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Enhanced degradation of aqueous norfloxacin and enrofloxacin by UV-activated persulfate: kinetics, pathways and deactivation

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Abstract

Two selected fluoroquinolones (FQs), norfloxacin (NOR) and enrofloxacin (ENR) were degraded using the UV/persulfate process. The degradation of FQs was mainly enhanced with the increasing dosages of persulfate (0.05mM-0.5mM) and lower FQs concentration (0.0026-0.052 mM). pH 9.0 was demonstrated as the optimal condition with the apparent rate constants at $0.186 \pm 0.018 \text{ min}^{-1}$ and $0.250 \pm 0.029 \text{ min}^{-1}$ for NOR and ENR respectively. The detailed degradation mechanisms for FQs by UV/persulfate were proposed. 9 (for NOR) and 12 (for ENR) intermediates were identified by high performance liquid chromatography–tandem mass spectrometry (HPLC-MS/MS). It is indicated that the degradation occurred mainly through defluorination, hydroxyl substitution and decarboxylation on the C-F bond or carboxylic acid by photon attack, and carbonyl-addition, hydroxyl substitution as well as decarboxylation on the piperazine group also constituted the decontamination, which was followed by the further oxidation, deamination and subsequent dehydrogenation. For NOR, the ethyl of the C-N heterocyclic ring was activated, while the alpha-C atom on the ethyl of the piperazine group was vulnerable for ENR. It was demonstrated that the UV/persulfate process has a great effect on the mineralization (up to 61.2-62.5%) and toxicity control (14.6-32.6%) for the fluoroquinolone antibiotics.

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