Photocatalytic Degradation of Ibuprofen and Ketoprofen
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The widespread use and availability of pharmaceutical and personal care products (PPCPs) has led to their prevalence in the environment. Wastewater effluent is the main source of PPCPs, which indicates the inadequacy of wastewater treatment plants (WWTP) in completely removing these pollutants from sewage.[1] The presence of the resulting degradation products in the environment poses a risk of long-term exposure, which can lead to chronic toxic effects for living organisms.[1] Furthermore, some of these components can be more toxic than the starting molecules. Therefore, there is a need to develop new methods for the degradation of such pollutants in order to better understand their toxicity to aquatic and human life and mitigate the health and environmental risks caused by their presence.

Photocatalytic degradation (PCD) is one approach that has become increasingly important in decomposing PPCPs during wastewater treatment. Photocatalysts use visible or near UV light to produce reactive species (like hydroxyl radicals) or to directly react with the PPCP, allowing them to react with and break down pollutants.[2] The PCD of ibuprofen (IBP), one of the most used non-steroidal anti-inflammatory drugs (NSAIDs), has been studied extensively. The drug and its degradation products have been identified as a major source of pollution, whose toxicity threatens the public's health.[3]

Bismuth oxychloride (BiOCl) is an alternative to traditional photocatalysts such as titanium dioxide (TiO_2) due to its competitive removal efficiencies of organic pollutants. We have recently shown that BiOCl nanosheets, irradiated at 254 nm wavelength UV light, are effective at decarboxylating IBP to form two primary photochemical products, 4-isobutylacetophenone (IBAP) and 1-(4-isobutylphenyl)ethanol (IBPE) (see Figure 1)[3].

This summer, I initiated PCD studies at Bowdoin, optimizing HPLC separation conditions, modifiying a photodegradation chamber to permit on-line sampling, testing filters to assess product recovery, and comparing our results with experiment conducted with a PCD chamber at the University of Maine, Orono[3]. I also carried out PCD experiments using two structurally related NSAIDs, IBP and ketoprofen and compared the PCD of IBP with TiO_2 and BiOCl.

Through my work, I showed that attention must be paid to filter selection to avoid product loss during sample preparation. I found that TiO_2 is less efficient at degrading IBP at 254 nm. I also showed that BiOCl is effective in photocatalytically degrading ketoprofen (KET), a pharmaceutical similar in structure to IBP and provided additional evidence to support the role of light-generated holes (h^+) in the initial photodegradation. With the overarching goal of developing methods to degrade persistent compounds in wastewater effluent, we have identified and quantified the photocatalytic degradation products of IBP and KET and determined their relative degradation rates using HPLC-DAD and LC-MS/MS analyses.

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References

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