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Ultrasound assisted fabrication of $InVO_4/In_2S_3$ heterostructure for enhanced sonophotocatalytic degradation of pesticides

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ABSTRACT

A cost effective and environmentally benign ultrasonic method has been developed for the synthesis of $InVO_4$ (InV), In_2S_3 (InS) and the $InVO_4/In_2S_3$ heterostructure (InV/InS). All the designed materials were evaluated for their structural, morphological, spectroscopic, and electrochemical characterizations. Materials were examined for photocatalytic, sonocatalytic, and sonophotocatalytic degradation of carbofuran (CBF) and diazinon (DZN) pesticides under visible light. InV/InS showed enhanced degradation of CBF and DZN when compared to InV and InS. Photocatalytic degradation was accelerated by ultrasonication and found to degrade 97 and 98 % of CBF and DZN in 60 and 70 min, respectively. The reaction conditions, like pH, catalyst dosage, acoustic intensity, and ultrasound power, were carefully optimized. Electron spin resonance (ESR) spectroscopy shows the generation of superoxide radical anion and hydroxyl radicals as reactive species during photoredox reaction. The CBF and DZN degradation intermediates were analyzed using liquid chromatography mass spectroscopy (LC-MS) that shows the mineralization of the CBF and DZN to CO_2 and H_2O. The effect of Cl^-, and PO_4^{3-} were examined towards degradation of CBF and DZN under optimal conditions in the presence of InV/InS. The degradation of CBF and DZN is decreased in presence of Cl^-, CO_3^{2-} and NO_3^- but PO_4^{3-} ions does not show any effect on degradation. The bandgap and Mott-Schottky results suggest the existence of type-II heterostructure between InV and InS through the interface. The synthesis of heterostructure and degradation of pesticides utilizes ultrasonic waves, which prove their multiple applications and attract researchers towards the effective use of sonication.

1. Introduction

Most of the country's development mainly relies on the agricultural industry. Continuous growth in the population essentially demands more food. To meet the high demand for food, farmers are using pesticides, insecticides, and fungicides to increase the quantity of crops in a short time [1,2]. Without sufficient information on how to utilize these pesticides on crops, they have been applied irrationally in massive amounts. Pesticides cause soil toxicity and environmental contamination when they are used frequently and extensively [3,4]. Many pesticides like carbofuran, Ethyl Parathion and dichloro-diphenyl-trichloroethane (DDT) were prohibited in United States of America due to the toxicity associated with them. Pesticides are dispersed throughout the ecosystem via water and air and concentrate along the food chain, where they can seriously endanger both human health and biodiversity [5,6]. Pesticides cause soil toxicity and environmental contamination when they are used frequently and extensively [7,8]. Unfortunately, pesticides have become so ingrained in contemporary agriculture that they can no longer be avoided. Therefore, it is currently essential to develop advanced technology to degrade pesticide residues to secure both agricultural harvests and ecological civilization [9]. In this sense, developing potent pesticide residue degradation technologies that not only assist environmental restoration but also preserve the long-term growth of the survival habitat is a more prudent option than

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