



Heterogeneous photocatalytic degradation and mineralization of 2,4-dichlorophenoxy acetic acid (2,4-D): its performance, kinetics, and economic analysis

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ABSTRACT

The photocatalytic degradation and mineralization of commercial solution of 2,4-dichlorophenoxyacetic acid (2,4-D) was carried out by UVA/P25 TiO₂ and UVA/P25 TiO₂/H₂O₂ oxidation processes under batch-mode conditions. In UVA + TiO₂ photocatalysis (TiO₂ 1.5 g L⁻¹, pH 5, initial 2,4-D 25 mg L⁻¹), 97.47% ± 0.27% degradation, 39.89% ± 3.42% mineralization, and 65.52% ± 4.88% oxidation were achieved in 180 min, and in UVA + TiO₂ + H₂O₂ photocatalysis (TiO₂ 1.5 g L⁻¹, pH 5, initial 2,4-D 25 mg L⁻¹, H₂O₂ 150 mg L⁻¹), 99.74% ± 0.08% degradation, 55.99% ± 2.67% mineralization, and 82.49% ± 1.90% oxidation were obtained in 180 min. The pseudo-first-order kinetic model fitted the experimental data well, and the photocatalytic degradation process was explained by the modified L-H model; k_c and K_{LH} were 1.293 mg L⁻¹ min⁻¹ and 0.232 L mg⁻¹, respectively. Fourier transform infrared (FTIR) spectroscopy spectra and scanning electron microscopy (SEM) analysis indicated degradation of organic bonds of the herbicide and adsorption of 2,4-D particles onto the TiO₂ catalyst during 24-h experiments. Moreover, the dependence of k_{app} on the half-life time was determined by calculating the electrical energy per order (E_{EO}). UVA/TiO₂/H₂O₂ photocatalysis may be applied as a pretreatment to 2,4-D herbicide wastewater at a pH of 5 for biological treatment.

Keywords: 2,4-dichlorophenoxyacetic acid (2,4-D); Cost analysis; Electrical energy per order; Photocatalytic degradation; Mineralization; UVA/TiO₂/H₂O₂

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