Fourier transform-infrared analysis [FT-IR]:

FTIR analysis, or Fourier Transform Infrared Spectroscopy, is a technique used to identify and characterize the chemical composition of materials by analyzing their absorption of infrared radiation.

• Particle Size Determination:

Determines the size, structure and shape of the nanoparticles, confirming their metallic nature and providing information on their parameters.

• zeta potential: zeta potential helps to measure the charge on the surface of the particle.

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Pharmacological Evaluation

Sr.No	Sample	Concentration	Zone of Inhibition (mm) B.subtili	Zone of Inhibition (mm) P.aeruginosa
1.	Control	-	-	-
2.	Standard Streptomycin	1mg/ml	25	26
3.	Sample- Silver Nanoparticles	5mg/ml 10mg/ml	01 12	01 04

II. CONCLUSION

Overall, the green synthesis of metal nanoparticles employing Opuntia ficus-indica extract provides an eco-friendly and sustainable method to obtain nanoparticles of specific properties. The phytochemicals from the cactus extract are also responsible for metal ion reduction as well as the stabilization of nanoparticles. The as-formed nanoparticles possess stability, monodispersity, and future applications in medicine. In summary, this green synthesis process offers a promising direction towards the development of nanoparticles with increased performance and biocompatibility, deserving further research and investigation for numerous applications.

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