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Modelling and Optimization Study on Biodegradability Enhancement of PVA-Contained Wastewater in a Continuous UV/H_2O_2 photoreactor

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Extended Abstract

Polyvinyl alcohol (PVA) is a water-soluble polymer with the alcohol group in its structure that has a high global consumption in various industries such as pulp and paper, cosmetics, textile, and so on [1]. High consumption of PVA leads to generating a considerable amount of wastewater containing PVA, which should be treated before discharging to the environment. PVA-contained wastewater is considered recalcitrant and non-biodegradable wastewater due to the long molecular structure of PVA and possessing the ratio of biochemical oxygen demand (BOD_5)/chemical oxygen demand (COD) <0.1 [2]. Thus, conventional biological treatment methods are not sufficient to degrade this type of compound.

During the last few decades, Advanced Oxidation Processes (AOPs) technique has been extensively studied and vastly proven to be an efficient water/wastewater treatment alternative to degrade recalcitrant/non-biodegradable compounds that may not be easily degraded by conventional biological treatment methods [3]. Among AOPs, many researchers working in the water/wastewater area are interested in investigating the UV/H_2O_2 process because of its proven effectiveness in degrading a vast variety of organic compounds in water/wastewater. Besides, in comparison with other AOP techniques, advantages of the UV/H_2O_2 process are the requirement of only one reagent (H_2O_2), the commercial availability of required materials and chemicals, operating at ambient temperature and pressure, and no sludge production. The UV/H_2O_2 process has been studied to degrade PVA-contained wastewater and observed results are desirable [4]. Using the UV/H_2O_2 process, despite achieving desirable results in the case of total organic carbon (TOC) removal and observing efficient PVA degradation by monitoring the wastewater average molecular weight reduction, fully removal of PVA from wastewater by this method is not cost-effective in comparison with conventional methods such as biological degradation. Hence, the idea is enhancing the biodegradability of PVA-contained wastewater by partial treatment of it using the UV/H_2O_2 process to achieve readily biodegradable wastewater instead of the full removal. The best criterion to represent the biodegradability of the wastewater is its BOD_5/COD content ratio. Studies show that the biological treatment of the wastewater is applicable and efficient only if BOD_5/COD ratio is equal to or greater than 0.4-0.5 [5].

Therefore, in this study, in a continuous UV/H_2O_2 process, the influence of PVA inlet concentration, H_2O_2 inlet concentration, and hydraulic retention time on the increasing of BOD_5/COD ratio of the PVA-contained wastewater will be studied. A mathematical model will be presented to predict the enhancement of wastewater BOD_5/COD ratio based on the aforementioned process operating variables. Using the developed prediction model, an optimum operating condition in the range of input variables is studied and the objective goal of the optimization study is to achieve the BOD_5/COD ratio of 0.5 or greater. Response surface methodology (RSM), a statistical approach to use a series of designed experiments to develop a prediction model and also obtain optimum process outcome, is used in this study.

Keywords: Advanced oxidation process (AOP); PVA Degradation; Biodegradability enhancement; BOD_5/COD; RSM; UV/H_2O_2 photoreactor

References

[1] Lin, Y. P., Dhib, R., Mehrvar, M. (2021). Recent advances in dynamic modeling and process control of pva degradation by biological and advanced oxidation processes: A review on trends and advances. In Environments - MDPI (Vol. 8, Issue 11). MDPI. https://doi.org/10.3390/environments8110116

[2] Hamad, D., Dhib, R., Mehrvar, M. (2016). Effects of hydrogen peroxide feeding strategies on the photochemical degradation of polyvinyl alcohol. *Environmental Technology (United Kingdom)*, *37*(21), 2731–2742. https://doi.org/10.1080/09593330.2016.1160959

[3] Ghafoori, S., Mehrvar, M., Chan, P. K. (2012). Free-radical-induced degradation of aqueous polyethylene oxide by UV/H 2O2: Experimental design, reaction mechanisms, and kinetic modeling. *Industrial and Engineering Chemistry Research*, *51*(46), 14980–14993. https://doi.org/10.1021/ie3005995

[4] Hamad, D., Mehrvar, M., Dhib, R. (2014). Experimental study of polyvinyl alcohol degradation in aqueous solution by UV/H2O2 process. *Polymer Degradation and Stability*, *103*(1), 75–82. https://doi.org/10.1016/j.polymdegradstab.2014.02.018

[5] Parsa, Z., Motevassel, M., Khosravi-Nikou, M. R., Jorfi, S., Ghasemi, B. (2017). Biodegradability enhancement of azo dye direct orange-26 using uv/fenton-like process: Optimization using response surface methodology. *Desalination and Water Treatment*, *81*, 233–241. https://doi.org/10.5004/dwt.2017.21096