



Bio-Synthesis of Copper Nanoparticles using An Extract of Jatropha Curcas Leaves and Photocatalytic Activity

Dr. Jagdeesh Meena

Assistant Professor, Department of Chemistry, Solar Energy Laboratory Govt. College Karauli, Rajasthan, India

Abstract--Currently, chemical processes are used mostly to create nanoscale metals, which might have unforeseen consequences such as environmental contamination, high energy consumption, and significant health issues. In response to these challenges, Bio-synthesis, which uses plant extracts instead of industrial chemical agents to reduce metal ions, has been developed. Bio-synthesis is more beneficial compare to traditional chemical synthesis because its decreases pollution, low costs, and improves environmental or human health safety. In this research work developments in the Bio-synthesis of Cu nanoparticles using jatropha curcas extract. The Bio-synthesis CuNPs were characterised by XRD, FT-IR, and UV-vis spectrophotometry. The average particle sizes of the Bio-CuNPs were found to be 11 ± 1 and 13 ± 1 nm, respectively. The SPR peaks were found at 270 and 340 nm, measured using electronic spectroscopy. Bio-synthesis CuNPs have potential photocatalytic activity methylene blue (MB) dyes in the presence of sunlight.

Keywords – Jatropha, copper nanoparticle, MB dye

I. INTRODUCTION

Nanometals are widely used in many fields such as medicine, environment, and engineering that synthesis of nanoscale metals is a timely topic. Heavy metals and various dyes are extensively dispersed in the environment and are ecologically significant owing to their high harmfulness for living organism including human being (1). Compared to non-Nano or bulk metals, nanoscale metals have a higher surface area. Moreover, they possess special physical and chemical properties not present in non-Nano metals as a result of the Miniature effect, surface effect, interface effect, and quantum effect. Numerous types of nanoscale metals are used extensively in biology, medicine, and engineering (2). Nanoparticles synthesis by medicinal plants shows more benefit; they may enhance the antibacterial activity of Copper nanoparticles, because the medicinally valuable active biomolecule present in the plants may bind on the surface of the nanoparticles and reduce the copper ions to copper nanoparticles.

Consequently, bio-inspired technology for NPs synthesis emerged as a prominent subfield in the field of nanoscience and nanotechnology (3,4). Many metal and metal oxide nanoparticles (NPs) have been made so far using plant extract, microorganisms, etc. (5,6). In addition to their numerous uses in the synthesis of NPs, our group and others have focused heavily on plant biomass as a catalyst for chemical synthesis (7,8) and the generation of biodiesel due to its abundant availability, renewability, and environmentally friendly character (9,10). Study of this plant by R.M. Agarwal et al. (2015) proved Analyses of the phytochemistry of Jatropha curcas L. throughout the year. Total phenols, tannins, and free amino acids in Jatropha curcas leaves varied seasonally. However, phytic acid concentrations were higher during the rainy season. Maximum levels of these compounds were identified in leaves collected during the summer months (May-June) and least during the rainy season (July-August) (11). In this study, we successfully reported the biosynthesis of copper nanoparticles using JC leaf extract. Synthesized copper nanoparticles were applied to dye degradation under sunlight irradiation.

II. REAGENTS AND CHEMICALS

copper chloride (CuCl_2) was purchased from Merk (Germany). Fresh Jatropha curcas leaf was obtained from a local College campus. All chemicals and reagents used were of the analytical grade as received and without further purification. All aqueous solutions were prepared with doubly-distilled water.

III. MATERIALS AND METHODS

3.1 Plant materials

The leaves of J. curcas were collected from local college campus karauli in rajasthan (india). In July 2023 (Fig. 1). The authentication of the plant species was done by subject experts Dr. Mahesh chand Assistant professor in the Department of Botany.



Fig.1: Fresh *Jatropha curcas* leaf

3.2 Preparation of Green Reducing Agent

Jatropha curcas leaves were gathered in Karauli, India, on the college campus. Finely chopped fresh leaves weighing 10 g were rinsed in double-distilled water and boiled in 100 mL of the same water for 10 minutes at 60 degrees. The leaf extract supernatant from the boiled mixture was collected and kept at 4 degrees Celsius for further nanoparticle formation.

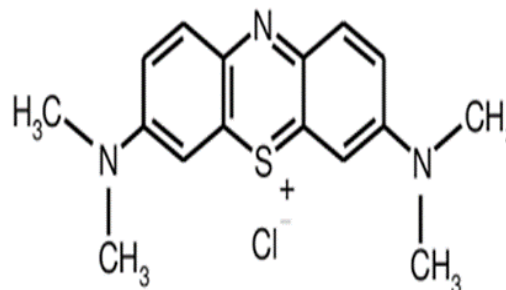


Fig.2: chemical structure of MB dye collect from in local college

3.3 Synthesis of copper nanoparticle

160 mL of copper chloride (3 mM) and 40 mL of the fresh extract of *J. curcas* leaf were added to an Erlenmeyer flask and swirled for 5 minutes. and the mixture was agitated continuously for a further 24 hours at room temperature. which went the colour change of the solution during the reaction, from deep brown to yellowish-brown. That is indicating the formation of the JC-CuNPs. UV-vis spectroscopy studies supported this result. Afterward, the final mixture was centrifuged at 10000–11000 rpm to extract the JC-CuNPs from it. The solution was then removed and the brown-black JC-CuNPs were collected.

IV. OPTICAL PROPERTIES

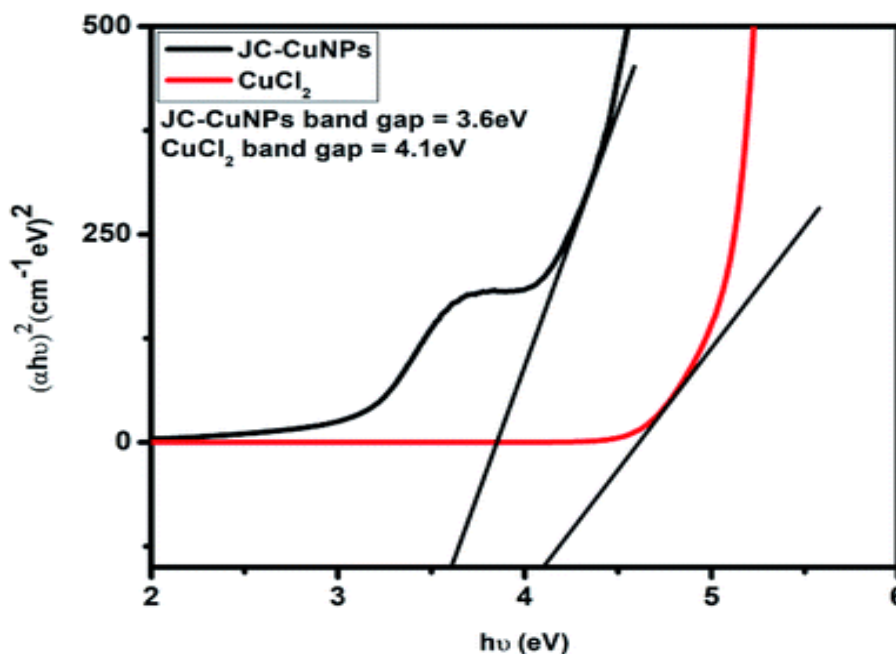


Fig. 3: Energy gap b/w VB & CB for the JC-CuNPs and for copper chloride.

In Fig. 3 the JC-CuNPs' UV-visible spectrum is shown. Using information from the UV spectrum, we computed the band gap energy. The band gap energy was calculated using Tauc's relation, illustrated in eq. (1)

$$(\alpha h\nu)^n = A(h\nu - E_g) \dots\dots\dots(1).$$

Where

α = absorption coefficient

A = a constant

E_g = optical band gap energy

n = exponent that varies on transition,

h = Planck's constant.

Plotting $(\alpha h\nu)^2$ vs $h\nu$ and projecting the linear section of the curve to $(\alpha h\nu)^2 = 0$ in Fig. 3 demonstrates the use of the Tauc relation to determine the optical band gap. As a result, the optical energy band gaps of copper chloride and JC-CuNPs were 4.1 and 3.6 eV, respectively. The band gap energy reveals that the JC-CuNPs have semiconductor properties and act as a active photocatalysts for the degradation of MB dye.

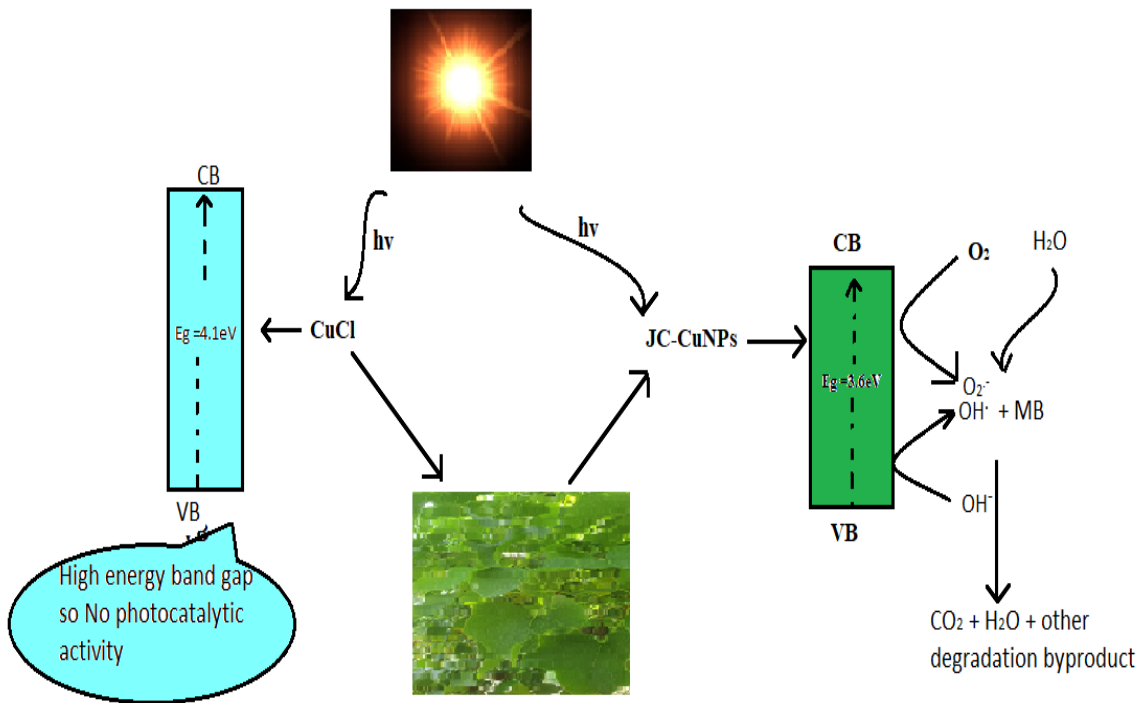


Fig.4: Schematically Representation of Synthesis of CuNPs using Jatropa curcas Leaves extracts and dye degradation

V. PHOTOCATALYTIC ACTIVITY OF JC-CUNPNS

The band gap value (3.6 ev) of JC-CuNPs suggests that the material has semiconductor properties.

Therefore, we investigated the photocatalytic activity of JC-CuNPs against different condition of organic dyes such as MB under sunlight.

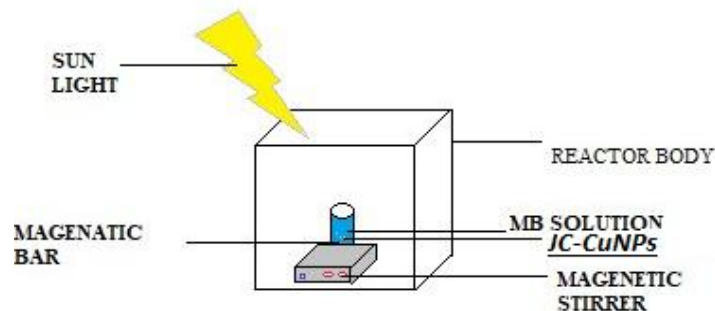


Fig. 5: PHOTOCHEMICAL REACTOR

5.1 Photocatalytic Activity of MB

Decolorization of MB was investigated under Three different experimental conditions through

SUN light alone (Photolysis)

SUN light + JC-CuNPs and (Photocatalysis)

Dark + JC-CuNPs (Dark Run)

Initially blank experiments were performed under Sun Radiation without addition of any catalyst and only 2.47 % decolorization was observed. Then photocatalytic experiments were carried performed under Sun Radiation with Nano catalyst the decolorization of dye was achieved after 85 min, where a 93.4 % decolorization of MB was observed in duration. There after the adsorption of the dye was observed with Nano Catalysts in Dark (Dark + PC) Only 5.048 %, adsorption of the MB dye was seen in the same time with catalysts under dark conditions.

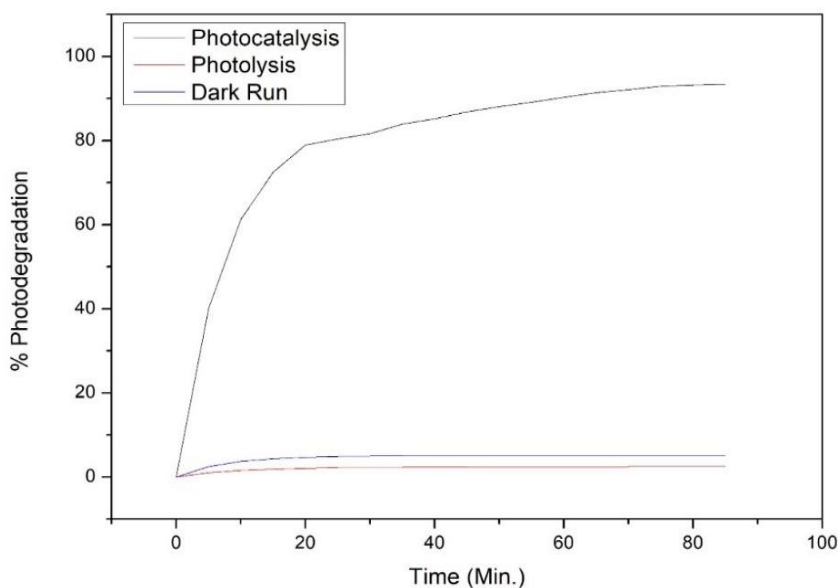


Fig. 6: Photocatalytic Activity of MB with JC-CuNPs

5.2 Effect of the initial dye concentration

Experiment was carried out by varying the initial concentrations of the dye from 10 to 25 mg/L in order to assess the appropriate amount of JC-CuNPs catalyst dose. As the concentration of the dye was increased, the rate of photo decolorization decreased indicating for either to increase the catalyst dose or time span for the complete removal.

Fig. 7 at different concentrations of dye solutions (10–25 mg/L). The possible explanation for this behavior is that main aspects as the initial concentration of the dye increases, the path length of the photons entering the solution decreases and in low concentration the reverse effect is observed, thereby increasing the number of photon absorption by the JC-CuNPs catalyst in lower concentration

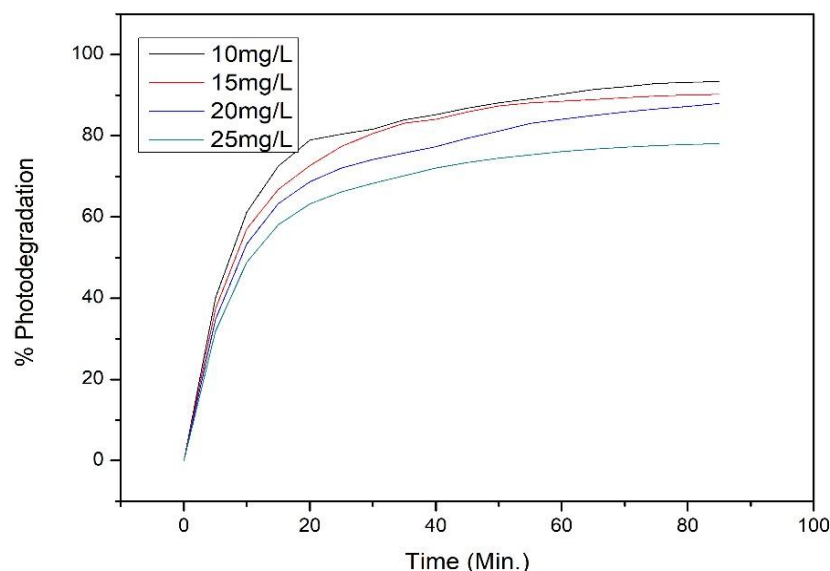


Fig. 7: Effect of Initial Dye Concentration on Photodegradation of MB JC-CuNPs

5.3 Effect of the JC-CuNPs catalyst Dose

It can be seen that initial slopes of the curves increase greatly by increasing JC-CuNPs catalyst loading from 5 mg to 10 mg/L for MB degradation. thereafter the rate of decolorization remains constant or decreases. Further increase in the dose of JC-CuNPs catalyst had no significant effect on decolorization of dyes. The photocatalytic destruction of other organic pollutants has also exhibited the same dependency on catalyst dose.

Because the total active surface area of the catalyst rises with an increase in dosage, more active sites are available on the catalyst surface. (12) But At the same time, due to an increase in turbidity of the suspension with high dose of JC-CuNPs photocatalyst there will be decrease in penetration of UV light and hence photoactivated volume of suspension decreases. (13-15). At higher catalyst loading may be due to the deactivation of activated molecules by collision with ground state catalysts, thus reducing the rate of reaction. (16).

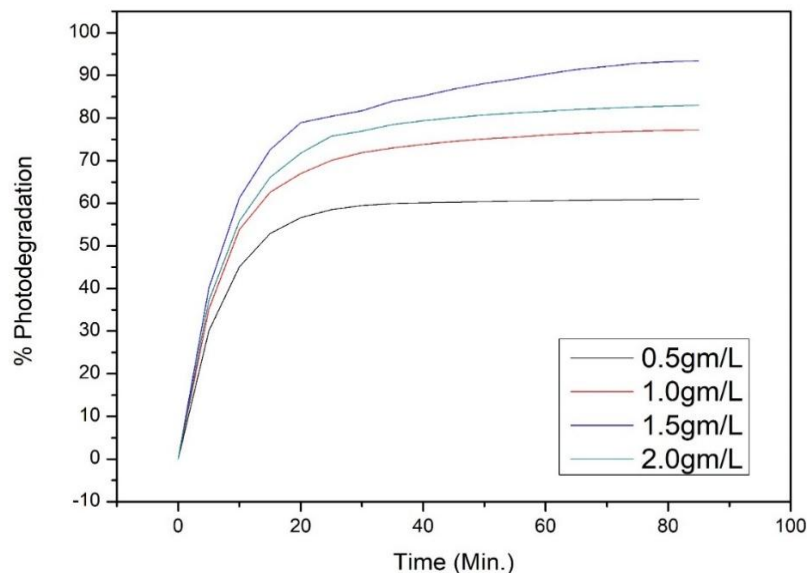


Fig. 8: Effect of JC-CuNPs catalyst Dose on Photodegradation MB dye

5.4 Effect of the pH

The pH value of a solution is a crucial factor to be considered in the decolorization of the MB solution. The implications of pH of solution medium on the period of synthesis, size and shape of the synthesized nanoparticles had been highlighted. The formation of nucleation centres in nanoparticles synthesis depend greatly on pH.

Experiments were conducted at different pH levels, ranging from 3.5 to 11.5 for constant dye concentration (10 mg/L) and catalyst loading (10 mg/L, respectively), in order to investigate the impact of pH on the decolorization efficiency. It has been found that the decolorization efficiency of MB dye rises with increasing pH, with the maximum rate of degradation occurring at pH 7. The difference in degradation results can be attributed to the different in type of used catalyst. (17).

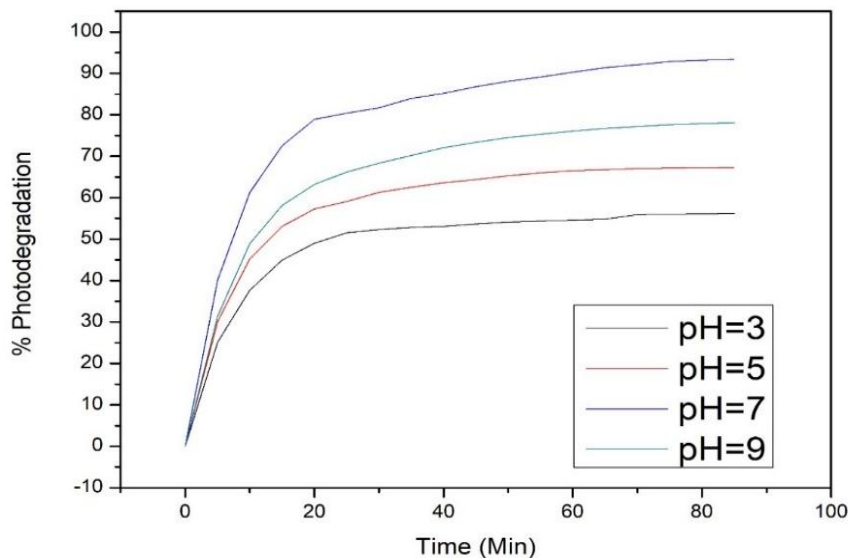


Fig. 9: Effect of pH on Photodegradation MB dye

VI. CONCLUSION

It's easy, cost effective, ecofriendly process it can be scaled up to large scale production, excellent biocompatibility, they can easily under goes to Bio-degradation process. But It is a very difficult to control the size and shape of nanoparticles. And Plants extracts cannot be stored for long time.

REFERENCES

- [1] Sushil R. Mathapati et. al Asian J. Research Chem. 2023; 16(2):105-108.
- [2] Zhao, X., et al., 2016.. Water Res. 100, 245–266.
- [3] P. Mohanpuria, N. K. Rana and S. K. Yadav, J. Nanopart. Res., 2008, 10, 507–517.
- [4] G. Pathak, K. Rajkumari and L. Rokhum, Nanoscale Adv., 2019, 1, 1013–1020
- [5] S. A. Saiqa Ikram, J. Nanomed. Nanotechnol., 2015, 6, 1000309.
- [6] S. Ahmed and S. Ikram, Nano Res. Appl., 2015, 1, 1–6.
- [7] K. Rajkumari, D. Das, G. Pathak and L. Rokhum, New J.Chem., 2019, 43, 2134–2140.
- [8] B. Changmai, I. B. Laskar and L. Rokhum, J. Taiwan Inst. Chem. Eng., 2019, 102, 276–282.
- [9] B. Changmai, P. Sudarsanam and L. Rokhum, Ind. Crops Prod., 2020, 145, 111911.
- [10] B. Nath, B. Das, P. Kalita and S. Basumatary, J. Cleaner Prod., 2019, 239, 118112.
- [11] R.M. Agarwal et al. Mol Biol Plants 2015 Jan;21(1):83-92. doi: 10.1007/s12298-014-0272-0. Epub 2014 Dec 24
- [12] 12. Z. Z. Vasiljevic et al. R. Soc. Open Sci. 7:(2020)
- [13] 13. M.A. Nadeem et al. RSC Adv.,vol. 4 (2014).
- [14] 14. Z.Z. Vasiljevic et al. R.Soc.Open Sci. vol. 7 (2022).
- [15] 15. Sushil kumar et al. Nanoscale Res Lett vol.4 (2009).
- [16] 16. Suhila Alkaykh et al. Heliyon Vol. 6, Issue 4, April 2020
- [17] 17. Poedji Loekitowati Hariani et al. Jon. Of Eco.Eng. 2022, 23(1), 118–12