

Development Of A CO₂ Direct Ocean Capture System Using Bipolar Membrane Electrodialysis

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Abstract

A CO₂ direct ocean capture system exploiting bipolar membrane (BPM) electrodialysis, gas-liquid contactor and pH-swing of the dissolved inorganic carbon species is designed for efficient and effective CO₂ capture. COMSOL Multiphysics was used to study the BPM electrodialysis and CO₂ ocean drawdown process involved in the system and optimize the system. (1) BPMs are membranes comprised of an anion-exchange layer and a cation-exchange layer. When potential is applied, BPM can promote water dissociation and therefore generate acid and base. A 2D model that combined electrochemistry, fluid dynamics and mass transport was developed to study the process of acid and base generation in the BPM electrodialysis cell. The model was used to optimize the geometry of the electrodialysis cell for better efficiency and durability. (2) A 3D model was developed to study the turbulent mixing and reactions in the CO₂ drawdown process. During the process, the decarbonized, alkalinized water is discharged into the ocean to promote CO₂ drawdown. The model considers the turbulence enhanced mixing of the chemical species and the buffering kinetics of the reactions between dissolved CO₂, carbonate and bicarbonate. Based on simulation results, the impact of the discharge on the local chemical environment and the drawdown rate is evaluated. The model predicted that the pH of the plume restores to a value close to natural ocean within a very small distance while the enhanced CO₂ drawdown continues to happen at a larger length scale.

Figures used in the abstract

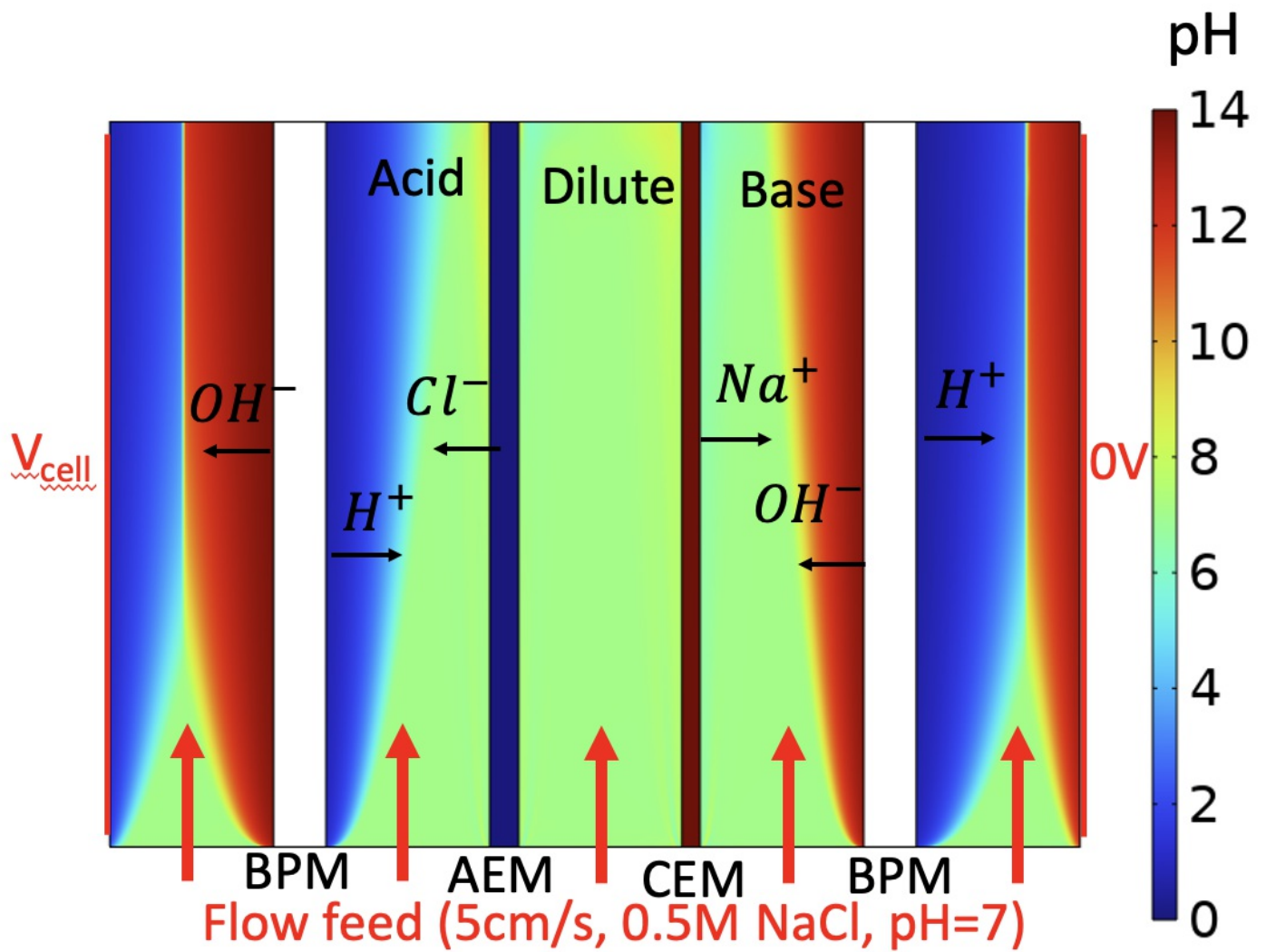


Figure 1 : Simulated pH of the BPM electrodesalination cell demonstrating the acid and base generation process from salt water.

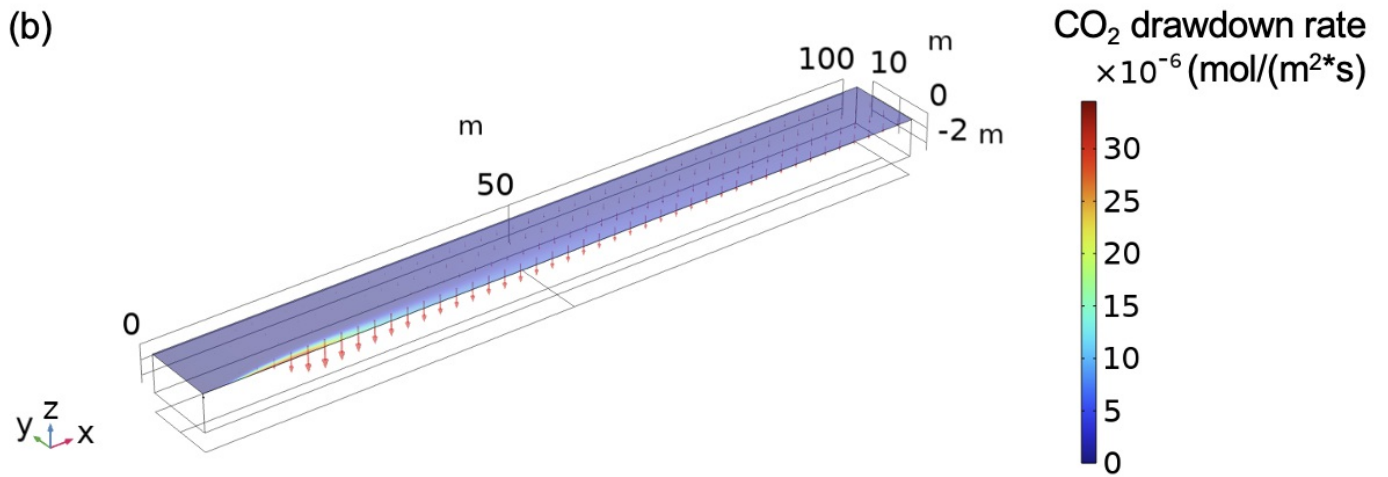
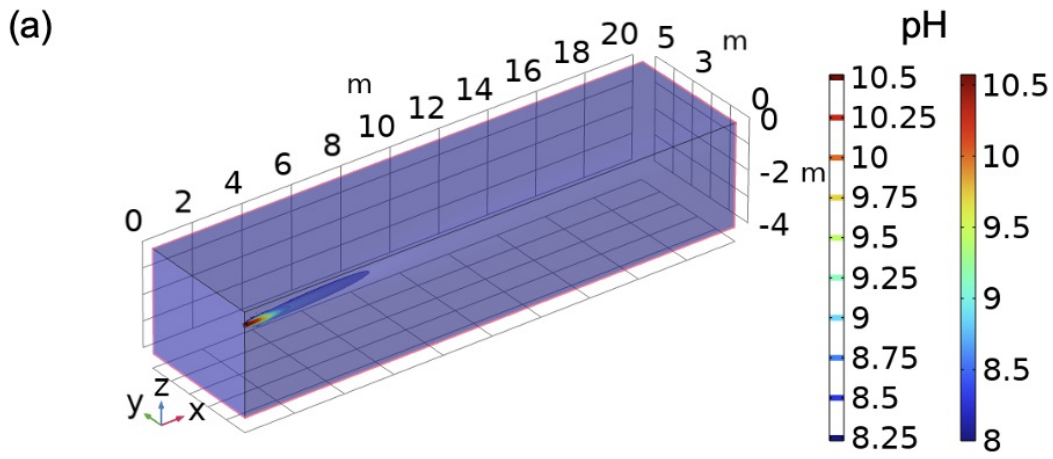


Figure 2 : Simulated CO₂ drawdown by ocean discharge. (a) pH distribution near the discharge port showing that pH value restores to that close to the natural seawater. (b) Enhanced CO₂ drawdown at a larger scale even with restored pH.