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Crystal phase-controlled synthesis of $BiPO_4$ and the effect of phase structure on the photocatalytic degradation of gaseous benzene

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Abstract

As a typical wide-band-gap semiconductor, $BiPO_4$ (BPO) has a great potential for photocatalytical degradation of highly stable benzene (C_6H_6) that has been regarded as a priority hazardous VOC substance in the indoor atmosphere. Hexagonal (H-BPO), monoclinic (M-BPO), and their mixture phase $BiPO_4$ (M/H-BPO) were selectively synthesized to study the effect of BPO phase structure on the degradation of C_6H_6. The samples were characterized by several techniques, including X-ray diffraction, FTIR spectroscopy, UV-vis diffuse reflection spectroscopy, N_2 absorption-desorption measurements, scanning/ transmission electron microscopy, and X-ray photoelectron spectroscopy. The results indicated that the monoclinic phase was a thermodynamically stable phase. The band gap energy of H-BPO, M-BPO, and M/H-BPO was 3.74, 3.93 and 3.86 eV, respectively. A transformation from rice-like hexagonal BPO to monoclinic phase nanorods was realized through varying the hydrothermal temperature and the composition of the solvent. The degradation of C_6H_6 was closely associated with the crystalline phase of BPO and the mineralization rates decreased in order of M- (7.3) > M/H- (1.51) > H-BPO (0.51 $\mu mol \cdot h^{-1} \cdot m^{-2}$). The rates were higher than that of well-known P25 (0.34$\mu mol \cdot h^{-1} \cdot m^{-2}$). The highest activity of M-BPO could be ascribed to its intrinsic distortion of PO_4 tetrahedron and the largest band gap structure. ·OH, $O_2^{-}\cdot$, and photoinduced holes were the major oxidation species accounting for the destruction of C_6H_6.

Keywords: Photocatalysis; $BiPO_4$; Benzene degradation; Hexagonal; Monoclinic; Phase structure

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