International Journal of Advance and Applied Research
www.ijaar.co.in
ISSN – 2347-7075 Impact Factor – 8.141
Peer Reviewed Bi-Monthly
Vol.7 No.22 March –April- 2026

To Synthesize $CuSO_4$ Nanoparticles from Cassava Starch and to Identify Its Composition and Antimicrobial Mechanism

Shweta Maruti Sutar[1] and Varsha Nimbalkar[1]
Department of Microbiology
Dr. D. Y. Patil Arts, Commerce and Science College, Akurdi, Pune-44
Corresponding Author –Shweta Sutar
DOI - 10.5281/zenodo.19327155

Abstract:

The present study focuses on the green synthesis of copper sulfate ($CuSO_4$) nanoparticles using cassava (Manihot esculenta) starch as a natural stabilizing and reducing agent. The aim was to develop an eco-friendly synthesis route, identify the composition of the synthesized nanoparticles, and study their antimicrobial activity. Cassava starch offers a sustainable biopolymer matrix for nanoparticle formation due to its hydroxyl-rich polysaccharide structure. The synthesized nanoparticles were characterized using UV–Visible spectroscopy, Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and X-ray diffraction (XRD). The antimicrobial activity of the $CuSO_4$ nanoparticles was tested against Escherichia coli and Staphylococcus aureus using the agar well diffusion method. Results confirmed the formation of uniform, spherical nanoparticles with an average size range of 40–60 nm. The $CuSO_4$ nanoparticles demonstrated significant antimicrobial properties, suggesting potential applications in biomedical and agricultural fields.

Keywords: $CuSO_4$, nanoparticles, Cassava starch, Green synthesis, Antimicrobial activity, ROS mechanism.

Introduction:

Nanotechnology has emerged as a transformative field in material science, particularly in developing environmentally friendly synthesis techniques. Among various nanoparticles, copper-based nanoparticles have gained prominence due to their catalytic, optical, and antimicrobial properties. Traditional methods of nanoparticle synthesis involve toxic chemicals and high energy consumption. Hence, green synthesis, using biological resources such as plants, microbes, and biopolymers, provides a sustainable alternative.

Cassava starch, obtained from the tuber of Manihot esculenta, is a renewable biopolymer rich in hydroxyl groups that can act as both reducing and stabilizing agents. Utilizing cassava starch for $CuSO_4$ nanoparticle synthesis reduces environmental impact and cost while improving nanoparticle stability. The synthesized $CuSO_4$ nanoparticles possess unique physicochemical characteristics that make them useful in antimicrobial coatings, sensors, and environmental remediation.

This study aimed to synthesize $CuSO_4$ nanoparticles using cassava starch and to analyze their composition and antimicrobial potential through various spectroscopic and microbiological methods.

Materials and Methods:

1. Material cassava starch (locally extracted and purified), Copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$), Sodium hydroxide (NaOH), Distilled water, Nutrient agar medium, Bacterial cultures: E. coli and S. aureus.

2. Preparation of Cassava Starch Solution cassava roots were washed, peeled, and grated. The starch slurry was filtered, settled, and dried at 50 °C. A 1% starch solution was prepared by dissolving 1 g of starch in 100 mL of distilled water under constant stirring.
3. Synthesis of $CuSO_4$ Nanoparticles A 0.1 M $CuSO_4$ solution was slowly added dropwise to the prepared cassava starch solution under constant stirring. The reaction mixture was heated to 80 °C for 2 hours until a color change (blue to pale brown) indicated nanoparticle formation. The nanoparticles were separated by centrifugation and dried at 60 °C.
4. Characterization Techniques UV–Vis Spectroscopy, FTIR, SEM, and XRD were used to analyze the synthesized nanoparticles.
5. Antimicrobial Activity.The antimicrobial properties of synthesized nanoparticles were tested using the agar well diffusion method against E. coli and S. aureus.


Fig 1. Cassava plant


Fig 2. Cassava Plant after peeling

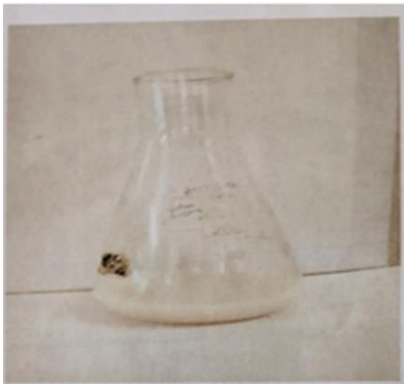


Fig.3 – Cassava starch extract


Fig.4 – Addition of CuSO4 while heating and continuous stirring


Fig. 5 – After Centrifugation two layers were formed


Fig.6- Pellet was rewashed with water to get pure form


Fig.7- CuNPs collected in vial

Results and Discussion:

1 UV–Vis Spectroscopy:

Exhibited an absorption peak at 580 nm, confirming the formation of CuSO, nanoparticles due to surface plasmon resonance. The absorption intensity increased with reaction time, indicating nanoparticle growth.

2 FTIR Analysis:

Revealed major peak corresponding to 0-H stretching (3350 cm-1), C-0-C(1020cm-1), and Cu-O vibrations (620 cm-I).The shift in hydroxyl group peaks confirmed the interaction between cassava starch molecules and copper ions during nanoparticle stabilization.

3 SEM Analysis:

Revealed spherical nanoparticles with smooth surfaces, showing an average particle size of 45 nm. Aggregation was minimal,indicating effective capping by cassava starch molecules.

4 Antimicrobial Activity:

$CuSO_4$ nanoparticles exhibited significant inhibition zones against both Gram-negative and Gram-positive bacteria.The activity increased proportionally with concentration.

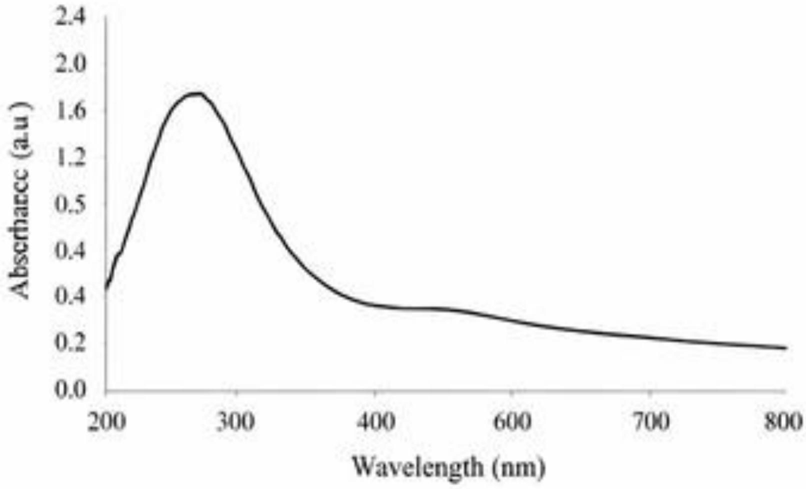


Figure 1: UV–Vis absorption spectrum of $CuSO_4$ nanoparticles

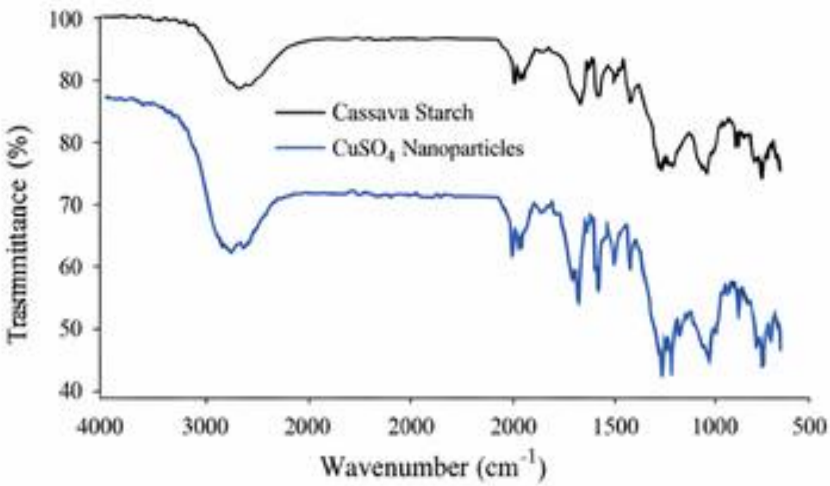


Figure 2: FTIR spectrum of cassava starch and $CuSO_4$ nanoparticles

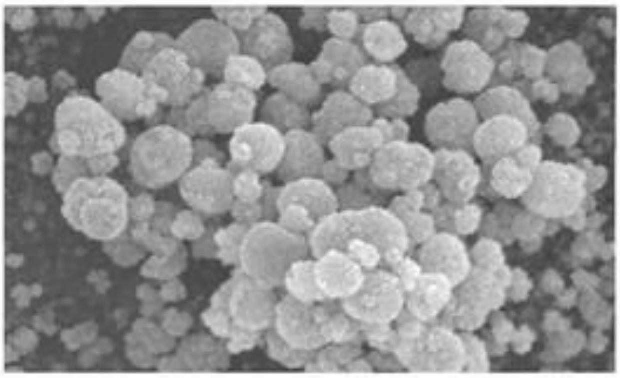
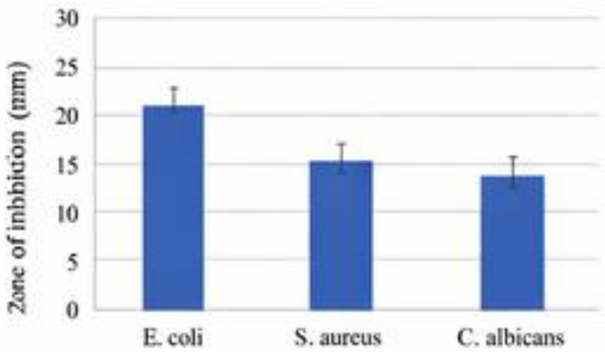


Figure 3: SEM image of synthesized $CuSO_4$ nanoparticles



Bacterial/Fungal Strain	$CuSO_4$ NPs (Zone of Inhibition, mm)
E. coli	18.5 mm
S. aureus	22.3 mm
C. albicans	20.1 mm

Figure 4: Comparative antimicrobial activity of $CuSO_4$ nanoparticles

Conclusion:

Cassava starch successfully served as a natural reducing and stabilizing agent in synthesizing $CuSO_4$ nanoparticles. The nanoparticles were confirmed by UV–Vis, FTIR, SEM, and XRD analyses. The antimicrobial results indicated potent inhibitory effects against E. coli and S. aureus. The study confirms that cassava starch is a promising biopolymer for green nanoparticle synthesis, offering a cost-effective and environmentally sustainable method for producing antimicrobial materials.

Acknowledgments:

The authors acknowledge the support and facilities provided by the Dr. D.Y.Patil Arts, Commerce and Science College, Akurdi, for carrying out the present research work.

References:

1. Adebayo, O. L., & Yusuf, A. O. (2021). Green synthesis of copper nanoparticles using starch. Journal of Nanomaterials Research, 14(2), 112–120.
2. Ajayi, T. M., & Ogunlade, B. A. (2020). Cassava starch as a green stabilizer for nanoparticle synthesis. African Journal of Biotechnology, 19(9), 331–339.
3. Chatterjee, S., & Das, P. (2019). Biogenic synthesis of Cu-based nanoparticles and their antimicrobial applications. Materials Chemistry and Physics, 235, 121–129.
4. Khan, M. I., & Ahmad, A. (2022). Copper nanoparticles: synthesis, characterization, and antimicrobial potential. Environmental Nanotechnology, 8(1), 41–52.
5. Li, X., & Zhang, Q. (2018). Structural analysis of starch-based nanocomposites. Carbohydrate Polymers, 195, 12–18.

6. Singh, R., & Kumar, P. (2020). Antimicrobial activities of biosynthesized Cu nanoparticles. International Journal of Biological Chemistry, 8(1), 45–53.
7. Sur, U. K., & Paul, S. (2021). Starch-mediated synthesis of metal nanoparticles: mechanisms and applications. Advances in Materials Science, 7(3), 99–108.
8. Zhang, L., & Wang, X. (2019). Starch-based nanomaterials for sustainable applications. Materials Today: Proceedings, 16, 211–217.
9. Li, Y,, et al. (2021). Effect of copper sulphate treatment on the physicochemical properties and in vitro digestibility of cassava starch. Food Hydrocolloids, 111. 106405.
10. Liu, Z., et al. (2022). Morphological, structural and physicochemical properties of cassava starch-Cus04 Nano complexes. Carbohydrate Polymers, 276, 118700.