Microbial reverse-electrodialysis electrolysis chemical-production cell for H_2 production and CO_2 sequestration

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Climate change has become one of the critical environmental issues due to increasing atmospheric CO_2 concentrations from anthropogenic combustion of fossil fuels[1,2]. It has previously been shown by our group that natural mineral carbonation can be enhanced to develop a significant sink for atmospheric CO_2 by using acid and alkali produced in microbial electrolysis desalination and chemical-production cells (MEDCCs)[3]. However, the MEDCCs required an external power supply with an applied voltage of 1 V, which increased the operational costs and potentially generated CO_2 if that energy was obtained from a fossil fuel power plant.

Here, a microbial reverse-electrodialysis electrolysis chemical-production cell (MRECC) was developed to produce acid and alkali using only renewable energy sources (organic wastes and salinity gradients) (Fig. 1). The MRECC was developed through combining a reverse-electrodialysis stack (RED) which produce electrical energy from salinity gradients[4,5] with a microbial fuel cell that can produce electricity from organic wastes[6,7]. The MRECC-generated acid and alkali solutions were then used to enhance mineral (serpentine) carbonation for CO_2 sequestration, and simultaneously generate valuable H_2.

Over a 24 h fed-batch cycle, there was a maximum of 0.69 mmol acid and 0.97 mmol of alkali produced with 50% (acid) and 70% (alkali) production efficiencies, as well as maximum of 11 mL H_2 (1 atm) with 71% production efficiency (anode volume was 28 mL). Mineral dissolution rates were increased 17~87 times by using the acid solution. About 8 mL of CO_2 was absorbed and 4 mg of CO_2 was fixed as magnesium/calcium carbonates by adjusting the product pH using the alkali solution. The operation cost is estimated to be as was low as approximately $26 to fix one ton CO_2 to carbonates based on the mineral mining and grinding cost, as well as the solution pumping cost. Additionally, considering further benefits provided by wastewater treatment (if wastewater is the source of organic matter) and H_2 generation, this system will be very attractive for CO_2 sequestration.

Acknowledgements
The authors acknowledge support from the King Abdullah University of Science and Technology (KAUST) by Award KUS-I1-003-13. The authors would also like to thank Dr. George Alexander from Department of Energy and Geo-Environmental Engineering, Penn State University for providing natural minerals.

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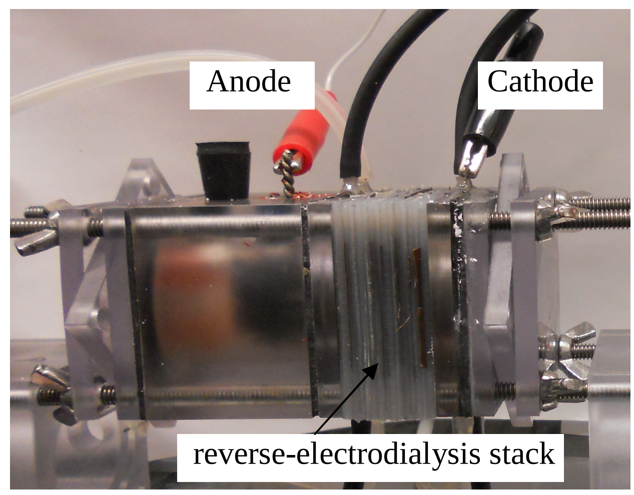

Fig. 1. The photo of the microbial reverse-electrodialysis electrolysis chemical-production cell.