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To Investigate the Accelerated, Environmental Friendly, and Sustainable Production of Copper Nanoparticles Utilizing the Flower Extract of Aloe Vera

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Abstract: In recent times, researchers have been focusing on the development of efficient methods for the green synthesis of metal nanoparticles. The objective is to discover a technique that is safe, cost-effective, and environmentally friendly for the production of well-defined nanoparticles. This study presents the phytosynthesis of copper nanoparticles using the extract of Aloe vera flowers. The copper ions in an aqueous solution were reduced from $Cu^{2}+$ to Cu^{0} when exposed to the flower extract, resulting in the formation of nanoparticles. The synthesized nanoparticles were characterized using a UV-Vis spectrophotometer, a field emission scanning electron microscope (FESEM), and Fourier Transform Infrared Spectroscopy (FTIR). The presence of an absorption peak at 578 nm in the spectrometer confirms the formation of Cu nanoparticles. The FESEM analysis was used to study the shape and morphology of the copper nanoparticles. FTIR analysis indicated the possible involvement of reductive groups on the surfaces of the nanoparticles.

Keywords: Green Synthesis, Copper, Nanoparticles, Precursor, Flower extract, Aloe Vera

I. INTRODUCTION

Nanotechnology is a burgeoning (flourishing) subject of study in modern science. Nanoparticles are widely used in medical chemistry, atomic physics, and other fields due to their small size, orientation, and physical properties, which have been shown to alter the performance of any other material that comes in contact with these tiny particles and have a size of 1-100 nm in one dimension. Different Chemical, Physical, and Biological processes can be used to make these particles. Because nanoparticles span the gap between bulk materials and atomic or molecular structures, they are of tremendous scientific interest. Physical and chemical qualities can alter as a result of changes in size. Metal nanoparticles are widely used due to their numerous applications in a variety of industries. One of the key goals in chemistry has been to create NPs with control over particle size, shape, and crystalline nature, which might be employed in biomedical, biosensor, catalyst for bacterial bio toxin elimination, and low-cost electrode applications. Because of their intriguing (interesting) uses, NPs with at least one dimension less than 100 nm, such as nano-sheets, nanotube, and nanowires, have gotten a lot of interest. Nanoparticles have been identified as a promising possibility for antimicrobial, antibacterial, and ant fungicidal drugs. To treat undesired malignant tumours, cytotoxic medicines kill chosen cells directly, influencing both the growth and behavior of surviving cells. Rheumatoid arthritis and systemic lupus erythematosus are two conditions that can be treated with cytotoxic drugs. They're frequently utilized in oncology therapies, which are one of the pharmaceutical and biotechnology industry's fastest-growing categories. While cytotoxic medicines have a wide range of therapeutic applications, their successful and safe manufacture necessitates a highly trained team of experts and well-controlled manufacturing facilities. Green biogenic metallic nanoparticles have the potential to be a powerful cytotoxic, apoptotic, and new antimicrobial agent. As a result, they're a suitable fit for medicinal, catalysis, electrochemistry. Biotechnology and trace-substance detection applications.

II. NEED OF THE STUDY.

1) The use of plants extracts for the production of copper nanoparticles due to its inexpensive and eco-friendly and biologically mediated process. 2) Nanoparticles Produced by plants are more stable and the rate of synthesis is faster than in the case of microorganisms. 3) It can be used as effective antimicrobial agent against pathogenic microorganism.

1. Green Synthesis Method of Nanoparticles

Green synthesis is the process of making materials from green or environmentally friendly resources by using a solvent, a good reducing agent, and harmless stabilizing ingredients. Furthermore, this synthesis method is simple; cost effective, trustworthy, long lasting, and somewhat repeatable, and its produces more stable molecules. Researchers have expressed interest in producing a variety of nano-materials, including metal/metal oxide nanoparticles, hybrid materials, using this biosynthetic approach. As a result, green synthesis is widely considered as an essential tool for reducing the negative effects (costly, dangerous, and expensive) of traditional nanoparticle synthesis methods used in laboratories and enterprises. Traditional nanoparticle production processes such as chemical and physical synthesis, have been shown to be costly, dangerous, and environmentally unfriendly. Not only that, various parameters such as size distribution, morphology, surface charge, surface chemistry, capping agents, and others may affect biological activities during nano production chemical synthesis. To prevent the negative consequences, scientist have identified the precise green routes, or naturally occurring sources and their products, that can be used to create nanoparticles. Researchers have found the specific green pathways, or naturally occurring sources and their products, that can be used to make nanoparticles to avoid this detrimental repercussion. (Harmful or damaging effect).

2. Probable Mechanism of Biosynthesis of Cu/CuO

Cu ions have different oxidation levels, such as Cu (I), Cu (II), and a few Cu (III) ions. To date, the synthesis technique reported for CuO, Cu2O, and Cu4O3 is the same in terms of plant extract, fungal extract, algal extract, bacterial extract, precursor concentration, pH, and temperature. However, these variables have the biggest influence on the type of Cu particles produced during green synthesis. The bio-molecules in the sample extract decrease the Cu2+ ion to Cu0 state and simultaneously oxidize it to generate CuO nanoparticles during the green synthesis. Certain bio-molecules included in the sample extract act as a capping agent and help to stabilize the nanoparticles generated.

3. Characterization of CuO/Cu-NPs

One researcher should go through a number of characterizations to determine the requirement for nanoparticle generation. The crystal structure and chemical composition of NPs are the first steps in the characterization process once they have been synthesized. Scanning electron microscopy, transmission electron microscopy, dynamic light scattering, particle analyzers, and field emission scanning electron microscopy were used to investigate the size and morphology of Cu/CuONPs, while UV–visible spectroscopy, X-ray diffraction, Fourier transform infrared spectroscopy, surface Plasmon resonance, and energy-dispersive X-ray spectroscopy were used to investigate the elemental chemical compositions of Cu/CuONPs.

III. RESEARCH METHODOLOGY

The methodology section outlines the plan and method that how the study is conducted. The details are as follows;

1 Preparation of Plant Extract

Fresh Aloe Vera blossoms were carefully washed with double distilled water, dried in an oven at 50 degrees Celsius for 72 hours, and cut into very fine pieces. 20 g of dried flowers were combined with 100 mL of double distilled water in an Erlenmeyer flask and heated for 5 minutes. The broth extract was filtered (0.45 mm) and stored at 4°C for future experiments, with the broth extract being used within a week.

2 Biosynthesis of Nanoparticles

Copper nanoparticles were typically made in the dark by mixing 20 mL flowers broth with 20 mL 5 mM Cu $(CH_3COO)\ _2H_2O$ aqueous solution. The reaction was carried out in a steam bath at 50°C for 30 minutes, until the solution's color changed from light green to dark green. The culture fluid was then chilled and incubated at room temperature overnight in the laboratory. The culture fluid had clearly deposited precipitate in the bottom of the flask the next day, leaving the colloidal supernatant at the top. Repeated centrifugation at 14,000 rpm for 10 minutes followed by redispersion of the pellet in deionized water purified the precipitated copper nanoparticles. Cu ions were produced in solution

3 Preservation Technique

Drying: One of the earliest and simpler methods of preserving flower is drying. Hot air drying in drying chamber: Compact flowers like marigolds, corn flowers. Aloe flowers and zinnias dry well in a fan-assisted, convection chamber. Non-ventilated chambers are not appropriate, because they generate too much moisture. The material must be dried at a low temperature (30-35˚Celsius), over many hours. The flowers are inserted into openings in a wire mesh rack, allowing the stems to hang freely below. The duration needed for this process varies depending on the number of flowers present.

Fig. 3.1: Inflorescences of Aloe Vera

IV. INSTRUMENT USED FOR PRELIMINARY ANALYSIS

1. UV-Visible Spectra Analysis

The UV-Vis spectrophotometer analysis was utilized to periodically monitor the production of copper ions in solution. A computer controlled Uv-vis spectrophotometer, specifically the Spekol 1500, was employed to conduct the UV-visible spectroscopy analysis within the wavelength range of 500 to 800 nm. To ensure accurate measurements, 0.2 ml of the suspension was diluted in 2 ml of deionized water and subsequently measured at room temperature.

2. Field Emission Scanning Electron Microscope (FESEM)

The examination of the size, shape, and morphology of the Cu nanoparticles was conducted using field emission scanning electron microscopy (FESEM). For analysis, a dried suspension of copper nanoparticles was synthesized through a reduction between Cu ions and the extract of Aloe vera flowers. The FESEM was utilized with an accelerating voltage of 25kV.

3. Fourier Transform Infrared Spectroscopy Measurements

Fourier transformed infrared radiation (FTIR) spectroscopy measurements were conducted to determine the potential biomolecules responsible for reducing Cu2+ ions and capping the copper nanoparticles synthesized using the flowers broth. The residual solution obtained after the reaction was subjected to centrifugation at 14000 rpm for 10 minutes to eliminate any remaining biomass residue or compounds, including unattached biological impurities, free proteins, or enzymes that are not the capping ligands of the nanoparticles. The resulting suspension was then re-dispersed in 10 ml of sterile distilled water. This centrifugation and redispersion process was repeated three times. The purified suspension was subsequently dried in an oven overnight at 60 degrees Celsius, yielding a small amount (0.01 g) for analysis using IR Spectroscopy.

V. RESULTS AND DISCUSSION

The reduction process of copper ions and the subsequent formation of nanoparticles commenced shortly after the initiation of the reaction at room temperature. A visual representation of Aloe vera, along with its flowers, is depicted in Fig. 5.1. The flower extract derived from this plant possesses the ability to convert Cu2+ to Cu0. It is widely acknowledged that UV-Vis spectroscopy is a suitable method for analyzing the size and shape of synthesized nanoparticles in an aqueous suspension. The absorption spectra displayed in Fig. 5.2, illustrate the changes in intensity of absorbance of the produced Cu nanoparticles over varying reaction times, without any significant shift in the maximum wavelength. Notably, the peak characteristic of copper nanoparticles was observed at approximately 578 nm.

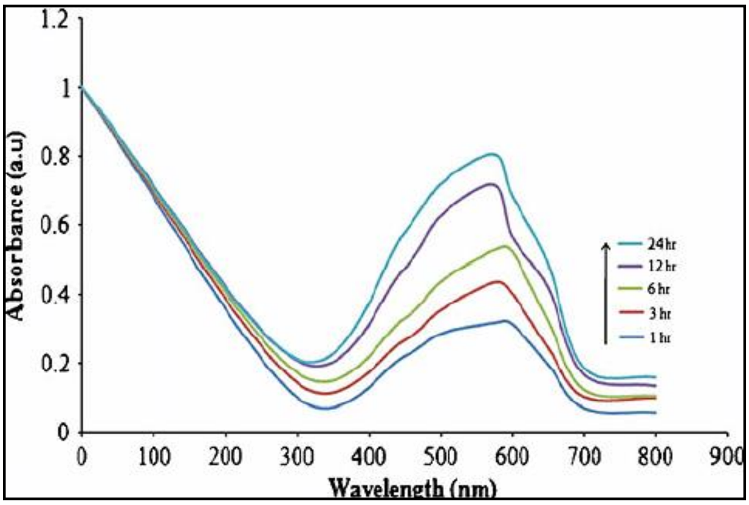
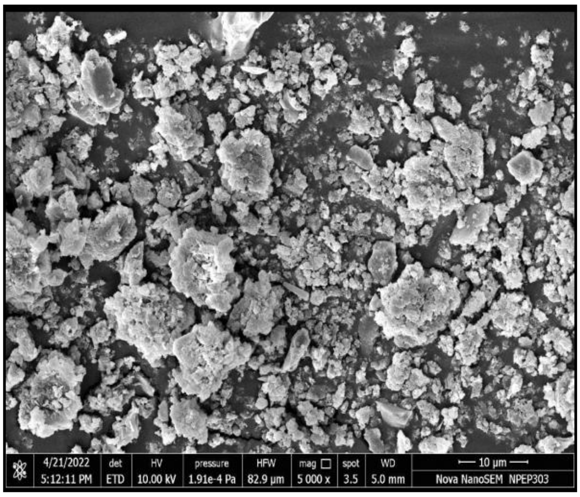
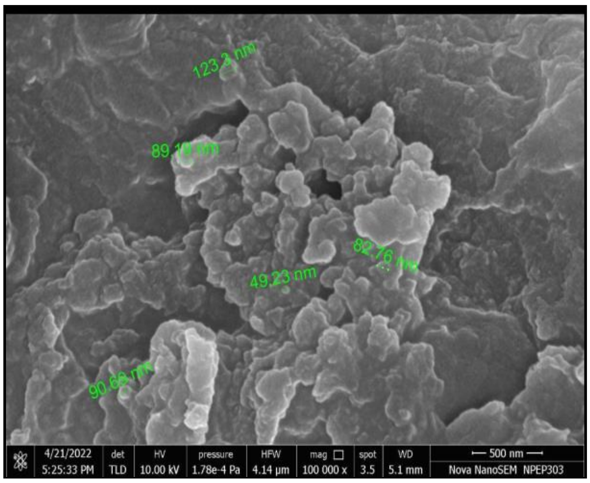


Fig. 5.1: UV-Visible Spectra of CuNPs from dried flower of Aloevera



(A) 10 µm NanoSEM



(B) 500 nm NanoSEM

Fig. 5.2: FESEM images of Copper Nano particles synthesized

In the FESEM study, it was observed that copper nanoparticles were formed and their morphological dimensions were determined. The average size of these nanoparticles was found to be 49.23 nm, and their shapes were spherical, (Fig. 5.2). The FESEM image provided additional evidence, confirming the synthesis of a large number of copper nanoparticles using the Aloe vera flowers extract. FTIR analysis was employed to identify the potential biomolecules accountable for the reduction of Cu ions and capping of the Cu nanoparticles generated using the flower extract. The FTIR spectrum of the copper nanoparticles (Fig.5.3) exhibited peaks at 3283, 2916, 2849, 1623, 1059, 721, and 523.32, in addition to other peaks. The peak at 2916 cm-1 corresponds to the stretching vibration of aliphatic amines or alcohols/phenols. The peak at 2849 cm-1 is attributed to the stretching vibration of aromatic amines. These peaks suggest the presence of proteins on the surface of the Cu nanoparticles. The variation in peak positions indicates that the proteins responsible for the synthesis of Cu nanoparticles are diverse.

These protein molecules serve as surface coating agents, preventing the internal agglomeration of the particles. The differences in peak positions suggest the presence of various metabolites, such as tannins, flavonoids, alkaloids, and carotenoids, which are abundant in the flower extract and can facilitate the production of Cu nanoparticles.

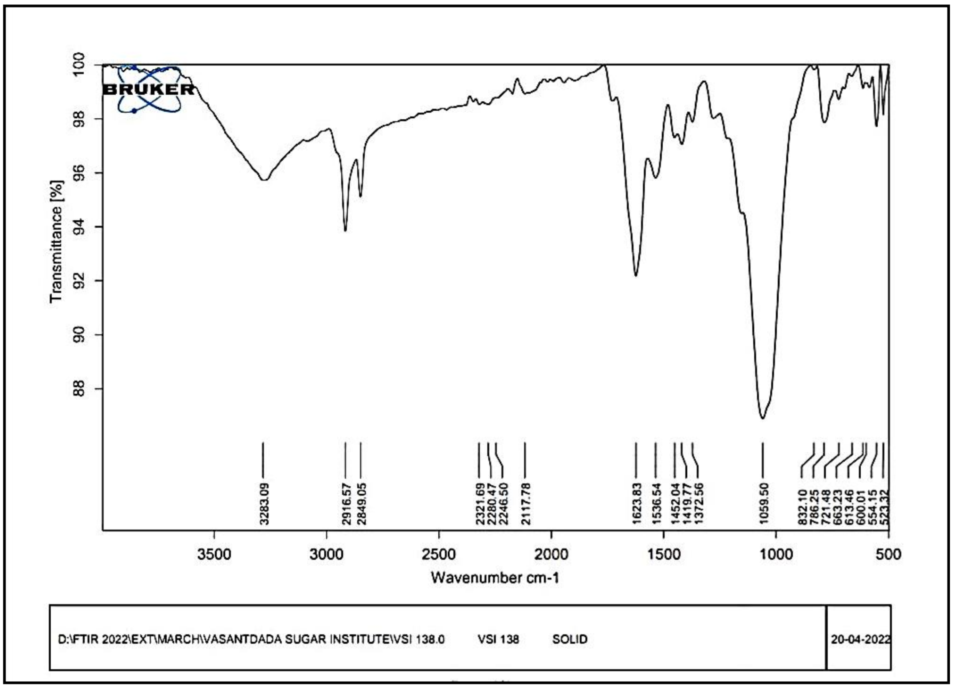


Fig. 5.3: FTIR adsorption spectra of Copper Nano particle synthesized by dried flower of Aloe Vera extract

VI. CONCLUSION

In conclusion, our study introduces an environmentally friendly and efficient method for synthesizing Cu nanoparticles. By utilizing Aloe vera flower extract, we were able to produce stable copper nanoparticles in a solution, replacing the need for chemical synthesis methods. This approach not only offers a greener alternative but also proves to be cost-effective. The copper nanoparticles obtained exhibited a spherical shape with sizes ranging from 40 to 89nm, as observed through FESEM analysis. Additionally, FTIR spectra indicated the presence of a protein-based thin film and secondary metabolites that coated the metal nanoparticles.

REFERENCES

1 Saxena, A., Tripathi, R.; et al. Biological synthesis of silver nanoparticles by using onion (Allium cepa) extract and their antibacterial activity. Dig. J. Nanomaterial Biostructure. 2010, 5, 427–432.

2 Mukherjee, P., Ahmad, A.; et al. Bioreduction of AuCl4¡ ions by the fungus, Verticillium sp.; surface trapping of the gold nanoparticles formed. Angew. Chem. Int. Ed. 2001, 40, 3585–3588.

3 Kumar, V.; Yadav, S. K. Plant-mediated synthesis of silver and gold nanoparticles and their applications. J. Chem. Technol. Biotechnol. 2009, 84, 151–157

4 Karimi Andeani, J.; Mohsenzadeh, S. Phytosynthesis of Cadmium Oxide Nanoparticles from Achillea wilhelmsii Flowers. J. Chem. 2013, Article 147613.

5 Kirthi, A. V., Iayaseelan, C.; et al. Biosynthesis and characterization of different nanoparticles and its larvicidal activity against human disease vectors. In: Marine Biomaterials; CRC Press, Boca Raton, 2013, 273–288.

6 Chandran, S. P., Chaudhary, M.; et al. Synthesis of gold nanotriangles and silver nanoparticles using Aloevera plant extract. Biotechnol. Prog. 2006, 22, 577–583.

7 Saifuddin, N., Wong, C.; et al. Rapid biosynthesis of silver nanoparticles using culture supernatant of bacteria with microwave irradiation. J. Chem. 2009, 6, 61–70.

8 Song, J. Y.; Kim, B. S. Rapid biological synthesis of silver nanoparticles using plant leaf extracts. Bioprocess Biosyst. Eng. 2009, 32, 79–84.

9 Ramyadevi, J., Jeyasubramanian, K.; et al. Copper nanoparticles synthesized by polyol process used to control hematophagous parasites. Parasitol. Res. 2011, 109, 1403– 1415.

10 Huang, H., Yan, F.; et al. Synthesis, characterization, and nonlinear optical properties of copper nanoparticles. Langmuir 1997, 13, 172–175. Dhas, N. A., Raj, C. P.; et al. Synthesis, characterization, and properties of metallic copper nanoparticles. Chem. Mater. 1998, 10, 1446–1452.

11 Kumar, R. V., Mastai, Y.; et al. Sonochemical synthesis of amorphous Cu and nanocrystalline Cu2O embedded in a polyaniline matrix. J. Mater. Chem. 2001, 11, 1209–1213.
12 Yeh, M.-S., Yang, Y.-S.; et al. Formation and characteristics of Cu colloids from CuO powder by laser irradiation in 2-propanol. J. Phys. Chem. B 1999, 103, 6851–6857