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Degradation of γ-HCH spiked soil using stabilized Pd/Fe^0 bimetallic nanoparticles: Pathways, kinetics and effect of reaction conditions

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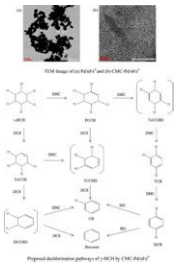
HIGHLIGHTS

- This study explores the potential of CMC-Pd/nFe^0 to degrade γ-HCH in spiked soil.
- Sorption–desorption characteristics and partitioning of γ-HCH is investigated.
- Three degradation pathways has been proposed and discussed.
- γ-HCH degradation mechanism and kinetics is elucidated.
- Activation energy reveals that γ-HCH degradation is a surface mediated reaction.

GRAPHICAL ABSTRACT



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ABSTRACT

This study investigates the degradation pathway of gamma-hexachlorocyclohexane (γ-HCH) in spiked soil using carboxymethyl cellulose stabilized Pd/Fe^0 bimetallic nanoparticles (CMC-Pd/nFe^0). GC–MS analysis of γ-HCH degradation products showed the formation of pentachlorocyclohexene, tri- and dichlorobenzene as intermediate products while benzene was formed as the most stable end product. On the basis of identified intermediates and final products, degradation pathway of γ-HCH has been proposed. Batch studies showed complete γ-HCH degradation at a loading of 0.20 g/L CMC-Pd/nFe^0 within 6 h of incubation. The surface area normalized rate constant (k_{SA}) was found to be 7.6×10^{-2} L min^{-1} m^{-2}. CMC-Pd/nFe^0 displayed ~7-fold greater efficiency for γ-HCH degradation in comparison to Fe^0 nanoparticles (nFe^0), synthesized without CMC and Pd. Further studies showed that increase in CMC-Pd/nFe^0 loading and reaction temperature facilitates γ-HCH degradation, whereas a declining trend in degradation was noticed with the increase in pH, initial γ-HCH concentration and in the presence of cations. The data on activation energy (33.7 kJ/mol) suggests that γ-HCH degradation is a surface mediated reaction. The significance of the study with respect to remediation of γ-HCH contaminated soil using CMC-Pd/nFe^0 has been discussed.

1. Introduction

Gamma-hexachlorocyclohexane (γ-HCH) commonly known as Lindane, is a broad spectrum insecticide, widely used from 1940s to 1990s throughout the world for agricultural and public health purposes. Owing to its toxicity and persistency, γ-HCH has been

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