Unravelling the visible light-assisted catalytic prowess of an n–n type In_2S_3/CeO_2 Z-scheme heterojunction towards organic and inorganic water pollution mitigation†

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Abstract

The exploitation of visible light active photocatalysts for the removal of various pollutants has been given tremendous consideration in water and wastewater treatment. Herein, a novel In_2S_3/CeO_2 n–n type heterojunction photocatalyst was successfully synthesized by a two step method involving hydrothermal synthesis and subsequent ultrasonic treatment to couple In_2S_3 with CeO_2 (5, 10 and 15 wt%). The as-synthesized samples were characterized extensively using analytical techniques such as XRD, UV-vis DRS, SEM-EDX, TEM, BET, PL, EIS and XPS to examine the chemical composition, phase structure, morphology and photo-chemical characteristics of the materials. Subsequently, the In_2S_3/CeO_2 nanostructures were employed in the degradation of oxytetracycline (OTC) (10 mg L^{-1}) and reduction of Cr(vi) (50 mg L^{-1}) in aqueous solutions, upon exposure to visible light. Under optimised experimental conditions, the nanocomposite constituting 10 wt% CeO_2 (In_2S_3/10 wt% CeO_2) showed the highest activity, reaching 87.9% OTC degradation and 97.5% Cr(vi) reduction after 60 min and 40 min of visible light irradiation, respectively. The nature and contribution of active species in the photocatalytic process were revealed through radical scavenging studies. Finally, a plausible band structure, charge separation and transfer mechanism were crafted to illustrate the synergy between In_2S_3 and CeO_2 which led to improved degradation kinetics. This work demonstrated a simple route for improving the visible light mediated activity of In_2S_3 by coupling with CeO_2 and the potential versatility of the composite material for the removal of both organic and inorganic pollutants from water.