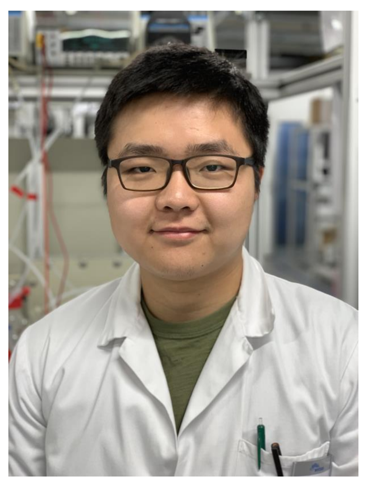
Novel methods for electrochemical capture and conversion of CO_2



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Motivation

Global warming is one of the most critical global challenges. Increasing atmospheric CO_2 concentration brought by anthropogenic emission is the major reason for this climate change problem. Capturing CO_2 from emission points and even directly from air provides a feasible solution to mitigate the amount of CO_2 emission and reduce the atmospheric CO_2 concentration. At Wetsus, under the theme Sustainable Carbon Cycle, we aim to develop novel CO_2 capture technologies that could be potentially energy efficient and environmentally benign [1].

Technological challenge

CO_2 can be captured by alkaline aqueous sorbent due to the high solubility of CO_2 under high pH. However, the conventional regeneration of the sorbent by calcination consumes a large amount of energy. Therefore, we aim to develop an alternative process for regenerating the alkaline solution in wet scrubbing process for direct air capture (DAC) application.

This alternative process is designed to create a pH-swing of the solution. We have noticed that the solubility of CO_2 in aqueous solvent is dependent on the pH of the solution (Figure 1). Thus, CO_2 can be desorbed at low pH and the sorbent can be regenerated at high pH. The configuration of the system is shown in Figure 2.

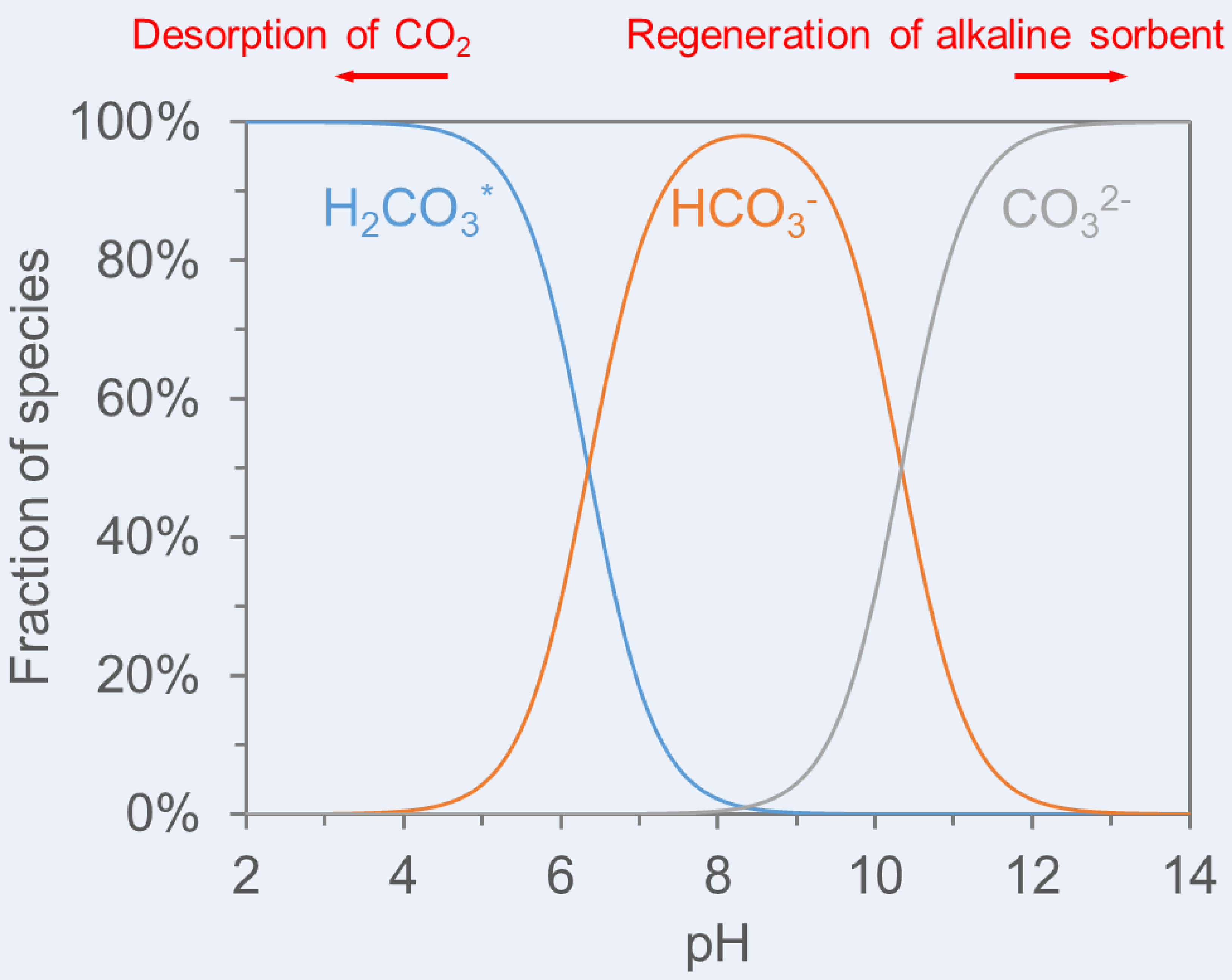

Fig 1. The fractions of different aqueous carbon species at different pH.

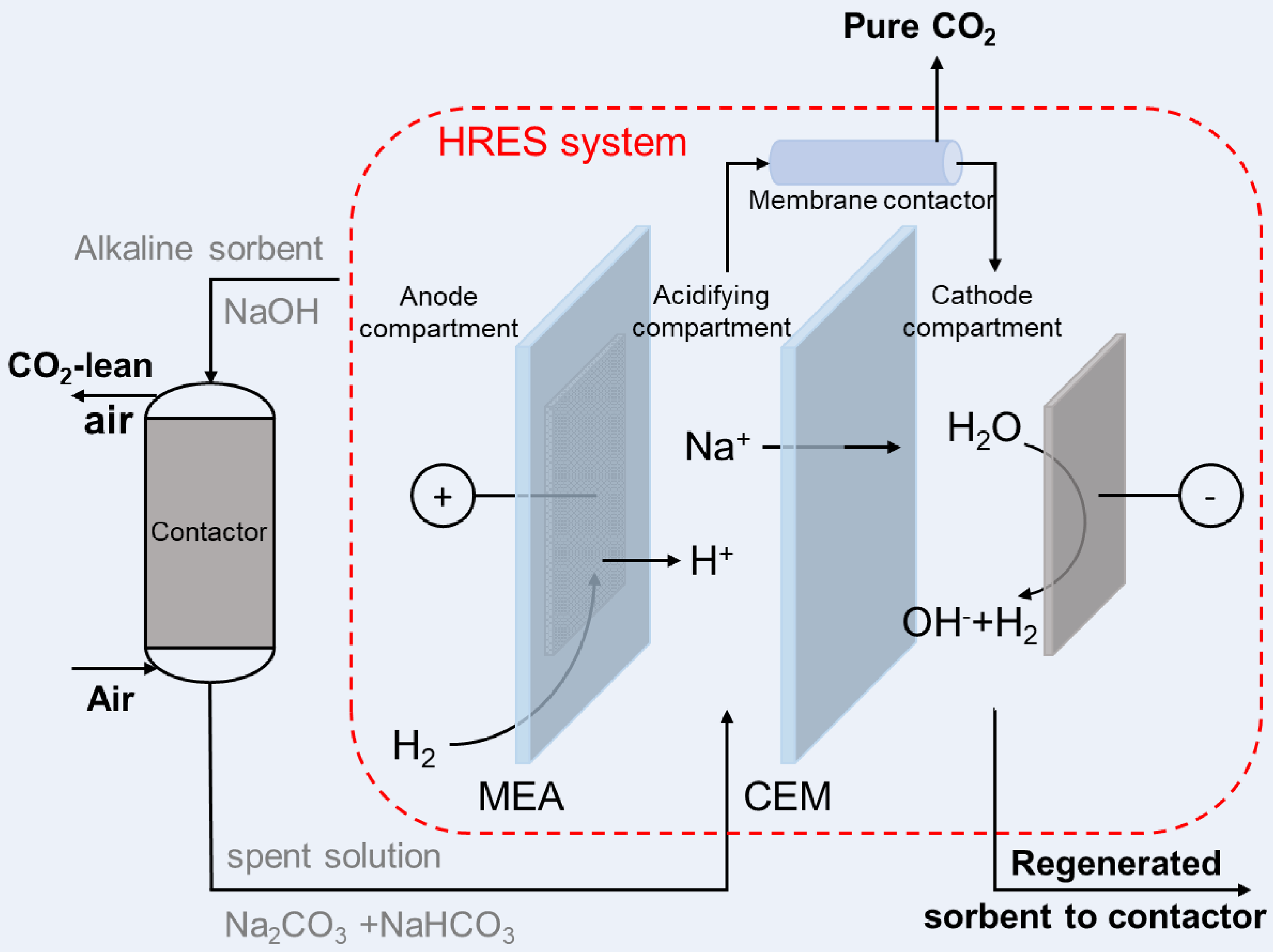

Fig 2. Principle of DAC process using a H_2-recycling electrochemical system (HRES) for CO_2 desorption and regeneration of alkaline sorbent.

The process is based on a H_2-recycling electrochemical system (HRES) which was originally developed for nitrogen recovery from wastewater [2]. Alkaline and acidic conditions are created in two adjacent compartments respectively in HRES, so simultaneous desorption of CO_2 and regeneration of alkaline sorbent could be achieved after the spent solution flows through the electrochemical cell [3].

Research goals

- Developing a novel electrochemical system for CO_2 capture based on the scheme shown in Figure 2
- Investigating the CO_2 capture performance and energy consumption of the system under different conditions
- Studying the performance of the system with different sorbents
- Developing a mathematical model of the system describing the kinetics and transport of different components
- Scaling-up study by integrating pairs of bipolar membranes in the electrochemical cell

[1] Legrand et al., Solvent-Free CO2 Capture Using Membrane Capacitive Deionization. *Environmental science & technology* **2018,** *52*, (16), 9478-9485.
[2] Kuntke et al., Hydrogen Gas Recycling for Energy Efficient Ammonia Recovery in Electrochemical Systems. *Environmental Science & Technology* **2017**, *51* (5), 3110-3116.
[3] Hamelers et al, Electrochemical device, system and method for electrochemical recovery and/or regeneration of carbon dioxide from a stream, NL2025044

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