



SYNTHESIS, CHARACTERIZATION AND APPLICATION OF ZN DOPED TiO₂ IN DEGRADATION OF ORGANIC DYE

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ABSTRACT:

The study of the degradation of dye into non-toxic form is desirable. In this paper the synthesis of Zn doped TiO₂ nano-photo catalyst was reported by sonication method. The synthesized nano material was characterized by XRD and FTIR techniques. Degradation of methylene blue as model substrate was reported in the present study. Degradation was carried out in the batch photo reactor. Rate of decolorization was estimated from residual concentration spectrophotometrically. The maximum decolorizing efficiency was occurred in 1 hour with 50 mg nano-photocatalyst dose.

Keywords:- Phosphors, Synthesis, Optical Properties, Combustion method.

INTRODUCTION:

Dyes are discharged in large quantities from various manufacturing plants, which pose serious environmental problems[1-2]. Due to the presence of these potentially carcinogenic contaminants in water, it has attracted the attention of many researchers [3-4]. To disinfect this water, various approaches have been introduced. Nano-photocatalysis is one of the most important photocatalytic processes, that has great potential for solving environmental problems[5]. In recent decades, many studies have been carried out on nano-catalysts enhanced oxidation processes for the decomposition of organic compounds [6-7]. Few studies have investigated the use of nanoparticles as efficient adsorbents and catalysts instead of micrometres particles in Advanced Oxidation Processes(AOPs) wastewater treatment[8]. Number of articles found on the use of nanoparticles in advanced oxidation processes degradation of organic dyes An important aspect of nano-photocatalysis is the selection of semiconductor material such as oxides of

metals which is an effective method due to its low cost, chemical stability, nontoxicity, high efficiency and providing photo generated holes with high oxidizing ability due to their wide band gap for the degradation of a wide range of organic chemicals and synthetic dyes[9-12]. This study mainly focuses on the synthesis, characterization and application of synthesized Zn doped TiO₂ for the dye degradation study.

MATERIALS AND METHODS:

Chemicals

Titanium (IV) butoxide [M = 340.76, Ti (OC₄H₉)₄], zinc sulphate [M = 297, Zn (SO₄).7H₂O], cetyltrimethylammonium ammonium bromide [M = 364.46, C₁₉ H₄₂BrN], Isopropyl Alcohol [M = 60, (CH₃)₂CHOH], and ethyl alcohol [M = 46, C₂H₅OH] The titanium (IV) butoxide and Zn (NO₃)₂6H₂O were used as the precursors for the TiO₂ and Zn components, and the solvent used was deionized water. All the chemicals used were of AR grade with 99.9% purity.

SYNTHESIS OF ZN DOPED TiO₂

A Zn doped TiO_2 nanoparticles were synthesized by sonication method. A solution containing 40 ml of ethanol and 5 ml of iso-propanol was mixed slowly with 5 ml (50 mmol) of Titanium (IV) butoxide under sonication. The resultant mixture was slowly added to 25 ml of zinc nitrate containing 0.5 g of cetyltrimethyl ammonium bromide (CTAB) to form a white precipitate. The system was kept under constant stirring at 80°C for 4 h. The excess water was removed by evaporation on the water bath with continuous stirring. The resultant precursor was then dried at 110°C for 12 hour and then finally calcined at 500°C for 4 h in high temperature muffle furnace. This preparation is summarised in the Fig. 1

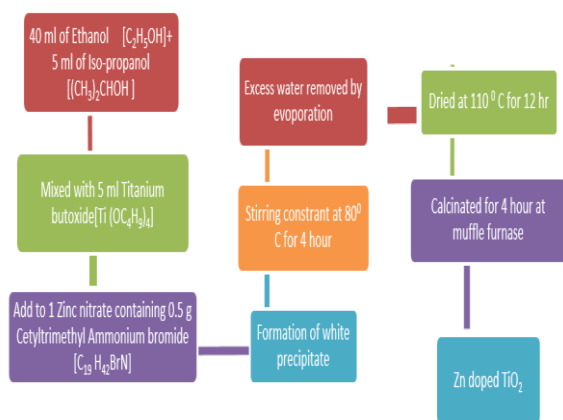


Fig. 1 -Flow Chart of the preparation of the nanophotocatalyst.

EXPERIMENTAL SET UP-

In the present study the model pollutant selected was methylene blue. Degradation study was monitored by using the colorimetric techniques. Calibration curve was generated from the standard solution of methylene blue. A blank sample using distilled deionized water was used to zero the spectrometer. The calibration curve between absorbance and concentration of MB dye gave a high linear regression coefficient Fig. 2. For the degradation experiments, 1.5×10^{-5} M dye

solution was prepared. 500 ml of this dye solution was taken in the photo reactor and different doses of the synthesized nano-photo catalyst was added to the experimental solution and the suspension was subjected to irradiation under UV lamp of 8W. The aq. solution was magnetically stirred throughout the experiment. Then a centrifugation process was applied to separate nano-photocatalyst particles after photo catalysis. Absorption spectra were recorded & the rate of decolourisation was observed in terms of change in intensity at maximum wavelength. Percentage degradation of the substrate was monitored at the regular intervals of time.

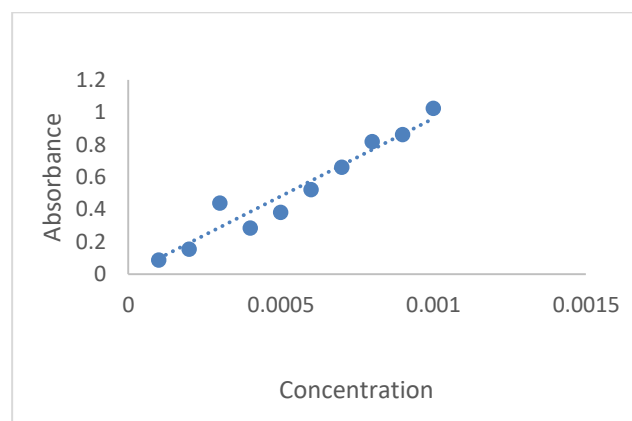


Fig. 2 Calibration Curve of the substrate

RESULT AND DISCUSSION-

Synthesized doped nano-photocatalyst was characterised using Viz., XRD (Fig. 3), and FTIR. Sharp Peak at $\sim 25^\circ$, is the most intense and sharpest peak indicates high crystallinity, possibly larger crystallite size, low lattice strain in this direction. Secondary Peaks are observed at higher 2θ Values ($\sim 37^\circ$, $\sim 48^\circ$, $\sim 55^\circ$, $\sim 63^\circ$, $\sim 70^\circ$). These are medium intensity, broad peaks, due to other planes of anatase TiO_2 (004), (200), (105), (211), (204). FTIR measures the absorption of infrared light by the sample, providing information about the functional groups present. Zn doped titanium oxide materials was confirmed by using FTIR which gave absorption peaks typically from around 4000 cm^{-1} to 400 cm^{-1} .

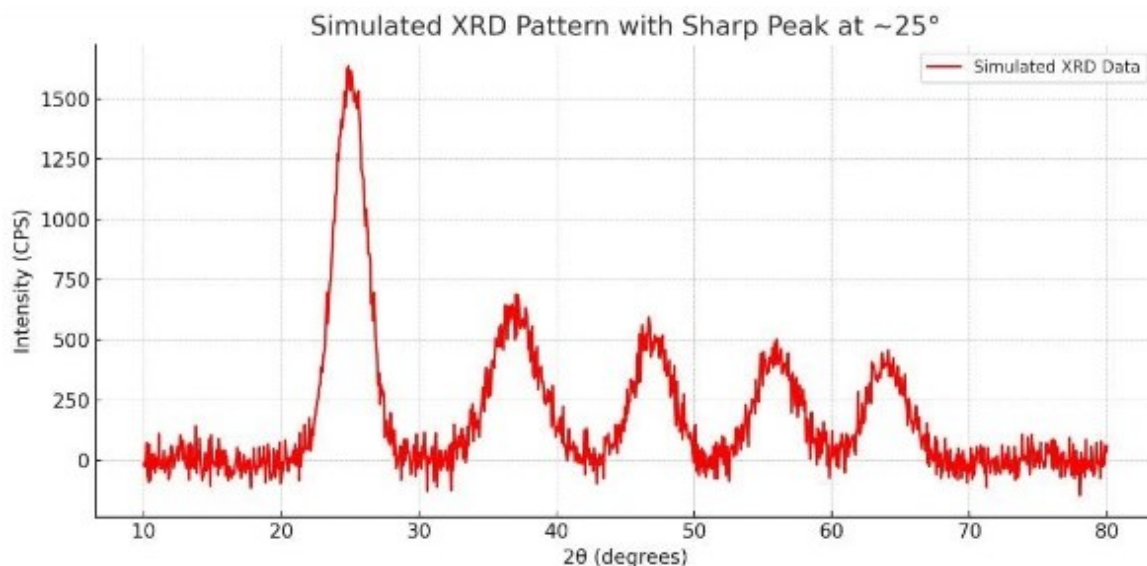


Fig 3 : XRD pattern of Zn Doped TiO₂

DEGRADATION STUDY OF THE SUBSTRATE-

The results of this study are summarized as follows-

Pollutant (MB) + H₂O₂ + Catalyst

Time	Absorbances	Concentration	C/C ₀
0 min	0.743	7.727×10^{-4}	1
5min	0.71	7.384×10^{-4}	0.9556
10min	0.646	6.718×10^{-4}	0.8694
15min	0.628	6.531×10^{-4}	0.8452
30 min	0.526	5.470×10^{-4}	0.7079
45 min	0.472	4.909×10^{-4}	0.6354
1 hour	0.415	4.316×10^{-4}	0.5585

CONCLUSION:

In this present paper very, simple route for synthesis of mesoporous nanocrystalline Zn-doped TiO₂ nanoparticles via sonication technique. XRD pattern of the synthesized sample calcined at 500 °C confirms the formation anatase phase with very good

crystallinity. From the XRD, FTIR results, it was confirmed that the doping of Zinc in TiO₂ decreases the grain size and shifts the absorption to higher wavelengths. The results of photocatalytic study confirm the highest photodegradation of methylene blue under UV light for 1 mol% of Zn-doped TiO₂.



The synthesized Zn-doped TiO₂ nanoparticles demonstrated excellent efficiency in the degradation of substrate, methylene blue, a model organic dye, highlighting its potential as a cost-effective and eco-friendly nanophotocatalyst. Zinc play a crucial role in enhancing the degradation performance, offering promising insights for future development of advanced photocatalytic materials for environmental remediation.

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