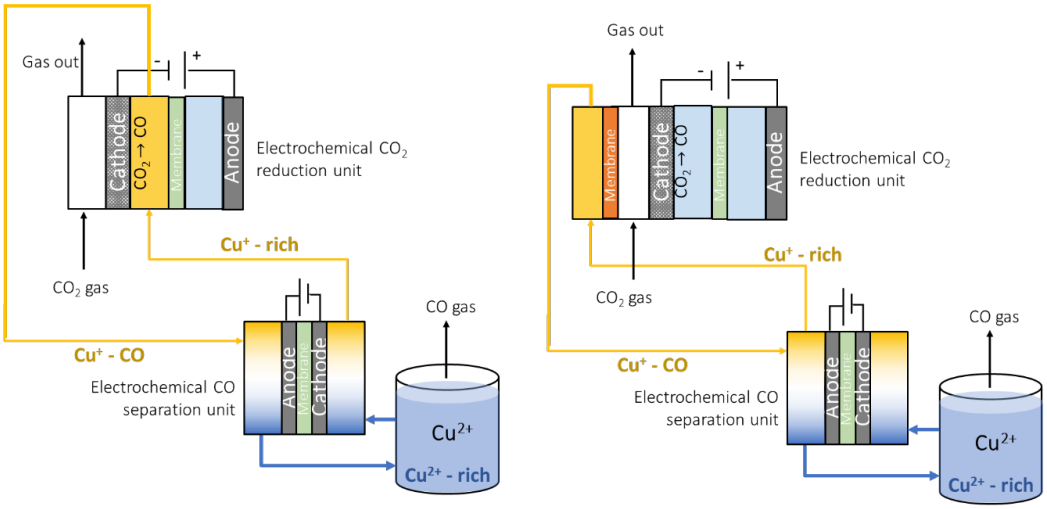
MSc thesis topic: Combined electrochemical CO production and separation

Daily supervisor: Christel Koopman (PhD student, c.i.koopman@tudelft.nl)
Supervisor: David Vermaas (responsible, D.A.Vermaas@tudelft.nl)



Configuration with carrier in catholyte solution

Configuration with carrier in separate compartment

As part of the transition to a circular carbon economy, there is a need to produce fossil-free carbon-based chemicals and fuels. Electrochemical CO_2 reduction enables the production of such chemicals using CO_2 as a reactant and (renewable) electricity as an energy source. CO_2 reduction with a silver catalyst produces CO, resulting in a gas mixture containing CO, the byproduct H_2, and unreacted CO_2. Conventionally this would require additional separation steps after the electrochemical cell. However in-situ removal could enhance the CO_2 reduction performance by removing the product and thus increasing the reactant partial pressure.[1] Therefore, this thesis aims to combine electrochemical CO production with in-situ CO separation. This separation of CO will require an absorbent material that can flow alongside the CO product and can be regenerated electrochemical. This electrochemical separation can be performed using transition metal complexes in solution, as shown by Terry et al.[2]

In this thesis, you will work on the combined production and separation of CO, exploring absorbent materials and cell configurations. The effect of in-situ product separation on the electrochemical CO_2 reduction will be studied by looking at the Faradaic efficiency and energy consumption of the CO_2 electrolysis cell, while the separation process will be evaluated on their product purity, energy consumption, and stability.

Your activities will be:

- Construct a proof-of-concept for combined electrochemical CO production and capture
- Analyse the suitability of different transition metal solutions for in-situ CO separation
- Design a continuous absorption process;
- Analyse the effect of in-situ product removal for CO_2 reduction looking at faradaic efficiency and energy consumption

We are looking for: M.Sc. Chemical Engineering students with an interest in innovation, electrochemistry, reactor design, and a willingness to perform experiments. **Starting is possible from approximately January 2025**.

What is in it for you?: Working on this topic will make you ready for an industry/research job by

- Working on circular economy technologies through improving separation process design;
- Using state-of-the-art experimental electrochemical techniques;
- Combining multiple disciplines into a practical technology analysis;

For more information please contact Christel Koopman (C.I.Koopman@tudelft.nl)

References:

1. Subramanian, S. et al. (2021). Spatial reactant distribution in CO_2 electrolysis: balancing CO_2 utilization and faradaic efficiency. Sustainable Energy Fuels, 2021, 5, 6040-6048
2. Terry, P.A. (1995). Electrochemically modulated complexation process for gas removal and concentration. AIChE journal. 41, 12, 2556-2564