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Abiotic Reduction of Chlorinated Ethylenes by Portland Cement Amended with Ferrous Iron

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ABSTRACT

Degradative solidification/stabilization (DS/S) is a novel remediation technology that combines chemical degradation with conventional solidification/stabilization. Ferrous iron (Fe(II)) in combination with Portland cement is effective in reductively dechlorinating chlorinated organics and can be used to achieve immobilization and degradation of contaminants simultaneously. Reactivities of chlorinated ethylenes (perchloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE), vinyl chloride (VC)) in Fe(II)/cement systems were characterized using batch slurry reactors. Reduction kinetics of the chlorinated ethylenes were sufficiently fast to be utilized for the proposed treatment scheme, and were described by a pseudo-first-order rate law. The order of reactivity of the chlorinated ethylenes was TCE > 1,1-DCE > PCE > VC. Reduction of TCE and PCE mainly yielded acetylene, implying that the transformation of the two compounds occurred principally via reductive β-elimination pathways. Transformation of 1,1-DCE and VC gave rise to primarily ethylene, implying that major degradation pathways were a reductive α-elimination for the former and a hydrogenolysis for the latter. The reactivity of the Fe(II)/cement systems in dechlorinating TCE was proportional to Fe(II) dose when the Fe(II)/cement mass ratio varied between 5.6% and 22.3%. The Fe(II)/cement systems with a higher Fe(II) loading were less extensively affected by pH in reductive reactions for TCE than in the previous experiments with PCE or chlorinated methanes. Amendment of Fe(II)/cement systems with Fe(III) addition was found effective in increasing the reactivity in the previous study, but the current findings indicated that the extent to

which the reaction rate increased by the amendment might be dependent on the source of the cement and/or the compounds tested.

Key words: Degradative Solidification/Stabilization, Chlorinated Ethylenes, Portland cement, ferrous iron