

UNIVERSITI TEKNOLOGI MARA

**DEVELOPMENT OF VISIBLE LIGHT
ACTIVE PLATINUM, NITROGEN
CO-DOPED TITANIUM DIOXIDE
PHOTOCATALYST VIA DRY
PHYSICAL METHOD FOR
PHOTODEGRADATION OF
METHYLENE BLUE DYE**

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PhD

January 2026

ABSTRACT

Titanium dioxide (TiO₂) has widely been studied as a photocatalyst; however, its efficiency is limited by poor visible light absorption and rapid electron-hole recombination. Thus, this research focused on the development of visible light active platinum, nitrogen co-doped TiO₂ (PTN-TiO₂) photocatalyst via dry physical method, involving a calcination and photodeposition procedures. The optimisation study was conducted for nitrogen doped (N-) and platinum doped TiO₂ (Pt-TiO₂) photocatalyst prior preparing the PTN-TiO₂ photocatalyst. The role of N and Pt in the PTN-TiO₂ photocatalyst for the photocatalytic degradation of methylene blue (MB) dye was investigated under different mode preparation, i.e., sequential and reverse modes, labelled as SEQPTN-TiO₂ and REVPTN-TiO₂. The crystallinity, structural, and dopant concentration were determined by X-ray diffraction (XRD), field emission scanning electron microscopy - energy dispersive X-Ray (FESEM-EDX), elemental analyser (EA) and inductively coupled plasma - optical emission spectroscopy (ICP-OES). The visible light photoactivity of the SEQPTN-TiO₂ photocatalyst was 3 and 1.6 times higher than unmodified TiO₂ and REVPTN-TiO₂ photocatalysts, where the photodegradation rate was obtained at about 0.0408 and 0.0777 min⁻¹, respectively. The ultraviolet-visible/ diffuse reflectance spectroscopy (UV-Vis/ DRS), high-resolution transmission electron microscopy (HR-TEM) and Brunauer – Emmett – Teller (BET) have revealed that the SEQPTN-TiO₂ photocatalyst showed a narrow bandgap energy of 2.8 eV, good Pt distribution and a higher specific surface area of 57 m² g⁻¹. Nevertheless, the photocatalytic activity of the SEQPTN-TiO₂ photocatalyst was obtained slightly lower when comparing to the single N- and Pt-TiO₂ photocatalyst, where it was calculated about (*ca.*) 0.1236, 0.138 and 0.1308 min⁻¹, respectively. A strong signal of Pt⁴⁺ ion in the SEQPTN-TiO₂ photocatalyst, evaluated by X-ray photoelectron spectroscopy (XPS) has contributed to lowering the charge transfer efficiency from TiO₂ to the Pt dopant due to an increase in Schottky barrier height. From the Mott-Schottky (M-S) analysis, the flat-band potential for the SEQPTN-TiO₂ photocatalyst has shifted to -0.30 V, potentially generating a broad depletion layer. This has influenced the charge carrier concentration, which was determined at 1.54 x 10¹⁸ cm⁻³ and was the reason for a lowered photoactivity. Therefore, the mechanism reaction effect of the synthesised photocatalyst was determined. This research provides a fundamental understanding of dopant distribution, band structure modification and charge carrier activity in the TiO₂ system. It has the practical potential for wastewater treatment applications in Malaysia, particularly in degrading dye wastewater from textile and batik industries.

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful.

All praise to Allah and His blessings on the completion of this thesis. I thank Allah for all the opportunities, trials, and strength that have been provided to me for completing my thesis. Throughout the journey, I learnt so much, both academically and personally.

First and foremost, I would like to express my sincere gratitude to my supervisor, Assoc. Prof Dr. Wan Izhan Nawawi, for invaluable guidance, patience, and unwavering support throughout this research. His helpful comments and continuous encouragement have helped me grow as a researcher. I am also deeply thankful to my co-supervisors, Prof. Dr. Mohd Azlan Mohd Ishak and Dr. Fairul Sharin Abd Razak for their expertise, constructive advice, and continuous support. Their valuable views and mentorship have helped me improve my research and broaden my scientific perspective.

A special thanks to my research group, ARAUCAT, for the valuable discussions, teamwork, and friendship that made this journey enjoyable. Special thanks to my colleagues and friends for their support, both academically and personally. To my close friends, who have stood by me through this journey, thank you for your patience and motivation. I would like to acknowledge Geran Insentif Penyelidikan (GIP) from Universiti Teknologi MARA for their financial support, which made this research possible. Additionally, my sincere appreciation goes to the technical and administrative staff who assisted me in various aspects of my work.

I would like to express my appreciation to my late father, Allahyarham Md. Natar Abd. Jabar, who encouraged and motivated me from the beginning and has been the main reason behind this success. This journey was meant for him, and I dedicate this work wholeheartedly to him. My deepest appreciation also goes to my beloved mother, and my family members for their endless support, unconditional love and prayers throughout this journey. Their encouragement has been invaluable in helping me complete this study. I also would like to acknowledge my late cats, Ciko and Oren, whose presence has brought comfort, warmth and countless blessings to my life.

Finally, I would like to extend my appreciation to myself for the perseverance and dedication in completing this study, despite exceeding my initially planned timeline. I am deeply and forever grateful for all the experiences, challenges and lessons I encountered along the way. Alhamdulillah.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Water is one of the essential elements in daily life, yet water quality is the most critical environmental issue in the world. In Malaysia's early history, rivers were preferred areas for human populations to conduct everyday work because it served as domestic, commercial, agricultural, navigational, hydroelectric, and recreational water supplies. Over the past year, the utilization of rivers for daily activities has decreased in society due to the rapid development of urban improvement. Rapid urbanization has caused river management challenges that are related to water quality.

About 477 rivers in Malaysia were surveyed for the Malaysian Environmental Quality Report 2016 and 47% of them were categorised as clean, 43% were considered slightly contaminated and 10% were declared polluted (The Department of Environment, 2016). Figure 1.1 illustrated the percentage of clean rivers has declined over time, reported by Goi et al. (2020). As a result, water contamination affects communities, businesses, and the government at all levels. Despite the lack of awareness by individuals, the major contribution towards water pollution was the failure of water management practices, such as improper wastewater discharge, especially from industrial wastewater.

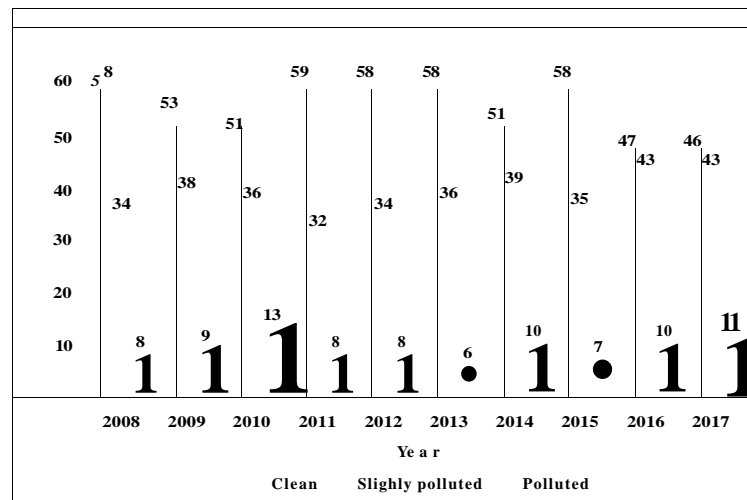


Figure 1.1 The river water quality in Malaysia from 2008 to 2017 (Goi et al., 2020).