

Synthesis of Copper Nanoparticles by Sonochemical Method Without Basic Medium

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Abstract—

Copper nanoparticles have different applications for different properties. It is used for adhesive, electrical wire conductors, batteries, and solar cells. The no. of methods for the synthesis of copper nanoparticles is found in the literature. In this present study, copper nanoparticles are synthesized through the reduction of ultrasound waves on the synthesis of nanoparticles using an ultrasonic bath. In this synthesis, the temp. Required is 333K. The entire process is carried out through an ultrasonic bath, and in this, the formation of the product is only because of the formation of ultrasound waves in the sonicator. While adding Hydrazine hydrate, the temp. Required is 333K. It is found that in most papers, the literature required a basic medium for the formation of copper nanoparticles. But in this present work, we have successfully adopted the methodology for the synthesis of copper nanoparticles without the use of any basic medium.

Keywords— Copper nanoparticles; Sonochemical synthesis; Ultrasonic bath; Nanomaterials; Hydrazine hydrate.I.
INTRODUCTION

Nanotechnology is the study of materials with dimensions in the nanometer range, where nanometer size is defined as between 1 and 100 nanometers. The idea of nanotechnology was first proposed by Richard P. Feynman in his famous lecture "There is Plenty of Room at the Bottom" in 1959. Nanomaterials have superior properties compared to regular materials. Copper nanoparticles are very significant due to their applications in conducting materials, batteries, solar cells, and electronics. The traditional method of synthesizing nanoparticles is done under very specific conditions, where the medium used must be basic. Here, an alternative method using sonochemistry is investigated to synthesize copper nanoparticles without using any basic medium.

II. LITERATURE REVIEW

Several techniques have been reported in the literature for the synthesis of nanoparticles, including top-down and bottom-up approaches. The top-down approach, including ball-milling and lithography, has some disadvantages, such as poor size control and impurities. The bottom-up approach, including sol-gel, chemical vapor deposition, and hydrothermal synthesis, has better size control.

Sonochemical synthesis of copper nanoparticles has opened avenues for efficient synthesis routes due to its ability to create extreme conditions for nanoparticle synthesis through acoustic cavitation. Most of the sonochemical synthesis routes for copper nanoparticles employed alkaline solutions like sodium hydroxide and ammonia to maintain pH, promote reduction, and regulate particle size. The alkaline medium is responsible for the enhanced kinetics of copper nanoparticle synthesis, yielding copper oxide nanoparticles. However, alkaline synthesis routes often involve impurities, purification difficulties, and environmental concerns. Hence, recent studies have focused on developing routes for copper nanoparticle synthesis without the use of alkaline solutions, while keeping particle size and properties under control. The non-basic sonochemical synthesis routes for copper nanoparticles involve employing alternative strategies for copper nanoparticle synthesis without alkaline solutions. The sonochemical synthesis routes involve employing various agents like reducing agents, surfactants, and plant extracts to promote copper nanoparticle synthesis. The ultrasound-assisted routes play an important role in copper nanoparticle synthesis without alkaline solutions, as sonochemistry generates reactive radicals to promote efficient copper nanoparticle synthesis. The green synthesis routes for copper nanoparticles, especially those employing plant extracts, show promise for copper nanoparticle synthesis without any impurities. However, there are difficulties in controlling oxidation, achieving high stability for copper nanoparticles, and scaling up for industrial applications.

III. METHODOLOGY

A. Materials Used

- Copper chloride (precursor)
- Hydrazine hydrate (reducing agent)
- CTAB (capping agent)
- Distilled water (solvent)

B. Principle of Sonochemical Method

Sonochemistry is based on acoustic cavitation, where bubbles form, grow, and collapse in a liquid. The collapse produces hot spots with temperatures of about 5000 K and pressures of about 1000 atm, suitable for chemical reactions and nanoparticle synthesis.

C. Experimental Procedure

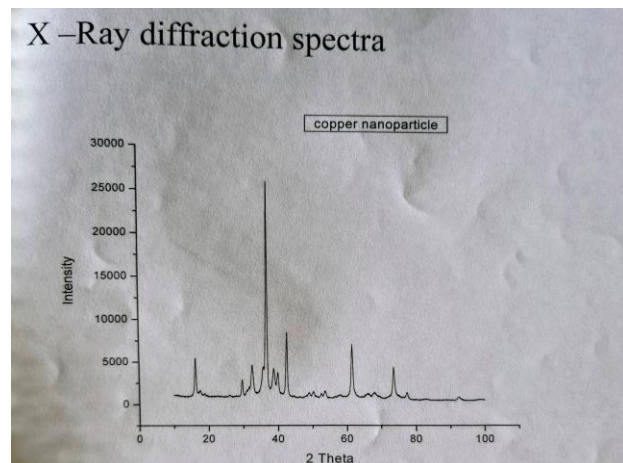
- 0.5 g of copper chloride was dissolved in 25 ml water to form a 0.1 M solution.
- 1 ml of CTAB was added as a capping agent.
- The solution was placed in an ultrasonic bath.
- Temperature was raised to 333 K.
- Hydrazine hydrate was added slowly using a microburette.
- Color change from green to brown confirmed nanoparticle formation.
- The solution was sonicated for 2 hours, followed by filtration and drying.

D. Characterization Techniques

1. **X-Ray Diffraction (XRD):** Confirmed crystalline structure
2. **FTIR Spectroscopy:** Identified functional groups
3. **SEM Analysis:** Studied morphology and particle size

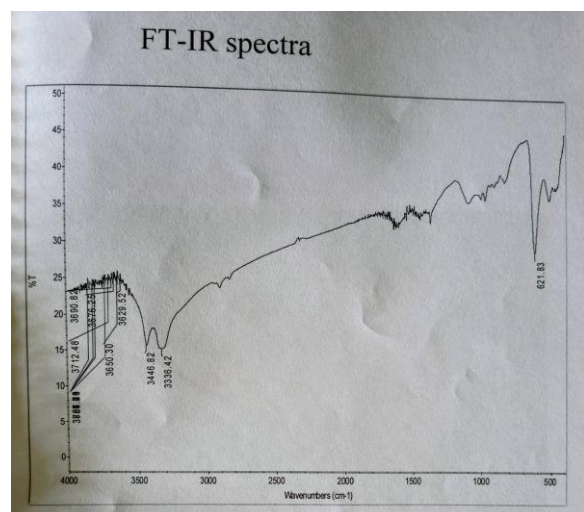
IV. RESULTS AND DISCUSSION

1. **X-Ray Diffraction (XRD):** Confirmed crystalline structure



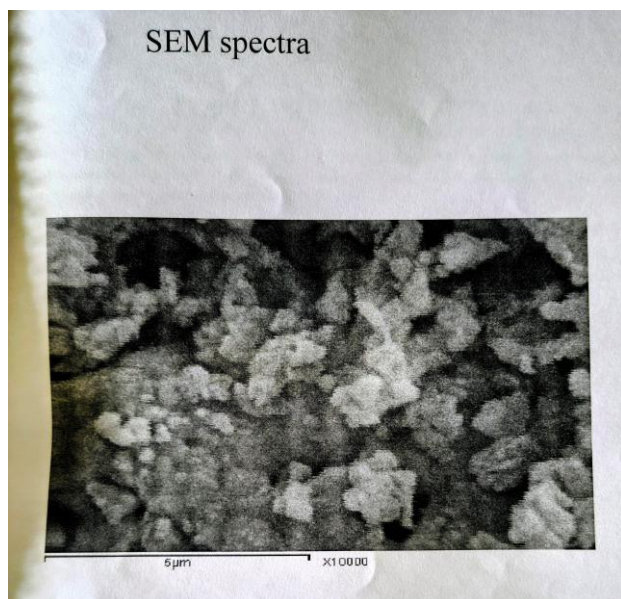
XRD Spectra is a significant characterization tool to identify the crystalline nature of copper (Cu) nanoparticles. This technique verifies the face-centered cubic structure of Cu nanoparticles with characteristic peaks at certain positions corresponding to the (111), (200), and (220) planes of the cubic structure. The XRD pattern of the copper nanoparticles shows the cubic nature of the copper nanoparticles, and sharp peaks indicate the crystalline nature of the copper particles. The size of the particles can be calculated using the formula: $D = K/B \cos B$. The particles are finely crystalline and ordered with a cubic nature, which is further confirmed by JCPDS.

2. **FTIR Spectroscopy:** Identified functional groups



FTIR Spectroscopy (Affinity) was used to record the Fourier Transform Infrared Spectra. The range for ATR is 4000 to 750 cm^{-1} with a resolution of 8 cm^{-1} . FTIR, Fourier Transformed Infrared Spectroscopy, is used for the analysis of freshly synthesized nanoparticles. The synthesized copper nanoparticles are analyzed using the Tra Jared Spectrum, ranging from 4000 to 550 cm^{-1} . The measurement of Fourier-transformed Infrared Radiation is carried out to determine the possible molecules responsible for the capping of copper nanoparticles. The information obtained through FTIR is that there are frequencies showing the presence of all elements in the sample. The frequencies obtained are 3336.42, 3629.52, 36550.3062, corresponding to the carbon atom present in the capping agent and another element present in the sample. The obtained frequency 621.83 corresponds to the copper nanoparticles present in the sample.

3. SEM Analysis: Studied morphology and particle size



Scanning Electron Microscopy: It is an essential tool for Cu nanoparticles characterization, where high-magnification images show Cu nanoparticles' morphology, shape, and size, usually with sizes less than 100nm. SEM Image shows surface morphology of copper nanoparticles, and they are fine crystalline nanoparticles. This image also shows the cubic shape of nanoparticles. The crystalline nanoparticles are prepared by heating and calcining the powder

V. CONCLUSION

Copper nanoparticles were successfully synthesized using a sonochemical method without the use of a basic medium. The method is simple, cost-effective, and environmentally friendly. Characterization results confirmed the formation of crystalline nanoparticles with nanoscale dimensions. This approach can be useful for large-scale production and applications in electronics and solar energy devices..

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