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Catalytic Ozonation Promoted by TiO_2 Catalyst for the Removal of Cyanotoxin Cylindrospermopsin from Water

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Extended Abstract

Cyanobacteria are present worldwide in drinking water reservoirs and cause of great concern for drinking water authorities [1]. The potential health hazards of toxin-producing cyanobacteria in drinking water supplies are well recognized. As an advanced oxidation process (AOP), heterogeneous catalytic ozonation exploits both the O_3 as well as the adsorptive and oxidative properties of solid-phase metal oxide catalysts to achieve room-temperature mineralization of organic pollutants [2]. As is well known, supported and unsupported metals and metal oxides are the most commonly tested catalysts for the ozonation of organic compounds in water. As a widely used catalytic material adopted in industrial processes as a heterogeneous catalyst with high catalytic activity, titanium dioxide (TiO_2) is also non-toxic, insoluble, and inexpensive. Several studies have also found TiO_2 be an active material, capable of accelerating the ozonation processes of different compounds [3]. This study evaluates the effectiveness of TiO_2-catalytic ozonation in reducing cyanobacterial hepatotoxic toxins CYN. Cylindrospermopsin (CYN) was oxidized and detoxified by improved ozonation using a TiO_2 catalyst. Chemical kinetics was determined for the reactions of ozone (O_3) and hydroxyl radicals ($OH^{\bullet}$) with CYN. Mutagenicity is quantified using the *Salmonella*/microsome assay and a Microtox test during catalytic ozonation with TiO_2 catalyst. The results indicate that TiO_2 significantly increases the degradation rate of CYN by increasing the production rate of hydroxyl radicals ($OH^{\bullet}$) attributed to the O_3 decomposition initiated on the catalyst surface. At a pH level of 8, through use of 1.5 O_3-mg/L and 500 mg/L TiO_2, the ratio (R_{ct}) between $OH^{\bullet}$ and O_3 concentration increases from 1.87×10^{-8} to 126.4×10^{-8}. Also, TiO_2 increases the overall reaction rate. Additionally, the overall rate constants ($k_{overall}$) increases the most at 500 mg-TiO_2/L; the $k_{overall}$ value increases by more than a five-fold as well. Moreover, TiO_2 catalytic ozonation is an efficient oxidation method in terms of reducing the toxic and mutagenic activities of CYN. Ames test indicates that CYN exhibits positive mutagenic activity in the *Salmonella*/microsome assay with the strains TA98 and TA100. Nevertheless, according to the mutagenic activity of CYN during oxidation processes, catalytic ozonation may either increase or reduce the toxic response of test samples. The mutagenic effects of samples are largely influenced by the TiO_2 dosages and reaction time, possibly resulting in by-products that may alter the mutagenic properties of CYN. Applying low O_3 dosages decreased toxicity in the presence of a TiO_2 catalyst, whereas decreasing the TiO_2 dosage increased the toxicity of treated samples for short periods of processing, due to the possible formation of intermediate by-products during the initial stage. However, most of the formed mutagens were removed after catalytic ozonation. Notably, as the toxin has not been thoroughly elucidated, further research should more thoroughly examine the oxidation of CYN. Moreover, toxicity of oxidation by-products must be assessed in the same manner as in other drinking water oxidation or disinfection processes such as advanced chlorination or ozonation.

References

[1] WHO, *Guidelines for drinking water quality*, vol. 1. 3rd ed. Geneva: World Health Organization, 2004.
[2] F. A. Momani, D. W. Smith and M. G. El-Din, "Degradation of cyanobacteria toxin by advanced oxidation processes," *J. Hazard Mater*., vol. 150, pp. 238–249, 2008.
[3] X. Guan, J. Du, X. Meng, Y. Sun, B. Sun and Q. Hu, "Application of titanium dioxide in arsenic removal from water: A review," *J. Hazard Mater*., vol. 215, pp. 1–16, 2012.