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"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

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Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh, Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

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

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
Johor Branch

(A-PP010) DEVELOPMENT OF VISIBLE LIGHT ACTIVE CRYSTALLINE CARBON NITRIDES FOR PHOTOCATALYTIC DEGRADATION OF MICROPLASTICS

Uma Mageswary Saravanan[1], Abilasha Chandran[1], Sharvini Mahi[1], Mohd Hayrie Mohd Hatta[2], Nurul Syuhadah Muhammad Tamrin[3*]

[1]Department of Biomedical Sciences, Faculty of Health Sciences,
Asia Metropolitan University, 81750 Johor Bahru, Johor, Malaysia
[2]Centre for Research and Development, Asia Metropolitan University,
81750 Johor Bahru, Johor, Malaysia
[3]Centre for Foundation, Languages, and General Studies,
Asia Metropolitan University, 81750 Johor Bahru, Johor, Malaysia

Corresponding author: syuhadah@amu.edu.my
(Nurul Syuhadah Muhammad Tamrin)

ABSTRACT

Plastic-based products are widely used in almost all aspects of our daily lives owing to their durability, low cost, and portability. However, these tiny pieces of plastic, known as microplastics, that enter our waterways have been acknowledged as a major contributor to water pollution, especially in seawater. In addition, these products are significantly impacting both human health and the environment on a global scale. Therefore, the full removal and degradation of microplastics from seawater is an important challenge in the 21st century. In removing organic-based compounds, the photocatalytic oxidation process using titanium dioxide (TiO_2) has been acknowledged as one of the promising methods. However, since sunlight comprises 45% of the visible light spectrum and TiO_2 only works excellently under ultraviolet (UV) light, a new visible light active material is required. Recently, crystalline carbon nitride (CN) has attracted worldwide attention, particularly in the field of photocatalysis, due to its low cost, environmental friendliness, and tunable structures. Unfortunately, some limitations associated with CN materials are their relatively low surface area and high band gap energy, which subsequently affect their photocatalytic performance. Therefore, constructing crystalline CN with a larger surface area that is highly active under visible light can be a challenging task. In this study, a mesoporous crystalline CN will be prepared to improve its surface area, while a dopant with a chemical structure similar to CN will be incorporated within the CN triazine structure to improve its visible light response. Their large surface area would facilitate the accumulation of more microplastics into the CN structure for the photocatalytic process to occur, while the addition of a dopant would enhance CN's light absorption in longer wavelengths.

Keywords: Carbon Nitride, Mesoporous, Microplastics, Photocatalysis.

1.0 INTRODUCTION

Microplastics are classified as tiny plastic particles formed from various commercial products and the breakdown of larger plastics. They are present in the oceans and on remote islands and have been identified as emerging pollutants that significantly threaten the environment and animal health. Generally, microplastics are composed of synthetic polymer compounds that form when plastic materials break down into particles smaller than 5 mm (Laskar and Kumar, 2019). Both humans and animals can easily be exposed to microplastics as these particles move through the food chain and persist in the environment due to their resistance to biodegradation (Lehel and Murphy, 2021). Because of their small size, down to micro or nano levels, microplastics are challenging to remove once they are released into the environment. These characteristics have the potential to cause hazards to humans and the environment. For example, long-term exposure can cause physical and mechanical harm, such as abnormalities in internal organs, cancer, cardiovascular diseases, inflammation, reduced fertility, and mortality (Yu et al., 2022). Consequently, there are concerns about the negative effects of microplastic accumulation in the human body.

Research from Nottingham University Malaysia indicates that Malaysia ranks third among the countries contributing the most to marine plastic pollution (Nottingham Malaysia). Therefore, microplastics removal from the environment is highly necessary to prevent major health issues. To address this issue, significant efforts have been made. However, microplastics are difficult to be fully removed due to their properties as synthetic polymers that are made to be highly resistant to any physiochemical processes, including biological processes (Kasmuri et al., 2022). Various methods and techniques have been reported for the degradation of microplastics, such as chemical oxidation method, biological processes, photocatalytic oxidation techniques, and thermal processes. Among these, the photocatalytic oxidation technique is considered a promising method due to its low cost, high thermal stability, efficiency, and wide acceptance in reducing environmental problems (Konstas and Konstantinou, 2021). Since its discovery in 1972, titanium dioxide (TiO_2) has become a promising semiconductor photocatalyst due to its outstanding physical and chemical properties, such as low-cost, non-toxicity, high thermal and chemical stability and most importantly, superior photocatalytic performance. However, its wide band gap (3.2 eV) only allows it to harvest light within the ultraviolet (UV) region (Nakata and Fujishima, 2012). Since our sunlight consists of 45% visible light and only 5% UV light, the use of photocatalysts that can harvest light in extended visible wavelength is recommended.

Graphitic carbon nitride (CN) has been considered as a promising photocatalyst due to its outstanding physical and chemical properties, such as low-cost and easily prepared, low band gap energy, and better thermal stability (Mishra et al., 2019). However, the CN that prepared via traditional method is typically in amorphous phase and associated with structural defects, hence, leading to low photocatalytic performance. Therefore, constructing CN with high crystalline phase can be considered as a promising strategy in improving its photocatalytic performance. Improved crystallinity of CN has been reported to reduce the high rate of electron-hole recombination, improve charge conductivity, and enhance light harvesting performance in the visible light region (Li et al., 2019). These outstanding characteristic make crystalline CN as a promising material in various photocatalytic applications, especially microplastics removal.

2.0 OBJECTIVE

The objective of this study is to develop a photocatalytic reactor to degrade microplastics obtained from environments such as seawater using a crystalline CN photocatalyst. The proposed reactor will be designed to be low-cost and convenient to operate. Meanwhile, crystalline CN will also be prepared via a simple and low-cost technique known as the ionothermal polycondensation method.

3.0 DESCRIPTION OF INNOVATION/METHODOLOGY

3.1 Material Preparation

The crystalline CN will be prepared using the ionothermal polycondensation method, with 5 g of melamine used as the precursor to CN. To enhance the crystallinity of CN, a mixture of 2.74 g of KCl and 2.26 g of LiCl will be added to the precursor to induce crystallinity. The resulting product will be washed with ethanol to remove excess salt residues.

3.2 Preparation of Photocatalytic Reactor

The experimental will be prepared as illustrated in Figure 1. The experimental set up will comprise of water cooling system, magnetic stirrer and a closed box. The photocatalyst that will be used in this studies is crystalline CN. The polystyrene microplastic will be selected as typical microplastic particles due to their widespread distribution in the environment. The photocatalytic degradation of microplastics will be systematically investigated under sunlight irradiation in the presence of microplastics.

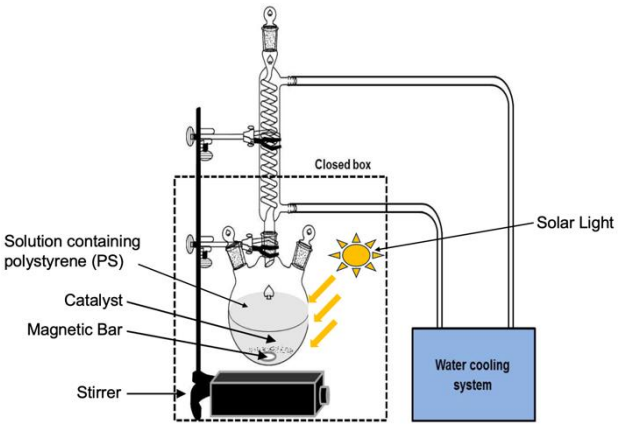

Figure 1 : Illustration of the photocatalytic reactor in degradation of microplastics

4.0 ADVANTAGE/IMPACT/RESULTS/NOVELTY

Photocatalysis has proven to be the most promising method for the degradation of microplastics. Besides microplastics, the presence of organic pollutants in water systems can also be addressed by the photocatalytic method. In this studies, the photocatalytic degradation of microplastics can be explained via four steps, which are initiation, propagation, branching, and termination. The first step (initiation) occurs when hydrogen (H) is abstracted or the C–C bond is cleaved at the impurity sites,

leading to the formation of alkyl radicals in the microplastics. The presence of crystalline CN increases the formation of alkyl radicals through the generation of active species. Meanwhile, radicals such as hyperoxides and peroxy radicals are produced during chain propagation. Additionally, oxidation induces chain branching and scission, leading to the formation of peroxide, hydroxyl, and carbonyl groups. These groups attack the surface of the polymer, causing micro-cracks. The highly reactive species then oxidize the organic compounds, converting them into non-harmful substances such as carbon dioxide and water. Figure 2 illustrates the proposed mechanisms in photocatalytic degradation of microplastics.

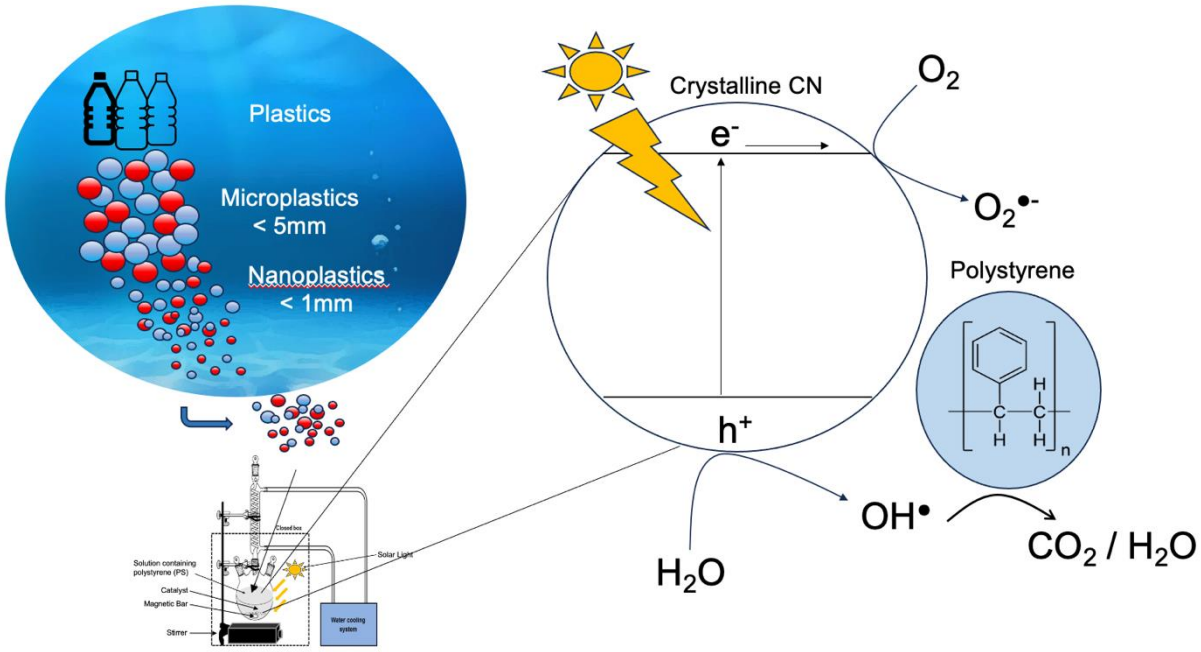

Figure 2 : The mechanisms of microplastics degradation via photocatalytic oxidation process.

5.0 CONCLUSION

Photocatalytic oxidation method is one of the promising technology to address the problems associated with microplastics. The efficiency of this method is due to the formation of reactive oxygen species such as hydroxyl radicals and superoxide, in inducing the degradation of microplastics. Moreover, the design of photocatalytic reactor for degradation of microplastic is simple and low-cost, thus, best fitted for pilot-scale up and beyond.

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