

electrochemical CO₂ conversion to formate and products

Publieke samenvatting / Public summary

Aanleiding

To achieve the 2030 climate goals and a circular, carbon-neutral industry by 2050, the chemical and electricity sectors face a dual challenge: reducing their carbon footprint while increasing production and affordability. Electrochemistry bridges these industries to produce high-value products, enhance energy storage, and cut emissions. Using captured CO₂ and renewable energy like wind and solar, chemicals like formic acid can be produced. Formic acid serves as a flexible energy/hydrogen carrier and after fermentation as renewable feedstock for sustainable aviation fuel. With low energy input requirements, electrochemical CO₂-to-formic acid conversion holds significant potential. However, the business case is not yet viable, requiring further development to reduce costs, boost efficiency, and assess the environmental impacts.

Doelstelling

The main aim of this project is to accelerate the development of electrochemical CO₂ conversion technologies towards formic acid (a commodity chemical) using renewable electricity and non-fossil CO₂. More specifically, we aim to reduce costs and increase energy efficiency, such that these technologies can be implemented in industry within 10 years. Contributing to CO₂ emission reduction and carbon circularity in the chemical industry and to a worldwide technology export position for high-tech process and equipment suppliers. This is in line with innovation theme 2 of the MOOI mission Industry, sustainable raw materials and

Projectinformatie / Project information

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MOOI324013

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Algemene informatie / General information

Penvoerder / Secretariat
Nederlandse Organisatie voor
Toegepast-Natuurwetenschappelijk
Onderzoek TNO

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intermediates based on CO and CO₂. Main benefits for technology providers are an improved business case and value creation. Benefits for all players in the value chain are ecosystem building and validation of utilization routes.

Korte omschrijving

TNO will enhance their low-pressure electrochemical reactor to produce potassium formate, lead the Techno-Economic and Market assessments and coordinate the overall project. GAFT will enhance their high-pressure electrochemical reactor to produce potassium formate and advance their bioprocess technology to convert formic acid into fatty acids, providing high-quality feedstock for sustainable aviation fuel. They will develop, test and validate an integrated high-pressure CO₂ electrolyzer and ED-BPM system, to produce 50% and 85% formic acid at a scale of liters/hour. Waterfuture will enhance their ED-BPM and ED system to produce 50% and 85% formic acid from formate. University of Twente will advance new, highly water-permeable low-cost BPMs, benchmarking them against commercial BPMs. DENS will develop and test a dehydrogenization reactor, using 85% concentrated formic acid instead of the current version which uses 99% fossil-based formic acid. All partners and Advisory Board members will engage in stakeholder events and knowledge dissemination as well as contribute to TEA's on electrochemical CO₂ conversion to formic acid and the developed utilization routes.

Resultaat

An integrated system of a high-pressure CO₂ electrolyzer and ED-BPM system with a daily capacity of 15L formic acid validated in a research Fieldlab (FLIE). A 40% OPEX reduction (due to KOH reclaiming and increase in energy efficiency) and a 30% CAPEX reduction (due to new/cheaper membranes and electrodes) compared to the current unintegrated system has been achieved. A low-pressure CO₂ electrolyzer validated in the lab shows a 20% decrease in cell voltage, a two-fold increase in current density, a Faradaic efficiency increase to 50-80%, a 30% reduction in specific

energy consumption to 3.8 kWh/kg, and a system lifetime of at least 1000 hours. A novel design of a dehydrogenization reformer which can handle 85% concentrated formic acid. An optimized fermentation process producing 80-300 L of biomass, while lipid extraction yields increase by 50%, ensuring sufficient quality for HEFA (hydroprocessed esters and fatty acids) companies adhering to SAF specifications. Techno-economic assessments are conducted on CO₂ conversion to formic acid and its utilization for SAF feedstock and as an energy/hydrogen carrier.

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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