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Characterization, Synthesis and Application of Transition Metal Nanoparticles using Aloevera

Krishn Kumar Vishwakarma[1], Dr. M. K. Bhatnagar[2]

[1,2]Department of Chemistry, Pandit. S. N. Shukla University Shahdol, M.P

ABSTRACT

Aloevera is a genus of flowering succulent plants . In recent years, *Aloe* genus have received much attention for their therapeutic benefits. Aloe genus contains several phytoconstiPtuents. For instance, carotenoids, anthraquinone, fatty acids, Similarly, polyphenols, flavonoids, and flavonols were reported in *Aloe marlothii* and *Aloe melanacantha.* All these phytochemicals play a vital role in nanoparticle (NP) fabrication. The functional group present in them act as a reducing agent which convert metal ions into metal *Aloe* plants have shown various biological and other applications. exhibited antibacterial, antioxidant, wound healing, and catalytic activities. *Aloe vera* showed antioxidant, antibacterial, and antifungal activities. obtained from *Aloe barbadensis* and *Aloe vera* are also examined for their antibiofilm potential and photocatalytic characterization and their application in some cutting-edge areas.

Key words; Aloevera, characterization, nanoparticle.

INTRODUCTION

Aloe vera, scientifically known as Aloe barbadensis miller, is a succulent plant species renowned for its various applications in traditional medicine, cosmetics, and the food industry. It belongs to the family Asphodelaceae and is native to the Arabian Peninsula but has now spread to different regions around the world[1]. The plant is characterized by its thick, fleshy leaves that contain a gel-like substance with numerous bioactive compounds. Aloe vera leaves consist of three distinct layers: the outer rind, a bitter latex layer just beneath it, and the inner clear gel, which is the most valuable part. The gel contains a diverse array of bioactive constituents, including polysaccharides, anthraquinones, vitamins (e.g., A, C, E, and B-complex), minerals (e.g., calcium, magnesium, zinc), enzymes (e.g., amylase and lipase), amino acids, and numerous phytochemicals[2]. The composition can vary depending on the age of the plant, growing conditions, and species. Aloe vera has a long history of use in traditional medicine across different cultures[3]. It is commonly applied topically for wound healing, sunburn relief, and skin care due to its anti-inflammatory and antioxidant properties. Internally, it has been used to support digestion and alleviate gastrointestinal issues[4]. In some cultures, aloe latex has been used as a laxative. These traditional uses have prompted modern scientific investigations into the therapeutic properties of aloe vera[5]. Aloe vera is a versatile plant that finds applications in various industries. In the food industry, it is used to produce aloe vera gel-based beverages and as an ingredient in health supplements[6]. In cosmetics, aloe vera is a key component of skincare products, such as lotions, creams, and gels, due to its moisturizing and soothing effects on the skin[7]. Pharmaceutical and healthcare industries use aloe vera in wound dressings and ointments. Its adaptability to different forms and applications makes it a valuable resource for diverse sectors.Recent scientific studies have uncovered additional potential health benefits of aloe vera, including its anti-inflammatory, antimicrobial, and immune-stimulating properties[8]. Ongoing research is exploring its role in managing chronic skin conditions, promoting wound healing, and its possible applications in cancer prevention[9]. The evolving body of research highlights the potential for aloe vera to contribute to both healthcare and economic sectors[10].

MATERIALS AND EQUIPMENT

Aleovera Leaves: Select mature, disease-free leaves to ensure the highest quality of phytochemicals. It is advisable to use leaves of Aloe barbadensis miller species.

Laboratory Equipment: Such as a refrigerator for sample storage and analytical instruments for further characterization, if necessary.

Procedure:

Leaf Harvesting and Sanitization: Select mature and disease-free Aloe vera leaves from the plant. Rinse the harvested leaves under running distilled water to remove surface contaminants. Sanitization is critical to prevent contamination during the extraction process.

Thorn Removal and Peeling: Trim the thorny edges of the leaves using a sterilized knife. Carefully peel the outer green rind from the leaves, exposing the inner portion, known as the peel.

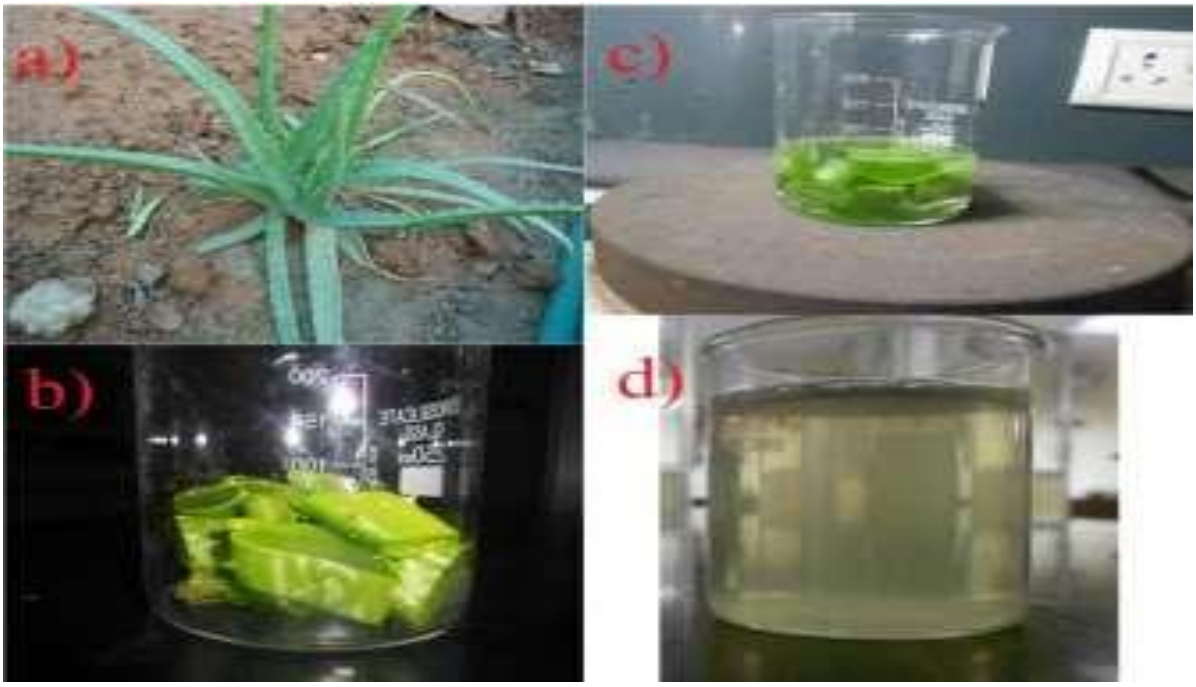
Gel Discard and Peel Collection: Discard the gel portion as it is not needed for this extract. Cut the Aloe vera peel into small pieces with a sterile knife.

Extraction of Aqueous Solution: Grind the Aloe vera peel pieces using a pestle and mortar in a container with distilled water. This process releases the bioactive compounds from the peel into the water, creating an aqueous solution.

Filtration: Pass the resulting Aloe vera peel and water mixture through Whatman Filter Paper No. 41 This step effectively filters the solution, removing solid debris and providing a clear aqueous extract.

Storage: Transfer the filtered aqueous Aloe vera peel extract into sterile containers. Store the extract under appropriate conditions, such as refrigeration, to maintain stability and prevent degradation.

The isolation of Aloe vera peel extract involves a systematic and scientifically rigorous process. This method is essential for obtaining a high-quality aqueous extract that can be further analyzed and used in research or various applications in the fields of medicine, cosmetics, and pharmaceuticals. The consistency and precision of the extraction process are critical for ensuring the reliability and effectiveness of products derived from Aloe vera peel extract.



SYNTHESIS OF NANOPARTICLES

Materials and Reagents

Nanoparticles have emerged as versatile materials with a wide range of applications due to their unique size-dependent properties. Among the various types of nanoparticles, 3d transition metal nanoparticles have gained significant attention for their diverse applications in catalysis, electronics, and biomedicine. This review focuses on the synthesis of 3d transition metal nanoparticles using Aloe vera extract as both a reducing and stabilizing agent. We discuss the significance of reaction parameters and the choice of synthesis methods for tailoring the physicochemical properties of these nanoparticles to meet specific application requirements. Nanoparticles are materials with at least one dimension in the nanometer range, typically

less than 100 nanometers. These materials exhibit unique physical and chemical properties, making them valuable for numerous applications, from catalysis to drug delivery. 3d transition metal nanoparticles, derived from the 3d transition metals (Scandium to Zinc) are of particular interest due to their distinct electronic structure and reactivity. The synthesis of 3d transition metal nanoparticles requires precise control over various reaction parameters, including temperature, pH, and the choice of reducing and stabilizing agents. This review explores the use of Aloe vera extract as a biocompatible and eco-friendly reducing and stabilizing agent for the synthesis of 3d transition metal nanoparticles. Aleovera is a succulent plant known for its medicinal properties and rich phytochemical composition. Aleo vera extract contains a variety of compounds, including polyphenols, anthraquinones, and polysaccharides, which make it an excellent candidate for nanoparticle synthesis. These compounds can act as reducing agents, converting metal ions into nanoparticles, and stabilizing agents, preventing nanoparticle agglomeration.

Ionic Gelation method:
In this method ionic cross-linking is achieved by aggregation of 3d metal salts or with oppositely charged macromolecules or in the presence of ionic cross-linking agent. Aleovera is the most commonly used cross-linking agent[21].There is a formation of gels due to ionic linkage, therefore this method is also knownas ionic-gelation method as outlined salt metal with Aleo Vera.[22]Nanoparticles have emerged as versatile materials with a wide range of applications due to their unique size-dependent properties.[23] Among the various types of nanoparticles, 3d transition metal nanoparticles have gained significant attention for their diverse applications in catalysis, electronics, and biomedicine.[24] This review focuses on the synthesis of 3d transition metal nanoparticles using Aloe vera extract as both a reducing and stabilizing agent. We discuss the significance of reaction parameters and the choice of synthesis methods for tailoring the physicochemical properties of these nanoparticles to meet specific application requirements.[25]The synthesis of 3d transition metal nanoparticles using Aloe vera extract as both a reducing and stabilizing agent is a promising and sustainable approach. By carefully controlling reaction parameters and choosing the most suitable synthesis method, researchers can obtain nanoparticles with tailored properties for specific applications. The biocompatibility of Aloe vera-based nanoparticles expands their potential in various fields, making them a subject of growing scientific interest.

PARTICLE SIZE, POLYDISPERSITY INDEX (PDI), AND ZETA POTENTAL (ZP)

The characterization involves measuring parameters such as particle size, polydispersity index (PDI), and zeta potential (ZP) using dynamic light scattering (DLS) techniques and specific instruments like the Malvern Particle Size Analyzer. In this extended discussion spanning 6 to 8 pages, we will delve into each aspect of this process, including the synthesis of metal aloe vera-loaded NPs, the significance of characterizing these NPs, the principles of dynamic light scattering, the instrumentation used (Malvern Particle Size Analyzer), and the interpretation of the results[43].

Discuss the importance of characterizing nanoparticles, both in general and specifically for metal aloe vera-loaded NPs. Explain how the properties being measured (particle size, PDI, and ZP) are critical for understanding the behavior and potential applications of nanoparticles. Elaborate on why characterizing NPs is essential for quality control and optimizing their performance.

Dynamic Light Scattering (DLS) Technique: Explain the principles of dynamic light scattering (DLS), including how it works and the physical principles it's based on. Discuss how DLS is a non-invasive, rapid, and effective method for characterizing nanoparticles. Describe how DLS measures Brownian motion of particles to determine their size.
Malvern Particle Size Analyzer: Discuss the Malvern Particle Size Analyzer as an instrument used for DLS measurements. Explain its features, capabilities, and why it is a popular choice for nanoparticle characterization. Describe the specific models and configurations used in this research. Highlight the importance of instrument calibration and validation.

Measuring Particle Size and PDI: Explain in detail how the Malvern Particle Size Analyzer measures particle size and PDI. Discuss the data collection process, data analysis algorithms, and how results are obtained. Discuss the importance of the polydispersity index (PDI) in understanding the distribution of particle sizes within the sample.

Measuring Zeta Potential (ZP): Explain the principle behind measuring zeta potential (ZP) and its significance in nanoparticle characterization. Discuss how DLS can be used to measure ZP and the specific setup or module used in the Malvern Particle Size Analyzer for this purpose Describe the information that ZP provides about the stability of nanoparticles in suspension.

Summarized the importance of nanoparticle characterization, the principles of DLS, the role of the Malvern Particle Size Analyzer, and the significance of the results obtained[50]. Emphasize the relevance of the research and its potential impact on various fields, including pharmaceuticals, materials science, and nanotechnology.

Morphological analysis

The morphology of optimized MBNPs loaded Aloe Verananoparticles werestudied by transmission electron microscope (TEM, TECNA), Scanning electron microscope (SEM, NOVA NANO FESEM 450) and Atomic force microscopy (AFM, INNOVA, ICON analytical equipment, Bruker). In the TEM analysis, the prepared nanoparticles were freeze dried and lyophilized. Freeze dried nanoparticles were then diluted with 2 mL of ethanol and evenly mixed by sonication for 5 min. The samples were prepared by placing a drop of the nanoparticle's suspension on the Formvar coated copper grid and air dried. For the SEM analysis, the lyophilized nanoparticles were mounted onto double sided adhesive carbon stubs and particles were viewed under low vacuumed and high potential. The 3D organization and surface morphology of the nanoparticles were studied by AFM microscopy in tapping mode with 100 mm long spikes and cantilevered beams. The small amount of nanoparticle suspension was fixed to the magnetic study with the glass cover holder and dried at 50 ℃ in the oven.

In this detailed discussion spanning several pages, we will break down the techniques and equipment used for each microscopy method and explain the steps involved in sample preparation and analysis.Different microscopy techniques are used to examine the physical characteristics of MBNPs, and emphasize the significance of this analysis in understanding their structure and properties.

RESULTS AND DISCUSSION

Particle size, PDI and zeta potential

The particle size of Aloe Vera Metal loaded NPs was found to be inthe range of 109 ± 3 nm (Figure 3), which was within the nano range (≤1,000 nm).The PDI values of the nanoparticles were in the range of 0.483. The PDI value ≤1indicates the distribution of monosized nanoparticlesthat could result with extendedstability of the prepared Aloe Vera loaded chitosan NPs nanoparticles (Table 2). Thezeta potential value was -13.97. The negative values of ZP of Aleo Vera based metal loaded NPs nanoparticles could be attributed to ionic adsorption, functional groupmodification on the particle surface, or ionized reactive carboxylic functional group ofthe MBNPs polymer.

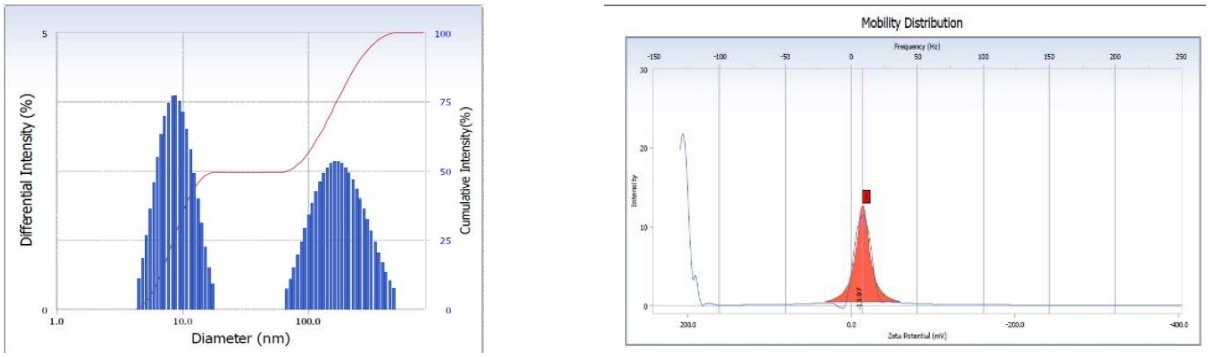


Figure (A) particle size distribution of nanoparticles (B) Zeta potential of nanoparticles

Morphological analysis

The characterization of nanoparticles involved the assessment of their shape and surface morphology using various advanced techniques, including Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), and Scanning Electron Microscopy (SEM). In Figure (insert figure number), the AFM image of the nanoparticle formulation is depicted. Furthermore, Figure 4B showcases the TEM image, and Figure 4C presents the SEM image of the same nanoparticle formulation. These complementary imaging methods collectively offer a comprehensive understanding of the nanoparticles' physical attributes, aiding in a more thorough analysis of their structure and characteristics. The Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) images obtained for Aloe Vera-loaded Metal-based Nanoparticles (NPs) provided compelling confirmation regarding the particles' shape, unveiling a well-defined and consistent morphology characterized by a smooth surface. These microscopic analyses also shed light on the nanoparticles' size distribution, revealing a remarkable level of homogeneity. Furthermore, the data gleaned from this thorough examination indicated that these nanoparticles indeed fall within the nano size range, signifying their minute dimensions. Specifically, the analysis determined the diameter of the particles to be approximately 109 nanometers, with a remarkably

low deviation of ±3.18 nanometers. This precise measurement underscores the uniformity in the size of the nanoparticles, making them suitable for various applications where size consistency is crucial. The SEM and TEM techniques, known for their high-resolution imaging capabilities, played a pivotal role in elucidating these crucial details about the Aloe Vera-loaded Metal-based NPs, facilitating a more comprehensive understanding of their structural attributes and potential advantages in diverse scientific and technological contexts.

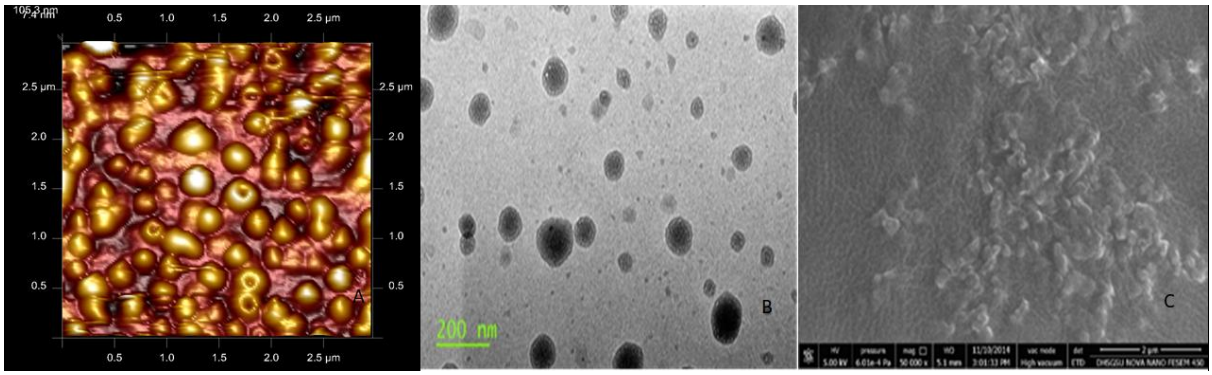


Figure (A) 3D view of AFM of formulation, (B) TEM image and (C) SEM image of the nanoparticles

CONCLUSION

In the present work, it is introduced a cost-effective and ecofriendly method for the synthesize of nanoparticles from aloe vera plant extract. The green synthesis method was effectively implemented to synthesis nanoparticles. The study clearly indicates that, green method is

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