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Towards industrial ethylene electrosynthesis: upscaling hurdles and perspectives

Mark Sassenburg[1], Elena Perez-Gallent[1], Simone Dussi[2], Francesc Sastre[3], Michele Tedesco[1*]

[1] TNO Sustainable Processes and Energy Systems, Lange Kleiweg 137, 2288 GJ Rijswijk, The Netherlands
[2] TNO Heat Transfer and Fluid Dynamics, Lange Kleiweg 137, 2288 GJ Rijswijk, The Netherlands
3 TNO Material Solutions, High Tech Campus 25, 5656 AE Eindhoven, The Netherlands
**Corresponding Author: michele.tedesco@tno.nl*

The potential of low-temperature electrolysis for direct conversion of CO_2 into fuels and commodities (CO, formate, alcohols, C_2+) has been demonstrated at laboratory scale. However, despite a fast-growing research field and a wide industrial interest, CO_2 electrolysis is still at TRL~3-5, and several fundamental knowledge gaps still remain at the level of a single electrochemical cell, as well as unknowns on reactor and process design. Integrating R&D at all levels (electrodes>cell> reactor>process>system) is urgently needed to bring the technology towards industrial implementation. In particular, in the case of ethylene, the electrochemical conversion route is especially challenging, with several limitations related to catalyst activity, selectivity, and stability, which could be (partially) overcome by novel tailored electrodes. Furthermore, the lack of testing at relevant scale leaves several open questions at process/system level (i.e., on gas-liquid distribution, flooding, module size, etc), that are crucial to improve performance and avoid undesired reactions.

We aim to advance the development of CO_2 electrolysis towards a first-of-a-kind CO_2-to-ethylene plant at industrial scale (100 kta). The focus is on developing strategic knowledge at all levels, i.e. by developing new and stable material electrodes, modelling tools, reactor and process design. Key objectives are:

1) Develop a multiscale modelling framework from cell- to system-level, to provide guidance for electrode development, and optimal reactor design and operations;
2) Design and fabricate process-tailored (gas diffusion) electrodes with optimized porosity, catalyst loading, and particle size distribution;
3) Upscaling and testing the technology at pilot-scale, by testing the developed electrodes, identifying suitable electrolysis conditions, and validate the developed computational models;
4) Define technical KPIs and upscaling strategy towards full-scale plants (100 kta), by using an integrated LCA/TEA approach and defined specific industrial use cases.

This lecture will present our latest R&D results on the four above-mentioned key objectives. By focusing on multiscale modeling, electrode design, lab-scale testing, and process development, we aim to identify upscaling hurdles in an early stage, and therefore contribute to advance the CO_2-to-ethylene technology towards industrial implementation in the near future.