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Biosynthesis, Characterization and Photocatalytic Activities of Ag-Cu Bimetallic Nanoparticles Derived from *mukia maderaspatana* Leaf Extract

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Abstract: The majority of studies focused on the biological synthesis of nanoparticles, which was one of the unexpansive methods. Utilizing mukia maderaspatana Leaf extract, we have focused on the Cheapest and simplest method for the synthesis of Ag-Cu bimetallic Nanoparticles. The synthesized Ag-Cu BNPs were further confirmed by UV-visible spectroscopy, FT-IR spectroscopy, Scanning electron microscope (SEM) and Energy dispersive X-ray spectroscopy (EDX). Further we also discuss the Photocatalytic absorption of Amido Black dye processed in UV irradiation at various time interval. This Biosynthetic method has been discovered to be economical, environmentally benign and promising for use in a variety of fields.
Keywords: Biosynthesis, Bimetallic Nanoparticles, mukia maderaspatana, Photocatalytic Activities.

I. INTRODUCTION

When compared to larger particles of the bulk material of which they are made, nanoparticles exhibit properties that are either entirely new or significantly improved based on specific characteristics like size, distribution, and morphology [1-5]. The surface-to-volume ratio of nanoparticles increases as their size decreases. Silver nanoparticles antimicrobial activity, catalytic reactivity, and other related properties all depend on a specific surface area. Due to a change in their unique physical, mechanical, optical, and electromagnetic properties, nanomaterials have a higher value than bulk materials [6]. Nanoparticles can be delivered through various strategies, with compound methodologies being the most famous. However, the synthesis protocol still calls for the use of toxic chemicals and these methods cannot avoid it. Gold, silver, and platinum nanoparticles are widely used in medical and pharmaceutical applications, as well as in areas where people come into contact with them, such as toothpaste, shampoo, soap, and detergents. As a result, environmentally friendly nanoparticle synthesis methods that do not rely on toxic chemicals are becoming increasingly important. As eco-friendly alternatives to chemical and physical methods, biological nanoparticle synthesis methods with microorganisms [8-10], enzymes [11], and plants or plant extracts [12] have been proposed. Because it eliminates the complicated process of maintaining cell cultures and can be appropriately scaled up for large-scale nanoparticle synthesis, using plants for nanoparticle synthesis may be preferable to other biological processes.

By screening the reaction and raising the temperature of the reaction, we were able to synthesize gold, silver, and platinum like nanoparticles at rates that were comparable to those of chemical methods [13]. By altering the reaction mixture's temperature and composition, the particle size could also be controlled from 15 to 500 nm. Due to their unusual electronic/optical and catalytic properties, bimetallic nanoparticles, either in the form of alloys or core-shell nanostructures, are being studied more and more in addition to pure metallic nanoparticles [14]. Utilizing *mukia maderaspatana* leaf for the competitive reduction of Ag and Cu, we synthesized bimetallic Ag-Cu nanoparticles and hypothesized that the characterization data suggested the formation of a bimetallic Cu core/Ag shell structure. An organic dye solution like Amido Black was used to study the Ag-Cu BNPs photocatalytic activities under a visible light source. The outcome got from photocatalytic degradation shown the way that the Ag-Cu BNPs can act as a reasonable Photocatalyst for the Amido Black like organic pollutants present in the environment.

II. MATERIALS AND METHODS

A. Preparation of mukia maderaspatana Leaf Extract

Initially, *mukia maderaspatana* leaves were collected and dried for 2 days at room temperature. The plant extract was prepared by taking approximately 3g of thoroughly washed and finely cut leaves in a 300mL Erlenmeyer flask with 100mL of distilled water. It was stirring for 5 minutes. After the stirring process filters the reaction mixture to get a plant extract which acts as a reducing or capping agent.

B. Synthesis of Bimetallic Nanoparticles

Bimetallic colloidal solution of Ag-Cu was synthesized by the Bio method. Initially, 100ml of sterile double distilled water containing 0.042g of $AgNO_3$ solution was refluxed for one hour at 90-100°C. Then 10 ml of plant extract (*mukia maderaspatana*) was slowly added to the reaction mixture. The colour change of the solution from colourless to greenish-yellow showed that silver nanoparticles were formed. After 30 min of boiling 0.01g of $CuSO_4$ solution was added drop wise directly to the Ag NPs solution and the heating was continued for one and half hours until the reaction mixture's colour changed, which indicates the formation of Ag-Cu Bimetallic Nanoparticles. The Ag-Cu BNPs solution was Centrifuge, the suspended particle collect and dry the product using muffle furnace.

C. Characterization

In order to determine the specific properties of the Synthesized Ag-Cu BNPs. Various characterization techniques were utilized. The absorption spectrum was recorded using UV-visible spectroscopy for optical properties. The shape of Ag-Cu BNPs was determined with the help of SEM. The functional groups were identified by FTIR spectrum. The element in BNPs were characterized by using EDX.

III. RESULTS AND DISCUSSION

A. UV-visible Spectroscopy

The solution UV-visible spectra and visual inspection of the solution are used to regularly monitor the reduction of metal nanoparticles from the solution.

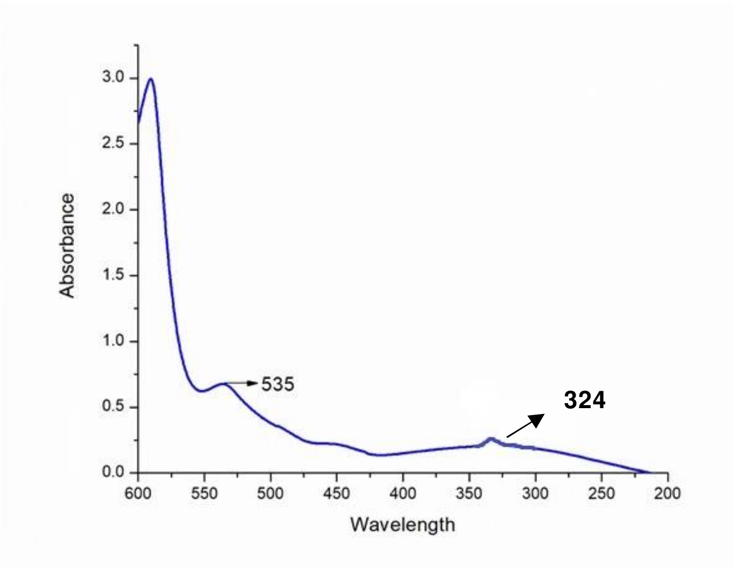

Fig 1: UV-visible spectrum of Ag-Cu Colloidal solution

The typical surface Plasmon peak of Ag NPs can be seen in the broad absorption peak at 535 nm. In contrast, the Ag-Cu BNPs exhibit the typical Plasmon peak at 535 and 324nm. The spectrum is used to predict the formation of the core shell as a starting point for analysis. Lastly, this study demonstrates that the colloidal solution contains only Ag-Cu BNPs.

B. Scanning Electron Microscopy (SEM)

One of the promising methods for studying the sample's morphology is scanning electron microscopy (SEM), which helps identify the grain's growth mechanism, shape, and size. Using SEM, the morphology of the Ag-Cu Bimetallic colloid was examined, as depicted in Fig 2. With more resolution.

It confirms the surface morphology and spherical structure of Ag-Cu bimetallic. The size of the bimetallic Ag-Cu is measured and found to be in the range of 10µm and the surface morphology of silver Nanomaterial's is aggregated form irregular Nano crystal of different shapes. Visual magnification can help identify it.

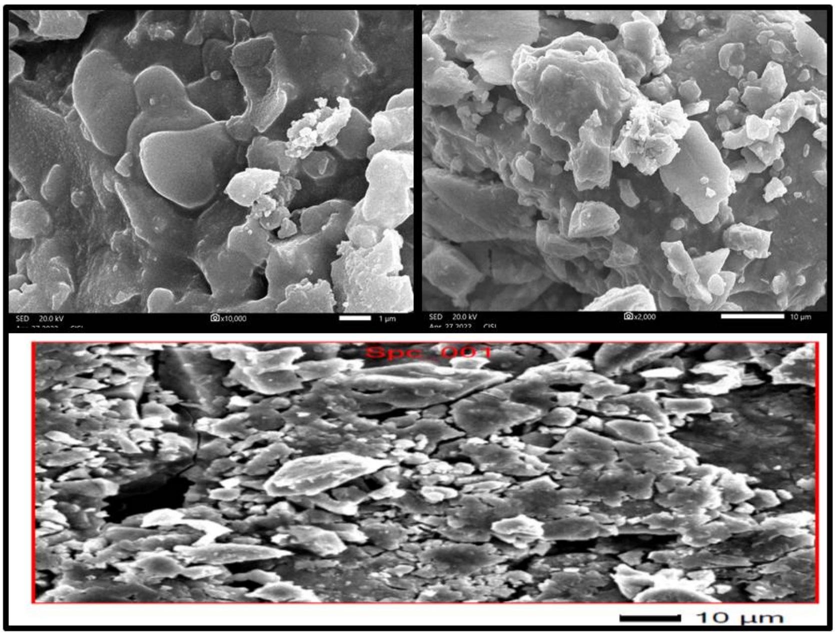

Fig 2: SEM image for Ag-Cu Bimetallic Nanoparticles

C. Energy Dispersive X-ray Analysis (EDX)

EDX analysis was used in the compositional analysis of the synthesized catalyst to identify the element in bimetallic nanoparticles. In order to increase the peak's spatial resolution, the majority of the EDX analysis makes use of an accelerating voltage of 10 kV. This accelerating voltage was sufficient to generate elemental peaks from the sample specimen.

The quantitative analysis of elements in the sample is detected by the peak intensity. Higher the peak intensity higher will be a composition of elements. Here in the EDX spectrum mass percentage was found to be silver is 91.18% and for copper is 88.2%. It demonstrates that bimetallic will be in core-shell form (Core-Cu/shell–Ag). From these, it is concluded that bimetallic is in core-shell formed is confirmed.

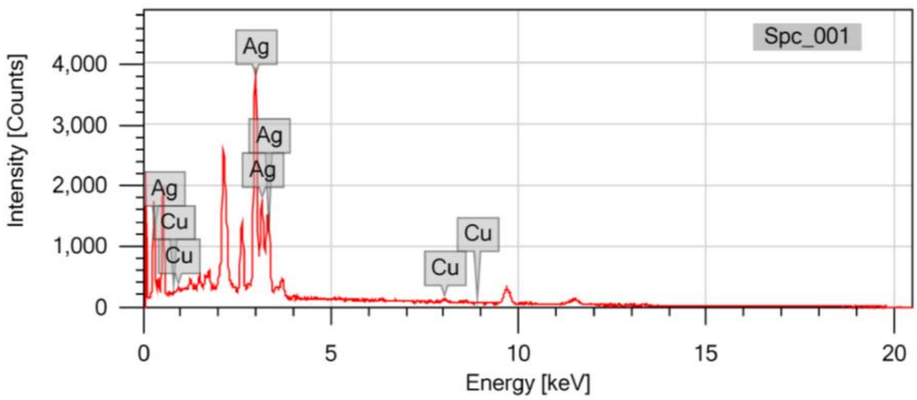

Fig 3: EDX image of Ag-Cu Bimetallic Nanoparticles

D. Fourier Transform Infrared Spectroscopy (FT-IR)

FT-IR spectroscopy has been recognized as a sensitive method for determining the functional groups and binding interactions of metal with plant extract using the IR region between 400 and 4000 cm^{-1}.

The stretching of the O-H band of alcohol groups and the C=H band of alkene produced the appearance of a band at 3298.4 and 1415 cm^{-1}, respectively. Additionally, the peak appearance at 1642.9 suggests the presence of asymmetric C=O groups. The consequence of this reviews recommend that *mukia maderaspatana* leaf extract being a suitable reducing agents for Ag-Cu BNPs synthesis.

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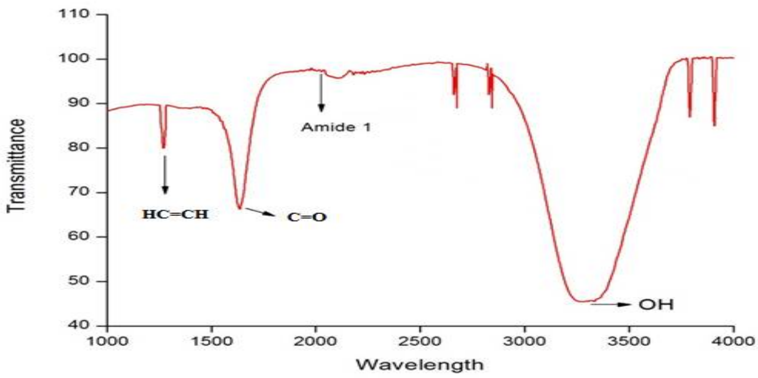

Fig 4: FT-IR Spectrum of Ag-Cu Colloidal Solution

Functional Group	FT-IR (cm^{-1})
>C=O	1642.9
-CH=CH-	1415
-OH	3298.4

Table 1: Functional groups and Characteristic Absorption

E. Photocatalytic Activity

In this studies, the degradation efficiency of the Amido Black dye were studied using *mukia maderaspatana* mediated bioactive Ag-Cu BNPs. The photo degradation ability of biosynthesized photo catalyst (Ag-Cu) were tested by applying them in the degradation of 20ml (20ppm) solution of Amido Black dye with 0.1g of catalyst. The experiment was carried out under stimulated light irradiation at 250Mw for 180min. In addition, the degradation experiment was performed using bare Ag-Cu in the absence of UV filter. This was intended to find out the influence of UV filter on photocatalytic performance of Ag-Cu BNPs.

A degradation spectrum of Amido black dye towards UV irradiation at various time interval is illustrated in Fig 5. The decreasing in absorbance with increasing in time intervals reveals the catalytic behaviour of Ag-Cu BNPs. A maximum absorbance of Amido black dye shows at 270nm. A 50% of degradation after 40min confirms the degradation potential of Ag-Cu BNPs. The following equation can be used to calibrate a degradation percentage

$$\%D = C_0 - C_t / C_0 \text{ X } 100$$

Where,

%D = Percentage of Degradation

C_0 = Initial Concentration

C_t = Concentration at Various Time Interval

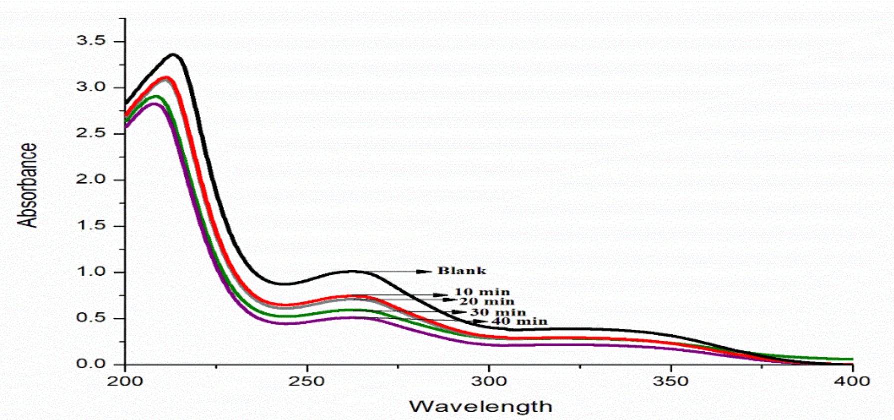

Fig 5: UV-Visible Spectrum of Amido Black dye on Degradation

S. No	Time Interval	Concentration
1	Blank	1.017
2	10min	0.762
3	20min	0.706
4	30min	0.603
5	40min	0.516

Table 2: Variation of Concentration at Different Time Interval

IV. CONCLUSION

Ag-Cu Bimetallic Nanoparticles were successfully synthesized by biogenic route using *mukia maderaspatana* leaf extract. The presence of Plasmon peaks at 535 and 324nm in the UV-visible spectrum attests to the production of Ag-Cu BNPs. The spherical structure of the synthesized Ag-Cu BNPs was discovered by SEM analysis. The Ag and Cu peaks in Ag-Cu BNPs were discovered through EDX analysis, which also revealed that the bimetallic structure will be core-shell form (Core-Cu/shell–Ag). FT-IR spectroscopy result shows *mukia maderaspatana* leaf extract being a suitable reducing agents for Ag-Cu BNPs synthesis. The Photocatalytic activity of Ag-Cu bimetallic nanoparticles was confirmed through Photo degradation of Amido black dye.

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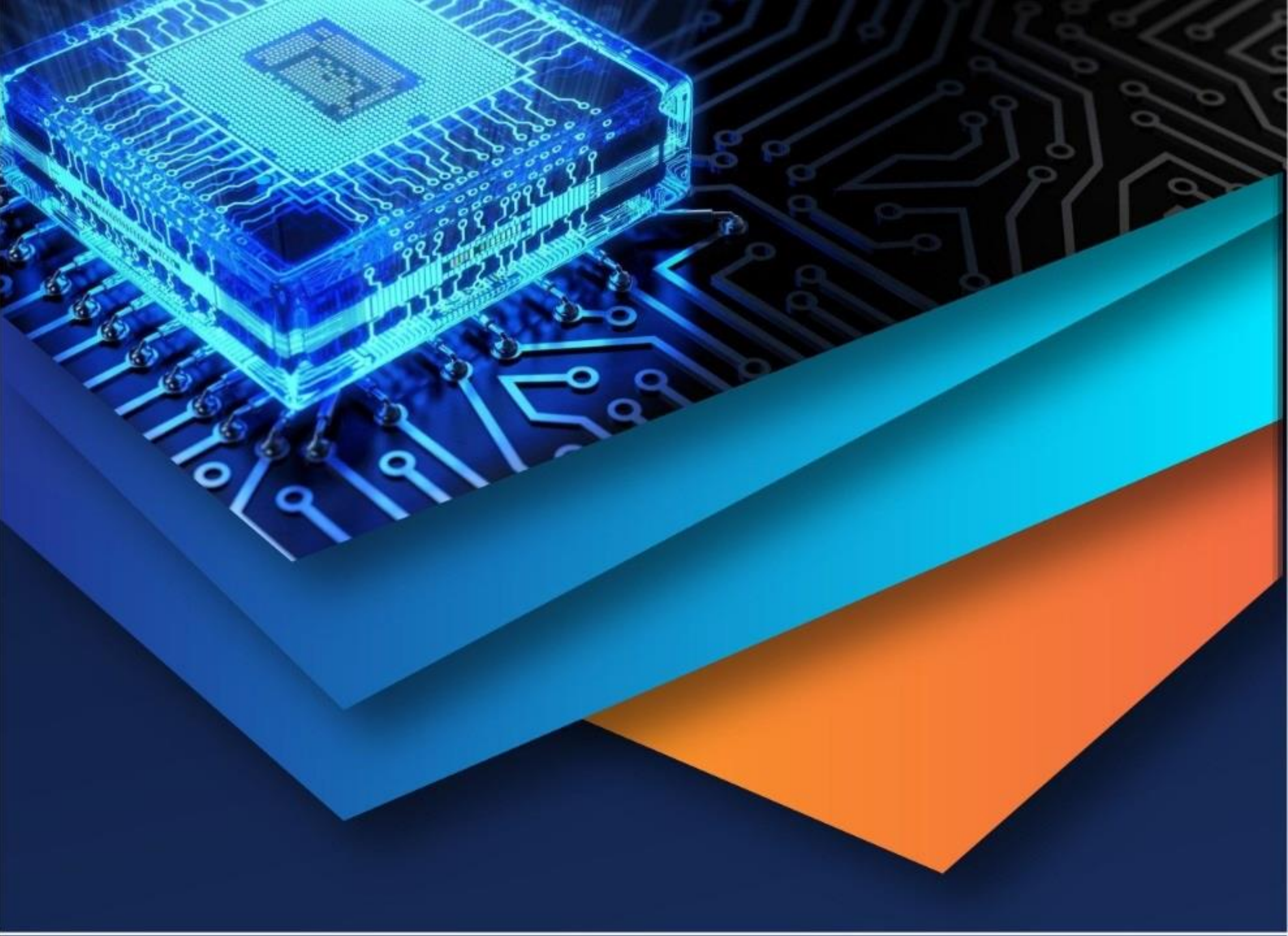

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