

Scale-up of Electrochemical Reactors for High Pressure CO₂ conversion

Publieke samenvatting / Public summary

Aanleiding

One of the prime ways of utilizing carbon that we can see on the horizon is the conversion of CO₂ into valorized products via an electrochemical reaction. Providing an economically viable technology platform to perform these reactions at industrial scales, and so to work towards the aims of TKI Nieuw Gas/CCUS, is at the heart of the motivation for this project. Electrochemical conversion of CO₂ is a well demonstrated technology at a large laboratory scale. It has a long history, but aside from a few exceptions the focus of research activities has been on improved materials for catalysts. The exceptions show the technologies potential, but don't go far beyond that. In fact, there exists no commercially available CO₂ electrolyzer that operates at industrially relevant scales. The motivation of this project is thus to work towards the true industrialization of the electrochemical conversion of CO₂. The main contributions of the proposed project to the CCUS program is that the development of new reactors concepts will support and facilitate different scenarios for the electrification of the Dutch chemical industry via power-to-gas and power-to-chemicals type activities.

Doelstelling

The electrification by electrochemistry will further be especially appropriate to provide flexible use of electricity, which is expected to be highly intermittent (in cost) in the future. The CO₂ mitigation achieved by the example products we

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focus on in this project (formaldehyde and glycolic acid) is another major contribution toward the goals of CCUS. In particular the production of 1 kg formaldehyde is expected to consume 1.6 kg of CO₂, and 1 kg of glycolic acid, around 1 kg of CO₂. Both of these figures are in addition to the loss of CO₂ emissions that would have normally been associated with these chemicals traditional production routes. Furthermore, these are only the example products in this project, the knowledge gained will have wide application to other potential CO₂ reduction products. In the long term, this work will contribute toward entirely sustainable chemical synthesis chains based on CO₂ conversion products.

Korte omschrijving

There are two main thrusts of activity in this project: experimental optimization and simulations, both in an effort to understand how to design and operate CO₂ electrolyzers. In both cases the activities will be centered on two examples products (formaldehyde and glycolic acid). For the experimental side, an elevated pressure, industrial-like experimental reactor will be designed, built, and tested. That reactor will then be used to validate a chemical engineering model of elevated pressure CO₂ electrolyzers, which is also developed as an activity in this project. The model will then be used to assist an experimental program investigating the optimization of the reduction of CO₂ to formaldehyde as a direct product, and glycolic acid, through two intermediary reactions. The other area of activity in the project will be an analysis of the entire value chain of CO₂ capture to utilization to sale in terms of both economics (TEA) as well as the environmental impacts (LCA).

Resultaat

In a reductionist sense the project will deliver a test reactor, the data from a battery of experiments, a computer model of an elevated pressure CO₂ electrolyzer, and the results of environmental and economic analysis of the two considered reactions. Together these will form design and operation rules for CO₂ electrolyzers particularly when powered by renewable sources, metrics for operation and design

of same (e.g. yield and selectivity), and guidelines for electrode design in both aqueous and non-aqueous electrolytes. More specially, special interest will be paid to how to design stacks of elevated pressure electrolyzers as well as how the purity CO₂ affects the entire process. Further, it will provide the details of a full value chain, based on a techno-economic assessment of CO₂ capture, electrochemical conversion of captured CO₂, downstream processing of the required product, and recycling of the unreacted CO₂.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.

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