Power2ValueChemicals: Valorization of carbon dioxide for the climate-neutral production of chemicals

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Abstract

Carbon monoxide is an essential building block in the chemical industry and is used on a large scale, both as a pure substance and in combination with hydrogen as synthesis gas, for the production of basic substances and specialty chemicals [1]. The large-scale production of CO is usually carried out through the incomplete combustion of carbon-containing materials, such as coal or natural gas [1,2]. Since carbon-containing raw materials like coal, natural gas, and petroleum are to be completely eliminated from production chains as part of the defossilation of the chemical industry, new production routes are needed to provide CO in sufficient quantities as a climate-neutral feedstock. One way to achieve this while keeping the carbon cycle closed is the co-electrolysis of carbon dioxide to CO using sustainably produced electricity [3].

As part of the Power2ValueChemicals project, the Forschungszentrum Jülich plans the installation and continuous operation of a low-temperature CO_2-to-CO electrolyzer developed by Siemens Energy in various operating modes. The electrolyzer on a mini-plant scale provides new insights into the relevant influencing factors and possible degradation processes, thus representing an important intermediate step towards the economic industrial use of this technology. In the second part of the project, the continuous conversion of the electrolysis gas through a homogeneously catalyzed methoxycarbonylation reaction will be carried out to evaluate the economic and ecological potential of the electrolysis gas for the chemical industry. For this purpose, a mini-plant will be planned and built at the Max Planck Institute for Chemical Energy Conversion. The long-term operation of the mini-plant enables the validation of the developed process model and various influencing parameters, such as load changes, can be investigated in more detail. In addition to the long-term tests, operando spectroscopic measurements will be conducted to gain an understanding of how the catalyst responds on a molecular level to potential side components in the electrolysis CO. With the help of these insights, measures can be developed to counteract the deactivation of the catalyst.

Literature:

[1] J. Bierhals J., Carbon Monoxide, Ullmann's Encyclopedia of Industrial Chemistry.
[2] X. Ma, J. Albertsma, D. Gabriels, R. Horst, S. Polat, C. Snoeks et al., Carbon monoxide separation: past, present and future, Chemical Society Reviews, 2023.
[3] S. Foit, I. C. Vinke, L. G. J. de Haart, R. A. Eichel, Power-to-Syngas: An Enabling Technology for the Transition of the Energy System?, Angewandte Chemie, 2017.