# Biosynthesis of AgNPs and CuNPs from plant extract of Gymnema Sylvestre

**Anamika S. Verma, Blesshyrose Biju, Vishaka S. Gupta, Priyanka R Kokate Manohar V Lokhande***

Research Center, Department of Chemistry, Sathaye College (Autonomous),

Mumbai-400057, Maharashtra, India

**Abstract:**

The biosynthesis of copper and silver nanoparticles (CuNPs AND AgNPs) is carried out in the aqueous medium of a stem extract of Gymnema Sylvestre. The synthesized nanoparticles are characterized by FTIR, UV-Vis, SEM, TEM, EDX, and X-RAY diffraction. As per the data of SEM and TEM the NPs are granules and spherical in TEM the synthesized NPs is the NPs of AgNPs is range between 2-20 nm and the Cu range is from 22-34nm. The UV-Vis spectra from 30,60,90,120 were constant at 530nm. In the EDX of CuNPs, the presence of Cu 84.2% by weight is confirmed and for AgNPs the presence of Ag by weight was confirmed. Here we have seen the catalytic as well as microbial activities of prepared Ag NPs and CuNPs. The CuNPs are a good reducing agent for 4-nitrophenol to 4-aminophenol confirmed by UV Visible and dyestuff through the amino group.

**Keywords:** SEM, TEM, EDX, XRAY, EDX, Catalytic property, Microbial activity, UV Visible.

**Introduction:**

Nanoparticles are tiny particles that are in nanometers in size, made of materials like metals, semiconductors, or polymers, with unique properties and applications in medicine, electronics, and environmental science[1-2]. Plant nanoparticles are nanoparticles derived from plants or plant-based materials. They can be synthesized using plant extracts, such as polyphenols, flavonoids, or alkaloids, which act as reducing agents to produce nanoparticles[3]. There are various methods for the synthesis of nanoparticles amongst which chemical reduction is widely used[4-5]. However, the chemical reduction method is rapid but toxic with negative environmental impacts. Whereas phytochemically mediated plant extract is eco-friendly and non-toxic. One limitation of this is that it requires a long time, to address this refluxing the plant extract at a controlled temperature is preferred. Refluxing helps to extract more phytochemicals from the plant material, resulting in a higher yield of the desired compound[6] . It can enhance the solubility of phytochemicals, making it easier to dissolve them in a solvent and synthesize nanoparticles. Another benefit of refluxing is that it can help to break down complex

phytochemicals into more bioactive forms, potentially increasing their medicinal or therapeutic properties and forming uniform particle size distribution[7-8]. This approach holds sustainable and efficient nanoparticle production.

In our current research, we report the synthesis of silver and copper nanoparticles. We have taken leaf extract of Gymnema sylvestre, commonly known as 'Gurmar[9]. It is native to the tropical regions of Asia, Australia, and Africa. In India, it is native to the tropical forests of central and southern India, particularly in the states of Maharashtra, Karnataka, Uttar Pradesh, and Tamil Nadu. These states provide the ideal climate and soil conditions for Gymnema sylvestre to thrive, with high humidity, warm temperatures, and well-drained soil[10].

The plant is a climber with leaves having soft hairs on the upper surface. The leaves are elongated-oval in shape. It has a small, yellow, umbelliferous inflorescence that is produced throughout the year. The leaves and extracts contain Gymnema acids, the major bioactive constituents that interact with taste receptors on the tongue to temporarily suppress the taste of sweetness[11] . Gymnema sylvestre has a long history of use in herbal medicine and a broad range of therapeutic properties[12]. Our research aims to explore the potential of Gymnema sylvestre nanoparticles.

**Fig.1 : G.Sylvestre plant**

**Methods and Materials :**

Stem extract of Gymnema sylvestre using metals like AgNO3, and CuSO4 of 0.01M (AR Grade chemicals) in aqueous medium.

**Preparation of plant extract:** The stem of Gymnema sylvester was collected fresh and was washed with salt water then distilled water to remove the dust particle. The stem was pressed and dried for about 10 days at room temperature then this dried stem was crushed using a motor pestle and then sieved with 3 different pore sizes to obtain very fine particles of the plant. This plant powder was weighed accurately 5gms, to it we added100ml double distilled water then it was boiled and was reduced to a volume of 50ml. Next step we filter the extract using Whatman filter paper.

**Fig.2: Powder form of G.Sylvestre**

**Fig.3 : Water Extract of G.Sylvestre**


**Synthesis of nanoparticle:** We prepared a 1:1 combination of each metal with plant extract then Ag-NPs and, Cu-NPs were refluxed at different time intervals such as 30 min 60 min 90min 120min. While mixing both extract and metal the color obtained was light and after reflux, we got a color of the NPs. The refluxed NPs were then centrifuged for 3 hours to obtain a clear solution of NPs .

**Fig.5: Preparation of CuNPs**

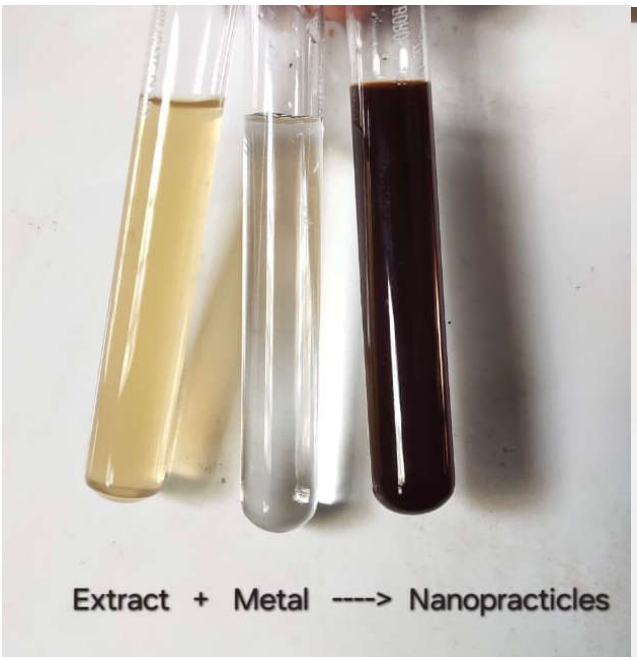


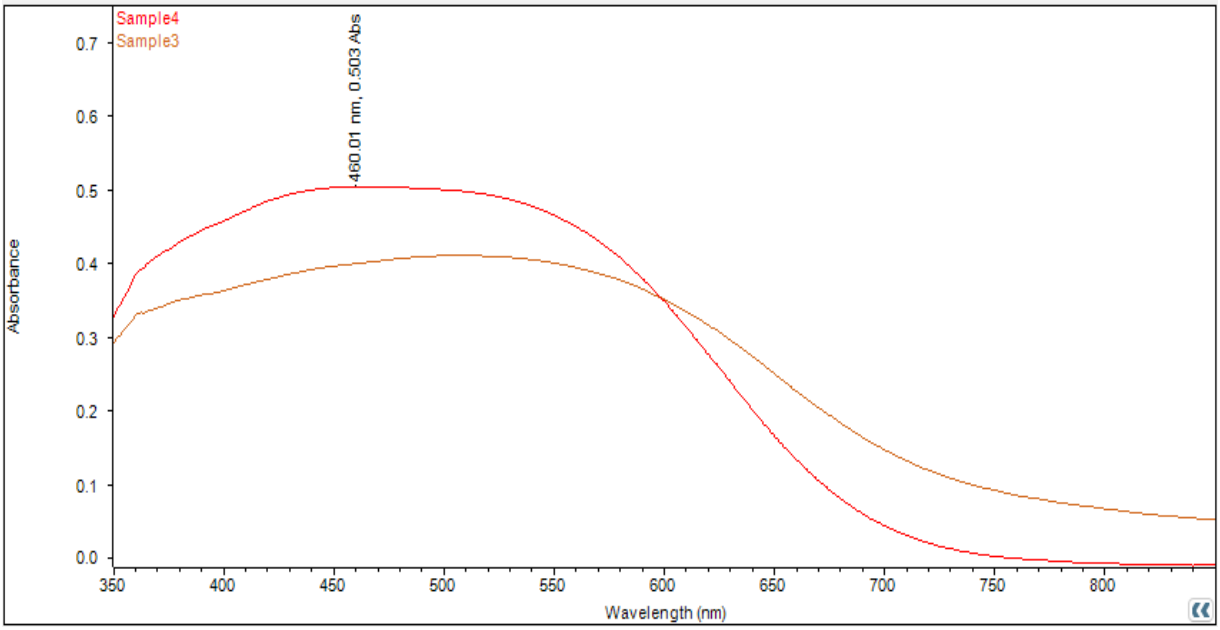

**Fig. 4: Preparation of AgNPs**


**Instrumental method:** Various factors can affect and modulate the characteristic properties of nanoparticles such as temperature, pH, reducing agents, biological activity, antimicrobial activity, shape, size, and surface phenomena. The technologies available to study the characters and properties of nanoparticles which were used UV visible spectroscopy (U.V -Vis ) Spectrometer range from 350 nanometers to 800 nanometers, Fourier transfer infrared spectroscopy commonly known as FTIR that was used which has wave numbers from 4000 to 450 per cm, Transmission electron microscope(TEM), Centrifuge machine which was -rpm and last EDX study.

**RESULT AND DISCUSSIONS**

**Ultra Violet Visible Spectrophotometer**: Nanoparticles have unique optical properties that are sensitive to the size, shape, concentration, agglomeration state, and refractive index near the nanoparticle surface, which makes **UV-Vis** a valuable tool for identifying, characterizing, and studying nanomaterials. U.V Visible spectra from range 350-850nm. During the synthesis, we found that the concentration concerning time changes the color of the solution. For Silver nanoparticles the color changed from yellow to brown this indicates the formation of silver nanoparticles and a smooth peak was observed at a range 450-465[13].

**Fig.6: UV- Visible spectra for G.Sylvestre AgNPs**




**FTIR: The m**easurements are usually performed to identify and classify probable biomolecules that can be reliable for capping leading to proficient stabilization of gold and silver nanoparticles. It is one of the most common methods for characterization of organic and inorganic materials. It is used to study nanoparticles in a variety of ways such as characterizing chemical composition, studying nanoparticle surface, identifying biomolecules, studying toxicity, studying surfactant bonding, and also to detect traces of impurities. The bond between silver nitrate present is an ionic bond due to which it can easily dissolve in water and dissociate into constituent ions, when dissolving it can release harmful nitrogen oxide gases so the reaction was carried out under controlled circumstances. The silver nitrate reacts with plant extract so the phytochemicals present such as phenols, flavonoids and antioxidants in plant extract can act as a reducing agent that converts silver ion (Ag+) from silver nitrate(AgNO3) into metallic silver nanoparticles(AgNPs) the reduction of silver ion forms tiny silver particles and it shows the color change from yellow to brownish color due to excitation of surface plasmon vibration.

The plant extract molecules that bind with silver ions can also act as a capping agent or stabilizing agent. Both agents influence the peak position and the synthesis method used influences the peak position. FTIR peak (1) for OH that is around 3300 per cm indicating the presence of hydroxyl group and from stabilizing agent,(2)for C=O stretching around 1600 per cm if the carboxyl group is involved, if N-Bonding around 1500 per cm.

**Fig 8:FTIR Image of AgNPs**

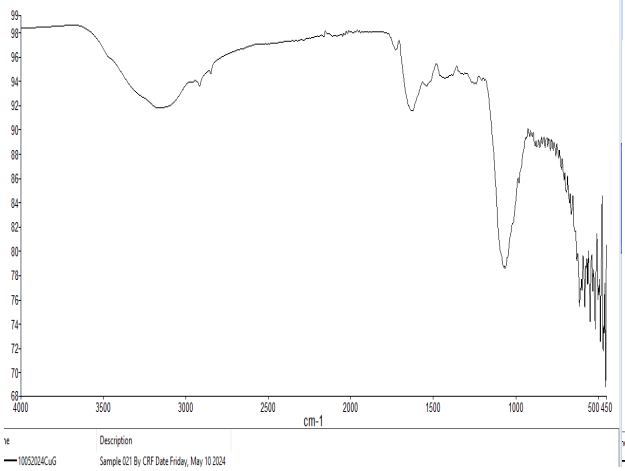
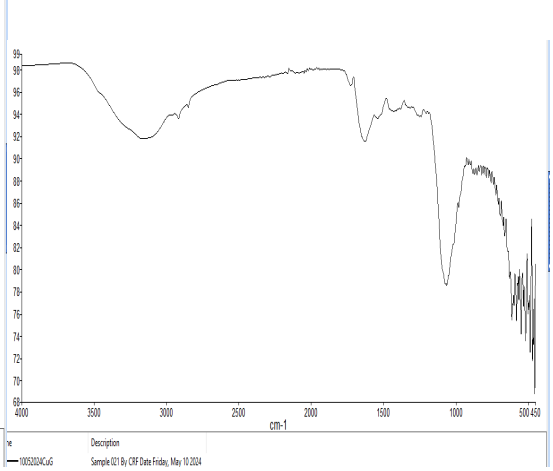


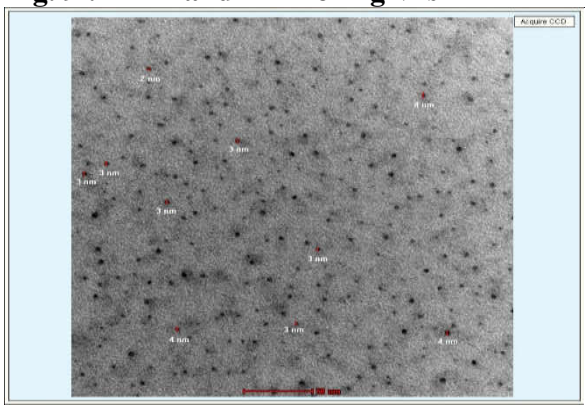

**Fig. 9: FTIR image of CuNPs**

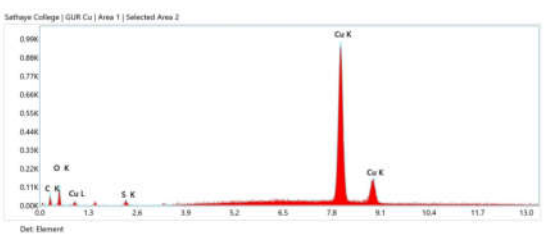



**TEM:** Transmission Electron Microscopy (TEM) can produce high-resolution images of nanoparticles, allowing the study of their size, shape, and structure at the nanoscale. TEM is a crucial tool for characterizing nanoparticles because it provides valuable information about their physical properties, which is essential for understanding their behavior and potential applications. TEM is widely used in various fields, including materials science, biology, and chemistry, to study the properties of nanoparticles and their interactions with other materials.

In this research Transmission Electron Microscopy analysis of *Gymnema sylvestre* plant extract revealed the presence of copper (Cu) nanoparticles, with a size range of 2-5 nanometers (nm). The size distribution of the nanoparticles was consistent with their wavelength range indicating a relatively narrow dispersion. These results suggest that the plant extract contains uniformly sized Cu nanoparticles, which could be utilized for various applications, including drug delivery for targeted therapy, catalysis to enhance chemical reactions, and electronics to create advanced materials for device

**Fig. 9 : TEM and EDX of AgNPs**



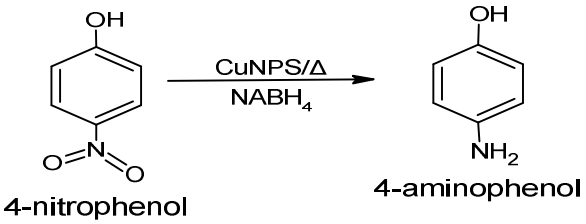




eZAF Quant Result

| Element | Weight % | MDL | Atomic % | Net Int. | Error % | R | A | F |
|---|---|---|---|---|---|---|---|---|
| C K | 12.3 | 0.55 | 40.0 | 11.7 | 16.5 | 0.7986 | 0.0520 | 1.0000 |
| O K | 3.0 | 0.11 | 7.5 | 21.5 | 13.7 | 0.8134 | 0.1495 | 1.0000 |
| S K | 0.5 | 0.02 | 0.6 | 10.0 | 11.9 | 0.8592 | 0.5614 | 1.0153 |
| Cu K | 84.2 | 1.30 | 51.9 | 498.8 | 3.1 | 0.9231 | 0.9820 | 1.0400 |

**EDX** (Energy Dispersive X-ray): Energy dispersive X-ray (EDX) analysis is a technique that can be used to identify the elemental composition of nanoparticles The qualitative elemental structure of green synthesized CuNPs of Gymnema sylvestre was assessed through EDX analysis. The graph given below shows the major peak of Cu at 8 keV with a mass percentage of 84.2 %. The EDX spectrum revealed a major peak of O at 1 keV and C at 0.5 keV [14]

**Catalytic reduction of 4-nitrophenol to 4-aminophenol:** The copper nanoparticles mixed with 4-nitrophenol give a reaction in the presence of nanoparticles and water with the addition of a catalytic agent such as sodium borohydride giving the color change from yellow to colorless in solution indicating the reduction from 4-nitrophenol to 4-aminophenol[15].




**Conclusions:**

This study demonstrates the successful bio-synthesis of silver (AgNPs), and copper (CuNPs) nanoparticles using the stem extract of *Gymnema sylvestre.* TEM analysis revealed CuNPs with a spherical shape and size range of 02-24nm. UV-Vis spectroscopy showed peak absorbance at 460.01nm, and 414.82nm, and confirmed the formation of AgNPs, and CuNPs, respectively. The results show that the bark extract-mediated synthesis method can produce nanoparticles with distinct sizes, shapes, and chemical compositions. This approach offers promising opportunities for various applications, including biomedical, catalytic, and electronic applications.

**Declaration of Competing Interest:**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Acknowledgement:**

All authors thank the Principal of Sathaye College, the HOD of Chemistry, and other members who have provided necessary research facilities and we also thank the ICON labs, Mumbai for providing the results for the TEM AND EDX study.

**Reference**

1) Khan I, Saeed K, Khan I. Nanoparticles: Properties, applications and toxicities, *Arabian Journal of Chemistry*. 2019;12(7): 908-931.https://doi.org/10.1016/j.arabjc.2017.05.011

2) Bahadar H, Maqbool F, Niaz K, Abdollahi M. Toxicity of nanoparticles and an overview of current experimental models. *Iranian Biomedical Journal*. 2016; 20: 1-11. https://doi.org/ 10.7508/ibj.2016.01.001
3) Kuppusamy P, Yusoff MM, Maniam GP. Natanamurugaraj Govindan, Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications – An updated report. Saudi Pharmaceutical Journal, 2016;24(4): 473-484. https://doi.org/10.1016/j.jsps.2014.11.013
4) Szczyglewska P, Feliczak-Guzik A , Nowak I. Nanotechnology–General Aspects: A Chemical Reduction Approach to the Synthesis of Nanoparticles. *Molecules*. 2023; 28(13) : 4932; https://doi.org/10.3390/molecules28134932
5) Bayda S, Adeel M, Tuccinardi T, Cordani M, Rizzolio F. The history of nanoscience and nanotechnology: From chemical-physical applications to nanomedicine. *Molecules***.** 2020**;** 25(1)*:* 112. https://doi.org/10.3390/molecules25010112.
6) Bitwell C, Indra SS, Luke C, Kakoma MK. A review of modern and conventional extraction techniques and their applications for extracting phytochemicals from plants. *Scientific African*. 2023;19: e01585. https://doi.org/10.1016/j.sciaf.2023.e01585.
7) Ilangovan R, Subha V, Earnest Ravindran RS , Kirubanandan S, Renganathan S. Nanomaterials: Synthesis, physicochemical characterization, and biopharmaceutical applications. *Nanoscale Processing, Micro and Nano Technologies.* 2021;2021: 33-70. https://doi.org/10.1016/B978-0-12-820569-3.00002-5.
8) Jain S , Kumar N, Tahir M, Garg S. Nanoparticle synthesis, characterization and applications, *The Impact of Nanoparticles on Agriculture and Soil*. 2023;2023:13-40. https://doi.org/10.1016/B978-0-323-91703-2.00007-5.
9) Tiwari P, Mishra BN, Sangwan NS. Phytochemical and Pharmacological Properties of *Gymnema sylvestre*: An Important Medicinal Plant. *Biomedical Research International.* 2014;2014:830285. https://doi.org/10.1155/2014/830285.
10) Tripathi A. Gymnema sylvestre: A medicinal plant with versatile therapeutic applications. *Journal of Nursing Research and Practices*. 2024;8(3):1-7.https://doi.org/10.37532/2632-251X.2024.8(3).1-7.
11) Junge JY, Andersen GH, Kidmose U. Suppression of sweetness: evidence for a central mechanism for suppression of sweetness from sucrose by citric acid. *Chemical Senses*. 2023, 48, 1–10. https://doi.org/10.1093/chemse/bjad036
12) Tiwari P, Mishra BN, Sangwan NS, Phytochemical and Pharmacological Properties of *Gymnema sylvestre*: An Important Medicinal Plant, *BioMed Research International*. 2014;2014:1- 18 https://doi.org/10.1155/2014/830285
13) Mapkar ZH, Benjamin S, Lokhande MV. Green Synthesis of AgNPs and CuNPs using Tambala (Pera) Stem Extract, *Journal of Applicable Chemistry*. 2019, 8 (6): 2336-2342.
14) Lokhande MV, Kokate PR, Sapkale KM, Tembulkar M. Bio-Synthesis of AgNPs and MnNPs of Philodendron giganteum Herbal Extract and catalysis's activity. *Asian Journal of Research in Pharmaceutical Sciences*. 2024;14(2):122-128. https://doi.org/10.52711/2231-5659.2024.00018.
15) Feng A, Lin C, Zhou H, Jin W, Hu Y, Dongyang L, Li Q. Catalytic transformation of 4-nitrophenol into 4-aminophenol over ZnO nanowire array-decorated Cu nanoparticles. *Green Chemical Engineering.* 2024; 5(2): 205-212. https://doi.org/10.1016/j.gce.2023.03.003.


---