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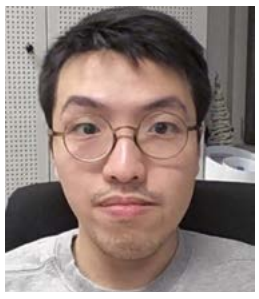
Novel electrochemically-assisted processes for electricity-driven CO_2 capture



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Motivation

Capturing CO_2 from industrial emissions to prevent further increase in atmospheric CO_2 concentration is essential to mitigate climate change and shift towards a climate neutral industry by 2050. Conventionally, CO_2 is absorbed in amine solvents which then are thermally regenerated. However, high energy cost and solvent degradation associated to thermal regeneration raised the interest in developing alternative processes. Here, electrochemical systems offer the clear advantage to conveniently use green (renewable) electricity as energy input for a pH-swing based regeneration. The scope of the study is to demonstrate a novel CO_2 capture process based on pH-swing regeneration (Fig.1) in an electrochemical system (Fig. 2).

Technological Challenge

Previous studies on electrochemical CO_2 capture and regeneration system proves the feasibility of the idea of establishing an acidic trap for the depletion of CO_2 in the basic solvent [1-2].
However, both energy and CO_2 removal efficiency are still below the benchmark of the state-of-the-art CO_2 capture via amine scrubbing [3]. Additionally, a full understanding of such a process from a thermodynamic perspective is still lacking in literature, and it would be fundamental to guide the design and further scale-up of the electrochemical technology. The technological challenge remains to understand and reduce the electrical overpotentials while maintaining a high current density and energy efficiency.
This novel process will be also investigated on pilot-scale, and addressing potential challenges in the scale-up process will be crucial to provide input for follow-up studies towards full-scale implementation.

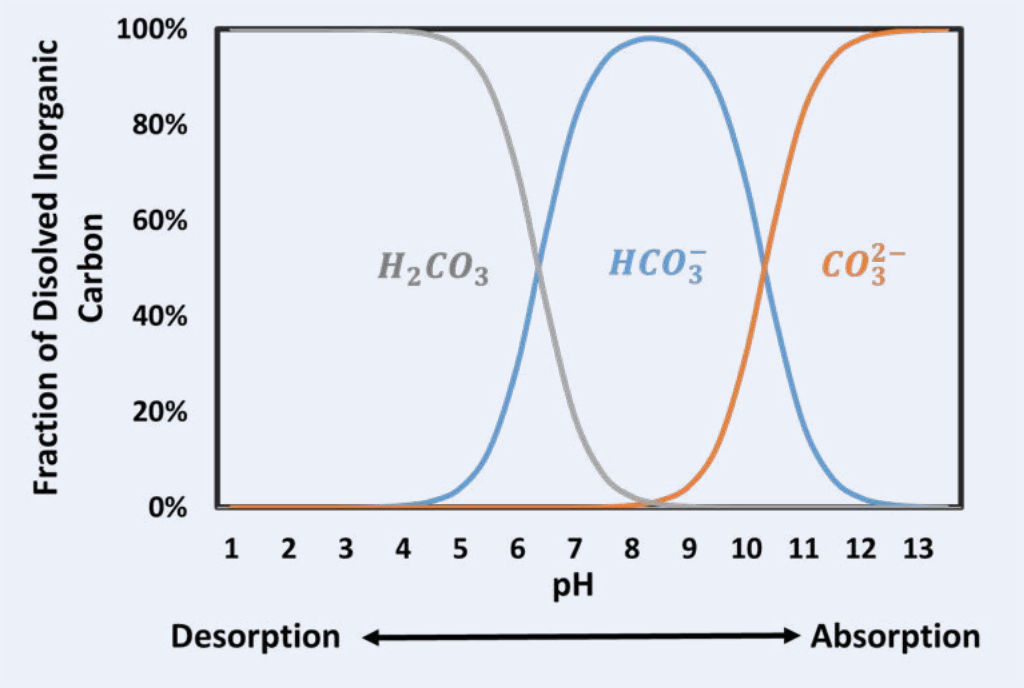

Fig. 1. Fraction of chemical species as function of the solution pH for the H_2O-CO_2 system at 25 °C.

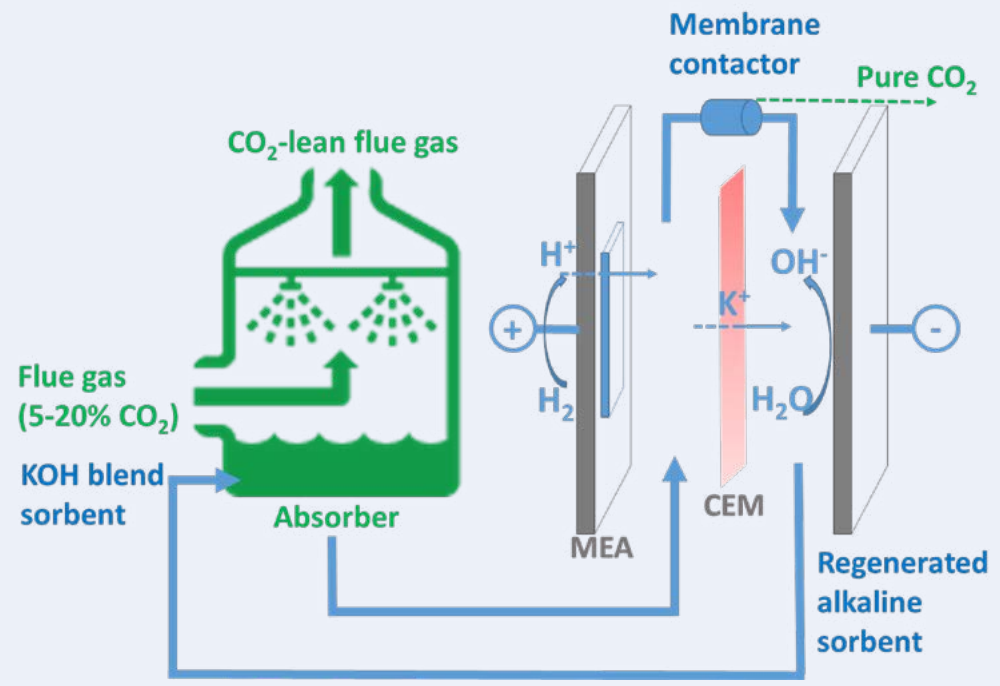

Fig. 2. Schematic illustration of the CO_2 capture process based on absorption in alkaline (KOH) blend and electrochemical regeneration.

Research goals

- Understand the thermodynamics behind the pH swing-based electrochemical regeneration;
- Optimize the electrochemical system for CO_2 capture based on a membrane electrolysis cell with pH swing;
- Reduce energy consumption of the system to compete with the conventional CO_2 capture technologies;
- Study the feasibility of the system and design optimization for further scale-up (100 kg/h CO_2).

References

[1] Legrand et al., Environmental Science & Technology (2018), 52(16), 9478-9485
[2] Shu et al., Environmental Science & Technology (2020), 54(14), 8990-8998
[3] Bui et al., Energy Environ. Sci. (2018), 11 (5), 1062–1176

Acknowledgments
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