

Transformation of Phenolic Contaminants by Environmentally Relevant Manganese Oxides

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Manganese (Mn) oxides are among the strongest naturally-occurring oxidants in near surface environments. These solids can oxidize many classes of inorganic and organic contaminants, including those with phenolic functional groups. This study evaluates the ability of synthetic δ -MnO₂, a poorly crystalline Mn(IV) oxide similar to biogenic birnessite, to oxidize a series of simple model phenols and complex environmental contaminants, including antimicrobial agents, endocrine disruptors, and surfactants. Kinetic modelling and quantitative structure-activity relationships between phenol oxidation rates and molecular descriptors (e.g., oxidation energies) provide insight into the rate-limiting steps and mechanisms of this redox reaction. In addition, the reactivity of δ -MnO₂ is compared to manganese-rich reclaimed minerals collected from a drinking water well in Madison, WI and acid mine drainage remediation sites in Pennsylvania. These minerals represent a range of elemental composition, surface area, and point of zero charge. Although the reclaimed solids are orders of magnitude less reactive with the studied phenols, they are capable of oxidizing compounds through both sorption and electron-transfer mediated pathways. The results of this study suggest that reclaimed minerals could be applied to treat contaminated water (e.g., stormwater) under environmentally-relevant conditions, and that the phenolic oxidation mechanism depends on both molecular descriptors and mineral characteristics, with implications for removal rates and product formation in these systems.