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T06: Homogeneous and heterogeneous photocatalysis

Investigation of the efficiency of BiOI/BiOCl composite photocatalysts using UV, cool and warm white LED light sources – photon efficiency, toxicity, reusability, matrix effect, and energy consumption

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Semiconductor photocatalysis driven by visible light has become the world hot topic of intensive interest due to its potential applications in environmental purification and solar energy conversion. In the recent past, bismuth oxyhalides (BiOX, X=Cl, Br, I) have been widely used for the photocatalytic degradation of organic pollutants and other environmental remediation. Because of their advantageous properties, bismuth oxyhalides serve as potential alternatives for TiO_2, the most often used photocatalyst. The unique characteristic layered structure of BiOXs tends to inhibit the recombination of photogenerated electron-hole pairs and allow them to tune their light response from visible to UV light range. Benefitting from the unique properties, BiOXs have shown promising photocatalytic applications for the degradation of organic pollutants.

BiOCl, BiOI, and BiOI/BiOCl composite photocatalysts were prepared using solvothermal crystallization method and characterized by X-ray diffraction (XRD), the Brunauer-Emmett-Teller (BET) specific surface area, X-ray photoelectron spectroscopy (XPS), and the UV-Vis diffuse reflectance spectra (DRS).

Transformation of the methyl orange dye and sulphamethoxypyridazine antibiotic weres used to determine the photocatalytic activity of BiOI, BiOCl, and their composites. BiOI/BiOCl composite photocatalysts showed enhanced adsorption capacity and activity in decolorization and transformation of methyl orange and sulphamethoxypyridazine comparing to the BiOI and BiOCl. The composite having the highest activity contained 80% BiOI and 20% BiOCl.

The photocatalysts' efficiency and apparent quantum efficiency for transforming the target substances were determined under radiation with various LED light sources: UV (398 nm), cold white light, and warm white light. The apparent quantum yield for visible light was just slightly lower than for 398 nm UV radiation.

The relative contribution of radical-based reactions and direct charge transfer were investigated via the effect of dissolved oxygen, methanol, and 1,4-benzoquinone. Results of competing reactions proved that the main pathway for the transformation in both cases the direct charge transfer, which results in the demethylation of methyl orange, and a sulfur dioxide extrusion of sulphamethoxypyridazine.

The reusability of the composite photocatalyst was investigated during 3 cycles. The transformation rate slightly decreased, and the accumulation of toxic intermediates was observed. There was no significant change in the photocatalyst structure; the decrease of efficiency is mainly due to the adsorption and accumulation of hardly degradable intermediates on the surface.

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