Electrochemically-Mediated Separations for Carbon Mitigation

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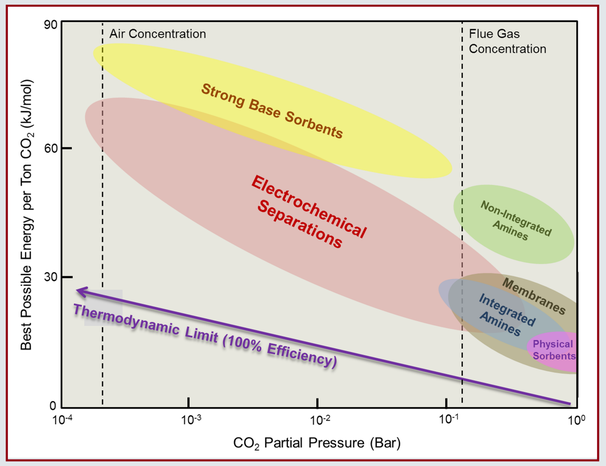
Introduction

Electrochemically-mediated separations (ECMS) offer a potentially high-efficiency "drop in" solution for post combustion carbon dioxide (CO_2) capture.

- No need for reconfiguration of turbine systems.
- Can be applied anywhere that electricity is available and does not require "waste heat."
- Can be used for capture of CO_2 from streams as dilute as air.



Why is ECMS more efficient?

ECMS, which relies on electrical power, is subject to the efficiency of electricity generation which is about 40%.

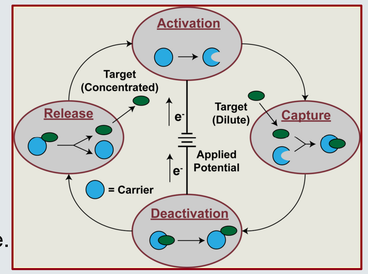
Non-integrated thermal-swings are limited by the Carnot Efficiency of their absorption and desorption temperatures, which is usually below 20%!

Pressure-swing systems like membranes and physical sorbents can also reach high efficiencies but can not be practically applied for dilute capture.

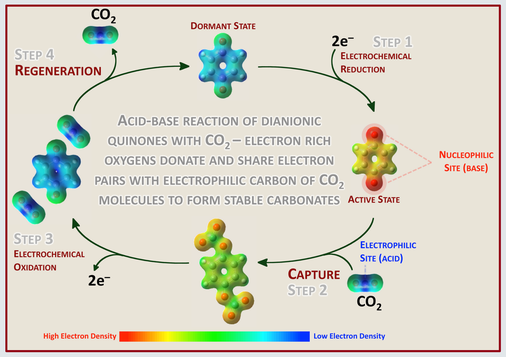
The ECMS Cycle

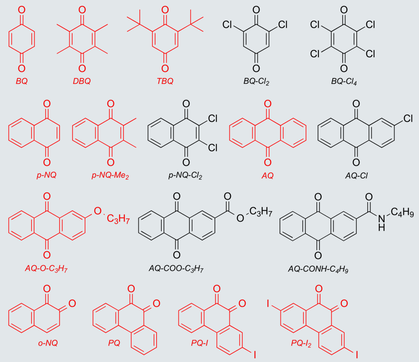
The ECMS cycle has four steps:

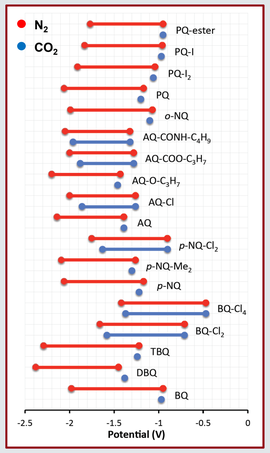
1. Activation of the redox carrier.
2. Contact and capture of the target molecule.
3. Deactivation of the carrier complex.
4. Release of the target molecule.

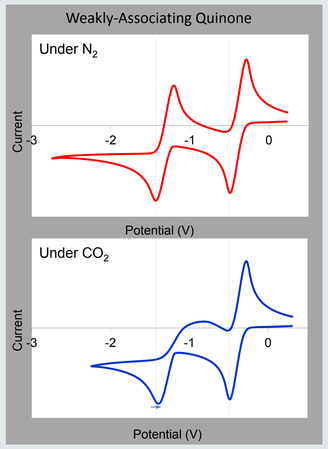


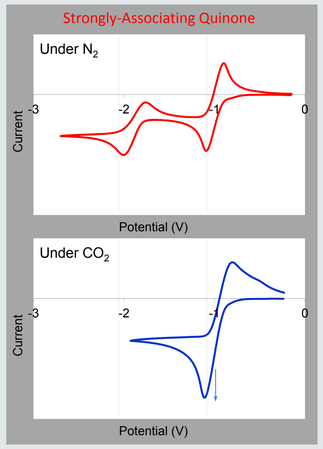
Quinone Electrochemistry

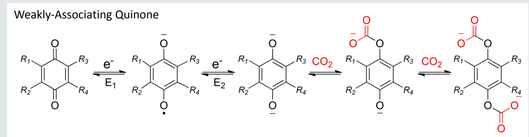


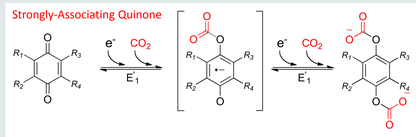


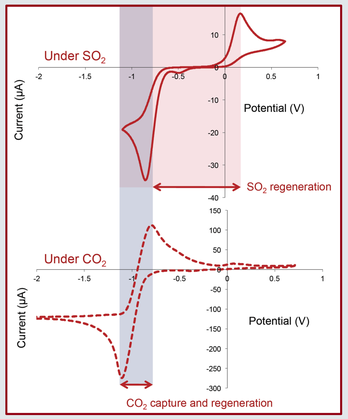












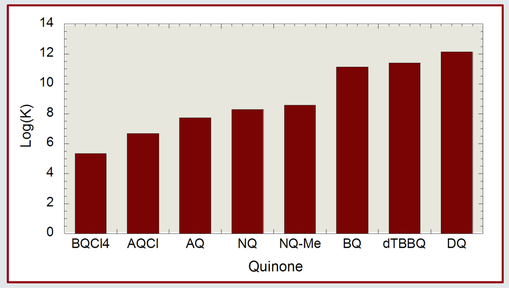
Quinones facilitate CO_2 capture and regeneration in the ECMS process.

Strong affinity of SO_2 toward reduced quinones offers an opportunity of ECMS for simultaneous co-capture of CO_2 and SO_2..

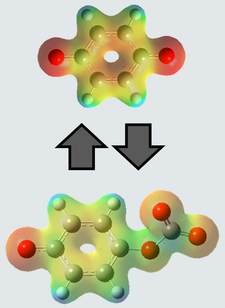
Higher oxidation potential of quinone-SO_2 adduct relative to quinone-CO_2 adduct offers selective regeneration of CO_2 and SO_2 with ECMS technology

Quantum Chemistry of ECMS

Quantum simulations allow for the quick and accurate evaluation of potential ECMS carriers.

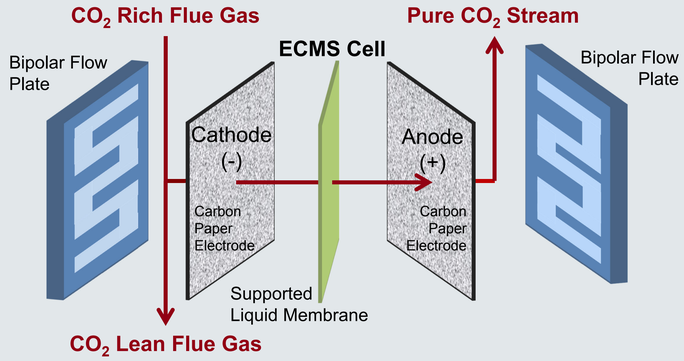


Complex Formation

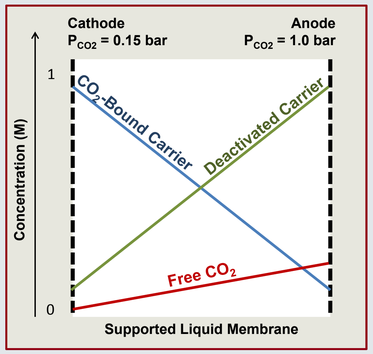


ECMS at Scale

ECMS systems can be applied to large scale separations through the use of electrically facilitated membranes.



The concentration of CO_2, and CO_2 bound species, dramatically increases at the cathode and diminishes to near zero at the anode due to the electrochemical reactions. The resulting concentration gradient enables enhancement of the CO_2 permeance by an order of magnitude..



Carrier Capacity	2 mole/L
Carrier Diffusivity	4.2×10^{-6} cm²/s
CO_2 Solubility	0.129 mol/L atm
CO_2 Diffusivity	8.5×10^{-6} cm²/s
Membrane Thickness	15 um
Carrier Facilitated Flux	3.76 sccm/cm²
CO_2 Counter Flux	0.84 sccm/cm²
Current Density	64.3 mA/cm²
Cell Thickness	1 cm
Cell Area per 500 MW	1.4×10^5 m²
Cell Volume per 500 MW	1.4×10^3 m³