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Oxidative degradation of the antineoplastic drugs 5-fluorouracil and cytarabine in aqueous solution by potassium permanganate

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ABSTRACT

5-Fluorouracil (5-FU) and cytarabine (Ara-C) are two commonly used antineoplastic drugs, which are ecotoxic and genotoxic and frequently detected in hospital wastewater. Potassium permanganate ($KMnO_4$) has been widely used to remove organic pollutants from wastewater. The oxidative degradation of 5-FU and Ara-C in aqueous solution by $KMnO_4$ has not been reported. In this study, the oxidative degradation of 5-FU and Ara-C with $KMnO_4$ in aqueous solution was investigated. 5-FU was oxidized rapidly by $KMnO_4$ due to the olefinic group in the central heterocyclic ring. The degradation kinetics of 5-FU was well described by the equation of $-d[5\text{-FU}]/dt = k_{app}[5\text{-FU}]_t^{0.77}[KMnO_4]_t^{0.86}$. The degradation kinetics of Ara-C followed a generalized second-order rate law. The apparent rate constant (k_{app}) of these two target compounds was strongly depended on the reaction temperature, pH, humic acid (HA) and water quality. The apparent activation energies (E_a) of 5-FU and Ara-C were 32 and 40 kJ·mol^{-1}, respectively, indicating that 5-FU was more easily decomposed by $KMnO_4$ as compared with Ara-C. The maximum values of k_{app} for 5-FU and Ara-C were 1.73×10^{-4} $\mu M^{-0.63} \cdot s^{-1}$ at pH 7.4 and 1.52 $M^{-1} \cdot s^{-1}$ at pH 3.5, respectively. The oxidative degradation of 5-FU was inhibited by HA, while the oxidation of Ara-C was enhanced by HA. Reaction of both 5-FU and Ara-C was influenced by water quality. Thus, this study provides new insights into the degradation of antineoplastic drugs.

Keywords: 5-Fluorouracil; Cytarabine; Potassium permanganate; Kinetics; Oxidative degradation

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