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Microbial desalination cells packed with ion-exchange resin to enhance water desalination rate

Alexandre Morel, Kuichang Zuo, Xue Xia, Jincheng Wei, Xi Luo, Peng Liang *, Xia Huang *

State Key Joint Laboratory of Environment Simulation and Pollution Control School of Environment, Tsinghua University, Beijing 100084, PR China

HIGHLIGHTS

- ▶ Ion-exchange resins packed MDC can enhance water desalination rate.
- ▶ Desalination rates of resins packed MDC were 1.5–8 times those of classic MDC.
- ▶ Ohmic resistances in resins packed MDC were lower than those of classic MDC.
- ▶ Resins in desalination chamber counteracted the increase in solution resistance.
- ▶ Resins packed MDC is especially promising for low salinity water or wastewater.

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ABSTRACT

A novel configuration of microbial desalination cell (MDC) packed with ion-exchange resin (R-MDC) was proposed to enhance water desalination rate. Compared with classic MDC (C-MDC), an obvious increase in desalination rate (DR) was obtained by R-MDC. With relatively low concentration (10–2 g/L NaCl) influents, the DR values of R-MDC were about 1.5–8 times those of C-MDC. Ion-exchange resins packed in the desalination chamber worked as conductor and thus counteracted the increase in ohmic resistance during treatment of low concentration salt water. Ohmic resistances of R-MDC stabilized at 3.0–4.7 Ω. By contrast, the ohmic resistances of C-MDC ranged from 5.5 to 12.7 Ω, which were 55–272% higher than those of R-MDC. Remarkable improvement in desalination rate helped improve charge efficiency for desalination in R-MDC. The results first showed the potential of R-MDC in the desalination of water with low salinity.

1. Introduction

Microbial desalination cell (MDC) is a recent discovery for low-cost water desalination. MDC is derived from modified microbial fuel cell (MFC) by inserting a desalination chamber constructed with a pair of anion exchange membrane (AEM) and cation exchange membrane (CEM) between the anode and cathode (Cao et al., 2009). In an MDC process, organic matter in wastewater is oxidized by electrochemically active bacteria on the anode; the released electrons flow from the anode to the cathode, where oxygen is typically reduced to form water. Cations and anions in salt water held in the desalination chamber migrate into the cathode and anode, respectively, because of the potential gradient created between the anode and cathode. This phenomenon leads to water desalination. MDC has drawn great attention because it provides a promising approach for desalinating water and simultaneously generating electricity without external energy input, while other commercialized desalination processes, such as electrodialysis, reverse osmosis (RO), and distillation consume extensive energy (Mohtada and Toraj, 2009; Shannon et al., 2008). Extended works based on the proof-of-concept MDC with ferricyanide cathode (Cao et al., 2009) have been successively reported. These studies include air cathode MDC (Mehanna et al., 2010b), continuously operated up flow MDC (Jacobson et al., 2011a, 2011b), stacked MDC for increasing desalination rate (Chen et al., 2011), series assembly of MDC for partial or complete seawater desalination (Kim and Logan, 2011), and simultaneous water desalination and hydrogen production using MDC (Luo et al., 2011; Mehanna et al., 2010a).

MDC is principally a bio-electrochemical system. Its performance highly depends on internal resistance, including ohmic, charge transfer, and mass transfer resistances (Liang et al., 2007). Ohmic resistance is present in electrolytes, electrodes, and membranes. During desalination, ohmic resistance increases significantly with decreasing water salinity and conductivity (Cao et al.,

* Corresponding authors. Tel.: +86 10 62772324 (X. Huang), Tel.: +86 10 62796790 (P. Liang).

E-mail addresses: liangpeng@tsinghua.edu.cn (P. Liang), xhuang@tsinghua.edu.cn (X. Huang).

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