Use of High-Valent Metal Species Produced by the Fenton (-like) Reactions in Water Treatment

Changha Lee

Abstract

The iron- and copper-based Fenton (-like) reactions produce high-valent metal species (ferryl and cupryl ions). Ferryl and cupryl ions as reactive oxidants are capable of oxidizing refractory organic compounds in water. Ferryl and cupryl ions can be used for the inactivation of microorganisms in both planktonic and biofilm states.

Keywords

High-valent metal species • Ferryl ion • Cupryl ion • Fenton reaction • Water treatment

The iron- and copper-based activation of oxygen and hydrogen peroxide via the Fenton (-like) reactions produce high-valent metal species such as ferryl and cupryl ions (i.e., Fe(IV) and Cu(III)). The high-valent metal species are less reactive than hydroxyl radical, but still, they are strong oxidants ($E^{o}[M^{(v+1)+}/M^{v+}]$ = ca. 1.5–2.5 V_{NHE}) capable of oxidizing refractory organic compounds in water. These reactive oxidants can be used in the oxidative degradation of organic contaminants as well as in the inactivation of harmful microorganisms. In spite of recent advances in the chemistry of high-valent metal species, limited information is available about the reactivity of these oxidants with organic compounds and the mechanisms through which organic compounds are oxidized in the reactions. In addition, the studies on the microbial inactivation using high-valent metal species are rare.

Our recent studies investigated the nature and reactivity of Fe(IV) and Cu(III) produced by different iron- and copper-based Fenton (-like) reactions, and assessed the potential of these oxidants for the degradation of organic contaminants and the inactivation of microorganisms (Kim et al. 2015a, b; Lee et al. 2016, 2017). It was found that the reactivity of Fe(IV) and Cu(III) vary with their forms; Fe(IV) and Cu(III) usually exist as coordination complexes, and the coordinating ligand affects the reactivity of these complexes. Fe(IV) and Cu(III) degraded different organic contaminants via selective and non-selective reactions, depending on the reactivity of Fe(IV) and Cu(III). In addition, Fe(IV) and Cu (III) effectively inactivated microorganisms in both planktonic and biofilm states.

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C. Lee (✉)
School of Chemical and Biological Engineering, Institute of Chemical Process (ICP), Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Republic of Korea
e-mail: leechangha@snu.ac.kr

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