ScienSage

Journal of Advanced Scientific Research

Available online through http://www.sciensage.info

ISSN
0976-9595
Research Article

PHOTOCATALYTIC DEGRADATION OF ALIZARIN RED AND XYELENE ORANGE DYES USING Au-ZnO-In_2O_3-Pt NANOCOMPOSITE

R. Dhanalakshmi*, L. Saritha

PG and Research Department of Chemistry, Saraswathi Narayanan College (Affiliated to Madurai Kamaraj University), Perungudi, Madurai, Tamil Nadu, India

**Corresponding author: dhanalakshmiramoorthy@gmail.com*

ABSTRACT

The present study focuses on the biosynthesis of nanocomposite (Au-ZnO-In_2O_3-Pt) along with its photocatalytic activity. The Au-ZnO-In_2O_3-Pt nanocomposite was synthesized using *Cocos nucifera* flower extract and was characterized using UV-vis spectroscopy and SEM. The photocatalytic activity of the nanocomposite has been tested on the degradation of organic dyes such alizarin red and xylene orange in aqueous solution under direct sunlight. The effect of various parameters such as pH of solution and total organic content (TOC) is studied thoroughly during degradation reactions.

Keywords: Nanocomposites, Photocatalytic activity, Au-ZnO-In_2O_3-Pt, Alizarin red, Xylene orange, Sun light

1. INTRODUCTION

Among the various environmental issues, the contamination of toxic waste into the atmosphere is one of the major challenges of the globe and it forms the various ecological problems to be very harmful to living organisms. The majority of environmental pollutants are the carcinogenic natured and non-degradable coloured dye effluents, to be discharged by the textile, leather, printing and paper industries, etc [1]. Most of the industries use colour dyes for uplifting the features of goods and hence unused or bare colorants during the industrial processes are discharged in water bodies or air [2]. Now-a-days, several researchers from all over the world are focused on the degradation of the dyes (or colorants) by different strategies. Among them, ZnO materials are commonly used as photocatalyst due to its overall cost, generation of reactive oxygen species, etc. However, ZnO has large band gap of 2.7 eV and the high recombination rate of electron/hole pairs; which retards its practical applications in visible light activated photocatalytic studies. To overcome these drawbacks, making nanocomposite (NC) with other material has been proved to be an impactful method to enhance the photocatalytic activity due to its significant impact on the modification of electronic and optical properties of material [3, 4]. In this work, metal nano composite Au-ZnO-In_2O_3-Pt was synthesized (simple and cost effective) using aqueous flower extract of *cocos nucifera*. The photocatalytic activity of synthesized nanocomposite (Au-ZnO-In_2O_3-Pt) was tested for the degradation of alizarin red and xylene orange dyes under solar irradiation.

2. MATERIAL AND METHODS

2.1. Material

Chemical used in present study such as auric chloride, zinc acetate, indium chloride, choloroplatinic acid hexahytrate ($H_2PtCl_6.6H_2O$) were received from Merck (India) Ltd.

2.2. Plant material and chemicals

The fresh *Cocos nucifera* flowers were collected and washed with distilled water to remove impurities, filtered through Whatmann filter paper (No.1) for further use.

2.3. Preparation of Plant extract

10g of *Cocos nucifera* flower powder were taken in a 250 ml of glass beaker with 100ml of the millipore water under gentle stirring and 60 min the colour of the solution turned from brown to grey colour. Then extract was filtered through 0.45µm membrane filter. The filtrate was used as reducing agent and stabilizer.

2.4. Synthesis of Au-ZnO-In_2O_3-Pt nanocomposite using *Cocos nucifera* flower extract

Zinc acetate (2ml), Indium chloride (5ml) solution was added to the flower extract (4ml), stirred vigorously for

5 hrs. To this solution 2ml of gold chloride solution added drop wise and after 2hrs, platinum solution was added drop wise then continuously stirred. Finally pale orange colour solution was formed; the solution vigorously stirred at 150 °C for 5hrs and allowed to cool at room temperature. A precipitate was obtained and filtered. Finally the compound was dried at 80 °C.

2.5. Instrumental analyses

The synthesized nanocomposite was characterized by UV-Vis Spectrophotometer (ELICO-SL 159). The nanocomposite morphology and size were determined by SEM. The SEM analysis was established by using (JSM-5600LV). Total organic carbon (TOC) was analyzed with a total organic carbon analyzer (Analytik Jena multi-N/C 3100).

2.6. Photocatalytic degradation experiment

The photocatalytic activity of the prepared nanocomposite photocatalyst was evaluated for the degradation of alizarin red and xyelene orange dyes. Batch tests were performed as per the following procedure: 0.2 g nanocomposite photocatalyst was added in 100 ml solution dye (10-50mg/l) in a beaker and the mixture was stirred in dark for 40 min to allow the physical adsorption of dye molecules on catalyst particles reaching the equilibrium [5]. The photo degradation experiments were carried out under natural sunlight. Reaction samples were collected at regular intervals and immediately centrifuged to remove suspended particles before recoding absorbance. The concentration of alizarin red and xyelene orange dyes were determined by measuring the absorption intensity at their maximum absorbance wavelength of 540 nm, by using a UV–vis spectrophotometer (SL-159 Elico UV Visible Spectrophotometer) with a 1cm path length spectrometric quartz cell, and then calculated from calibration curve. The percentage of dye degradation was calculated from the following equation:

$$\% \text{ dye degradation} = (A_0\text{-}A_t/A_0)X\ 100$$

Where A_0 is absorbance of dye at initial stage, A_t is absorbance of dye at time "t".

2.7. Effect of pH of the solution

The effect of pH on the rate of photocatalytic degradation of xylene orange dye was investigated in the pH range of 2 to 14. The pH was maintained each time by using 1 M HCl or 1 M NaOH and measured using a pH meter.

3. RESULTS AND DISCUSSION

3.1. UV-Visible absorption study

The UV-Vis absorption spectra (Fig. 1) of Au-ZnO-In_2O_3-Pt nanocomposite material was recorded at different temperatures. The synthesized nanocomposite was dispersed in ethanol with the concentration of 0.1% water, and the solution was used to record UV-Vis spectra at wavelength range between 200 and 900 nm. The spectra reveal a characteristic absorption peak of ZnO nanocomposite material ~300 nm [6,7]. The absorbance increases in the higher wavelength side indicating the role of nano Au, Pt particles in ZnO. More numbers of Au, Pt are dispersed into ZnO, and these metallic particles rest on the surface of ZnO nanocomposite making the surface area increased and showing plasmonic resonance peak in the UV-Vis spectra. This is an important method in which Au-ZnO-In_2O_3-Pt composite has been shown and elevated by UV absorption.

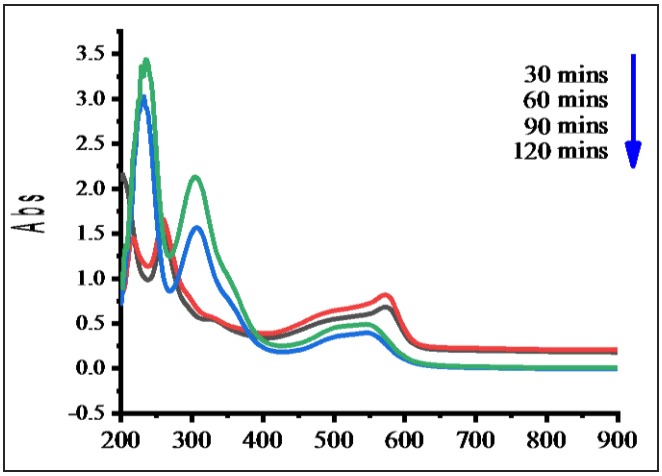

Fig.1: UV-Vis absorption spectrum of Au-ZnO-In_2O_3-Pt nanocomposite material was recorded at different temperatures.

3.2. SEM analyses of Au-ZnO-In_2O_3-Pt nanocomposite material

The SEM uses a focused beam of higher energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron sample interactions reveal information about the sample including external morphology [8]. SEM images reveals the formation of agglomerated nano-crystalline nature of the bare ZnO-In_2O_3 (Fig.2a, b) as well as Au-ZnO-In_2O_3-Pt nanocomposites (Fig. 2c, d) with average grain size 51 nm to 600 nm.

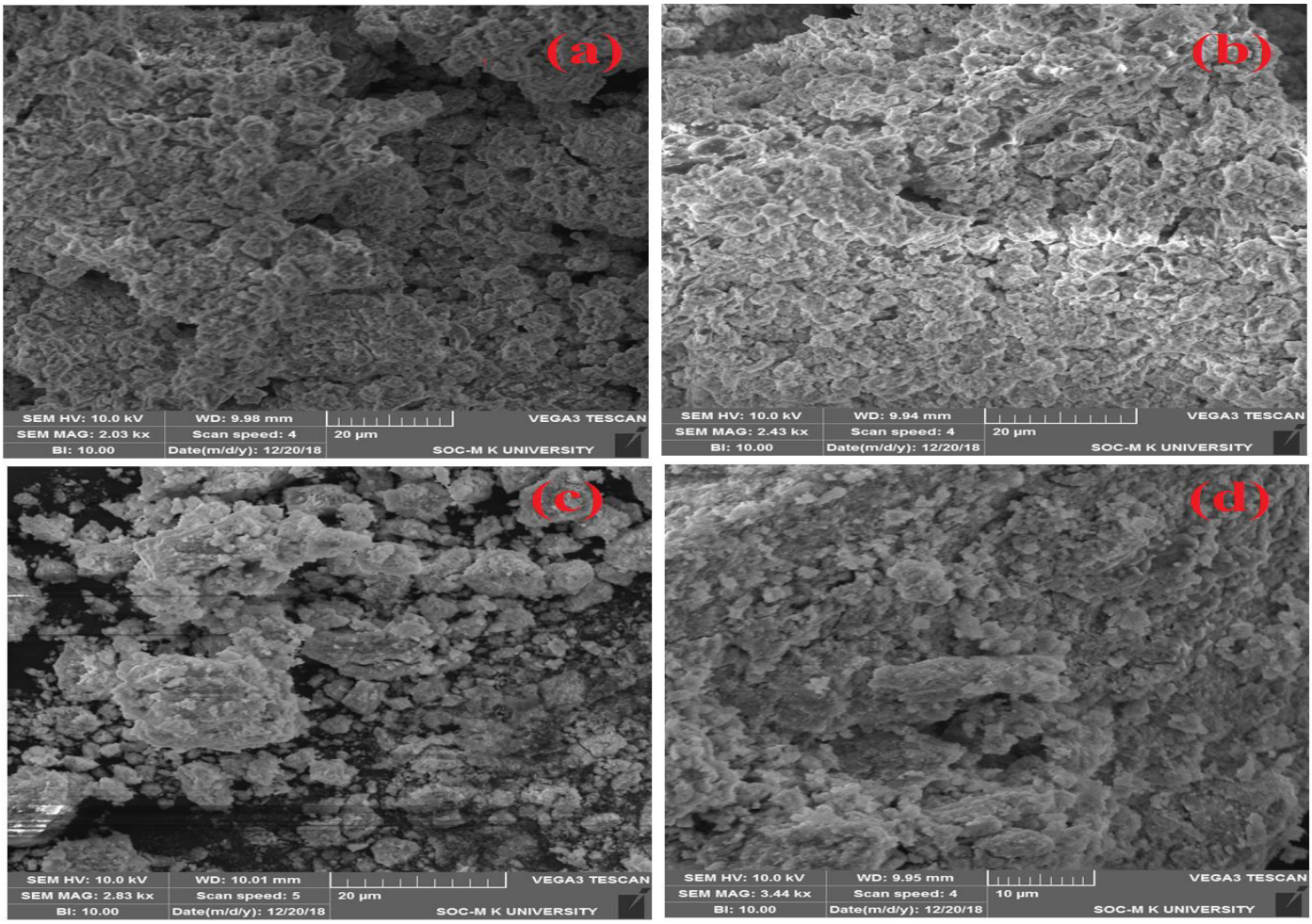

Fig.2: SEM images of bare ZnO-In_2O_3 (a, b) and Au-ZnO-In_2O_3-Pt nanocomposites (c, d)

3.3. Effect of pH on decolorization of dye

Effect of pH was analyzed (pH range 2.0 to 14.0), keeping temperature 30 °C and dye concentration 50 mg/l as constant. When pH increased, % of degradation also increased (Fig.3). Maximum degradation obtained at pH 8.0, after that % degradation decreases.

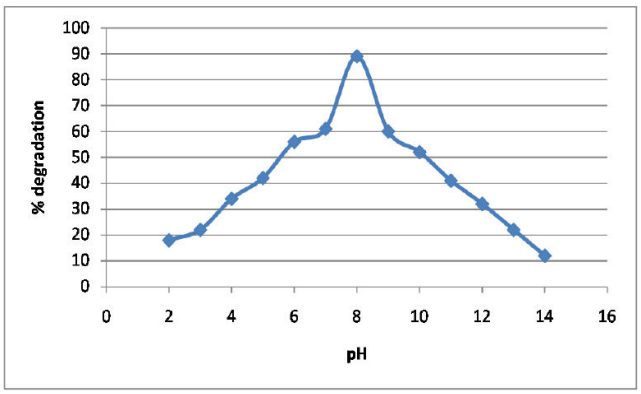

Fig.3: Effect of pH on degradation of xylene orange

3.4. Photocatalytic activity

The photocatalytic redox reaction takes place mainly on the surface of the photocatalysts, and therefore the surface properties significantly influence the efficiency of photocatalytic activity [9-11].

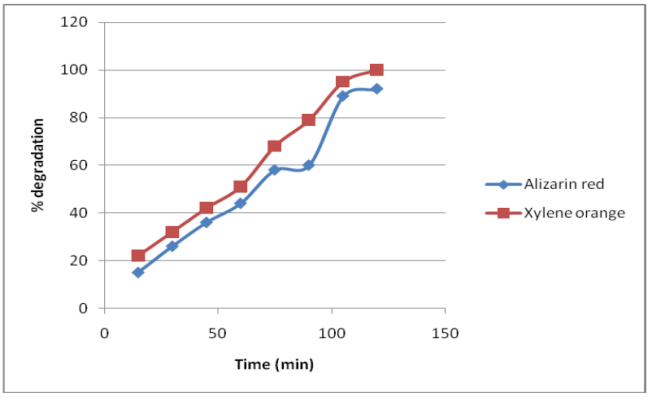

Fig.4: Photocatalytic degradation of Alizarin red and Xylene orange dyes by nanocomposite at various time durations

The photocatalytic activity of prepared nanocomposite is evaluated for degradation of alizarin red and xyelene orange dyes. It was observed that 100% degradation occurred in 120 min sunlight irradiation for xylene orange, where as 92% degradation obtained in 120 min for alizarin red dye (Fig.4). The photocatalytic performance was dependent on the calcination temperature, catalyst loading, solution pH, initial dye concentration and light source [12].

3.5. Mineralization

TOC (total organic carbon) values have been related to the total concentration of organic in the solution and the decrease of TOC reflects the degree of mineralization at the end of the photocatalytic process [13]. Mineralization of dye was studied by monitoring TOC loss in the dye solution. The TOC removal with solar irradiation time is shown in Fig. 5.

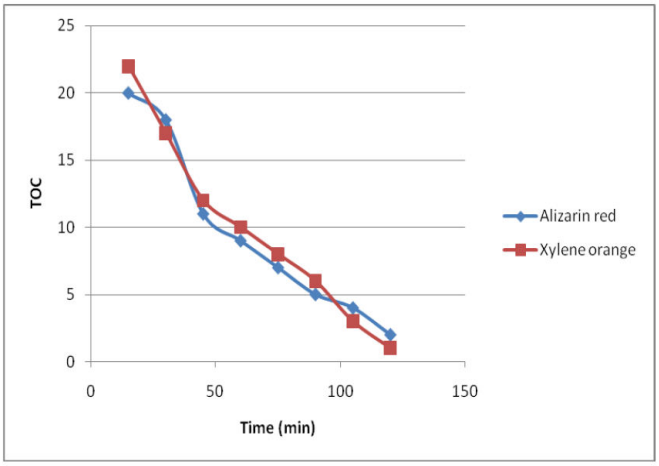

Fig.5: TOC removal of alizarin red, xylene orange dyes versus time

At the beginning of the reaction, an initial period of slowly decreasing TOC values occurred. After the complete decolorization of the solution, the TOC values decreased, and then reached a plateau at the reaction time of 120 min. The initial period of constant or slowly decreasing TOC values could correspond to the fact that dye molecules are decomposed to lower-molecular-weight compounds and the intermediates still contribute to the TOC of solution. The continuous decay of TOC value confirmed the progressive mineralization of dye under high solar irradiation. During the initial time (15-45 min), there was only a small decrease of TOC. After the decolorization of the solution, TOC decreased sharply, reaching a terminal value of about TOC 2.0 mg L^{-1} and 1.0 mg L^{-1} for alizarin red and xylene orange respectively (Fig.5). These results indicating that the amount of excited electron-hole pairs is truly the main reason for the photocatalytic mineralization procedure. The tendency of the mineralization process is similar to the previous results [13, 14].

4. CONCLUSION

In this study, the Au-ZnO-In_2O_3-Pt nanocomposites were synthesized and characterized. SEM images revealed morphology of nanocomposites with irregular size, which was randomly orientated. Photocatalytic performances of nanocomposites was evaluated using alizarin red and xylene orange solutions as the indicator under the natural sunlight. The results demonstrated that the photocatalyst was very efficient, 100% degradation have been observed for xylene orange at 120 min. The obtained results in mineralization processes showed that maximum exposure to sunlight could dramatically improve the mineralization rate and enhance the degree of mineralization in the photocatalytic reaction.

5. CONCLUSION

Authors wish to thank School of Chemistry, Madurai Kamaraj University, Madurai 625 021, Tamil Nadu for SEM study.

6. REFERENCES

1. Sutar RS, Barkul RP, Delekar SD, Patil MK. *Arab J Chem*, 2020; **13**:4966-4977.
2. Sankar R, Manikandan P, Malarvizhi V, Fathima T, et al. *Spectrochim Acta A Mol Biomol Spectrosc*, 2014; **121**:746-750.
3. Fu G, Vary PS, Lin C-T. *The J Phys Chem B*, 2005; **109**:8889-8898.
4. Li H, Bian Z,Zhu J, Huo Y et al. *J Am Chem Soc*, 2007; **129:**4538-4539.
5. Hemalatha K, Manivel A, Kumar MS, Mohan SC. *Int J Biol Chem*, 2018; **12**:1-7.
6. Ni Y, Cao X, Wu G, Hu G, Yang Z, Wei X. *Nanotech*, 2007; **18(15):** Article ID 155603.
7. H. Karami, Fakoori E. *J Nanomat*, 2011; Article ID 628203, 11 pages.
8. Vijayakumar TS, Karthikeyeni S, Vasanth S, Ganesh A et al. *J Nanosci*, 2013; Article ID 785064.
9. Georgekutty R, Seery MK, Pillai SC. *J Phys Chem C*, 2008; **112:**13563-13570.
10. Yang X, Wang Y, Xu L, Yu X, et al. *J Phys Chem C* , 2008; **112:**11481- 11489.

11. Saravanan R, Karthikeyan N, Govindan S, Narayanan V, et al. *Adv Materials Res*, 2012; **584**: 381-385.
12. Lum PT, Foo KY, Zakaria NA, Palaniandy P. *Materials Chem Phy*, 2020; **241**:122405.
13. Qian Zhang, Chaolin Li, Ting Li. *Int J Photoenergy*, 2012; Article ID 398787.
14. Houas A, Lachheb H, Ksibi M, Elaloui E, Guillard C, Herrmann JM. *App Catalysis B*, 2001; **31**:145-157.