IEAGHG 8th Post Combustion Capture Conference

16th to 18th September 2025 Marseille, France

Two-step regeneration system for hydroxide-based solvents

Diego Di Domenico Pinto[a]*, Debadrita Ganguly[a], Tao Wang[b], Zandrie Borneman[b], Kitty. Nijmeijer[b]

[a]Hovyu B.V., Karl Weisbardstraat 181, 3015 GM, Rotterdam, The Netherlands.
[b]Membrane Materials & Processes, Technology University of Eindhoven, The Netherlands

Abstract

Amine-based absorption is the state-of-the-art for post-combustion carbon capture. The process is based on an absorption-desorption loop operated in a thermal swing mode. The gas containing CO_2 is fed to an absorber column where it reacts with a solvent which removes the CO_2 from the gas. The solvent is later sent to a regeneration section composed of a stripper column and a reboiler. Energy is supplied usually in the form of steam to the reboiler where the reaction between CO_2 and the solvent is reversed releasing the captured CO_2.

In many industrial sites, this heat demand cannot be supplied and an additional unit, usually a combined heat and power (CHP) system is required. The additional CHP system, which is typically running with natural gas, will produce additional CO_2 that needs to be captured. This will increase both the size of the equipment (e.g., column) and the energy required to capture the CO_2. On top of the energy required, traditional solvents such as monoethanolamine (MEA) or CESAR1 (a blend of 2-Amino-2-methyl-1-propanol and piperazine) suffer from degradation and formation of heat stable salts that not only decreases the absorption efficiency but also potentially form undesirable components. Furthermore, some degradation components contribute to equipment corrosion while others can form harmful compounds (e.g. nitrosamines).

Hydroxides, on the other hand, can also react with CO_2 forming (bi)carbonates, thus absorbing CO_2. Moreover, they exhibit stability against degradation. Thermal regeneration is not possible under reasonable temperature conditions, though, but electrochemical methods have been demonstrated as an effective approach for directly converting (bi)carbonates back to their hydroxide form. Moreover, when electricity is produced from fully renewable sources such as wind or solar, it is a sustainable approach as well. However, scaling up is still challenging, for example gas diffusion electrodes design and construction for large scale operations. Moreover, long-term tests are lacking to support the durability of the equipment and materials.

In this work, we now test a two-step regeneration process at pilot scale where the (bi)carbonate solution is first neutralized with a weak organic acid, releasing the CO_2 and forming an organic salt that is then converted into the organic acid and the hydroxide in an electrodialysis process. Figure 1 shows the simplified diagram of this two-step regeneration process.

* Corresponding author.
E-mail address: diego.pinto@hovyu.com

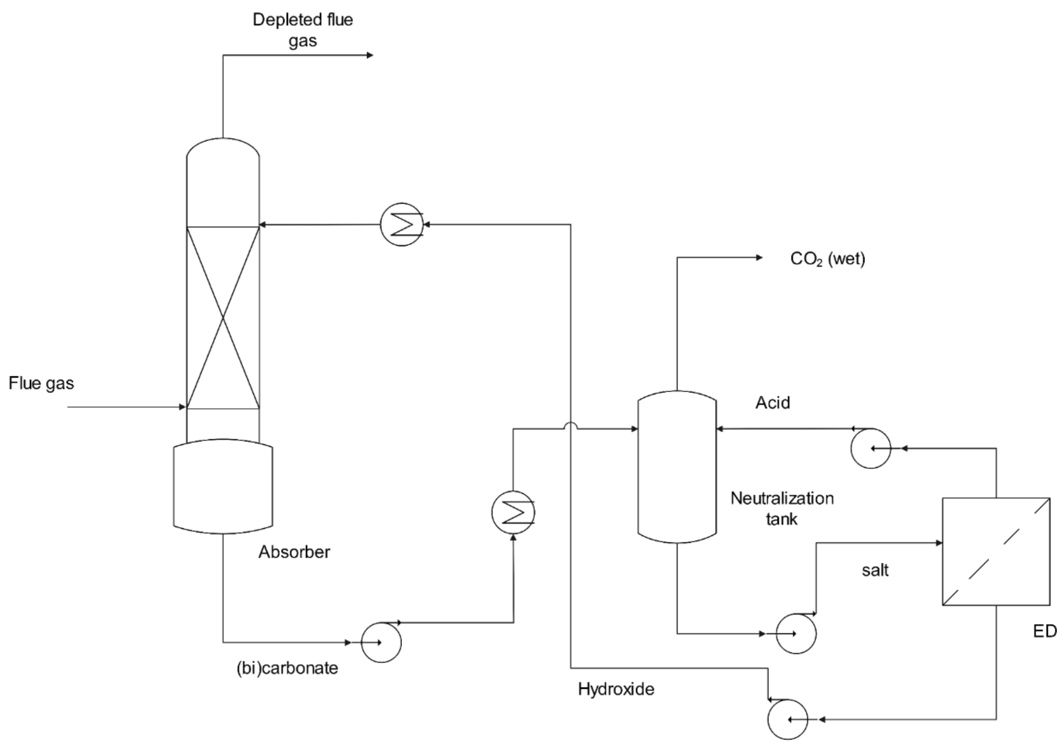

Figure 1: Two-step regeneration process simplified diagram.

A new bipolar membrane (BPM) with an enhanced interfacial bipolar area was developed by Eindhoven University of Technology (TU/e) and will be used in the tests to evaluate the energy requirement to regenerate the hydroxide solvent. The bipolar membranes are fabricated via electrospinning technique, in which multiple electrospun mats are hot-pressed together to build a BPM. Due to the nanofiber structure of electrospun mats, the 3D entangled interfacial layer enhances stability, increases catalytic site density, and facilitates transport pathways for H_2O, H^+, and OH^-. Figure 2 shows the configuration of the BPM and ED process for recovering acid and hydroxide.

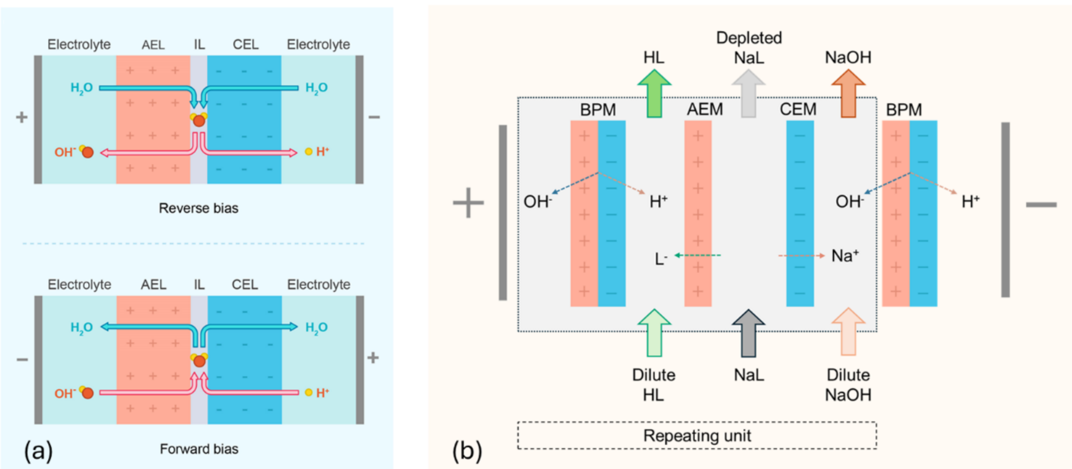

Figure 2: (A) the structure of a BPM and the water dissociation and water formation under reverse bias and forward bias, respectively; (B) the typical electrodialysis process with BPMS for organic acid and base regeneration. HL represents lactic acid and NaL represents sodium lactate.

A skid with a capacity of treating up to 80 kg/h of salt solution was built and will be tested at different inlet salt concentrations, solution temperatures, and current densities. The total membrane area of the setup is 0.3 m^2. The experiments will identify optimal operating conditions and will give an insight into the electrical energy required for regenerating the solvent. These experiments will serve as a basis to scale the process up.

Acknowledgements
This research has been funded by CETpartnership, the Clean Energy Transition partnership under the 2022 CETPartnership joint call for research proposals, co-funded by the European Commission (GAN 101069750) and with the funding organisations detailed on https://cetpartnership.eu/fundingagencies and call modules. The authors would like to thank the Netherlands Enterprise Agency (RVO) for supporting this work.

Keywords: CO_2 capture; hydroxide solvent regeneration; bipolar membranes; scale-up;