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Photochemical degradation of vinyl chloride with an Advanced Reduction Process (ARP) – Effects of reagents and pH

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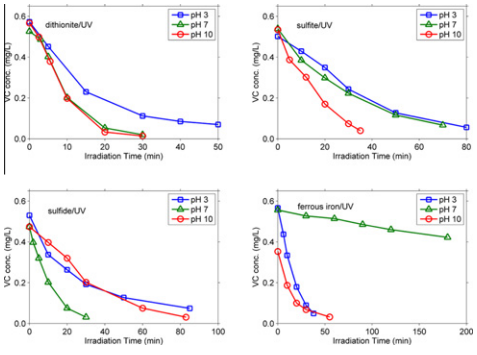
HIGHLIGHTS

- Advanced Reduction Process (ARP) is developed to produce highly reactive species.
- Vinyl chloride (VC) is degraded in all ARP that combine UV with reducing reagents.
- Removal of VC is attributed to sulfur-containing radicals and hydrated electrons.
- The degradation kinetics and dechlorination extent are influenced by solution pH.

GRAPHICAL ABSTRACT



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ABSTRACT

A new treatment technology, called an Advanced Reduction Process (ARP), was developed by combining UV irradiation with reducing reagents to produce highly reactive reducing free radicals that degrade contaminants. Batch experiments were performed under anaerobic conditions to investigate the degradation of vinyl chloride (VC) by this ARP. All degradation reactions were found to follow a pseudo-first-order decay model and the rate constants (k_{obs}) were characterized for all experimental conditions. The influence of pH on k_{obs} was studied in experiments with direct photolysis as well as experiments with ARPs using reagents activated by ultraviolet (UV) light. Values for k_{obs} in direct photolysis were found to be 0.012, 0.011, and 0.018 min^{-1} at pH 3, 7 and 10, respectively. Values of most of the k_{obs} in experiments with ARP increased at all pH values compared with corresponding values obtained for direct photolysis. The increase in k_{obs} was due to the production of reactive species produced by photochemical reaction of the reducing reagents with UV light. The pH effect on k_{obs} observed with the ARP can be explained in terms of changes in the absorption spectra of the reagents at various pH. The rate of light absorption determines the rate of formation of the reactive species which determines the rate of contaminant degradation. Chloride ion and chloroethane were detected as the products of VC degradation. The increase in pH value was shown to promote the transformation of VC to chloride.

1. Introduction

Large amounts of chlorinated organics are manufactured every year for industrial and commercial uses. Vinyl chloride (VC) is a chlorinated ethene that is present as a colorless gas with high toxicity and carcinogenicity toward humans. The major sources of VC contamination in surface water, ground water and air are releases from industrial plants that synthesize polyvinyl chloride (PVC) and other vinyl products [1]. Incineration of chlorinated plastic and landfill volatilization can also cause VC pollution. VC is always found at hazardous waste and landfill sites as a biodegradation product of chlorinated organics. In particular, VC is present as an accumulated intermediate during the reductive degradation of

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