NST 2021_Using Photocatalyst to Enhance Resin Performance in Reducing Carcinogenic Compounds

by Euis Nurul Hidayah

International Seminar of Research Month 2021
Volume 2022
http://dx.doi.org/10.11594/nstp.2022.2445

NST PROCEEDINGS

OPEN ACCESS

Conference Paper

Using Photocatalyst to Enhance Resin Performance in Reducing Carcinogenic Compounds

Euis Nurul Hidayah[1], Ram Babu Pachwarya[2], Okik Hendriyanto Cahyonugroho[1], Jihan Ilvi Nurdiana[1]

[1]Faculty of Engineering, Universitas Pembangunan Nasional "Veteran Jawa Timur", Surabaya, 60294, Indonesia
[2]Department of Chemistry, University of Delhi, New Delhi, India

**Corresponding author:*
E-mail: euisnh.tl@upnjatim.ac.id

ABSTRACT

Existing techniques of wastewater treatment are not able to remove all water-soluble organic pollutants, including hydrocarbons and a few carcinogens like pesticides, completely, inorganic pollutants, and microbes besides generating secondary chemical pollutants. Therefore, reducing the organic compounds effectively would still require more advanced technology with shorter time and lower cost operations. Using a new innovative material through resin immobilized heterogeneous photocatalyst with UV light or sunlight. The specific objectives are knowing the efficiency of Dowex resin-immobilized heterogeneous photocatalyst ZnO (RIP-ZnO) and photocatalyst TiO2 (RIP-TiO2) for reducing disinfection by-products. RIP-ZnO performed a slightly higher removal of THMs, and HAAs concentration than RIP-TiO2.

Keywords: Resin, carcinogenic, photocatalyst

Introduction

The existing wastewater treatment techniques like flocculation, coagulation, reverse osmosis, filtration, boiling, etc. failed to address all types of water pollution problems especially water pollution due to organic pollutants. Existing techniques are not able to remove all water-soluble organic pollutants (including hydrocarbons and a few carcinogens like pesticides, weedicides, etc.) completely, inorganic pollutants (like ammonia), and microbes (sometimes) besides generating secondary chemical pollutants (Pachwarya & Meena, 2011). Therefore, reducing the organic compounds effectively would still require more advanced technology with a shorter time and lower cost operations. Thus, applying the best methods for wastewater management is important for sustainable environmental development (Yahya et al., 2018). Ion exchange by using resin technology which is categorized as a physical method is one of the couraging treatment choices for contaminant reduction due to unaffected toxicity, its simplicity, efficiency, and low cost (Cornellisen et al., 2008). Ion exchange is unable to remove or decrease the pollutants if it is solely utilized, but concentrates the contaminants through absorption and separates it from the treatment processes. Using a new innovative material through resin immobilized heterogeneous photocatalyst with UV light or sunlight is based on the principle of advanced oxidation processes (AOPs) for wastewater treatment (sewage water, polluted water of rivers, domestic effluent, and industries effluent), is an alternative material that could be applied in advanced technologies (Pachwarya & Meena, 2012). This technique is based on the generation of hydroxyl radicals OH* and these hydroxyl radicals can oxidize most organic pollutants and also a few inorganic pollutants. This hybrid technology for wastewater treatment techniques can degrade and oxidize

How to cite:
Hidayah, E. N., Pachwarya, R. B., Cahyonugroho, O. H., & Nurdiana, J. I. (2022). Using photocatalyst to enhance resin performance in reducing carcinogenic compounds. *International Seminar of Research Month 2021*. NST Proceedings. pages 294-297. doi: 10.11594/ nstp.2022.2445

most water-soluble organic pollutants and few inorganic pollutants in a sustainable, economical, and eco-friendly manner without the production of a secondary pollutant. It will solve the problem of water pollution including non-biodegradable organic pollutants. The objectives of this study are to know the efficiency of Dowex resin-immobilized heterogeneous photocatalyst ZnO (RIP-ZnO) and photocatalyst TiO_2 (RIP-TiO_2) for reducing disinfection by-products in the different characteristics of wastewater.

Material and Methods

The experimental design for resin immobilized photocatalyst technology research. Preparing resin-immobilized photocatalyst: approximately 1000 ppm concentration of ZnO solution in double-distilled water and added 20gr Dowex-11 resin in this solution and shaking well. Another 1000 ppm concentration of TiO_2 is prepared with the same protocol as well. Put this mixture inside the pores of the resin for 3 days for complete immobilization of each, of the ZnO photocatalyst and TiO_2 photocatalyst. Experimental processes were conducted in a dark place. ZnO and TiO_2 immobilized resin were filtered from the solution after 3 days, then wash these resins with double distilled water two times, and utilize this material as a photocatalyst (Pachwarya & Meena, 2011). This protocol is prepared for the ratio photocatalyst over resin = 1:20. The photocatalytic reactor, a 1 L beaker glasses equipped with a stirrer to make complete mixing and filled with various amounts of resin immobilized photocatalyst. The height of the reactor is 20 cm, and beaker glasses were used because this system is UV/Vis light transparent and easy to observe. Four tungsten lamps with every 50 watts were used, and the radiation intensity was 10.4 mW/cm^2. Experimental processes were conducted at room temperature with a pH adjustment of about 7 (Pachwarya et al., 2019). The sample will use tofu and batik wastewater, which both has high organic concentration. Trihalomethanes (THMs) and halo acetic acids (HAAs) analysis used a gas chromatograph equipped with a purge and trap module and an electron capture detector (ECD) under protocol in Standard Method (APHA, AWWA, and WEF, 2012).

Results and Discussion

Figure 1 shows a comparison between the percentage removal of THMs concentration in the tofu wastewater and tannery wastewater. Both samples have been treated by resin, resin immobilized photocatalyst with TiO_2 (RIP-TiO_2) and resin immobilized photocatalyst with ZnO (RIP-ZnO). The solid line is drawn at a 1: 1 slope representing an equal percentage removal of those two different samples. First, the figure describes that resin, RIP-TiO_2, and RIP-ZnO could remove organic matter and eventually give an impact on reducing carcinogenic compounds such as THMs. It has been observed that organic matter is the precursor of the formation of carcinogenic in treated water if the existed organic matter reacts with chemical disinfectants, such as chlorine, sodium hypochlorite, etc (Hidayah et al., 2016). Second, the data shows that using RIP-ZnO performed a higher removal than resin and RIP-TiO2. It is probably due to ZnO having a higher electron volt (eV) (Ong et al., 2018), the effect of physical adsorption, and electrostatic interaction since most organic have a negative charge (Reddy et al., 2017). Third, the figure shows that data distribution is mostly in the left side, which indicates higher removal of THMs concentration in the tannery wastewater than in the tofu wastewater. This can be understood because tannery wastewater has lower loading organic than tofu wastewater.

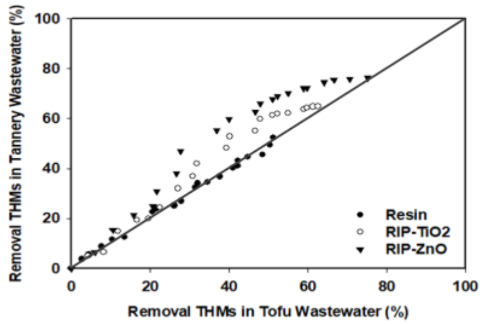

Figure 1. Comparison between the percentage removal of THMs concentration in the tofu wastewater and tannery wastewater, under resin, RIP-TiO_2 and RIP-ZnO.

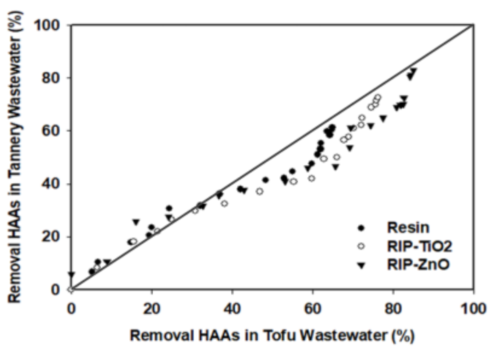

Figure 2. Comparison between the percentage removal of HAAs concentration in the tofu wastewater and tannery wastewater, under resin, RIP-TiO_2 and RIP-ZnO.

Figure 2 shows a comparison between the percentage removal of HAAs concentration in the tofu wastewater and tannery wastewater. Both samples have been treated by resin, resin immobilized photocatalyst with TiO_2 (RIP-TiO_2) and resin immobilized photocatalyst with ZnO (RIP-ZnO). The solid line is drawn at a 1: 1 slope representing an equal percentage removal of those two different samples. First, the figure describes that resin, RIP-TiO_2, and RIP-ZnO could remove organic matter and eventually give an impact on reducing carcinogenic compounds such as HAAs. It has been observed that organic matter is the precursor of the formation of carcinogenic in treated water if the existed organic matter reacts with chemical disinfectants, such as chlorine, sodium hypochlorite, etc (Hidayah et al., 2016). Second, the data shows that using RIP-ZnO performed a higher removal than resin and RIP-TiO_2. It is probably due to ZnO having a higher electron volt (eV), the effect of physical adsorption, and electrostatic interaction since most of the organic has a negative charge (Reddy et al., 2017; Ong et al., 2018). Third, the figure shows that data distribution is mostly on the right side, which indicates higher removal of HAAs concentration in the tofu wastewater than in the tannery wastewater removal. It is the opposite phenomenon as compared with the THMs removal.

Both figures conjecture that characteristics of organic matter give a significant influence on the formation of disinfectant by-products (DBPs) in terms of THMs and HAAs formation potentials. It has been observed that the fraction of biopolymer and aliphatic groups is the mainly THMs precursor, while the fraction of humic substances is mainly HAAs precursor (Singer et al., 2006; Hidayah et al., 2016). This study suggested that resin, resin immobilized with TiO_2 and with ZnO have different capacities in efficiently removing a specific fraction of organic matter, which eventually could affect THMs and HAAs removal (Uyguner et al., 2017). More specifically, resin and resin immobilized could be the choice of a water treatment plant if THMs and HAAs are a problem for its treated water.

Conclusion

Resin, resin immobilized photocatalyst with TiO2 (RIP-TiO_2), and resin immobilized photocatalyst with ZnO (RIP-ZnO) could be used to minimize the formation of the carcinogenic compound as shown as THMs and HAAs. RIP-ZnO performed a higher efficiency than resin only and RIP-TiO_2. The characteristic of tannery wastewater is a precursor of THMs formation potential, while tofu wastewater is a precursor in the formation of HAAs.

Acknowledgment

6

This research was financially supported Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM), Universitas Pembangunan Nasional Veteran Jawa Timur through research scheme International Research Collaboration (KLN) with contract No:SPP/89/UN.63.8/LT/IV/2021.

References

APHA, AWWA, and WEF. (2012) *Standard Methods for the Examination of Water and Wastewaters*, 21th ed.; American Public Health Association: Washington, D.C.

Cornellisen, E. R., Moreau, N., Siegers, W. G., Abrahamse, A. J., Rietveld, L. C., Grefte, A., Dignum, M., Amy, G., & Wessels, L. P. (2008). Selection of anionic exchange resins for removal of natural organic matter (NOM) fractions. *Water Research, 42,* 413-423. https://doi.org/10.1016/j.watres.2007.07.033

Hidayah, E.N., Chou Y.C., & Yeh, H. H (2016). Using HPSEC to identiy NOM fraction and the correlation with disinfection by-product precursors. Water Science and Technology: *Water Supply, 16*(2). Doi:10.2166/ws.2015.139

Ong, C.B., Ng, L.Y., Mohammad, A.W. (2018). A review of ZnO nanoparticles as solar photocatalysts: synthesis, mechanisms and applications, *Renewable and Sustainable Energy Reviews, 81*(1), 536-551

Pachwarya, R.B., & Meena, R.C. (2011). Degradation of Azo Dyes Ponceau S, S-IV from the Wastewater of Textile Industries in a New Photocatalytic Reactor with High Efficiency Using Recently Developed Photocatalyst MBIRD-11, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 33 (18), 1651–1660. https://doi.org/10.1080/15567036.2011.577654

Pachwarya, R.B., Rang, M. M., & Ramanathan, A.L. (2019). Degradation of MCIBV 14: Using heterocyclic dye based photocatalyst methylene blue immobilized resin Dowex 11 and TiO_2 Nano Particles Mixture 1:1. *Heterocyclic Letters, 9*(3), 265-272

Reddy, P.V.L., Kavitha, B., Reddy, P. A.N., & Kim, K.H. (2017). TiO_2-based photocatalytic disinfection of microbes in aqueous media: A review. *Environmental Research, 154,* 296-303

Singer, P.C. (1995) DBPs in chlorinated North Carolina drinking waters. *Journal American Water Works Association*, *87*(10), 83-92.

Uyguner, C. S., Birben, N. C., & Bekbolet, M. (2017). Elucidation of background organic matter matrix effect on photocatalytic treatment of contaminants using TiO2: A review. *Catalysis Today, 284,* 202-214

Yahya, N., Aziz, F., Jamaludi, N.A., Mutalib, M.A., Ismail, A.F., Salleh, W.N.W., Jaafar, J., Yusof, N., Ludin, N.A. (2018). A review of integrated photocatalyst adsorbents for wastewater treatment. *Journal of Environmental Chemical Engineering, 6*(6), 7411-7425

NST 2021_Using Photocatalyst to Enhance Resin Performance in Reducing Carcinogenic Compounds

ORIGINALITY REPORT

11%	7%	8%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	eaapublishing.org Internet Source	1%
2	Lin Liang, Philip C. Singer. "Factors Influencing the Formation and Relative Distribution of Haloacetic Acids and Trihalomethanes in Drinking Water", Environmental Science & Technology, 2003 Publication	1%
3	repository.stieyapan.ac.id Internet Source	1%
4	Hsuan-Hsien Yeh, I-Cheng Tseng, Shan-Jhen Kao, Wen-Liang Lai, Jen-Jeng Chen, Grace T. Wang, Sheng-Herng Lin. "Comparison of the finished water quality among an integrated membrane process, conventional and other advanced treatment processes", Desalination, 2000 Publication	1%
5	vdoc.pub Internet Source	1%

6	jabn.upnjatim.ac.id Internet Source	1 %
7	proceeding.nstproceeding.com Internet Source	1 %
8	www.ieomsociety.org Internet Source	1 %
9	Konstantinos V. Plakas, Athina Taxintari, Anastasios J. Karabelas. "Enhanced Photo-Catalytic Performance of Activated Carbon Fibers for Water Treatment", Water, 2019 Publication	1 %
10	N. Yahya, F. Aziz, N.A. Jamaludin, M.A. Mutalib, A.F. Ismail, W.N.W. Salleh, J. Jaafar, N. Yusof, N.A. Ludin. "A review of Integrated Photocatalyst Adsorbents for Wastewater Treatment", Journal of Environmental Chemical Engineering, 2018 Publication	1 %
11	www.scirp.org Internet Source	1 %
12	ouci.dntb.gov.ua Internet Source	1 %
13	Chhabilal Regmi, Bhupendra Joshi, Schindra K. Ray, Gobinda Gyawali, Ramesh P. Pandey. "Understanding Mechanism of Photocatalytic	<1 %

Microbial Decontamination of Environmental Wastewater", Frontiers in Chemistry, 2018

Publication

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		