KnE Engineering
JICOMS
Jakarta International Conference on Multidisciplinary Studies towards Creative Industries
Volume 2024

Research Article

Photocatalytic-based Titanium Dioxide and Its Application in Reducing Organic Pollutant of River Water

Paulina Mutiara Latuheru[1], Fisca Dian Utami[1]*, Yulia Puspita Sari[1], Noor Sulistiyono[1], Handika Dany Rahmayanti[2], Dui Yanto Rahman[3], Indah Rosidah Maemunah[4]

[1]Politeknik Transportasi Sungai, Danau, dan Penyeberangan Palembang, Palembang, Indonesia
[2]Politeknik Negeri Media Kreatif, Jakarta, Indonesia
[3]Universitas PGRI, Palembang, Indonesia
[4]Osaka University, Japan

Abstract.
The Indonesian region of Sumatra has many rivers, and several of them are currently polluted by household and industrial wastes. Due to this, the river water looks cloudy and not clear. An easy method is needed to reduce the impact of this organic waste pollution. Photocatalysts are known for their ability to destroy organic pollutants which are environmentally friendly, cheap, and have the potential to be widely developed on a large scale. The principal mechanism of photocatalyst are generating the hydroxyl radicals (OH), which act as strong oxidants to mineralize organic contaminants. These principal photocatalyst mechanism includes the generation of hydroxyl radicals (OH), which act as strong oxidants to mineralize organic contaminants. A handy spray-immobilization method of TiO_2 powders on the solid plastic buffer has been utilized in a destroying effluent system. The photocatalytic activity of the TiO_2-immobilized transparent plastic were evaluated by the degradation of organic contaminant under sunlight irradiation. The titania catalyst have the most potential destroying impact of about 98% after 10 days of sun irradiation. This investigation proved the potential of titanium oxide in handling organic waste in rivers.

Keywords: titanium dioxide, photocatalytic, water treatment, river

Corresponding Author: Fisca Dian Utami; email: fisca.dian.utami1@gmail.com

Published 7 March 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the JICOMS Conference Committee.

1. Introduction

The rapid growth of global industry has escalated the cruciality of problems such as climate change, lack of access to clean water, and water pollution. In addition to the rise in the number of pollutants, the development of high-tech industries has also led to the diversity of contaminants discharged into the environment [1,2]. It has a detrimental impact on water bodies (oceans and rivers) that are important for life and ultimately impacts human life and sustainable social development [3-7]. Globally, an estimated 80% of industrial, domestic and municipal effluent is released into water bodies and environment without prior treatment, leading to negative impacts on public health and biota ecosystems. This proportion is even higher in least developed countries,

How to cite this article: Paulina Mutiara Latuheru, Fisca Dian Utami*, Yulia Puspita Sari, Noor Sulistiyono, Handika Dany Rahmayanti, Dui Yanto Rahman, Indah Rosidah Maemunah, (2024), "Photocatalytic-based Titanium Dioxide and Its Application in Reducing Organic Pollutant of River Water" in *Jakarta International Conference on Multidisciplinary Studies towards Creative Industries*, KnE Engineering, pages 662–667. DOI 10.18502/keg.v6i1.15457

which lack sanitation and effluent treatment facilities. Of particular concern are organic pollutants such as pesticides and waste dyes that are widely found in rivers. Especially in the case of residual dye waste, which can be identified by its physical properties and is clearly visible even at low concentrations, it has an impact on the water environment. This waste also has high absorption properties of sunlight, which can lead to instability of aquatic biota and may pose a health hazard if it enters the human body as it is toxic and carcinogenic [8].

In recent years, photocatalysis has become the most studied potential technology for organic waste degradation. Photocatalysts are known for their ability to destroy organic pollutants which are environmentally friendly, cheap and have the potential to be widely developed on a large scale. These principal photocatalyst mechanism are generate on the generation of hydroxyl radicals (OH), which act as strong oxidants to mineralize organic contaminants. Among various advanced oxidation processes (AOPs), semiconductor-promoted photocatalysis has recently received immense attention because of its prosective to mineralize a variety of recalcitrant organic effluents into harmless substances under ambient temperature and pressure [9, 10]. The aim of this work is to focus on the organic pollutant elimination. Organic pollutants are modeled here using methylene blue compounds, which are commonly found in dye industry waste.

TiO_2 is an attractive candidate for photocatalytic materials because it is stable after repeated catalytic use, does not generate harmful by-products, has stable thermal and chemical characteristics, and is inexpensive [11]. Previously, many photocatalytic technologies have been studied on slurry systems (finely powdered TiO_2 suspensions). However, the removal of TiO_2 after photocatalytic treatment results in a significant reduction in the potential benefits of the photocatalytic mineralization process, as it is energy-intensive and expensive. Alternatively, titanium dioxide immobilization techniques are used with buffers to optimize the working of the photocatalyst material [10]. Immobilization TiO_2 onto transparent plastic by spray method has also been investigated [11,12]. Now, we promote a spray method in scale-up application. The titania performance was explored from photocatalytic test in contaminant destroying technic.

2. Material and Methods

2.1. Materials

Comercial Titanium Dioxide and textile dyes Methylene blue (MB) were supplied by Bratachem and used as received. DI Water and Alcohol 95% were suplied by ROFA Lab

(Local suppliers, Indonesia). All materials were used without any further purification. We used transparent plastic as buffer from Local supplier.

2.2. Experiment

At this stage, anatase TiO_2 is immobilized on the substrate surface (transparent mica). The method used is spraying. The spray technique was selected because it is handy to use, inexpensive and permits for manufacturing in large quantities. The first step taken during the TiO_2 coating stage was to prepare the solution, namely by mixing TiO_2 anatase powder from Bratachem and DI water with a proportion of 50 mL: 5 gr each using a magnetic stirrer for 40 minutes. Furthermore, wash the clear mica plastic with 95% alcohol. The stirred solution is set in a sprayer. To measure the sample transmittance value and MB degradation, UV-Visible characterization was used. All photocatalyst tests were carried out under direct sunlight irradiation. The photocatalytic rate was confirmed by monitoring the absorption of MB as a polutant. The shift of polutant absorption peak (UV-Visible) indicates the change of polutant concentration and thus determines the photocatalyst performance (UV-Vis instrument: Ocean Optics USB2000 fiber optic spectrometer).

3. Result and Discussion

The immobilization of TiO_2 on a clear plastic buffer by spraying was successfully achieved. This titanium catalyst is then placed on the pollutants to see the performance and efficiency of using the catalyst. Tests of the photocatalysis effect on methylene blue were carried out on a total of 16 liters with a methylene blue concentration of 15 ppm. After irradiation under sunlight, the results were obtained as shown in Figure 1. From Figure 1, it can be seen that 16 liters of pollutant with a concentration of 15 ppm were successfully degraded under the influence of the use of this catalyst. Compared to the control solution (without catalyst), the degradation rate of contaminant (MB) using catalyst was much faster. This is influenced by the catalyst in the form of semiconductor material TiO_2 which is subjected to photons and direct contact with the organic compounds of methylene blue [9].

The photocatalyst effect is influenced by several factors, including the number of catalysts that can be activated by the photon source. The more the surface of the catalyst is activated and comes into contact with pollutants, the more the photocatalyst effect increases. The buffer transparency also affects the photons that activate the titania material. The higher the transparency, the more titania on the surface is activated. Only

TiO_2 present on the surface is in direct contact with the waste and can bind to organic compounds present in the waste [13].

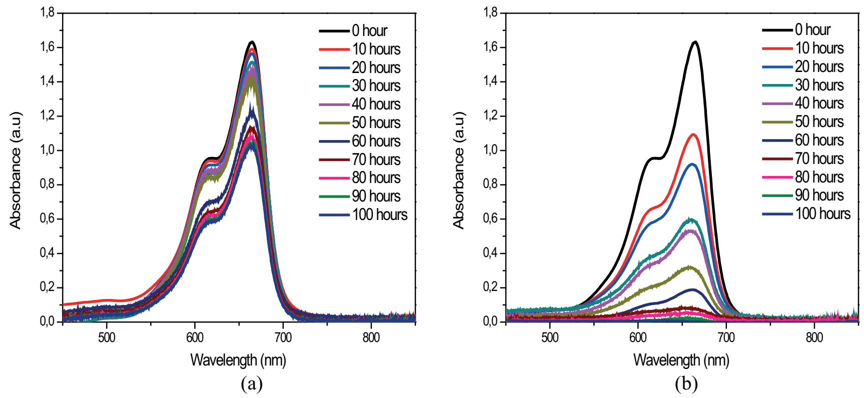

Figure 1: Absorbance Spectrum of Methylene Blue 15 ppm (16 Liters) (a) Control; (b) TiO_2 spray 10 times.

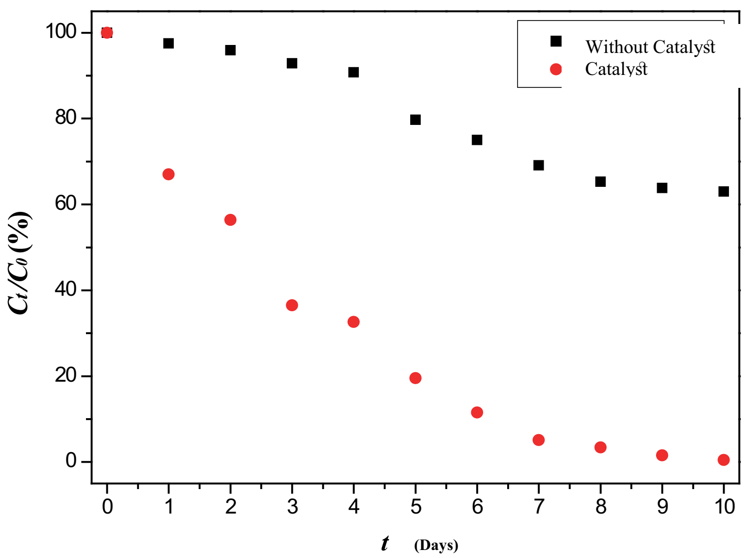

Figure 2: The impact of TiO_2 catalyst on the degradation rate of MB 15 ppm.

Over the course of 10 days of sun exposure, it is evident that methylene blue was effectively decomposed by 98% (Figure 1 and 2). Figure 1 illustrates how the duration of exposure affects the methylene blue breakdown process. The decomposition of methylene blue increases with increasing sun exposure time. This is demonstrated by the solution's color changing from blue to clear, which shows that the amount of methylene blue in the solution is getting less. The absorbance value of the solution also indicates the amount of methylene blue present in the solution. The methylene blue absorbance peak shifts towards lower wavelengths and the absorbance spectrum diminishes with increasing exposure time. The MB absorption spectrum at a concentration of 15 ppm is around 663-664 nm.

4. Conclusion

The photocatalytic activity by titania catalyst was investigated for the destroying the organic polutant of methylene blue. It conducted under sun irradiation directly. Based on this result experiment, we have successfully fabricated titania catalyst by practical spray method. We employed transparent plastic solid as a buffer of powder titania. A total of 16 liters of methylene blue organic waste was successfully degraded using a titanium catalyst in 10 days. The reduction process of organic pollutants will proceed more quickly the more TiO_2 particles that are deposited on the surface because this will put more TiO_2 in direct contact with the organic contaminant and allow photons of high light intensity to activate the catalyst.

References

[1] Breffle W, Muralidharan D, Donovan R, Liu F, Mukherjee A, Jin Y. Socioeconomic evaluation of the impact of natural resource stressors on human-use services in the great lakes environment: A Lake Michigan case study. *Resour Policy*. 2013;38(2):152–161.

[2] Pink RM. Water rights in China and India: A human security perspective. *Asian Aff*. 2016;43:19–35.

[3] Hassan M, Zhao Y, Xie B. Employing TiO_2 photocatalysis to deal with landfill leachate: Current status and development. *Chem Eng J*. 2016;285:264–275.

[4] Liu Y, Liu F, Pan X, Li J. Protecting the environment and public health from pesticides. *Environ Sci Technol*. 2012;46(11):5658–5659.

[5] Broséus R, Vincent S, Aboulfadl K, Daneshvar A, Sauvé S, Barbeau B, et al. Ozone oxidation of pharmaceuticals, endocrine disruptors and pesticides during drinking water treatment. *Water Res*. 2009;43(18):4707–4717.

[6] Fujishima A, Honda K, Fujishima A, Honda K. Electrochemical photolysis of water at a semiconductor electrode. *Nature*. 1972;238(5358):37–38.

[7] Kanan S, Moyet MA, Arthur RB, Patterson HH. Recent advances on TiO_2-based photocatalysts toward the degradation of pesticides and major organic pollutants from water bodies. *Catal Rev, Sci Eng*. 2019;62(1):1–65.

[8] Zangeneh H, Zinatizadeh AA, Habibi M, Akia M, Isa MH. Photocatalytic oxidation of organic dyes and pollutants in wastewater using different modified titanium dioxides: A comparative review. *J Ind Eng Chem*. 2015;26:1–36.

[9] Alinsafi A, Evenou F, Abdulkarim EM, Pons MN, Zahraa O, Benhammou A, et al. Treatment of textile industry wastewater by supported photocatalysis. *Dyes Pigments*. 2007;74(2):439–445.

[10] Shan AY, Ghazi TI, Rashid SA. Immobilisation of titanium dioxide onto supporting materials in heterogeneous photocatalysis: A review. *Appl Catal A Gen* 2010;389(1–2):1–8.

[11] Utami FD, Rahman DY, Sustini E, Abdullah M. Immobilization of TiO_2 on transparent plastic and its application in photocatalytic wastewater treatment. *J Phys Conf Ser*. 2019;1171(1):012030.

[12] Utami FD, Rahman DY, Margareta DO, Abdullah M. Photocatalyst based on TiO_2 and its application in organic wastewater treatment using simple spray method. *J Phys Conf Ser*. 2019;1204(1):012086.

[13] Borges ME, Sierra M, Cuevas E, Garcia RD, Esparza P. Photocatalysis with solar energy: Sunlight-responsive photocatalyst based on TiO_2 loaded on a natural material for wastewater treatment. *Sol Energy*. 2016;135:527–535.