Simultaneous CO2 treatment and blue energy generation from wasted industrial streams

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1 Introduction

Needs of the region

Qatar
3rd Largest Natural gas and oil reserves

Main source of pure drinking water is desalinated water

Global Desalination Capacity — 60% Seawater Reverse Osmosis (SWRO)

Limitations of technology

Huge amount of Rejected RO Brine

Ammonia production plants in Qatar (Such as QAFCO)

Produce

Huge amount of Wastewater — CO_2 emissions

Global SGP potential is approximately 2.4 – 2.6 terawatts (TW)

is obtained by exploring the Gibbs free energy available in the mixing of two aqueous solutions with different salt content.

Salinity gradient energy (Blue Energy)

Low concentration Wastewater stream

Energy Recovery from RO Brine

From its high salinity content

Effluent brine of SWRO desalination plant has very high salinity levels

Reaches about 35,000 ppm (25 bar osmotic pressure)

From its high pressure

Effluent brine of SWRO desalination plant is highly pressurized

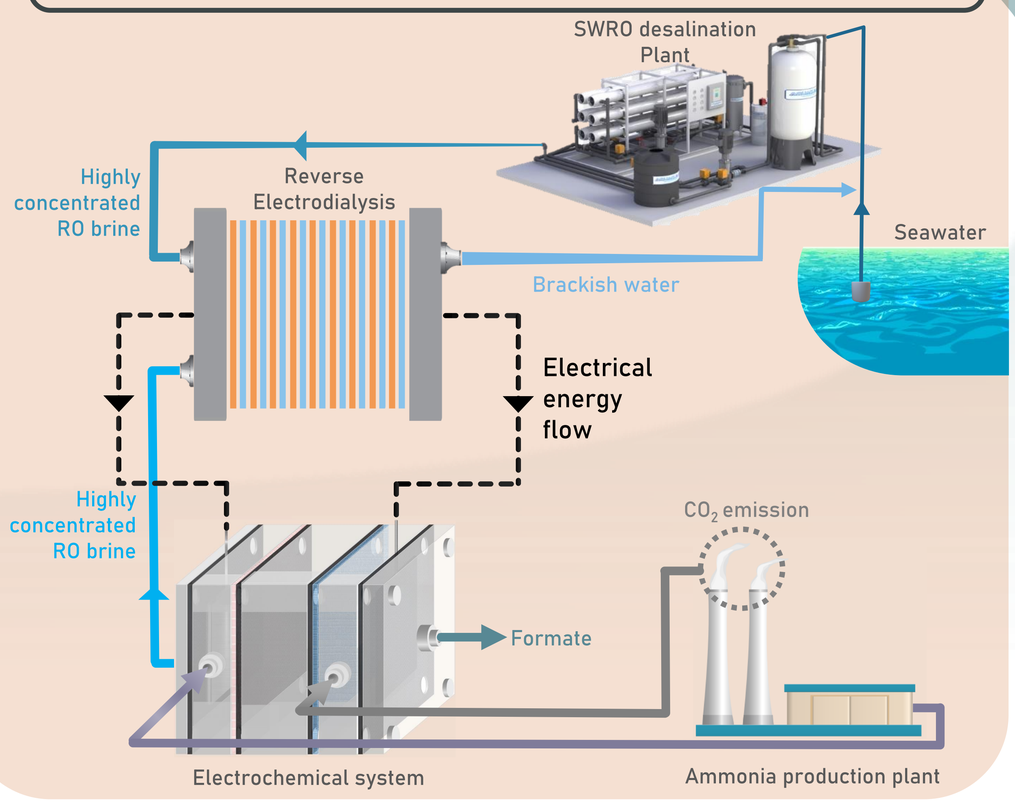
Nearly 75 bars

Energy recovery devices (ERD) are the most efficient for harnessing this energy

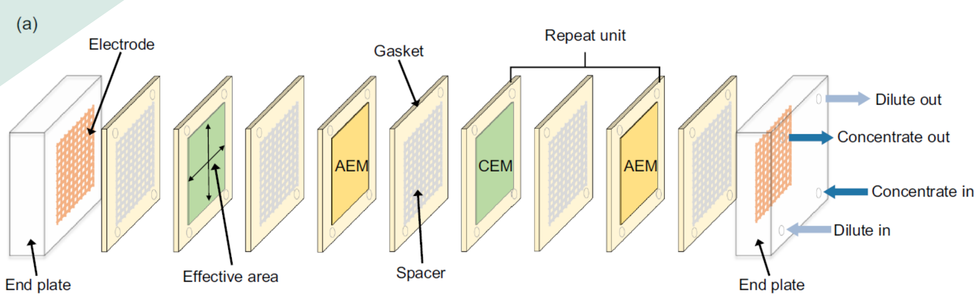
Selected approach to address the needs

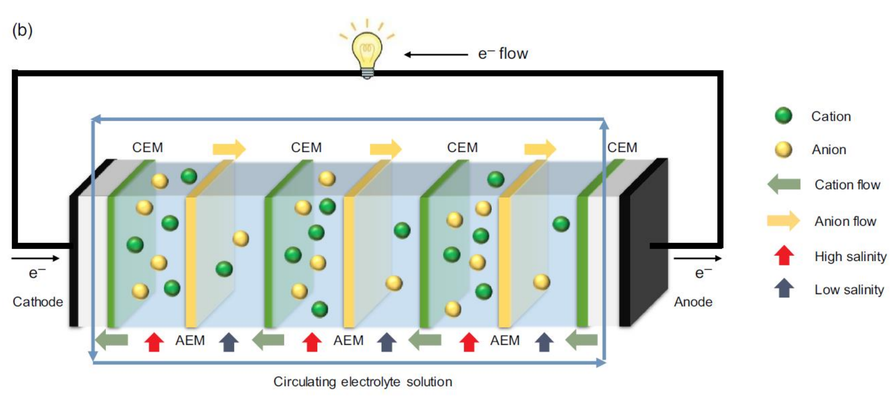
98% Energy Recovery ☑

Motivation and proposed process

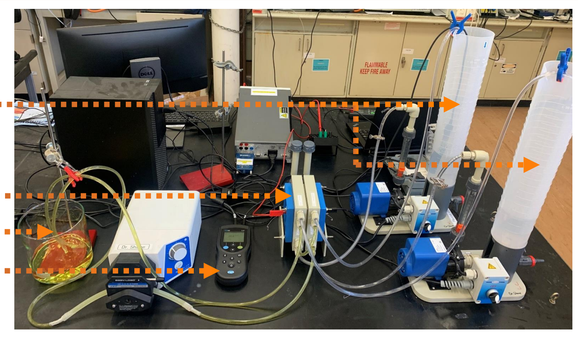


RED Working Principle





2 Experimental Setup and methodology

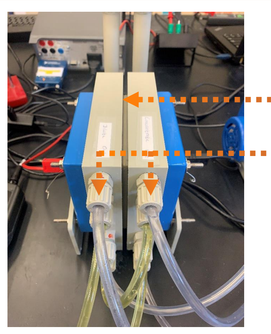


LC and HC solutions

RED cell

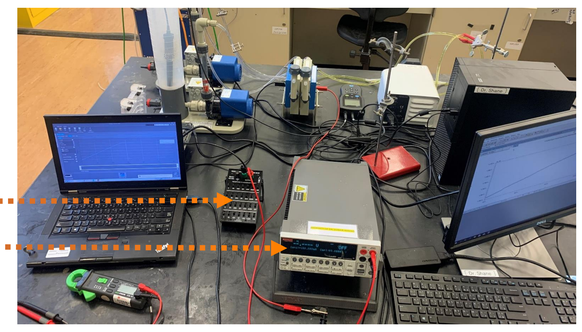
Rinse solution

Conductivity meter



RED membrane stack

Inlet and outlet nozzles

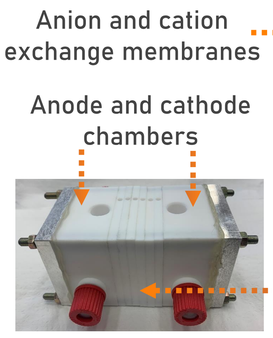


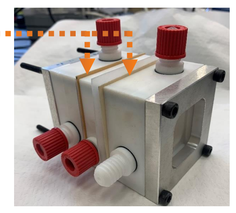
External load

Source measure unit

Anion and cation exchange membranes

Anode and cathode chambers





Desalination chamber

RED Process Optimization

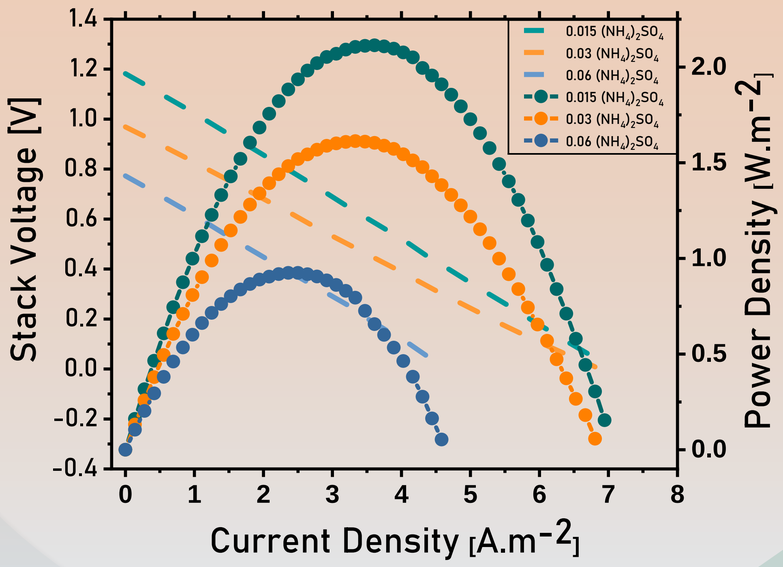


Figure 1. RED performance with various Low Concentration (LC) solution composition using High Concentration solution of 1 M NaCL and 5Ω external load.

3 Results

15 membrane pairs Provide -1.5 V for CO_2 conversion

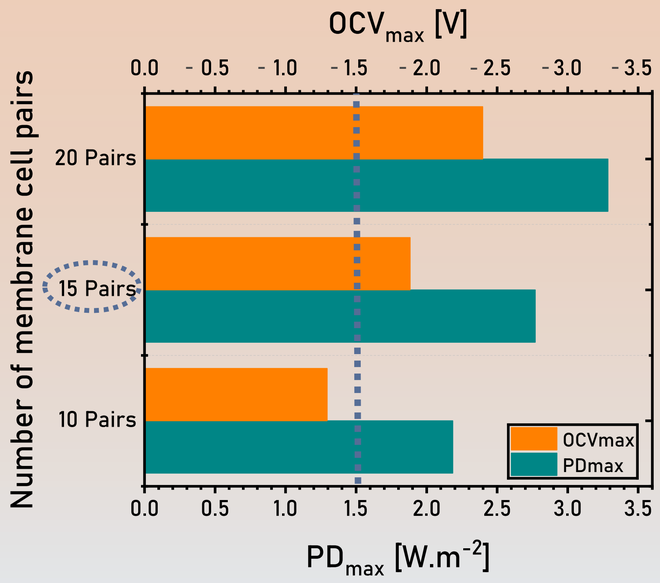


Figure 2. Effect of varying Number of cell membrane pairs in RED with 1 M NaCl solution as HC solution and 0.015 M (NaCl + $(NH_4)_2SO_4$) solution as LC solution.

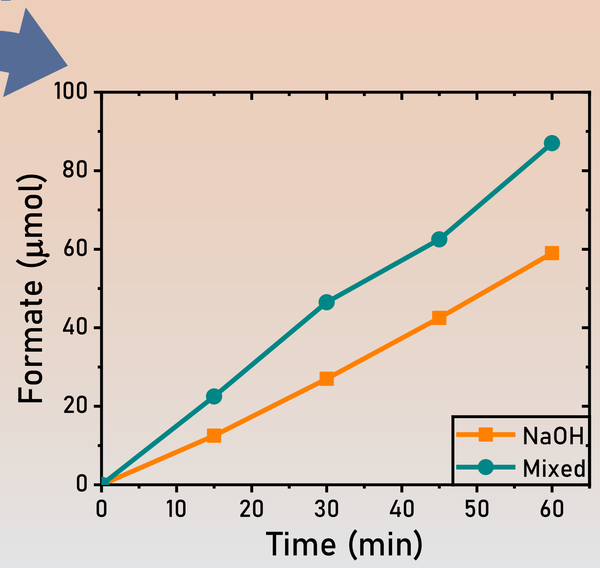


Figure 3. Electrocatalytic formate production from CO_2 using Bi foam electrodes at –1.5 V vs SCE in CO_2-purged aqueous solutions of NaOH (0.1 M) and NaOH + K_2SO_4 (each 0.05 M).

4 Conclusion & Significance

- Successful optimization of RED cell was achieved via exploring the influence of concentrate and dilute stream concentrations, compositions and flowrates on acquired power density, giving a maximum of 3.25 W.m^{-2} with 20 membrane pairs a salinity gradient of 0.98M.
- 15 cell pairs were needed to provide -1.5 V of energy to drive CO_2 conversion to formate.

Towards energy sustainability and industrial waste management

Acknowledgment

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