ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM

THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:
三重大学
MIE UNIVERSITY

2nd International Science, Engineering and Technology Colloquium

(ISETC 2025)

Faculty of Applied Sciences,

Universiti Teknologi MARA,

Perak Branch, Tapah Campus,

35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025

Publication date: 9th September 2025

Proceedings of Extended Abstracts

EDITORS

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

e-ISBN: 978-629-97630-5-5

Published by Faculty of Applied Sciences, Universiti Teknologi MARA,

Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

PHOTODEGRADATION OF METHYL ORANGE DYE OVER ZnO/CdS PHOTOCATALYST UNDER VERY LOW UVC LIGHT

Sarah Balqis Zaizul Jifri, Zul Adlan Mohd Hir*

Faculty of Applied Sciences, Universiti Teknologi MARA, Cawangan Pahang,
26400 Bandar Tun Abdul Razak Jengka, Pahang, Malaysia

**Corresponding author: zuladlan@uitm.edu.my*

Abstract: Methyl orange (MO) dye has been used widely in various industries. The fact that one of the most water contaminant dominants by MO residue due to the expansion of textile, paper and food colouring used in daily consumption. The variant colours produced from the MO that brought the issue of the water pollutant become concerning as more industries usage in produce more appealing product. Thus, advanced oxidation processes (AOPs) are a method that degrades organic pollutants like MO by converting it into harmless species with the heterogeneous semiconductor oxide as photocatalyst. The absorption edge of the CdS is 516 nm, that allow the visible light to be absorb since the narrower bandgap width with (2.4eV) compared to the other photocatalysts that have broader bandgap (Ebg>3.0eV) that only can absorb the ultraviolet light. Hence, CdS's narrow band gap (2.4 eV) can be used to adjust the ZnO band gap of (3.37 eV) as CdS help the ZnO absorbs the visible light better consequently, overcome the electron-hole recombination issue. The light-yellow sample of ZnO/CdS obtained by the mixture of ZnO and ($Cd(NO_3)_2{\cdot}4H_2O$) with the thiourea solution added ensure that all cadmium ions react with thiourea to form CdS, and the CdS is deposited on ZnO.. Therefore, the stabilisation of doped ZnO photocatalysts with CdS given that the combination of CdS and ZnO can increase the range of solar light absorption, encourage the separation of photogenerated carriers, and accelerate surface reaction kinetics. Subsequently, the surface morphology and composition of ZnO/CdS composites will be examined by the application Fourier transform infrared (FT-IR) spectra in will be used to identify the photocatalyst's functional groups using a FT-IR spectrometer. The implementation of ZnO/CdS composite photocatalyst the greater visible light efficiency will in photodegraded the methyl orange dye in aqueous solution. As a potentially promising material for methyl orange dye pollutant that contaminant in wastewater that can be overcome in water treatment applications, the ZnO/CdS photocatalyst is expected to effectively trap the methyl orange dye under the low UV light.

Keywords: *ZnO/CdS composite, photocatalyst, methyl orange dye, photodegradation, wastewater treatment*

INTRODUCTION

The synthesis of a ZnO/CdS composite photocatalyst was done with a facile mixing process starting with the synthesis of CdS by reaction Cadmium Nitrate in the presence of Thiourea followed by the deposition of CdS onto ZnO. The goal of this approach was to utilize both semiconductor materials: the absorbance benefits of CdS's narrow bandgap of approximately 2.4 eV and the high photocatalytic activity of ZnO. This was aimed to resolve the primary challenges of photocatalytic activity: reduction in charge carrier recombination and efficient promoter separation—separation of electrons and holes. To analyze the functional groups and chemical structure of the yellow ZnO/CdS composite FTIR was performed.

After that, a series of photodegradation tests were done to evaluate the effectiveness of the synthesized ZnO/CdS composite in methyl orange dye degradation at low UVC light intensities. MO, as a model pollutant, was selected due to its recalcitrant nature in water bodies. During these experiments, the UVC photocatalytic reaction tests were conducted by adding the photocatalyst to methyl orange (MO) dye solution.

There were photocatalysts formed with the (MO) solution along with UVC irradiation. The importance of the formation of semiconductor heterojunctions such as ZnO/CdS is aimed to extend the usable range of the absorbance spectrum and facilitate the separation of photogenerated carriers. The heterojunction interface enhances the charge transfer and the redox reaction occurring at the catalyst surface. The photocatalysis is promoted due to the presence of surface hydroxyl groups which assist in the generation of radicals which are responsible for the degradation of organic pollutants including dyes. ZnO/CdS composite photocatalyst offers a cheap and environmentally friendly strategy to treat wastewater with the decomposition of recalcitrant dyes such as methyl orange under visible/solar light (Baig et al., 2025).

MATERIALS AND METHODS

Materials

Commercial zinc oxide (ZnO, < 99% of purity) and methyl orange (MO, < 99% of purity) dye is supplied by R&M Chemicals (Selangor, Malaysia). Cadmium nitrate ($Cd(NO3)2·4H2O$, <99% of purity) is supplied by Sigma-Aldrich (Selangor, Malaysia). Every chemical is used exactly as supplied. Through the preparation of the photocatalyst and photocatalytic testing, distilled water is utilized.

Synthesis of CdS

Firstly, a clear of solution is formed after 3.09g of of $Cd(NO_3)_2·4H_2O$ was dissolved in 50 mL of ethanol. Then, under continuous stirring, 1.52g of thiourea was added. The process was carried out at room temperature. Finally, the formation of CdS powder is obtained after dried in 100°C in oven overnight.

Synthesis of ZnO-CdS

The ZnO-CdS composite photocatalyst is prepared by using facile mixing method. Primarily, 50 mL of distilled water was added with 0.5g of ZnO. CdS powder of different masses then were added to the solution and magnetically stirred for 1 h. Subsequently, the mixture was dried in the oven at 100°C overnight and the samples were collected and used for photocatalyst evaluation.

Photocatalytic Evaluation

The photocatalytic testing is conducted in a 300 mL beaker as illustrated in Figure 3.1. 0.1g of ZnO/CdS of prepared composites is added in a beaker along with 100 mL of a 10 mg/L methyl orange (MO) dye as the target pollutant. Initially, the adsorption/desorption equilibrium is achieved by the MO dye is stirred for half an hour in the dark. The mixture is then continuously mixed while exposed to a UVC lamp (λ = 254 nm, 9 W) for 120 minutes. 5 mL samples is collected during the experiment with the interval of 10 minutes. The concentration of the sample is measured by A UV-vis Spectrophotometer (PerkinElmer Lambda 35) set to λ max = 464 nm and the degradation percentage is calculated by equation (1).

$$Degradation\,percentage(\%) = \frac{(Co - Ct)}{Co} \times 100 \qquad (1)$$

where Co represents the MO dye concentration at the beginning and Ct represents the concentration after "t" minutes.

RESULTS AND DISCUSSION

The photocatalytic degradation of Methyl Orange (MO) under low-intensity UVC light was evaluated in the present study using pure ZnO, pure CdS, and ZnO/CdS composites (ZS1, ZS3, ZS5). According to the results, pure ZnO had a high average degradation efficiency of 83.32%, while pure CdS displayed very little activity (2.60%). Of the composites, ZS3 performed better than pure ZnO and other ZnO/CdS formulations, with a degradation efficiency of 88.46% as depicted in Figure 1.

The optimal heterojunction formation between ZnO and CdS has the prominent performance compared to ZS 1 and ZS 5, which enhances charge carrier separation and reduces recombination by adding specific cations, doping can create trapping sites for photogenerated charge carriers(Ajil et al., 2023). Correctly balanced CdS can effectively transport electrons and stabilize the photocatalytic system. But ZS5, which contained an excessive amount of CdS, may have blocked the active sites of ZnO and hindered UV absorption, which would have decreased the degrading efficiency. On the other hand, ZS1 was unable to considerably aid charge transfer because it contained insufficient CdS. Research in heterostructured ZnO/CdS systems by Murali et al. (2023) and Mezher et al. (2023), who reported similar results, has validated these conclusions. Nevertheless, due to its smaller bandgap (~2.4 eV) and increased susceptibility to photocorrosion when exposed, CdS's photocatalytic activity is restricted by UV light.

However, pure zinc oxide's broad bandgap (~3.2 eV) enables it to effectively absorb UV light and generate reactive oxygen species (ROS), which is why it excels under UV light (Sarker et al., 2025). Consequently, CdS is ineffective under UV light on its own; however, it promotes in the separation and stabilization of charges when combined with ZnO, particularly in compositions such as ZS3 cause of the ZnO-CdS interface shifted from CdS to ZnO, holes would appear in the CdS (Mezher et al., 2023).

These results emphasize the importance of compositional balance in the development of efficient photocatalyst. A well-structured ZnO/CdS heterojunction, such as ZS3, allows for improved utilization of photogenerated charges and enhanced photodegradation performance under lower UVC light.

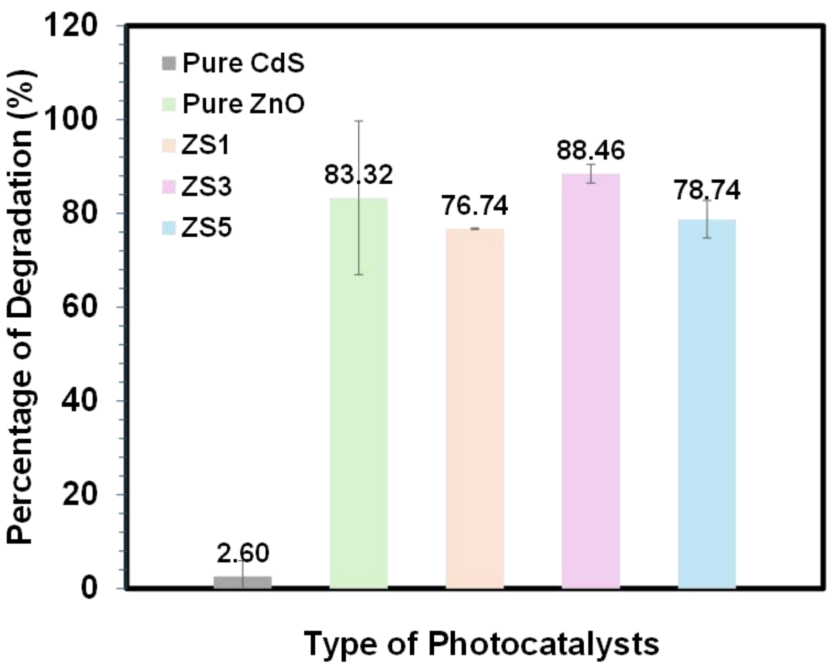

Figure 1. Percentage of degradation of MO in aqueous solution by different type of photocatalyst under UVC-light. [MO] = 10 mg/L, mass = 0.1 g, pH = 5.8, reaction time = 120 min

CONCLUSIONS

Methyl Orange (MO) was effectively broken down by ZnO/CdS composites under low-intensity UV light, with the ZS3 formulation achieving the highest degradation rate of 88.46%. Pure ZnO (83.32%) and pure CdS (2.60%) both performed worse than this, indicating that the optimal ZnO:CdS ratio in ZS3 significantly improved the separation of photogenerated charge carriers and decreased recombination. The formation of an effective heterojunction is what gives ZS3 its structural stability and photocatalytic consistency over pure ZnO. The fact that ZS3 has a lower standard deviation (±2.01) than pure ZnO (±16.39) lends credence to the notion that this junction enhances electron–hole separation.

The binary composite's successful synthesis was further confirmed by the FTIR characterization of the composites, which revealed distinctive absorption peaks around 430–450 cm^{-1} for Zn–O bonding and 610–630 cm^{-1} for Cd–S bonding. Surface –OH and H–O–H stretching vibrations, which are beneficial for charge transfer and adsorption during photocatalysis, were still visible in additional FTIR bands at 1400–1600 cm^{-1} and 3400 cm^{-1}. Among the samples that were evaluated, ZS3 was the most promising option overall due to its improved structural integrity, reproducibility, and increased degrading efficiency. To achieve this, CdS's role as ZnO's stabilising partner under appropriate loading was crucial. These results demonstrate how important compositional modification and interfacial engineering are in photocatalyst design.

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