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Synthesis of Green ZnO-NPs from Fruit Waste for Organic Waste Water Treatment by Photocatalysis

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ABSTRACT

In the realm of nanotechnology, the environmentally conscious practice of using fruit waste and plants for synthesizing nanoparticles is increasingly captivating the attention of researchers. This approach, regarded as "Green Nanotechnology," offers an eco-friendly substitute for the conventional methods that involve the deployment of hazardous chemicals. The current study focuses on the fabrication of zinc oxide nanoparticles (ZnO-NPs) by utilizing a distinctive fruit waste and zinc sulfate as precursors, by sol-gel method. The resulting ZnO-NPs exhibit a hexagonal (wurtzite) shape and have been meticulously scrutinized and characterized through FTIR (Fourier Transform Infrared Spectroscopy) technique, then it was applied on a safranin o dye wastewater giving a promising degradation of 60% of initial concentration.

Keywords: wastewater, photocatalysis, Nanoparticles, green energy.

1 Introduction

Nanoparticles, engineered materials at the nanoscale, revolutionize material chemistry, especially in catalysis. They offer advantages like increased yields and simple synthesis processes, appealing to researchers. Applications span catalysis, medicine, information technology, food safety, environmental science, energy, and electronics. As heterogeneous catalysts, nanoparticles, including zinc oxide, enable swift and eco-friendly conversions, particularly in complex reactions, due to their unique surface properties.[1], [2] ZnO's outstanding optical and electrical properties make it versatile for applications in optoelectronics, pharmaceuticals, cosmetics, solar energy, gas sensors, and more. It offers advantages like affordability, moisture resistance, reusability, commercial availability, and eco-friendliness as a non-toxic catalyst. [3], [4]. Using plants for ZnO nanoparticle synthesis is a sustainable alternative to traditional methods, aligning with contemporary eco-friendly approaches in nanoscience [5]. The present study reports for the first time the use of a know fruit peel waste for ZnO nps synthesis, which is proved with the characterization.

2 Experimental

2.1 Nanoparticles synthesis

A known quantity of the fruit peel is boiled at 60 c for 30 minutes and it was filtered by a whatman no .1 filter, then a 0.5 M $ZnSO4$ solution was prepared nanoparticles in 2 beakers, containing a volume of $ZnSO4$ solution. Different volumes of the fruit peel extract where added: 15, and 20 ml, they were kept under and heat between 70-80°C and stitting, a gel is formed. The resulting paste is then placed in an oven at 450°C for 2.5 hours.[6].

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2.2 Photocatalytic experiment

To evaluate the effectiveness of ZnO nanocrystals in removing Safranin O from water. A photocatalytic experiment was conducted using a 500 mL aluminum-coated Pyrex photoreactor tube. To ensure continuous mixing, an air pump with a flow rate of 150 mL/min was employed. Following the photocatalytic process, all samples underwent centrifugation at 6000 rpm for 5 minutes to separate the catalysts from the water solution. The dye concentrations in the centrifuged samples were measured using a UV–VIS spectrophotometer (HACH-DR3900). The efficiency of dye removal was determined using a specific equation.

$$\textit{Removal Efficiency}(\%) = ((C0 - Ce)/C0) \times 10$$

where C0 is the initial dye concentration and CE is the dye concentration after defined reaction time t (min).

3 Results and Discussion

3.1 FTIR spectra analysis for both chemical and green sol-gel method for ZnO-nps synthesis

Fourier-Transform Infrared is a powerful analytical technique used to identify and characterize chemical compounds based on their interaction with infrared (IR) radiation. FTIR spectrum was used to characterize the functional groups of synthesized nanocomposite materials. Figure 1 and 2 show FTIR of ZnO NPs prepared by a green method, the shown bands at 3146, 3144 cm^{-1} for K20, K15 (K20 refers for 20 ml of fruit extract and k15 refres to 15 ml of fruit extract) are related to O–H stretching and bending vibration from adsorbed water from air and atmospheric moisture [7].The absorption at 857.8 ,858.82 cm^{-1} for the latter particles is due to the formation of tetrahedral coordination of Zn. The bands at 530.84, and 535.01cm^{-1}, are assigned to metal–oxygen bond which is Zn–O bond [8], [9].

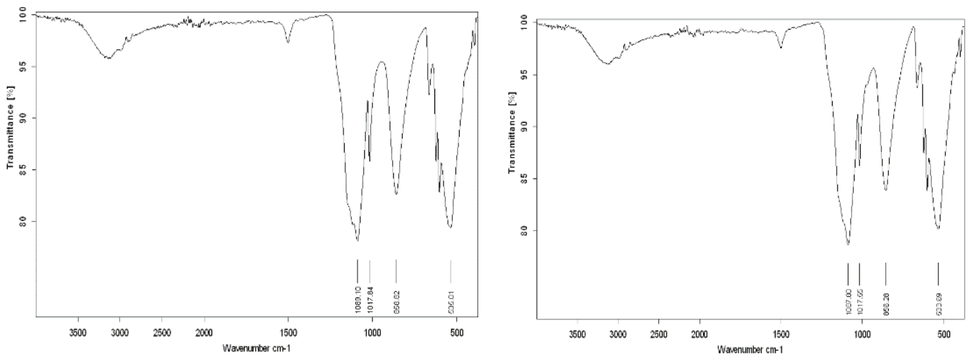

Figure1: ZnO nps FTIR for both 15 and 20 ml of fruit waste extract

In the Safranin Dye Photodegradation experiment, two ZnO nanoparticles (ZnONPs) catalysts weresynthesized using different concentrations of fruit waste (15 and 20 ml). The figure reveals distinctelimination rates, with ZnONPs prepared with 15 ml of fruit waste achieving approximately 30% degradation, while those prepared with 20 ml demonstrated a more effective elimination at around 60%. This observation suggests a significant influence of fruit waste concentration during synthesis on the photocatalytic activity of ZnONPs.

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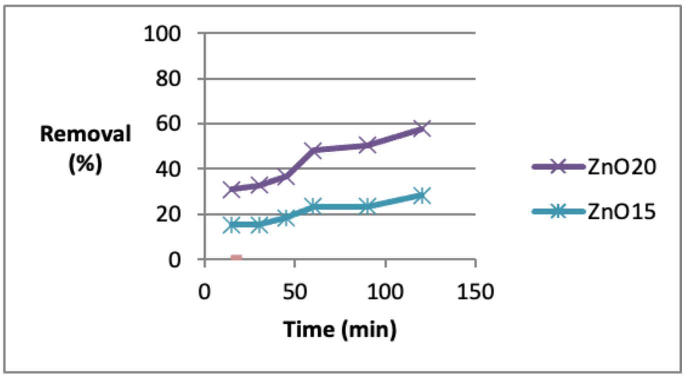

Figure2*:*Safranin photocatalytic degradation by both ZnO 15 and ZnO 20 nanopaticle

4 Conclusions

In this study, we synthesized green ZnO nanoparticles using an unexplored fruit peel, confirmed by FTIR analysis. Notably, ZnONPs with 20 ml of fruit waste exhibited superior photocatalytic properties, emphasizing the importance of optimizing synthesis conditions for efficient Safranin Dye photodegradation. Our findings offer promising directions for sustainable wastewater treatment solutions and future research applications.

References

[1] A. Ansari, A. Ali, N. Khan, M. Saad Umar, M. Owais, and Shamsuzzaman, "Synthesis of steroidal dihydropyrazole derivatives using green ZnO NPs and evaluation of their anticancer and antioxidant activity," Steroids, vol. 188, Dec. 2022, doi: 10.1016/j.steroids.2022.109113.

[2] M. Kiamehr and F. M. Moghaddam, "An efficient ZnO-catalyzed synthesis of novel indole-annulated thiopyrano-chromene derivatives via Domino Knoevenagel-hetero-Diels–Alder reaction," Tetrahedron Lett, vol. 50, no. 48, pp. 6723–6727, Dec. 2009, doi: 10.1016/J.TETLET.2009.09.106.

[3] H. Abdul Salam, R. Sivaraj, and R. Venckatesh, "Green synthesis and characterization of zinc oxide nanoparticles from Ocimum basilicum L. var. purpurascens Benth.-Lamiaceae leaf extract," Mater Lett, vol. 131, pp. 16–18, Sep. 2014, doi: 10.1016/J.MATLET.2014.05.033.

[4] F. Tamaddon, M. A. Amrollahi, and L. Sharafat, "A green protocol for chemoselective O-acylation in the presence of zinc oxide as a heterogeneous, reusable and eco-friendly catalyst," Tetrahedron Lett, vol. 46, no. 45, pp. 7841–7844, Nov. 2005, doi: 10.1016/J.TETLET.2005.09.005.

[5] R. Dobrucka and J. Długaszewska, "Biosynthesis and antibacterial activity of ZnO nanoparticles using Trifolium pratense flower extract," Saudi J Biol Sci, vol. 23, no. 4, pp. 517–523, Jul. 2016, doi: 10.1016/J.SJBS.2015.05.016.

[6] M. Aminuzzaman, P. S. Ng, W. S. Goh, S. Ogawa, and A. Watanabe, "Value-adding to dragon fruit (Hylocereus polyrhizus) peel biowaste: green synthesis of ZnO nanoparticles and their characterization," Inorganic and Nano-Metal Chemistry, vol. 49, no. 11, pp. 401–411, Nov. 2019, doi: 10.1080/24701556.2019.1661464.

[7] G. Nagaraju et al., "Electrochemical heavy metal detection, photocatalytic, photoluminescence, biodiesel production and antibacterial activities of Ag–ZnO nanomaterial," Mater Res Bull, vol. 94, pp. 54–63, Oct. 2017, doi: 10.1016/j.materresbull.2017.05.043.

[8] N. J. Usharani, R. Shringi, H. Sanghavi, S. Subramanian, and S. S. Bhattacharya, "Role of size, alio-/multi-valency and non-stoichiometry in the synthesis of phase-pure high entropy oxide (Co,Cu,Mg,Na,Ni,Zn)O," Dalton Transactions, vol. 49, no. 21, pp. 7123–7132, Jun. 2020, doi: 10.1039/d0dt00958j.

[9] N. Jayarambabu, K. Venkateswara Rao, and Y. Taraka Prabhu, "BENEFICIAL ROLE OF ZINC OXIDE NANOPARTICLES ON GREEN CROP PRODUCTION Effects of Temperature, Deposition Time and Catalyst Loading on the Synthesis of Carbon Nanotubes in a Fixed Bed Reactor View project Light Rare Earth/ Lanthanide (Ce & Sm) Oxides decorated on Nano-Carbon for Sensing Applications View project," 2015. [Online]. Available: https://www.researchgate.net/publication/301541596

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