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Indium Doped Mesoporous Carbon Nitride based Ternary Heterojunction for Photodegradation of Pollutant: Synthesis, Performance Evaluation and Toxicity Profile Assessment

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Introduction:

Amplified wastewater outputs, due to the expanding population along with swift industrialisation, have proven humanity's main components of environmental concern. According to the WHO, around 2.4 billion people are living in high water-stressed countries (Summary Progress Update: SDG-6 - "Clean water and sanitation for all") [1]. Furthermore, the effective utilization of light energy to drive the chemical transformation of organic pollutants has grabbed highest attention of researchers because of their great efficiency and importance in the socio-economic context. Photocatalysis has emerged as a green and sustainable approach that utilises inexhaustible clean energy viz. light/solar energy to mineralise pollutants into simpler forms by generating highly reactive species like hydroxyl, superoxide and sulphate radicals [2]. Composite with effective polymeric materials, like graphitic carbon nitride, have several advantages over pristine photocatalysts like efficient light absorption, high thermal and chemical stability, large surface area, and slow charge recombination [3]. Herein, a noble ternary heterojunction photocatalyst was synthesized for the photodegradation of methylene blue dye.

Objectives:

1. Synthesis and characterisation of Indium vanadate/graphitic carbon nitride-2-amino benzonitrile (GCNA-$InVO_4$) heterojunction photocatalyst
2. Photocatalytic performance evaluation and comparison of the prepared catalyst for pollutant removal (methylene blue dye) in simulated and river water solutions
3. Toxicity profiling of the treated water; Algal and Phyto-toxicological assessment after the photocatalytic process
4. Prediction of probable reaction mechanism and role of reactive species

Methodology:

The GCNA-$InVO_4$ ternary heterojunction photocatalyst was synthesised via hydrothermal synthetic routes by using precursors Dicyandiamide, 2-aminobenzonitrile, Indium nitrate, and Ammonium metavanadate; and various characterisations like SEM, TEM, XRD, XPS, and DRS were performed to understand the physicochemical and electronic arrangements of the photocatalyst. The performance of the photocatalyst and effects of several parameters were assessed and compared in both simulated and river-water solutions to check the influence of other existing pollutants on the efficiency. To evaluate the efficiency of the photocatalyst, the toxicity profiling of the treated water was performed using a toxicological assay. The probable reaction mechanisms and roles of different reactive species were predicted by radical scavenger experiments.

Results:

The characterisation results showed an increase in surface area, pore distribution, and reduction in bandgap after successful doping of the metal ion. The photocatalyst showed a removal efficiency of more than 90% in both simulated water and spiked river water solution, which signifies that the development of this ternary heterojunction can be a potential solution for the degradation of a range of organic pollutants. The toxicological assessment results revealed the complete removal of toxicity during the process of photocatalysis.

Conclusion:

The synthesised photocatalyst material can be a potential candidate for the real-time treatment of wastewater because of its high efficiency and performance. The heterojunction material can pave a noteworthy solution for a water treatment system and an efficient wastewater management practice before discharging effluents.

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