International Journal of Research and Development in Engineering Sciences
ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , Conference Proceedings
International Conference on Emerging Trends in Engineering, Technology and Management 2025
11-12th April 2025 , www.icetm.in , ICETM 2025 , Hybrid Mode
Viswam Engineering College (Autonomous) , Madanapalle , Andhra Pradesh , India
Conference Proceedings , https://doi.org/10.63328/IJRDES-V7C1-ICETM2025
Regular Issue, Vol. 7, ICETM 2025 , Pages: 42 – 47 , ISBN : 978-81-984440-5-9
Received: 11 January 2025 ; *Accepted:* 09 April 2025 ; *Published:* 26 June 2025
https://doi.org/10.63328/IJRDES-V7CIP8
Conference Paper : Original – Classification Research – Qualitative Research Paper

Copper Oxide Nanoparticles Synthesized by Precipitation Method Towards Biomedical Applications

M Sunitha [1], G Manikandan [2], G Ramesh [3], K Haritha [4]

[1,3,4] Department of Chemistry, Basic Sciences and Humanities, Viswam Engineering College, Madanapalle, 517325
[2] Department of Chemistry, Annamalai University, Annamalainagar 608002, Tamilnadu, India
manideva.ktm@gmail.com

** Corresponding Author : M Sunitha ; sunithayadavm@gmail.com*

Abstract: Chemical processes to sustainable and eco- friendly techniques. Of these, green synthesis, also known as biosynthesis has been found to be a viable approach that exploits biological systems, and their biomolecular constituents, to create nanoparticles. It is not only the most environmentally friendly, but also presents unique operational capabilities such as cost-effectiveness, energy efficiency and just one-pot reactions at ambient temperatures. Green synthesis offers a safer and more eco-friendly solution by not requiring the utilization of dangerous reagents and the special conditions of the conventional processes. This review will give a critical summary of the principles of the green synthesis, and more specifically its mechanistic nature in biological and chemical pathways. They provide critical comparisons with the traditional methods and give an assessment of the sophisticated characterization tools that are needed to authenticate the structural, morphological, and functional characteristics of synthesized nanomaterials. Furthermore, some uses of green-synthesized nanoparticles are examined in the biomedicine, environmental cleanup, farming, and technologies in the energy sector. Existing issues such as scalability, reproducibility and mechanistic ambiguities are critically examined and possible ways of overcoming these challenges are presented. This body of evidence supports the case of green synthesis as not only an environmentally friendly alternative, but also as an extremely versatile and technologically better platform that can produce functionally improved nanomaterials to be used in industrial and biomedical innovations in the future. This paper discusses the synthesis of copper oxide nanoparticles (CuO NPs) with Carica papaya leaf extract as the reducing and stabilizing agents. Using the leaves in the precipitation technique, rapid production of CuO NPs was easily biosynthesized and pollution-free without any environmental harmful effects. X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), and scanning electron microscopy (SEM) were used to determine the properties of the nanoparticles. The size of the particles measured using the Scherer equation showed that they were between 50- 60 nm in samples prepared through chemical precipitation. The manufactured CuO NPs had the right characteristics to be used in biomedical uses, which points to the possibility of green synthesis offering sustainable nanotechnology.
Keywords: Copper nanoparticles, Carica Papaya Leaves, Biosynthesis, Biomedical.

1. Introduction

Nanotechnology is a process that involves the production of particles in Nano range i.e. 1 to 100 nm. Their surface area is huge since the past decades have seen the technology of nanomaterials develop an impressive leap in the medical field due to the combination of biotechnology and nanotechnology, which is known as bio-nanotechnology with the target to be eco-friendly and biosynthetic technology. Green synthesis that aim at reduction of the use of dangerous chemicals. It is necessary to develop green nanotechnology that will help achieve sustainability. It involves the making of nanomaterials of natural bioactive material such as plant material, microorganisms and a wide variety of bio-wastes such as agricultural wastes, eggshells, vegetable wastes, and fruit peels among other organic wastes. It is to plan a sustainable environment, waste water degradation, waste

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 7, ICETM 2025 , https://doi.org/10.63328/IJRDES-V7CIP8

reduction, recycling of the things, which are consumed by the developing society of the day to day life. There are three major methods of making nanoparticles, namely, physical, chemical, and biological. It is also referred to as green synthesis and among others, biosynthesis is less damaging to the environment, less costly and less toxic. Microorganisms and plant parts are typically both used as templates in biosynthetic pathways, and as reducing and capping agent. The prokaryotic bacteria along with the yeast and fungi are used as microorganisms in the process of biosynthesis. The usual techniques, which include chemical reduction, milling etc., most physical and chemical processes have been applied in the production of NPs synthesis at the beginning of the 20th century, and most of them are expensive and toxic chemicals, which cannot be considered an environmentally friendly process.

Nanoscience and nanotechnology refers to a field of study on matter that is manipulated at an atomic scale in regards to the manufacture, characterisation, discovery and/or exploitation of nanostructured materials to the benefit of man. One of the most active spheres of study of modern material science is nanotechnology; The preceding decades witnessed the arrival of a flock of scientists who show interest in metal oxide nanomaterials, and the latter have turned into a research niche in the recent past, as they are used in various applications during creation of magnetic data storage devices [5], fuel cell development [6], sensors [7], and in catalytic reactor development [8]. The manganese oxide nanoparticles are also imperatively used in various applications out of the metal oxide nanoparticles.

2. Related Work

Plant Extract Preparation

Copper nanoparticles were prepared using Carica papaya and neem leaf extract on the basis of its cost effectiveness, convenience of availability and its medicinal property. Fresh leaves were taken at my house. They were washed on the surface using running tap water to remove dust and other organic contaminated materials and then washed using the double distilled water and dried under room temperature. Approximately 15 gm of the well-cut leaves were stored in a beaker with 150 mL of double distilled water and they were boiled after 20 min. It was cooled, filtered using Whatman filter paper no.1 and extracted was stored at 3 C to be used further [3].

Copper oxide nanoparticles Biosynthesis

A clean and dry conical flask of 100 mL was taken and 50 mL of 0.2 M sodium hydroxide (NaOH) was added drop by drop using burette with constant stirring using magnetic stirrer under constant temperature of 60-70 degC. 2.5 M solution of cupric sulphate (CuSO45.H2O) 100 mL of the same was added to the conical flask and 50 mL of 0.2 M solution of sodium hydroxy The entire mixture of the solution was stirred in 1 hours' time to induce the precipitation of nanoparticles as it was established when the colour of the solution changed to brown. The beaker was centrifuged and the precipitate obtained. It was then dried at 50-60 degC followed by 3 hours in a muffle furnace at 450 degC to get the desired copper nanoparticles

Nanomaterials Production in a New Paradigm, Green Synthesis

Green Synthesis definition Green synthesis, or biosynthesis, or biological methods, is a radical shift in the production of nanomaterials. It is an environmentally friendly, natural and sustainable process, which utilises easy to obtain biodegradable and renewable resources as the main reducing and stabilizing agents. Such a method is based on the principal concepts of green chemistry where emphasis is placed on minimizing pollution and replacing the harmful elements with the less harmful ones.

The approach is fundamentally a bottom-up approach, where nanoparticles are synthesized on the basis of small molecules or atoms. It is generally a simple and one pot reaction in which a metal salt solution is combined with a natural bio-reductant extract and the resulting nanostructures are formed in a few minutes.

2.2. Critical comparison with the conventional methods :

The distinction between the green synthesis and the conventional methods is quite obvious, and this is the reason why so much attention is paid to the former. Not only is it an academic comparison, but it has far-reaching implications on the viability of industries, the ecological stewardship and production efficiency.

2.2.1. Environmental impact / health impact Conventional methods of synthesis The use of hazardous reagents and toxic solvents is traditionally linked to physical and chemical methods. One such way is by employing the traditional chemical synthesis in which rough reducing agents such as sodium borohydride, may be employed, which leave traces of toxins on the nanoparticles and it is hazardous to the human body. Additionally, the products of such reactions are also toxic and they must be disposed in involved and expensive disposal procedures.

Aspect	Conventional Methods	Green Synthesis
Environmental Impact	High pollution; generates harmful	Eco-friendly; biodegradable materials and minimal waste.

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 7, ICETM 2025 , https://doi.org/10.63328/IJRDES-V7CIP8

	byproducts.	
Cost	High; involves expensive chemicals and waste control.	Low; uses cheaper, natural materials.
Energy Consumption	High; often requires high temperatures and pressure.	Low; occurs at ambient conditions (room temperature).
Reagents Used	Toxic reducing agents (e.g., sodium borohydride), “hazardous reducing agents	Natural sources (e.g., plant extracts, microorganisms).
Biocompatibility	Low; potential for toxic residues and harmful effects.	High; naturally coated with biocompatible biomolecules.
Process Complexity	Often multi-step and complex (e.g., Sol-Gel).	Simple one-pot process.

Biological agents and their mechanistic functions

A panoply of biologic resources Green synthesis is based on a broad range of biologic materials where nanoparticle fabrication is conducted. The most frequently used resources include; Plants and plant extracts: Plants are favored because they are readily available, cheap and because of the high number of phytochemicals available. The extracts of various portions of the plant like leaves, roots, stems, bark, and fruit exocarp are used because, they contain a large amount of bioactive compounds which can be employed as effective reducing and stabilizing agents.

Microorganisms: It has also successfully been reported that microorganisms such as bacteria, fungi and yeast and algae should be used to synthesize various nanoparticle systems. The redox reactions that involve the use of enzymes such as nitrate reductase to reduce the metal ion to nanoparticles are the most crucial microbial redox ones.

Bio Waste: New highly viable trend that can be employed is agricultural and industrial biowaste. Recycling of the natural resources such as the peel or pod of Cajunus cajun (pigeon pea) not only provides a cheap solution of attaining the natural reduction agents, but also plays a role in controlling a significant issue affecting the world, that is, waste management, which introduces a circular economy.

Use of the phytochemicals to make nanoparticles

In these biological resources, the key to the green synthesis mechanism is the presence of such bioactive compounds - phytochemicals- as available bioactive compounds. It is these substances that reduce and stabilize the new nanoparticles, and metal ions.

Key Phytochemicals

The reducing and stabilizing agents of primary phytochemicals are:

Polyphenols: It is a broad category of chemicals and is characterized by one or more aromatic rings containing hydroxyl groups.

Terpenoids: A heterogeneous group of isoprene-based secondary metabolites. Most of the essential oils contain them and had diverse biological activities.

Proteins And Amino Acids: these biomolecules possess both amino and carboxyl groups and may even contain metal ions trapped and fixed and consequently deprotonate them.

Other Phytochemicals: Alkaloids and sugars are also additional phytochemicals which aid in the reduction of the metal ions.

Table.3 Common Characterization Techniques and Their Primary Purpose

Technique	Principle of Operation	Key Information Gained
UV-Vis	Surface Plasmon Resonance (SPR)	Confirmation of nanoparticle formation; particle size and concentration.
FTIR	Absorption of infrared radiation by molecular vibrations	Identification of functional groups of reducing/capping agents on the nanoparticle surface.
SEM	Imaging with a focused electron beam	Surface morphology, size, and size distribution.
TEM	Imaging with a transmitted	High-resolution morphology, size,

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 7, ICETM 2025 , https://doi.org/10.63328/IJRDES-V7CIP8

	electron beam	internal structure, and lattice details.
XRD	X-ray scattering based on Bragg's Law	Crystalline structure, phase purity, and crystallite size.

Characterization Of Green-Synthesized Nanoparticles

Significance of characterization.

Once nanoparticles are successfully synthesized, it is significant to conduct an extensive characterization of the nanoparticles. It is done through a combination of analysis methods in order to ensure the composition of nanomaterials and examine their physical and chemical characteristics, size, shape, crystalline structure, surface morphology, and capping agents. The broad spectrum of this analysis provides the synthesized nanoparticles to fulfill the particular requirements needed in the applications that they are to be used and also enables the optimization of synthetic parameters.

Main spectroscopic and microscopic methods

Green-synthesized nanoparticles are thoroughly analyzed by a variety of complementary and advanced methods.

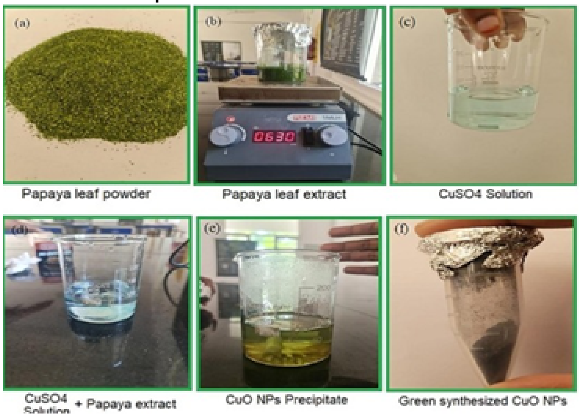
UV-Vis Spectroscopy: It is a simple method that is used to ascertain the composition of the metal nanoparticles. It operates on the principle of surface plasmon resonance (SPR) that can be found in metal NPs. The existence of an SPR peak at a given wavelength (ex: 400-480 nm in the case of silver nanoparticles) is a major indication of successful synthesis. The size, shape and concentration of the nanoparticles determine the wavelength and intensity of this peak.

FTIR (Fourier-Transform Infrared Spectroscopy): This type of Spectroscopic technique is essential to the determination of functional groups of biomolecules that are involved in the reduction of metal ions and capping of NPs. The formation of certain absorption bands is a direct indication of the successful binding of phytochemicals to the surface of nanoparticles, which proves the use on stabilizing agents.

SEM (Scanning Electron Microscopy) and TEM (Transmission El).

Approach for Synthesis of Nanomaterial:

bottom up and top down strategy.
sol-gel process
Chemical Vapour deposition
Thermally Activated CVD
Precipitation process
Calcination process
Schematic representation



Techniques that we are utilizing in order to locate characterization of nanoparticles

X-Ray diffraction (XRD)

X-ray diffraction (XRD) is a non-destructive technology, which utilizes the X-rays in a bid to determine the structure and the composition, of materials. It is used in the bulk of industries including pharmaceuticals and cars production.

XRD can be used to analyse:

- XRD can be used to analyse:
- Crystalline structure of materials.
- Material structure Chemical.

The mechanical properties of materials. The phase structure of materials.

- The orientation of crystals
- The dimensions of the units of materials.
- Nanoparticles crystallinity.

TEM analysis

The size, shape and morphology of nanoparticles have been identified by use of transmission electron microscopy (TEM). It shows that the silver nanoparticles are dispersed and mostly spherical in shape, Transmission electron microscopy (TEM) involves the use of an electron beam to create an image of the object - with high resolution - including its internal structure - on the nanoscale. TEM analysis finds extensive applications in such industries as materials science, microbiology, and nanotechnology.

SEM Analysis

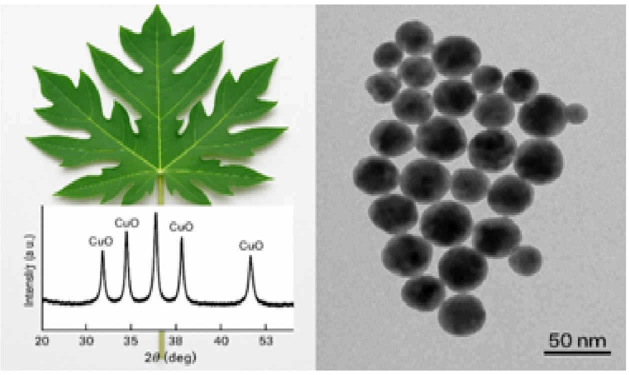
SEM can be used to study the surface morphology (shape, size and arrangement) homogeneity and the grain size of the deposited film, which is the most versatile and most popular instrumental technique used to study the surface

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 7, ICETM 2025 , https://doi.org/10.63328/IJRDES-V7CIP8

morphology and surface topology.

electronics

Analysis of XRD



Yes, the graph shown in the lower-left part of the image is a representative XRD (X-ray Diffraction) pattern.

It displays:

- Intensity on the y-axis and 2θ in degrees on the x-axis.
- Distinct peaks labelled as CuO, which are typical of copper oxide phases.

Environmental and Energy Programs

Table 4: Summary of Nanoparticle Applications by Sector

Sector	***Specific Application***	***Relevant Nanoparticles (NPs)***
Biomedical	Cancer therapy, antiviral treatments, targeted drug delivery	Gold (Au) NPs, Silver (Ag) NPs, Iron Oxide NPs
Environmental	Water treatment, dye degradation, oil spill clean-ups	Manganese Dioxide (MnO_2) NPs, Silver (Ag) NPs, Iron Oxide NPs
Energy	Lithium-ion batteries, supercapacitors, solar panels	Manganese Dioxide (MnO_2) NPs, Iron Oxide (Fe_3O_4) NPs
Agriculture	Nano-fertilizers, natural pesticides	Various metal NPs, Biogenic NPs
Other	Self-cleaning surfaces, biodegradable packaging,	Various Metal NPs, Metal Oxide NPs

3. Conclusion

Green synthesis is an extreme and much needed change in the realm of nanotechnology. It is not only a greener solution compared to traditional methods, but a radical one that takes into consideration the problem of the environment with a multifaceted environment, economic and health concerns. It is a low-cost, low-energy use method, as well, to utilize the energy of natural biological systems to generate nanomaterials with an increased degree of functionality, specifically, in biocompatibility and stability. Despite the fact that the problems of scalability and reproducibility remain, the additional convergence of different areas of science and focus on the innovative answers will provide the approach to the next level of the sustainable and advanced production of nanomaterials. The uncouth and noteworthy applications mentioned in this review indicate that green synthesis has a colossal capacity of assisting in transforming humanity and the aviation industry to a more legitimate, well-being and sustainable future. These peaks confirm the crystalline character of the CuO nanoparticles that can easily be seen in the precipitation and green synthesis process like using papaya leaf extract.

Reference

[1]. A. Ikram, S. Jamil, and M. Fasehullah, “Green Synthesis of Copper Oxide Nanoparticles from Papaya/Lemon tea Extract and its Application in Degradation of Methyl Orange,” *Materials Innovations*, vol. 2, no. 4, pp. 115–122, Apr. 2022. doi: 10.54738/MI.2022.2401.

[2]. A. Susan, “Green Synthesis of Copper Oxide Nanoparticles: Characterization and Applications,” M.S. thesis, Dept. Chemistry, St. Teresa's College, Mahatma Gandhi University, Kerala, India, 2021.

[3]. M. Nasrollahzadeh, S. M. Sajadi, R. Iravani, and S. Varma, “Green synthesis of metal nanoparticles using plant extracts and their applications in catalysis,” *Green Chemistry*, vol. 17, no. 1, pp. 102–122, 2015. doi: 10.1039/C4GC01463G.

[4]. S. Rajeshkumar and L. Bharath, “Mechanism of plant-mediated synthesis of silver nanoparticles – A review on biomolecules involved and nanoparticles characterization,” *Chemico-Biological Interactions*, vol. 273, pp. 219–227, 2017. doi: 10.1016/j.cbi.2017.06.019.

[5]. [J. Singh, G. Dutta, and R. Kim, “Green synthesis of metallic nanoparticles: Applications and limitations,” *Scientific Reports*, vol. 11, no. 1, pp. 1–11, 2021. doi: 10.1038/s41598-021-83202-5.

[6]. Carica Papaya leaf-infused metal oxide nanocomposite: a green approach towards water treatment and antibacterial applications

ISSN: 2582 - 4201(Online) , http://www.ijrdes.com/ , IJRDES, Vol. 7, ICETM 2025 , https://doi.org/10.63328/IJRDES-V7CIP8

[7]. Rangayasami Aswini · Kannupaiyan Jothimani · Karthik Kannan · Ramyakrishna Pothu · Paramasivam Shanmugam · Rajender Boddula · Ahmed Bahgat Radwan · Govindasami Periyasami · Perumal Karthikeyan · Noora Al-Qahtani https://doi.org/10.1007/s10653-024-02090-4

[8]. Green synthesis of copper oxide nanoparticles using Bryophyllum pinnatum leaf extract and its antibacterial potential against Listeria monocytogene

[9]. Molla FentieDepartment of Biotechnology, School of Engineering and Technology, Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh, India Corresponding author email: mollafentie3@gmail.com

[10]. Garima ChouhanDepartment of Biotechnology, School of Engineering and Technology, Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh, India

[11]. Meron MogesDepartment of Biotechnology, School of Engineering and Technology, Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh, India

[12]. Priya TyagiDepartment of Biotechnology, School of Engineering and Technology, Sharda University, Knowledge Park III, Greater Noida, Uttar Pradesh, India

[13]. Antibacterial Activity of synthesized Copper Oxide Nanoparticles using *Malva sylvestris* Leaf Extract

[14]. Awwad, A.M.1, Albiss, B.A2, Salem N.M.3 [1]Royal Scientific Society, El Hassan Science City, Amman, Jordan. ordan University of Science and Technology, Irbid, Jordan. [3]Faculty of Agriculture, the Jordan University, Amman, Jordan Tanning Wastewater Sterilization in the Dark and Sunlight Using *Psidium guajava* Leaf-Derived Copper Oxide Nanoparticles and Their CharacteristicsNatrayan Lakshmaiya, Raviteja Surakasi, V. Swamy Nadh, Chidurala Srinivas, Seniappan Kaliappan, Velmurugan Ganesan, Prabhu Paramasivam,* and Seshathiri Dhanasekaran

[15]. Antibacterial Activity of Ecofriendly Biologically Synthesized Copper Oxide Nanoparticles

[16]. Dina A. Ali, Mohamed A. Ismael, Mohamed A. Hashem and Magda A. Akl**Department of Chemistry, Faculty of Science, Mansoura University, Mansoura 35516, Egypt*Comparative Studies of Synthesized Copper Oxide Nanoparticles using Aqueous Extract of Leaves

[17]. *Emmanuel Oladeji Oyetola [1], Friday Onyekwere Nwosu [2], Gboyega Oluwaseun Oyeleke [3], Ismaila Jide Olawale [4], Bosede Mofoluwake Adegoke [5] and Usman Oladayo Afolabi [6]*

[18]. Green synthesis and characterization of copper nano particles using *Carica Papaya* leaf extractDepartment of Chemistry, Theivanai Ammal College for Women, Villupuram, Tamil Nadu, Ind Synthesis Of Copper Oxide Nanoparticles By Chemical Precipitation Method For The Determination Of Antibacterial Efficacy Against *Streptococcus* Sp. And *Staphylococcus* S

[19]. Shraddha Shirsat1, Dhanashri Pawar1, Nishita Jain1, Jayant Pawar2, Vidya S Tale1*, Rabinder Henry2

[20]. Ghosh, S., & Dash, A. (2022). Plant-based green synthesis of nanoparticles: Production, characterization, and applications. Nanotechnology Reviews, 11(8), 902. https://doi.org/10.3390/catal11080802 MDPI+1

[21]. Iravani, S., Korbekandi, H., Mirmohammadi, S. V., & Zolfaghari, B. (2018). 'Green' synthesis of metals and their oxide nanoparticles: Applications for environmental remediation. Journal of Nano biotechnology, 16, 84. https://doi.org/10.1186/s12951-018-0408-4 Bio Med Central

[22]. Nadaroglu, H., Alaylı Güngör, A., & İnce, S. (2017). Synthesis of nanoparticles by green synthesis method. International Journal of Nanoscience and Nanotechnology Research, 1(1), 6-9. https://doi.org/10.15379-/injirr.2017.1.1.673126