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Photocatalytic degradation of 2,4-dichlorophenol using natural iron oxide and carboxylic acids under UV and sunlight irradiation: intermediates and degradation pathways

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ABSTRACT

The photocatalytic degradation of 2,4-dichlorophenol (2,4-DCP) has been studied using natural iron oxide (NIO) as a heterogeneous catalyst under various conditions. NIO was found to be inactive for 2,4-DCP degradation under UV irradiation (wavelength 365 nm); however, it was very effective under solar light. 2,4-DCP was nearly completely removed with solar light in about 6 h. This can be due to the higher absorptivity of NIO in the solar system. The dependence of 2,4-DCP photodegradation on carboxylic acids in NIO–carboxylate–UV systems was investigated. The presence of oxalic acid allows the highest photocatalytic oxidation rates than other carboxylic acids such as citric, tartaric, malic and malonic acid. The results demonstrated that the 2,4-DCP photodegradation using NIO in the presence of oxalic acid followed the first-order kinetic $k = 3.270 \times 10^{-2}$ min^{-1}. The optimal content of the NIO and oxalic acid concentration were found to be 1.0 g L^{-1} and 5.0 mM, respectively. The use of 2.0% of isopropanol as a scavenger confirmed the intervention of hydroxyl radicals in the photodegradation of 2,4-DCP. The reaction intermediates were identified by an ultrahigh performance liquid chromatography coupled high-resolution mass spectrometry analysis and a reaction mechanism was proposed. Complete mineralization has been confirmed by chemical oxygen demand analysis. A series of experiments were also carried out with solar light in order to compare the results with those obtained with UV irradiation. The process NIO–carboxylate (oxalate, citrate, tartrate and malate) shows good efficiency under solar light, it is an economically viable method for pretreating wastewaters containing recalcitrant pollutants such as chlorophenolic compounds.

Keywords: Natural iron oxide; 2,4-Dichlorophenol; Photodegradation; Solar light; Hydroxyl radicals

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