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Synthesis and Characterization of Highly Oriented Bismuth Oxyiodide Thin Films for the Photocatalytical Degradation of Pharmaceuticals Compounds in Water

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Abstract : Heterogeneous photocatalysis is a promising method to achieve the complete degradation and mineralization of organic pollutants in water via their exhaustive oxidation. In order to take this advanced oxidation process towards sustainability, it is necessary to reduce the energy consumption, referred as the light sources and the post-treatment operations. For this, the synthesis of new nanostructures of low band gap semiconductors in the form of thin films is in continuous development. In this work, thin films of the low band gap semiconductor bismuth oxyiodide (BiOI) were synthesized via the Successive Ionic Layer Adsorption and Reaction (SILAR) method. For this, Bi(NO3)3 and KI solutions were prepared, and glass supports were immersed in each solution under strict rate and time immersion conditions. Synthesis was performed at room temperature and a washing step was set prior to each immersion. Thin films with an average thickness below 100 nm were obtained upon a cycle of 30 immersions, as determined by AFM and profilometry measurements. Cubic BiOI nanocrystals with average size of 17 nm and a high orientation to the 001 plane were observed by XRD. In order to optimize the synthesis method, several Bi/I ratios were tested, namely 1/1, 1/5, 1/10, 1/20 and 1/50. The highest crystallinity of the BiOI films was observed when the 1/5 ratio was used in the synthesis. Non-stoichiometric conditions also resulted in the highest uniformity of the thin layers. PVP was used as an additive to improve the adherence of the BiOI thin films to the support. The addition of 0.1 mg/mL of PVP during the washing step resulted in the highest adherence of the thin films. In photocatalysis tests, degradation rate of the antibiotic ciprofloxacin as high as 75% was achieved using visible light (380 to 700 nm) irradiation for 5 h in batch tests. Mineralization of the antibiotic was also observed, although in a lower extent; ~ 30% of the total organic carbon was removed upon 5 h of visible light irradiation. Some ciprofloxacin by-products were identified throughout the reaction; and some of these molecules displayed residual antibiotic activity. In conclusion, it is possible to obtain highly oriented BiOI thin films under ambient conditions via the SILAR method. Non-stoichiometric conditions using PVP additive are necessary to increase the crystallinity and adherence of the films, which are photocatalytically active to remove recalcitrant organic pollutants under visible light irradiation.

Keywords : bismuth oxyhalides, photocatalysis, thin films, water treatment
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