The 8th Latin-American Congress of Photocatalysis, Photochemistry and Photobiology - LACP3 2023
Ottawa, Canada – June 04 - 06, 2023
Paper No. LACP3 116
DOI: 10.11159/rtese23.116

Biodegradability Improvement of Water-Soluble-Polymers in Wastewater in a Continuous UV/H_2O_2 Photoreactor

Zahra Parsa, Ramdhane Dhib, Mehrab Mehrvar
Department of Chemical Engineering, Toronto Metropolitan University
350 Victoria St, Toronto, Ontario, Canada M5B 2K3
zahra.parsa@torontomu.ca ; rdhib@torontomu.ca ; mmehrvar@torontomu.ca

Water-soluble polymers have a diverse range of applications from industrial raw materials to household product ingredients such as detergent capsules. However, the ubiquitous presence of these chemicals in both industrial and municipal wastewater streams is of concern. Although present in high and low concentrations in industrial and municipal wastewaters, respectively, these polymers are not easily biodegradable mainly due to their complex and lengthy structures. Moreover, their high solubility in water renders them invisible and often overlooked [1]. Consequently, their persistence and potential accumulation in the environment could lead to long-term environmental risks. Thus, a better understanding of the environmental fate of non-biodegradable water-soluble polymers is essential for the development of effective management strategies to minimize their impact on the environment.

Polyvinyl alcohol (PVA) is a well-known member of the water-soluble polymer family, and its unique physicochemical characteristics have led to its widespread use in various industrial applications, especially in textiles [2]. As a representative of this group of chemicals, PVA has been selected for investigation in this study. Although PVA is generally considered non-toxic to humans and is even used in some medical packaging, it can pose significant risks to the environment, particularly in aquatic ecosystems [3]. Its high foaming ability can lead to oxygen depletion in open water resources while its capacity to transport chemicals, including heavy metals, from soil to underground water may cause the accumulation of harmful contaminants in underground water resources. Therefore, it is essential to remove PVA from wastewater streams before discharge to mitigate its environmental impact [4].

Advanced oxidation processes (AOPs) could effectively degrade a wide range of chemicals including those that are recalcitrant [5]. The UV/H_2O_2 process is a well-known AOP that has shown great promise for implementation in real wastewater treatment plants, primarily due to its simpler operation compared to other AOPs. The UV/H_2O_2 process employs UV radiation and hydrogen peroxide to produce extremely reactive hydroxyl radicals capable of decomposing organic compounds [6].

The primary objective of this investigation is to assess the effectiveness of a UV/H_2O_2 photoreactor at a laboratory scale in enhancing the biodegradability of wastewater containing PVA. The ratio of biochemical oxygen demand to chemical oxygen demand (BOD_5/COD) is used as a measure of wastewater biodegradability, with the goal of increasing it from 0.1 to over 0.5, resulting in an easily biodegradable effluent [7], [8]. Additionally, the impact of key operational parameters, such as inlet PVA concentration, inlet H_2O_2 concentration, and hydraulic retention time on the BOD_5/COD ratio, is investigated. A mathematical model is then developed based on the experimental data to predict and improve the biodegradability of the wastewater as a function of the operational variables. Response surface methodology (RSM) and Box-Behnken design (BBD) were employed to design experiments, develop a prediction model, and optimize process outcomes. The experimental results at the recommended optimal operating conditions validate the findings of the optimization study. Finally, the impact of partial treatment on reducing operating costs of AOP-based wastewater treatment was analyzed.

Keywords: Water-soluble polymers; Wastewater treatment; Advanced Oxidation Processes (AOPs); PVA Degradation; Biodegradability enhancement; BOD_5/COD; RSM; UV/H_2O_2 process

References

[1] D. Hamad, M. Mehrvar, and R. Dhib, “Photochemical Kinetic Modeling of Degradation of Aqueous Polyvinyl Alcohol in a UV/H2O2 Photoreactor,” *J Polym Environ*, vol. 26, no. 8, pp. 3283–3293, Aug. 2018, doi: 10.1007/s10924-018-1190-y.

[2] Y. P. Lin, R. Dhib, and M. Mehrvar, “Recent advances in dynamic modeling and process control of pva degradation by biological and advanced oxidation processes: A review on trends and advances,” *Environments - MDPI*, vol. 8, no. 11. MDPI, Nov. 01, 2021. doi: 10.3390/environments8110116.

[3] M. Julinová, L. Vaňharová, and M. Jurča, “Water-soluble polymeric xenobiotics – Polyvinyl alcohol and polyvinylpyrrolidon – And potential solutions to environmental issues: A brief review,” *Journal of Environmental Management*, vol. 228. Academic Press, pp. 213–222, Dec. 15, 2018. doi: 10.1016/j.jenvman.2018.09.010.

[4] Z. Parsa, R. Dhib, and M. Mehrvar, “Utilizing an Advanced Oxidation Process (AOP) for the Degradation of Water-soluble Polymers,” presented at *45th Annual Symposium On Polymer Science/Engineering 2023*, Waterloo, ON, CA, May 2023.

[5] Z. Parsa, R. Dhib, and M. Mehrvar, “Dynamic Modelling, Process Control, and Process Monitoring of Biological and Advanced Oxidation Processes of Wastewater Treatment: A Review,” Toronto Metropolitan University, Toronto, ON, CA, internal report, 2023.

[6] R. Jahani, R. Dhib, and M. Mehrvar, “Photochemical degradation of aqueous artificial sweeteners by UV/H2O2 and their biodegradability studies,” *Journal of Chemical Technology and Biotechnology*, vol. 95, no. 9, pp. 2509–2521, Sep. 2020, doi: 10.1002/jctb.6432.

[7] Z. Parsa, M. Motevassel, M. R. Khosravi-Nikou, S. Jorfi, and B. Ghasemi, “Biodegradability enhancement of azo dye direct orange-26 using uv/fenton-like process: Optimization using response surface methodology,” *Desalination Water Treat*, vol. 81, pp. 233–241, Jun. 2017, doi: 10.5004/dwt.2017.21096.

[8] M. B. Johnson and M. Mehrvar, “Co-Treatment of Winery and Domestic Wastewaters in Municipal Wastewater Treatment Plants: Analysis of Biodegradation Kinetics and Process Performance Impacts,” *Sustainability*, vol. 15, no. 8, p. 6741, Apr. 2023, doi: 10.3390/su15086741.