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Inactivation of bacterial planktonic cells and biofilms by Cu(II)-activated peroxymonosulfate in the presence of chloride ion

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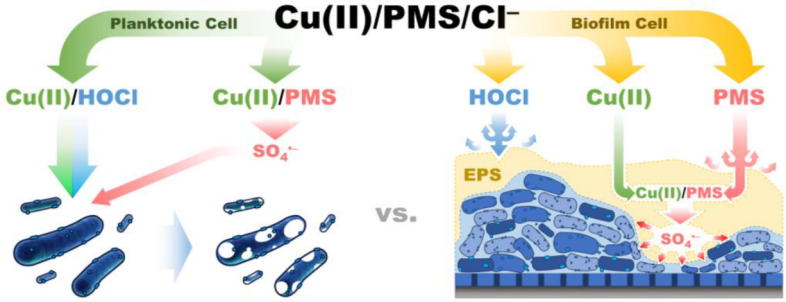
HIGHLIGHTS

- The Cu(II)/PMS system effectively inactivated planktonic and biofilm bacterial cells.
- The presence of chloride ion enhanced the inactivation of planktonic cells.
- The EPS barriers suppressed the inactivation of biofilm cells by oxidants.
- The Cu(II)/PMS system is applicable as a pretreatment for RO desalination.

GRAPHICAL ABSTRACT



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ABSTRACT

The combination of Cu(II) with peroxymonosulfate (PMS) (i.e., the Cu(II)/PMS system) synergistically inactivated *P. aeruginosa* cells in the planktonic state, and in biofilms grown on RO membranes. The enhanced bacterial inactivation by the Cu(II)/PMS system appears to be due to the reactive oxidants produced by the catalytic reactions of the Cu(II)/Cu(I) redox couple with PMS. In the presence of chloride ion (Cl^-), the Cu(II)/PMS system showed increased microbicidal effects on the planktonic *P. aeruginosa* cells, which was explained by the role of hypochlorous acid (HOCl) produced by the reaction of chloride with PMS. In addition, the combination of Cu(II) with HOCl showed synergistic microbicidal effects on the planktonic cells. Compared to planktonic cells, biofilm cells were more resistant to the Cu(II)/PMS treatment. Cl^- did not significantly affect the inactivation of biofilm cells by the Cu(II)/PMS system. It is believed that the extracellular polymeric substances of biofilms play a role as oxidant sinks (particularly HOCl), protecting the cells inside the biofilm matrix. The HOCl-generating systems, such as PMS/Cl^- and Cu(II)/PMS/Cl^-, greatly degraded proteins and polysaccharides in biofilms. Experiments on the cross-flow filtration of NaCl solution showed that the Cu(II)/PMS treatment of fouled RO membranes resulted in partial recovery of permeate flux.

1. Introduction

Biofilms are a common industrial problem, and they negatively impact the membranes upon which many industries rely. These include membranes used in water and wastewater treatment, desalination, beer and wine filtration, juice and pulp processing, and protein purification [1–5]. One of the primary hinderances to desalination operation is the formation of biofilms on reverse osmosis (RO) membranes. Biofilms on

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