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Degradation of Fast Green FCF dye through Ecologically Sustainable ZnO NPs

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INTRODUCTION & AIMS

- Industrial wastewater contamination has increased significantly in recent years due to various pollutants like dyes, industrial waste etc [1]. Among these dyes, *Brilliant Blue FCF* (commonly referred to as Brilliant Blue), an anionic triphenylmethane dye, stands out due to its widespread use and environmental persistence. Its chemical stability, resistance to biodegradation, and potential toxicity to aquatic life and humans make it a significant environmental concern [2].
- Conventional nanoparticle synthesis involves toxic chemicals, high energy requirements, and costly procedures. Green synthesis using plant extracts offers a sustainable, low-cost, and eco-friendly alternative for producing nanoparticles with varied structures and morphologies [3].
- Among various photocatalysts investigated, zinc oxide nanoparticles (ZnO NPs) have emerged as a promising material for photocatalytic activity due to non-toxicity, low cost, and chemical stability [4]. Some of the green-synthesized ZnO NPs and their photocatalytic activity against various dyes are given in Table 1.

Table 1: Some of Green synthesized ZnO NPs and their Photocatalytic activity

S. No.	Plant extract	Dye	Light source	Time (Minutes)	Degradation efficiency (%)	Reference
1	*Pluchea indica*	MB	Sunlight	150	95%	[5]
3	*Thymus vulgaris*	methylene blue (MB), sunfix red (SR)	Visible	60 and 120 min	91 and 75%	[6]
4	*Syzygium Cumini*	MB	Sunlight	180 min	91.4%	[7]
5	*Mentha pulegium*	MO and RhB	UV	180 min	85 and 92%	[8]
6	*Olea Europeae*	MB and MO	Sunlight	180 min	75% and 87%	[9]

METHODOLOGY

1. Synthesis of ZnO NPs:

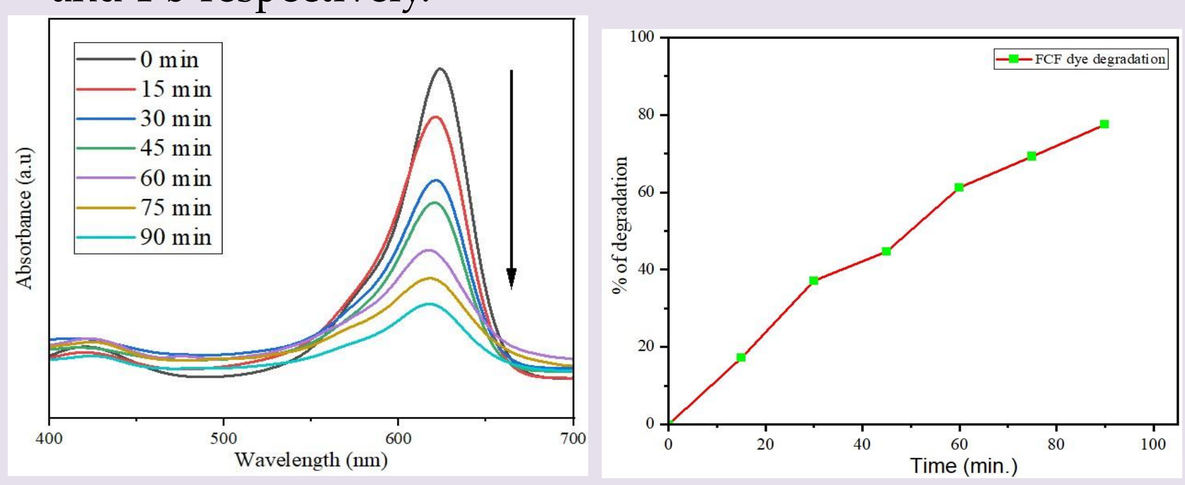
Livistona chinensis leaf extract was used as a green reducing and stabilizing agent. 50 mL of 0.01 M zinc acetate was heated to 60°C, and 10 mL of the extract was added dropwise under stirring. The pH was adjusted to 10-11 with NaOH and maintained at 80°C for 2 h. The resulting white precipitate was washed, dried (80°C, 6 h) and obtain ZnO NPs after 3h calcination at 500-600 °C.

2. Photocatalytic Dye Degradation:

The activity of ZnO NPs was tested for Brilliant Blue FCF (10 mg/L) under visible light (22 W LED). 50 mg ZnO NPs were added to 50 mL dye solution, stirred in the dark for 30 min, and then irradiated for 120 min. Samples were collected at every 15-

RESULTS & DISCUSSION

- The green-synthesized ZnO nanoparticles exhibited significant photocatalytic activity against Brilliant Blue FCF under visible light. UV-Vis analysis showed a steady decrease in the dye's absorbance (at λ_{max} 624 nm) indicating progressive degradation. The NPs achieved approximately 76% dye degradation within 90 minutes, demonstrating their effective photocatalytic performance.
- The photocatalytic degradation of Brilliant Blue FCF by ZnO NPs occurs due to the generation of reactive oxygen species (ROS) under visible light. Hydroxyl radicals (•OH) and superoxide anions (O_2^-•) form on the NPs surface and attack the dye's chromophoric groups, degrading molecules into simple molecule like CO_2 and H_2O [10]. The UV-Visible spectra of Photocatalytic degradation of Brilliant Blue FCF by ZnO NPs and % degradation of dye were given as figure 1 a and 1 b respectively.



(a) (b)

Fig.1 (a) UV-Visible spectra of Photocatalytic degradation of Brilliant Blue FCF by ZnO NPs (b) % Degradation

CONCLUSION

- This study demonstrates that green-synthesized ZnO nanoparticles using *Livistona chinensis* leaf extract act as an efficient, eco-friendly, and cost-effective photocatalyst for dye degradation under visible light. The Photocatalytic activity of Brilliant Blue FCF showed 76% degradation in 90 minutes.
- The study emphasizes the benefits of utilizing ZnO NPs as a visible-light-activated, cost-effective, and environmentally friendly photocatalyst. These findings suggests that the NPs could be used as sustainable wastewater treatment.

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