# STUDY OF PHOTO-CATALYTIC DEGRADATION OF METHYL ORANGE ON ZnO CATALYST SYNTHESIZED USING MEDICINAL PLANT (*CATHARANTHUS ROSEUS)* AS BIO-TEMPLATE

**Savita Sharma[1], Anjali Oudhia[2], Nameeta Brahme[3], Pragya Kulkarni[4]**

*[1,2]Department of Physics, Govt. V.Y.T. PG. Auto. College Durg, Chhattisgarh, (India)*

*[3]SOS in Physics, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, (India)*

*[4]Department of Microbiology, Govt.V.Y.T. PG., Auto.College,Durg,Chhattisgarh, (India)*

**ABSTRACT**

*Materials found in nature have many inspiring structures that endow them with amazing functions, such as energy harvesting and conversion, antireflection, structural coloration, super hydro-phobicity, and biological self-assembly. Bio-templating is an effective strategy to obtain morphology-controllable materials with structural specificity, complexity, and related unique functions. Herein, we highlight the synthesis and application of biotemplated ZnO NPs for the area of energy and environment technology namely photo-catalytic degradation. In this study, ZnO catalyst was prepared using leaf extract of a medicinal plant (Catharanthus roseus) as bio template. The prepared ZnO NPs were characterized through SEM, XRD, FTIR and UV-Visible Spectroscopy techniques and used for photo-catalytic degradation of methyl orange (MO) dye solution in presence of UV light. 98% degradation was observed within 120 min. exposure of UV light which was compared with degradation in dark.*

***Keywords: Bio-template, ZnO photo-catalyst, Energy harvesting, Medicinal Plant.***

## I. INTRODUCTION

Zinc oxide (ZnO), a II-VI compound semiconductor with a wide direct bandgap (3.37 eV) and a large exciton binding energy (60 meV) at room temperature, has attracted increasing interest over the past 10 years due to its specific electrical and optoelectronic properties and wide potential applications in luminescence, photocatalysts, surface acoustic wave filters, piezoelectric transducers and actuators, gas sensors, solar cells, and so on [1, 2, 3]. The potential use in photo-catalysis (e.g., photolysis of water to generate hydrogen, photodecomposition of organics) has particularly aroused great interest, as there have been several examples of ZnO displaying more impressive photo-catalytic activity than widely studied titanium dioxide [4].

*Catharanthus roseus* is an important medicinal plant belonging to the family Apocynaceae, the other common names are periwinkle, Madagascar periwinkle, sadabhar. Traditionally *Catharanthus roseus* has been used in folk medication to take care of diabetes, high blood pressure and diarrhea [5, 6, 7]. Lot of work had been carried out on *C. roseus* for isolation of secondary metabolites but reports on synthesis of nanoparticles particularly

ZnO-NPs are scanty. Here In this paper we used wet chemical method for synthesis of ZnO nano-catalyst by using Catharanthus *roseus* leaf acting as bio-template.

## II. MATERIALS AND METHODS

### 2.1 Synthesis of ZnO Nanoparticles Using Leaf Extract Template

10gm of *Cathranthus* leaf extract was crushed with clean sand in a pestle and mortar, cleaned, and then mixed with 100 ml of Double distilled (DD) water in chilled conditions for the preparation of the extracts. The so obtained solutions were centrifuged by standard centrifugation method and stored at $5^0$C in a refrigerator for further use. Zinc acetate (0.5M) was dissolved in DD water. The cathranthus extract was stirred using a magnetic stirrer (~ 600rpm) at ~ $70^0$C. NaOH was added to this solution to adjust the pH~ 11.5. An equal volume of zinc acetate solution was added drop vice to the above solution during a span of 1hour. The solution was kept standing at room temperature for 24 hours. The precipitated ZnO NPs were filtered, washed with ethanol and DD water for several times, dried and stored in powdered form at room temperature.

### 2.2 Structural and Morphological Analysis

The crystal structure, size, and shape of the as prepared ZnO NPs were investigated using XRD (PAN analytical Xpert PRO, CuKa radiation $\lambda$=1.5406A$^o$) and SEM (Hitachi SU6600). For optical characterization, UV-visible spectrophotomer (UV spectrophotometer 119, Systronics, Software Version 1) and FTIR (Shimadzu IRAFFINITY-1) were used.

### 2.3 Photo-catalytic Degradation Experiment

The photo-catalytic experiments were carried out using a home-made photo-reactor (100cm ×100 cm × 100 cm), and using a 340 W mercury lamp for UV irradiation. The distance between the solution surface and the light source was about 12 cm. In a typical experiment, 100 mL of aqueous Methyl Orange(MO) with an initial concentration of 10 mgL$^{-1}$ (pH 7.0, maintained by added NaOH or HCl) were placed in a beaker, the photo catalyst (10mg L$^{-1}$) added and the suspension stirred for 30 min in the dark, at room temperature, to ensure the establishment of the adsorption/desorption equilibrium. The UV lamp was turned on while the suspension was magnetically stirred. At fixed intervals of time, 3 mL of sample were withdrawn, centrifuged, and the supernatant transferred into a spectrophotometer cell for measurement of the absorbance of MO. Absorbance measurements were also recorded in the range of 200-700nm, using a UV-Vis spectrophotometer. Finally, photo-catalytic degradation efficiency (PDE) of MO solutions was calculated with the following formula:

$$PDE\ (\%) = \frac{A_0 - A}{A_0} \times 100\% \quad \text{\_\_\_\_\_\_\_} (1)$$

Where, $A_0$ and A are the UV–Vis absorption of MO solution and MO solutions in suspension after time t.

## III. RESULTS AND DISCUSSION

### 3.1 SEM Analysis

SEM image of the ZnO NPs prepared by plant leaf as bio-templates are depicted in Fig. 1. Most of the particles exhibited ellipsoidal (rice grain like) morphology having the dimensions ~19nm width and 20nm to 400nm length.

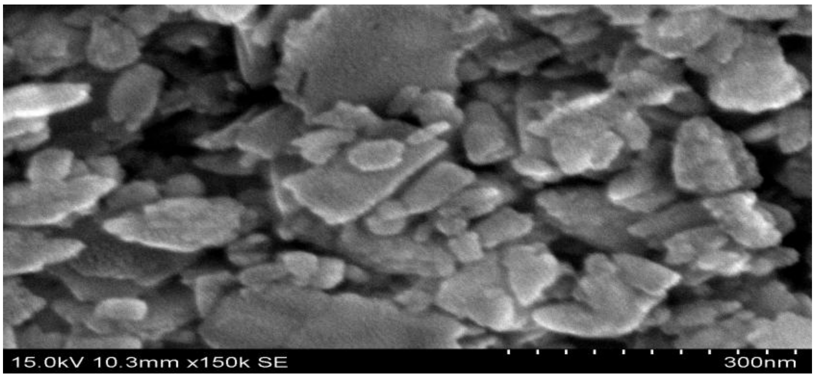


**Figure 1. SEM imege of ZnO NPs synthesized by *Catharanthus roseus* Leaf extract as biotemplate.**

### 3.2 XRD Analysis

Fig.2 shows the X-ray diffraction (XRD) pattern of ZnO, NPs. The XRD pattern revealed the orientation and crystalline nature of ZnO NPs. The Presence of (100),(002) and (101) peaks in XRD patterns indicate a polycrystalline wurtzite structure of the as obtained ZnO NPs.The average crystalline size of the synthesized ZnO NPs was calculated to be ~22nm by using Debye-Scherrer equation [8].

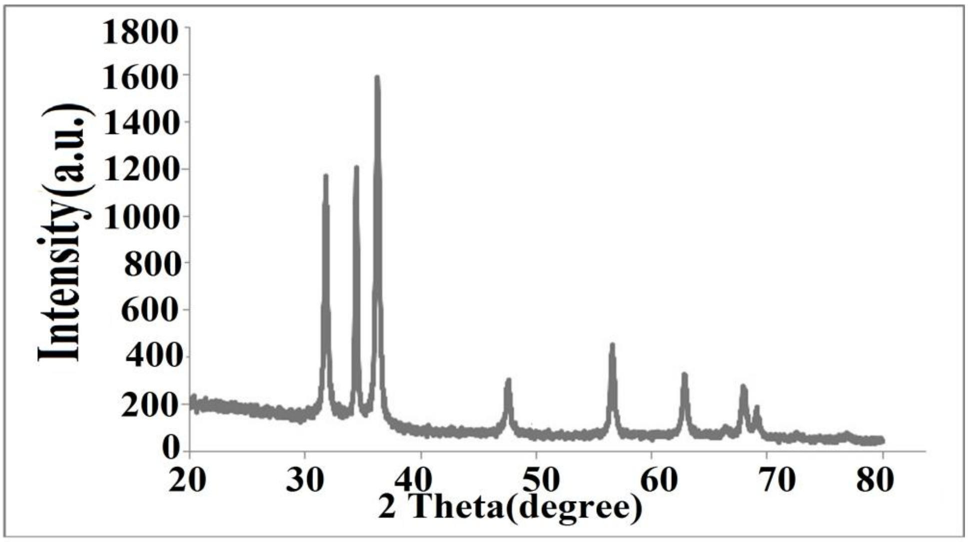


**Figure 2. XRD imege of ZnO NPs synthesized by *Catharanthus roseus as* biotemplate.**

### 3.3 FTIR Analysis

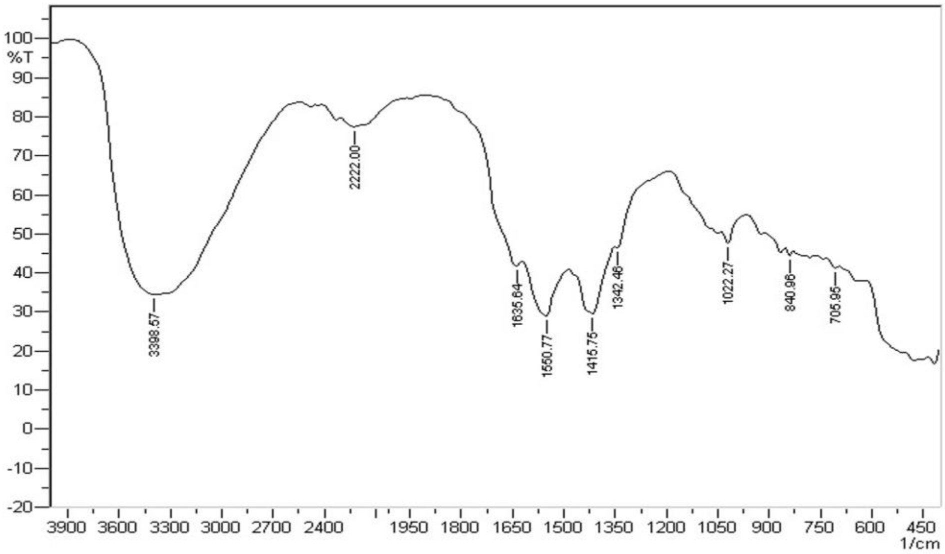


**Figure 3. FTIR imege of ZnO NPs synthesized by *Catharanthus roseus as* biotemplate.**

The FTIR spectra of ZnONPs prepared in various part of *Catharanthus* plant are shown in Fig.3.The stretch for ZnO NPs was found to be around 705cm$^{-1}$.The FTIR spectrum shows a strong and sharp band at 1342 cm$^{-1}$ which can be attributed to the stretching vibration of Zn-N and Zn-O bonds. This peak indicates the formation of chemical bond between zinc and amino nitrogen and, zinc and carboxylate groups of *Catharanthus roseus* molecules[9]. It confirms that the organic molecules of *C. roseus* is bound to the Zn either through carboxylate group at 1550cm$^{-1}$ correspond to symmetric and asymmetric C = 0 stretching vibrations of carboxylate group respectively. FTIR spectroscopic study confirmed that the carboxyl group of amino acid residues of *C.roseus* has a strong binding ability with Zinc suggesting the formation of ZnO-NPs.

### 3.4 Photo-Catalytic Activtity

The time-dependent UV-Vis spectra of the MO solution during irradiation are illustrated in Figures 4. For the grain- like ZnO catalyst, it can be observed that the maximum absorbance at 460 nm had degraded by 14% after irradiation for 20 min, whereas, after 120 min of irradiation, the peak degraded by 98% (calculated by equation (1)) as shown in Fig. 4.

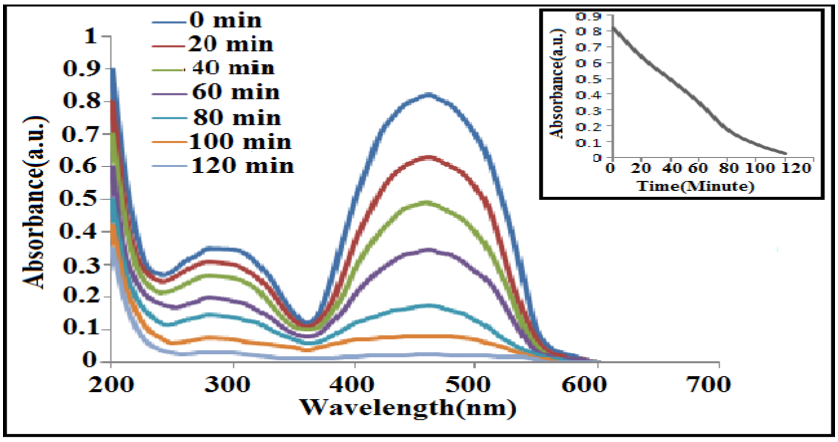


**Figure4. UV-Vis adsorption spectra of MO after different irradiation times using ZnO NPs as a photo-catalyst.**

## IV. CONCLUSIONS

In this paper a green method for synthesis of ZnO photo-catalyst by an eco friendly and low cost method using medicinal plant (*Catharanthus roseus)* as Bio-template was developed successfully. The as prepared ZnO catalyst showed a rice grain like structure and their photo-catalytic efficiencies was investigated by the degradation of a methyl orange dye solution. MO was decomposed after 120 min of UV irradiation in presence of the grain like ZnO photo-catalyst .Hence, based on its excellent performance, the ZnO nano- grain may be useful for the photo-catalytic purification of water polluted by MO.

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