Degradation Kinetics of 4-chlorophenol Wastewater and Toxicity Evolution in the Process of Electrochemical Reduction-Oxidation Coupling under Three-Electrode Diaphragm System

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Electrochemical reduction-oxidation process was used to degrade simulated paper wastewater using three-electrode diaphragm system with Pd-Fe/graphene gas-diffusion cathode. The degradation efficiency and toxicity variation assessment were analyzed during the 4-chlorophenol (4-CP) wastewater degradation process. The 4-CP wastewater was degraded effectively and the removal efficiency of chemical oxygen demand (COD) in simulated paper wastewater was 78.2% (anodic), 80.7% (cathodic 1) and 81% (cathodic 2). The toxicity inhibition effect of two cathodic and anodic almost reached 100%, 100%, and 81.0% at 120 min, respectively. The comparison showed concentration for 50% of maximal effect (EC₅₀) of simulated paper wastewater increased with the raise of EC₅₀ of 4-CP. The elimination of toxicity exhibited a hysteresis effect and a rise tendency within 60 min, which might be attributed to the formation of more toxic intermediates such as benzoquinone. A good kinetics model was used to predict degradation of 4-CP and two possible reaction pathways were proposed, featuring a series of steps including cleavage of C-Cl bond, hydrodechlorination, hydroxyl radical addition and oxidation. The Pd-Fe/graphene gas-diffusion cathode was promising to dechlorination and detoxication of simulated paper wastewater containing 4-CP.

Keywords: simulated paper wastewater; 4-chlorophenol; reduction-oxidation process; kinetics; toxicity

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