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Short Communication

Microbial desalination cell with capacitive adsorption for ion migration control

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HIGHLIGHTS

- ▶ A new microbial desalination system without releasing salts to the electrolytes.
- ▶ Integrated system for organic removal, current production, and desalination.
- ▶ Demonstrated activated carbon cloth can be an effective material for MDCs.

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ABSTRACT

A new microbial desalination cell with capacitive adsorption capability (cMDC) was developed to solve the ion migration problem facing current MDC systems. Traditional MDCs remove salts by transferring ions to the anode and cathode chambers, which may prohibit wastewater beneficial reuse due to increased salinity. The cMDC uses adsorptive activated carbon cloth (ACC) as the electrodes and utilizes the formed capacitive double layers for electrochemical ion adsorption. The cMDC removed an average of 69.4% of the salt from the desalination chamber through electrode adsorption during one batch cycle, and it did not add salts to the anode or cathode chamber. It was estimated that 61–82.2 mg of total dissolved solids (TDS) was adsorbed to 1 g of ACC electrode. The cMDC provides a new approach for salt management, organic removal, and energy production. Further studies will be conducted to optimize reactor configuration and achieve *in situ* electrode regeneration.

1. Introduction

The sustainable supply of fresh water through saltwater desalination has been developed significantly in the past century, but one remaining challenge is high energy use during the desalination process. Popular desalination methods include reverse osmosis (RO) and multistage flash evaporation (MSF) are considered energy intensive, because for treating 1 m^3 of seawater, RO typically uses 3–7 kwh/m^3 of electricity and MSF may require up to 68 kwh/m^3 (Avlonitis et al., 2003; Xu et al., 2009). Recently, a new desalination technology called microbial desalination cell (MDC) was developed and demonstrated that salt water can be desalinated without using external energy. Moreover, this process can also simultaneously achieve wastewater treatment and energy production in the format of electricity or hydrogen gas. (Cao et al., 2009; Jacobson et al., 2011; Kim and Logan, 2011; Luo et al., 2011, 2012a,b). MDC reactor uses exoelectrogenic bacteria to oxidize biodegradable substrate (i.e. wastewater) in an anode chamber and transfer the electrons to the anode. The electron flows through an external circuit to a cathode, where external electron acceptors (i.e. O_2) are reduced. When a middle chamber is inserted in between the anode and cathode chamber using a pair of ion exchange membranes, desalination can be achieved. The potential difference between the anode and cathode electrodes drives the migration of ions out of the desalination chamber, with anions (Cl^-) migrating to the anode chamber across an anion exchange membrane and cations (Na^+) migrating to the cathode chamber across a cation exchange membrane. The process can remove more than 99% of the salt water and potentially produce more energy than the external energy required for the system, making it a promising desalination process with net energy gaining (Jacobson et al., 2011; Mehanna et al., 2010) .

One main challenge with the MDC technology is that while the salts are removed from the middle chamber, they become concentrated in the anode and cathode chambers, which results in salinity increases in the anolyte and catholyte. While this ion addition is generally acceptable for wastewater treatment and helps with conductivity conditioning, it may cause concerns for water benefi-

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