# Novel 3D $In_2S_3/In_2O_3$ Heterostructures for Efficient Photocatalytic Application

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Novel 3D $In_2S_3/In_2O_3$ heterostructures comprised of 3D $In_2O_3$ microflowers and $In_2S_3$ nanoflakes were synthesized via a facile hydrothermal process followed by an in situ anion exchange reaction. In the $In_2S_3/In_2O_3$ heterostructures, the $In_2S_3$ nanoflakes were in-situ generated and uniformly assembled on $In_2O_3$ microflowers. The microstructures, optical properties, oxygen vacancy concentration, and photoreactivity of the heterostructures could be tuned by adjusting the amount of sulfide source. The effect of $In_2S_3$-nanoflakes modification on the oxygen vacancy concentration, optical properties, charge carrier separation, and charge carrier lifetime of $In_2O_3$ were investigated systematically. The catalytic activity of the proposed heterostructures for degradation of gaseous ortho–dichlorobenzene (o–DCB, a representative chlorinated volatile organic compounds) was higher than that of either unmodified $In_2O_3$ or $TiO_2$ (P25). Meanwhile, oxygen vacancies, systematically explored by Raman, X-ray photoelectron spectroscopy (XPS), and low-temperature electron spin resonance (ESR) spectroscopy, were demonstrated to have a two-side effect on the photocatalytic performance. Particularly, the main reaction products including o–benzoquinone type species, phenolate species, formates, acetates, and maleates were verified with in situ FTIR spectroscopy. Additionally, ESR examination confirmed that •OH and $•O_2^-$ were the predominant reactive oxygen species involved in the degradation of gaseous o–DCB. The current research provides new insight into utilizing In-based heterostructures as promising and efficient visible-spectrum-responsive catalysts for the removal of harmful chlorinated volatile organic compounds.