

Integrated biogenic CO₂ capture with electrochemical conversion to oxalic acid

Publieke samenvatting / Public summary

Aanleiding

One of the emerging ways of utilizing carbon dioxide is based on the conversion of carbon dioxide into value-added chemicals produced via an electrochemical reaction. Carbon capture and utilization (CCU) requires the integration of range of different process steps. Developing an economically viable CO₂ conversion route will support the main objectives of TKI Nieuw Gas/CCUS and the program Systeemintegratie. Electrochemical conversion of CO₂ is mainly demonstrated at the lab-scale, with the development of stable and selective electrodes at the heart of the research. Less attention has been paid to the essential steps of integrating the different processes, like capture, conversion, and product recovery, and, in particular, the scale-up of an electrochemical stack has not been considered, yet. The motivation of this project is thus to work towards the commercialization of electrochemical conversion of CO₂ into a high-value product.

Doelstelling

The main contribution of the proposed project to the CCUS program is the development of new electrochemical reactor concepts, which will support and facilitate different scenarios for both electrification and CO₂ utilization. The main focus is on the process design for an integrated capture and conversion process, with efficient recovery of the solid product (oxalic acid). Additionally, scale-up of the electrochemical flow reactor in terms of current density and production rate, is one of the main realizations. The CO₂ mitigation achieved by

Projectinformatie / Project information

Projectnummer / Project number
TEEI119012

Subsidiebedrag / Grant amount
€ 326.991,00

Algemene informatie / General information

Penvoerder / Secretariat
Nederl Organisatie voor toegepast-natuurwetenschappelijk ond

Publicaties en materialen / Publications and attachments

- 15.11.2023

Eindrapport TEEI119012

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the example product we focus on in this project (oxalic acid) is another major contribution toward the goals of CCUS. Per kg of oxalic acid around 2 kg of CO₂ is consumed, and this will add to the reduction in CO₂ emission that would have normally associated with the traditional production route based on fossil fuel. In the long term, the proposed work will contribute toward entirely sustainable chemical synthesis chains based on CO₂ conversion products.

Korte omschrijving

There are three key activities in this project: molecular simulations for screening of solvent-electrolyte combinations, experimental optimization of the combined CO₂ capture and conversion step, and process design. The various activities will facilitate a better understanding of how to design and operate CO₂ electrolyzers. In particular, two different integration concepts will be explored. The first concept is based on integration of capturing CO₂ from flue gas, the second concept on the integration with a high partial pressure sources of CO₂ (e.g. biogas and hydrogen production). Experimental results for a combined capture solvent-electrolyte liquid will be validated using a numerical, engineering model. A process design will be made using a flow-sheeting program to integrate and optimize the overall process of a CO₂ capture step, a CO₂ conversion step conversion, and a product recovery step. Additionally, the other area of activity will be an analysis of the entire value chain of CO₂ capture and CO₂ utilization to producing a commercial product, in terms of both the economics (TEA) and the environmental impact (LCA).

Resultaat

The overall result of the project will deliver a test setup comprising of a capture unit, an integrated pressurized reactor, and a solid - liquid separator. Additional results include the data from a series of experiments evaluating ionic liquids that serve as solvent-electrolyte solution, a computer model of an elevated pressure CO₂ electrolyzer, and the results of an environmental and economic analysis of a full

CO₂ value chain with oxalic acid as the added-value product. Special interest will be paid to how to design stacks of elevated pressure electrolyzers as well as how the source of the CO₂ (purity and pressure and temperature conditions) affects the entire process. The main target in this project is to have a current density of 100 mA/cm² and faradaic efficiency of 80%. Finally, based on a techno-economic assessment, the proposed activities will provide the details of a full CO₂ value chain and a dedicated business case. Moreover, an exploration will be made to identify other products made from CO₂ which can also benefit from this methodology.

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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