# Seawater $CO_2$ capture using bipolar membrane electrodialysis

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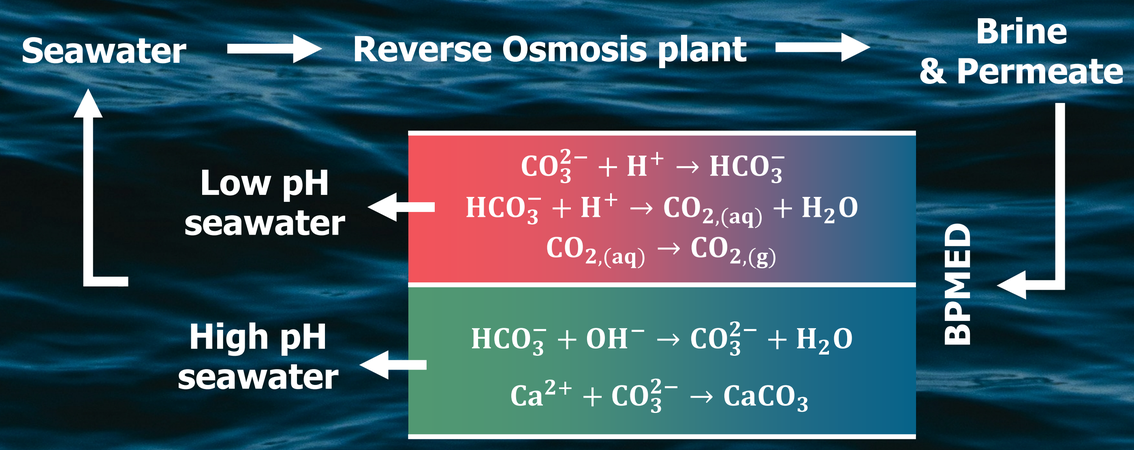
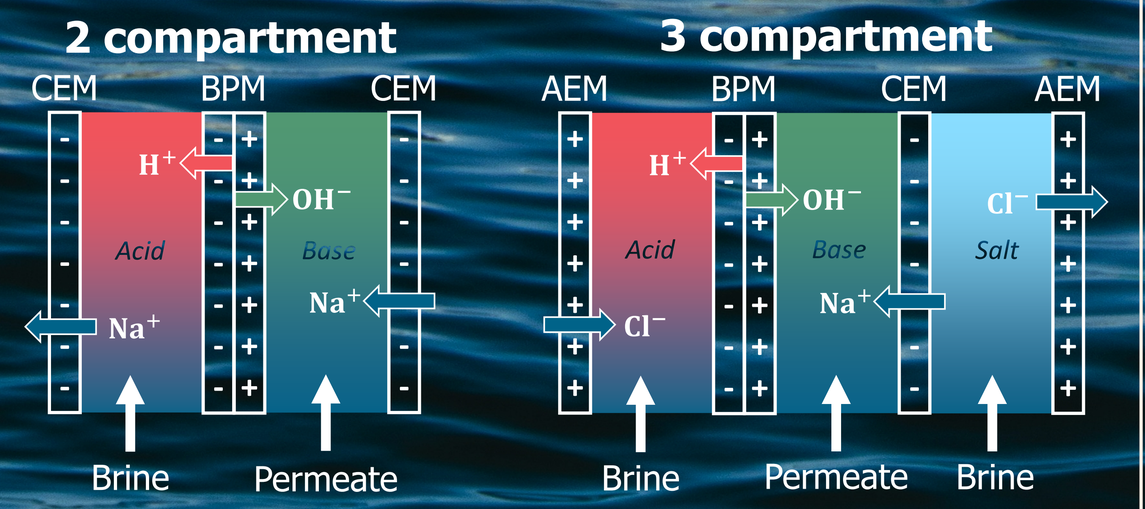
## 1. Motivation

To achieve net zero emissions by 2050, we need $CO_2$ as a resource for synthetic fuels and chemicals and negative $CO_2$ emissions to offset hard-to-abate emissions. Hence, $CO_2$ capture from the environment will be indispensable. We present a method to indirectly capture $CO_2$ from the air via seawater using bipolar membrane electrodialysis (BPMED) induced pH swing. Bipolar membranes generate $H^+$ ions that convert seawater's dissolved inorganic carbon (DIC) to a gaseous stream of $CO_2$ while generated $OH^-$ ions precipitate DIC in the form of $CaCO_3$.

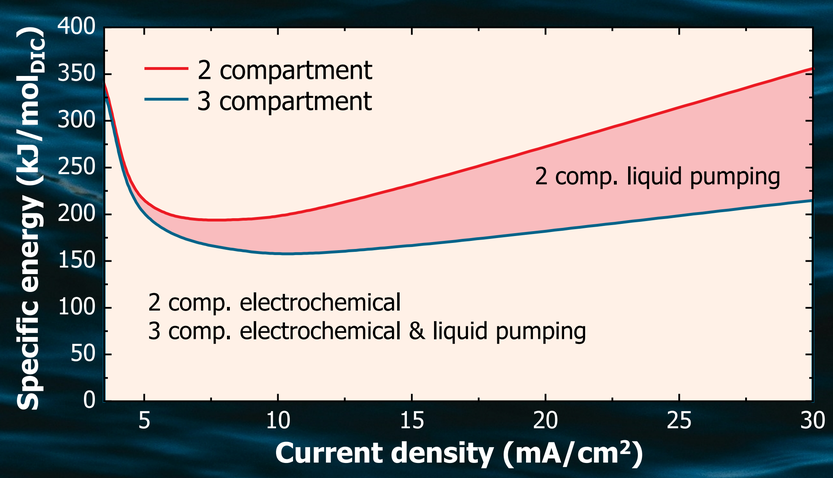



In this project, the BPMED unit is coupled with a reverse osmosis (RO) plant. We extract DIC from brine, concentrated seawater (RO waste product) and use permeate, demineralized seawater (RO main product) to avoid precipitation inside the BPMED stack.

## 2. Choosing BPMED structure

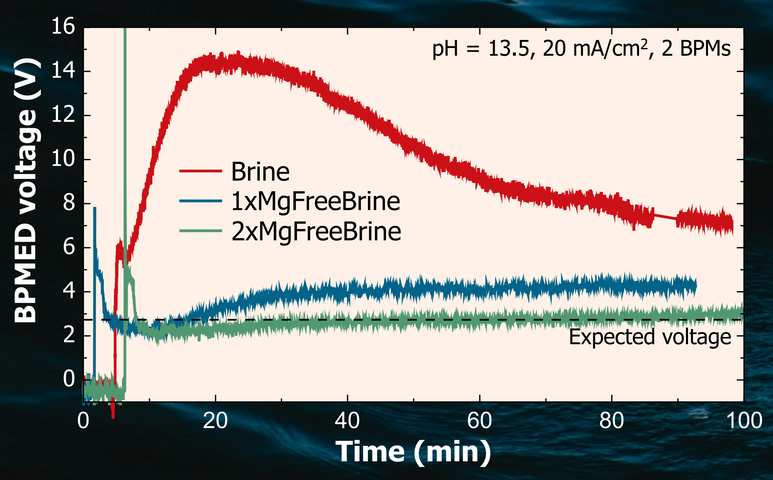



- 3 compartment BPMED can produce both concentrated acid and concentrated base
- 2 compartment BPMED uses fewer membranes and liquid channels and promises lower BPMED ohmic resistance
- Each BPMED structure changes the whole process design

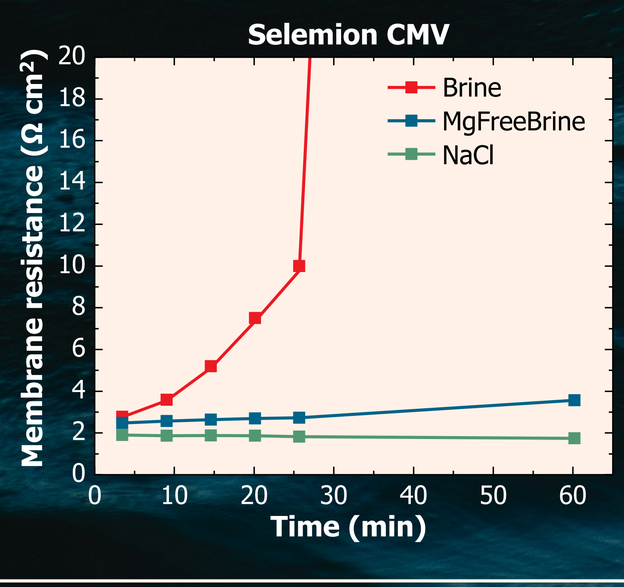



- In the 2 compartment BPMED all processed seawater must be pumped through the BPMED stack
- Liquid pumping prevents the 2 compartment BPMED design from achieving competitive values of energy consumption

## 3. $Mg^{2+}$ ions pose a challenge

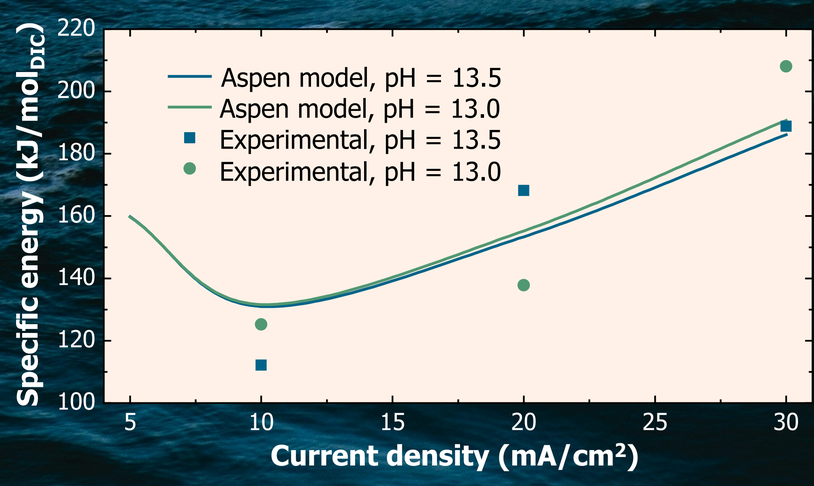



- Removing $Mg^{2+}$ and $Ca^{2+}$ ions from the salt compartment reduces extra voltage loss *(1xMgFreeBrine)*
- Removing $Mg^{2+}$ and $Ca^{2+}$ ions from both salt and acid compartments is necessary to achieve the expected voltage




- The extra voltage loss originates from the precipitation of $Mg(OH)_2$ on the surface of CEMs
- This scaling reduces membrane active area and increases membrane resistance

## 4. Promising future?




- Minimum specific energy reaches 112 kJ/mol$_{DIC}$
- 6x higher than thermodynamic minimum, but approximately 2x lower than BPMED for direct air capture
- These values exclude seawater pre-treatment

## 5. Outlook

- Address efficient removal of $Mg^{2+}$ and $Ca^{2+}$ ions
- Extraction of gaseous $CO_2$ suffers from poor gas purity

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