Electrochemical CO_2 capture

Limiting the global temperature increase to 1.5°C will require deployment of CO_2 negative emission technologies. Wide-scale implementation is, however, largely limited by the high CO_2 capture cost. While electrochemical CO_2 capture shows several potential advantages over more conventional capture techniques, CO_2 capture using a bipolar membrane electrodialysis (BPMED) and its integration with an air contactor unit, all remain scarcely researched.

We employ aqueous alkaline solution (usually KOH) to capture CO_2 from air using an air contactor (**Figure 1**). Once absorbed, CO_2 reacts with OH^- ions to form HCO_3^- and CO_3^{2-} ions. Such CO_2-rich solution is then directed to the BPMED unit (**Figure 2**). Central to the BPMED unit is the bipolar membrane (BPM) which under an applied voltage generates H^+ and OH^- ions. H^+ ions shift the carbon equilibrium back to gaseous CO_2 that is collected as the main product. Simultaneously, now lean solution collects OH^- ions yielding the alkaline solution and closing the loop.

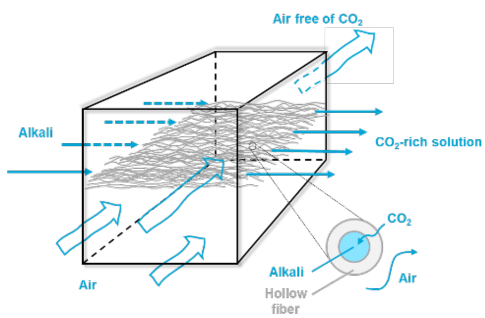

***Figure 2**. Conceptual scheme of an air contactor employing hollow fibers.*

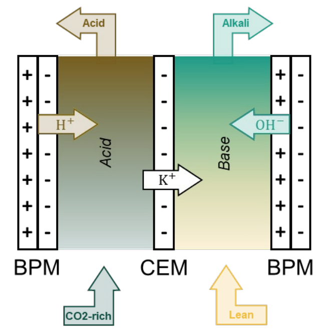

***Figure 2.** Internal periodically repeating structure of a BPMED unit.*

In this project, we will first explore performance of an air contactor (hollow fiber membrane contactor). We will investigate various alkaline solutions and attempt to answer what configuration of hollow fibers (develop a simple 2D numerical model) leads to the most energetically efficient air contactor.

Second, we will use the BPMED unit to explore how efficiently can CO_2 be recovered from the earlier produced CO_2-rich solution. Energetics of the BPMED unit are complicated by the immediate generation of CO_2 bubbles which increases the BPMED resistance. As such, we need to understand the gas evolution inside the stack (compare against theoretical expectations) and answer what operating conditions minimize the specific energy consumption.

Finally, since the composition of the CO_2-rich solution has a great impact on the energetics of the BPMED unit, but is solely governed by the air contactor, the final goal of this project is to find an answer to how we can efficiently couple both the air contactor and the BPMED unit such that the overall specific energy consumption is minimized.

Your activities will be:

1. Use the existing experimental setups to probe the performance of the air contactor and the BPMED unit
2. Use the acquired data to understand and extrapolate the behavior of the air contactor and the BPMED unit
3. Explain how these two units can be coupled such the overall energy consumption is minimized

We are looking for:

An MSc student in Chemical Engineering or Sustainable Energy Technology with an interest in experimental (modelling) work, an independent and innovative way of thinking, and a drive for technology development.

What's in it for you?

Working on this topic will make you ready for an industry/academia job by

- Specializing yourself in the field of process engineering and electrochemistry
- Improving your problem-solving skills and acquiring a deeper knowledge in the field of CO_2 capture

For more information, please contact: Vojtech Konderla (v.konderla@tudelft.nl)