Co-electrolysis and its Integration into Power-to-X Concepts as a Key Step in a Renewable Energy System

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Abstract

The generation of syngas is an inevitable process step in Fischer-Tropsch (FT)-based Power-to-X concepts. Syngas production via electrolysis can basically be achieved via two routes: combination of water electrolysis with a downstream reverse water-gas shift (rWGS) reactor or co-electrolysis in a solid oxide electrolyzer (SOEL). The application of an SOEL does not only offer a direct route to syngas, but also a considerably higher efficiency in comparison to the two-step route including an rWGS reactor. Additionally, due to the high operating temperature of the SOEL and the applied cathode material, internal reforming of short-chained hydrocarbons – which are often undesired in small-scale FT-based Power-to-X concepts – is possible. These advantages have been frequently discussed in literature [1]. However, even with first SOEL plants reaching industrial scale [2], experimental performance data of stand-alone co-electrolyzers are scarce. In this work, results on a remote SOEL plant with a nominal input power of 12 kW will be presented. Even though the scale is small in comparison to industrially relevant MW plants, the electrolyzer contained all necessary features that allow for a comprehensive assessment of the technology.

One of the main advantages of SOEL – the increase in efficiency – can only be achieved if steam can be provided by a heat source. Thus, coupling with the exothermal Fischer-Tropsch synthesis is a favorable approach for Power-to-X concepts. Results on a lab-scale plant combining both co-electrolysis and FT synthesis [3] as well as progress on containerized demonstration plants for integrated processes not only based on CO_2 and water but also on biogas will be presented.

Focusing the X in Power-to-X, the utilization of FT synthesis offers a vast product spectrum that can be used as feedstock both for chemicals but also for synthetic fuels. Currently, facing the huge challenges in reducing CO_2 emissions in the mobility sector, the production of synthetic kerosene is of increasing interest. Thus, increasing the efficiency of a Power-to-X process does not only depend on the electrolyzer but also heavily on the synthesis step if a specific product fraction is focused. Therefore, the development of Fischer-Tropsch catalysts with increased kerosene yield and the assessment of their impact on the overall system efficiency is addressed within the CARE-O-SENE project.

[1] A. Hauch et al., Science (New York, N.Y.) 2020, 370, DOI: 10.1126/science.aba6118.
[2] K. Schwarze et al., Meet. Abstr. 2021, MA2021-03, 188, DOI: 10.1149/MA2021-031188mtgabs.
[3] G. Herz et al., Energy Technoloy, 2022, 2201057, DOI: 10.1002/ente.202201057.