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Synergistic CO_2 capture & scaling prevention for desalination

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Motivation

In order to reduce or even eliminate the scaling (Figure 3) risk in membrane based seawater desalination methods, a pre-treatment using **Bi**p**o**lar **M**embrane **E**lectro**d**ialysis (BPMED) can be used. BPMED can decarbonize the seawater, by removing CO_2 in gaseous form on the acidic side of the BPM or as solid $CaCO_3$ precipitate on the alkaline side Figure 1 [1]. Furthermore, decarbonization of seawater can reduce the carbon-footprint of desalination units such as, Reverse Osmosis (RO).

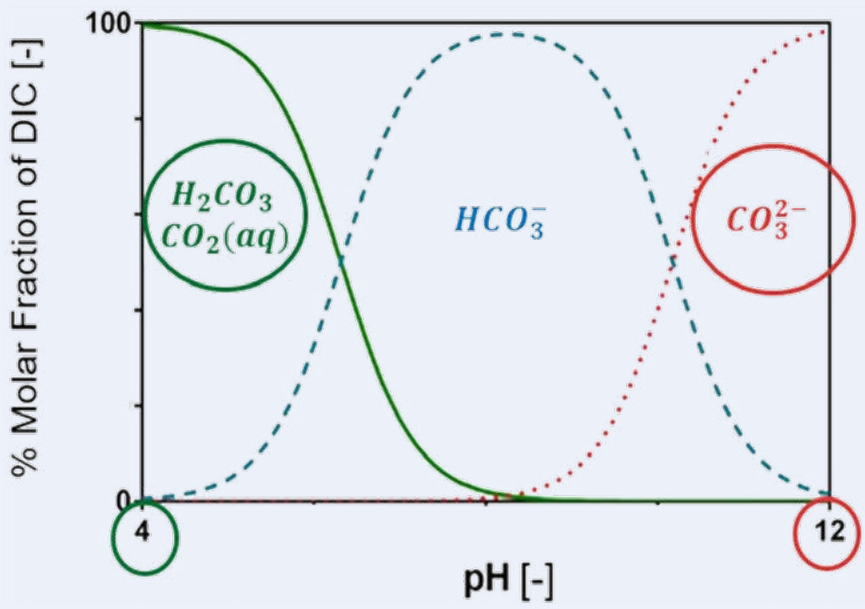

Figure 2. Effect of pH on Carbonate equilibrium (for a closed system where total Dissolved Inorganic Carbon, DIC, remains constant as pH changes).

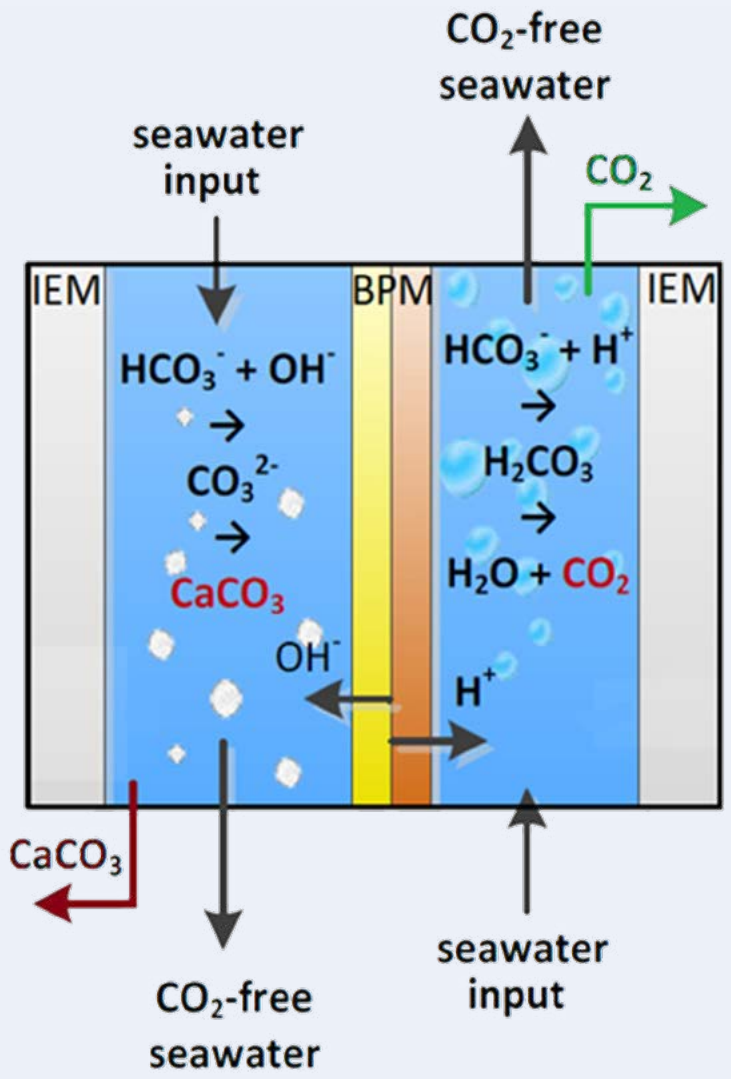

Figure 1. Decarbonization using BPMED; Acid route (right) and Base route (left). Ion Exchange Membrane (IEM) can be anionic or cationic type, depending on the stack design.

A BPM consists of an anion exchange membrane (AEM) and a cation exchange membrane (CEM). When inserted in an electric field, it can produce acid and base through enhanced water dissociation [2-3]. The subsequent alteration in pH of the input seawater shifts the carbonate equilibrium as indicated in Figure 2 [4].

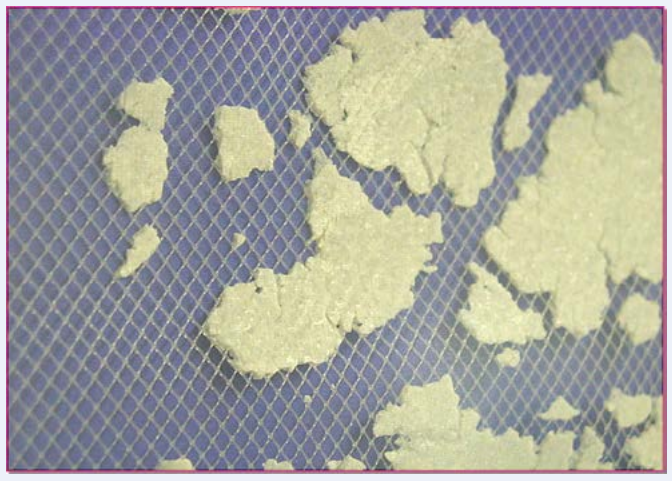

Figure 3. Membrane scaling (www.impomag.com)

Technological challenge

Although a rather new technology, CO_2 capture using BPMED has been investigated by different authors from flue gas, atmosphere, remains a challenge in this field. The bipolar membrane, usually takes up around 80% of the energy input in BPMED. Therefore, This research aims to explore and optimize influential parameters that affect the BPMED energy consumption for decarbonization.

Research goals

This project aims to:

- Determine the main factors affecting the energy consumption of BPMED for sea/brackish water decarbonization.
- Study the effect of DIC present in the BPMED cell, on the BPM resistance and eventual carbon recovery.
- Investigate the ion transport near and through the BPM's, especially for low pH gradient and low current densities.
- In-situ crystallization control of carbonate [5].
- Investigate on membrane scaling removal techniques for calcium carbonate removal, such as air sparging.

[1] De Lannoy et al., INT J GREENH GAS CON (2018), 70, pp 243-253.
[2] GeorgWilhelm, F., (2001). Bipolar Membrane Electrodialysis.
[3] Vermaas et al., Sustainable Energy & Fuels (2018),10.1039/C8SE00118A.
[4] Wang et al., J. Phys. Chem. A (2010), 114 (4), pp 1734–1740.
[5] Wagterveld et al., Crystal Growth & Design (2012), 12 (9), pp 4403-4410.

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