Investigating the Impact of Structural Variations on the Photocatalytic Degradation of Phthalates

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Phthalates are a group of synthetic chemicals that are used as plasticizers in different types of plastic products to improve flexibility. They are added to tools, industrial equipment, and even personal care products such as hair spray.[1] Phthalates are easily able to leach off of these frequently used products into our water ways, where their endocrine disrupting properties pose a threat to humans and animals alike.[2] Current wastewater treatments are not able to fully remove phthalates from the water, and can also use large amounts of energy or create harmful byproducts. The dangers and prevalence of phthalate pollution make finding safe and low-energy removal processes a key issue in wastewater treatment.

One emerging wastewater treatment is photocatalysis, a process a that uses light to trigger a chemical reaction between a photocatalyst and contaminant, resulting in the contaminant's breakdown.[1] In this study, I investigated the potential for photocatalysis to degrade phthalates as well as the impacts of different phthalate structures on this degradation. Specifically, I compared the effects of two photocatalysts, titanium dioxide (TiO_2) and bismuth oxychloride (BiOCl). These photocatalysts are thought to primarily use different mechanisms to degrade contaminants, so comparing these photocatalysts allowed me to understand how structural variations in phthalates influence their susceptibility to these different photocatalysis mechanisms. To assess the impacts of alkyl chain length, alkyl chain substitution, and carboxylic acid group presence on the photocatalytic degradation of phthalates, I determined the rate of photocatalysis reactions for several phthalates and related molecules: dimethyl phthalate (DMP), dibutyl phthalate (DBP), dioctyl phthalate (DOP), diethyl hexyl phthalate (DEHP), and phthalic acid (PA).

To experimentally determine the rates of photocatalytic degradation for these phthalates, I irradiated each compound in solution with each photocatalyst (BiOCl and TiO_2) with UV light for 60–120 minutes and used high-performance liquid chromatography (HPLC) to determine the amount of phthalates remaining in the solution at different time points during the photocatalysis treatment. These measurements allowed me to determine the rate of degradation for each phthalate. I found that, for both photocatalysts, phthalates with longer alkyl chains degraded faster than those with shorter chains, whereas alkyl chain substitution had no significant impact on phthalate photocatalytic degradation rates. However, the generally slow degradation rates of these phthalates suggests that photocatalysis would not be an effective treatment to remove phthalate pollution from wastewater. This is likely because the presence of carboxylic acid groups (such as in phthalic acid) speeds photocatalytic degradation rates, and molecules in the phthalate family lack carboxylic acid groups, making them poor targets for photocatalysis.

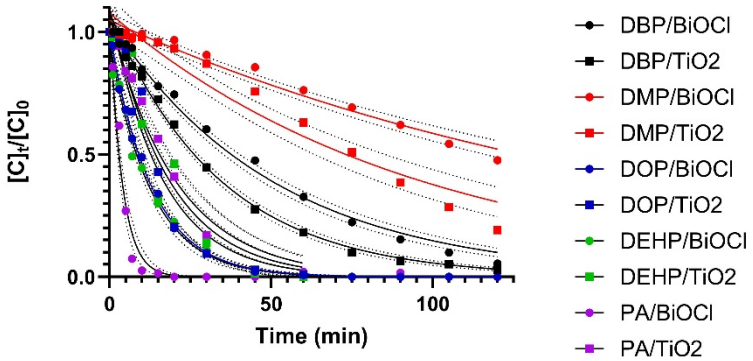

Figure 1. Photocatalytic degradation of phthalates and phthalic acid BiOCl and TiO_2 . Fit to a one-phase decay model, with dotted lines representing 95% confidence intervals.

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References

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