Federal Ministry of Education and Research

CO_2WIN
Use Carbon Sustainably

GAMES – Gas Diffusion Electrodes for Coupled Microbial Electrochemical Syntheses

CO_2 as a sustainable source of carbon – Pathways to industrial application (CO_2-WIN)

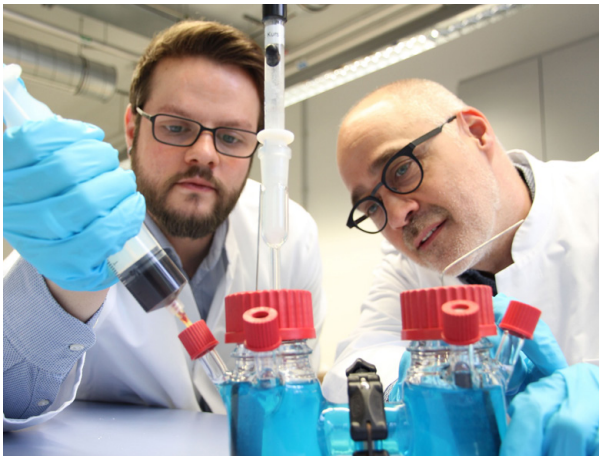
The research project "GAMES" examines how raw materials from CO_2 and electric energy can be produced efficiently for the chemical industry. The overall objective is to extend the application potential of microbial electrosynthesis from CO_2, based on gas diffusion electrodes and formiat. The project is funded as part of the funding measure "CO_2 as a sustainable source of carbon – Pathways to industrial application (CO_2-WIN)". The measure supports projects that utlilize carbon dioxide as raw material for the German economy.

Electrochemistry with Biotechnology

The increasing share of renewable energies in the overall energy mix affords the storage of temporary energy or local energy surpluses. Aside from battery technology as a storage possibility, electrochemical synthesis is a further technological option for storage and direct usage. An electrochemical synthesis transforms electrical energy into chemical energy and, thus, enables safe and manageable storage and the use for the synthesis of chemicals. However, using CO_2 as a raw material for electrochemical synthesis only allows a very limited spectrum of possible products. For the most part, only C1-compounds can be obtained through a high selectivity and electron efficiency. In turn, the pure biosynthesis from CO_2 needs an external energy source, for instance, H_2. In order to enable a value-added synthesis based on CO_2, "GAMES" examines the development of exemplary processes for a coupled electrochemical-microbial synthesis. In a first step, CO_2 is reduced to formiat at a gas diffusion electrode. This formiat is then or in situ transformed biotechnologically into industrially relevant recyclable materials.

Extension of the Process Window

In the project "GAMES", five partners jointly work on the industrial implementation of CO_2 via the intermediate formiat to recyclable materials such as methane, the biopolymer polyhydroxy butyric acid (PHB), isopropanol, and ectoine. Based on the applicants' previous work, electrochemical, microbiological, biotechnological, and process technological aspects are combined to develop new synthesis routes for technically relevant chemicals. The research work is targeted to extend the process window of microbial electrosynthesis, the development of biocompatible drop-in electrolyses, the construction and evaluation of a broadly applicable electrolysis reactor, as well as the practical operation of the systems. By extending the process window in the direction of higher temperatures and/or higher salt contents, ideally electrochemical target valuesand bioprocessing aspects, for example, can be addressed. The higher salt contents result in higher conductivities, which positively effect the energy efficiency of processes. Higher temperatures usually result in higher electrochemical turnover rates. From a biotechnological point of view, it is expected that this results in less challenges with regard to contamination safety.



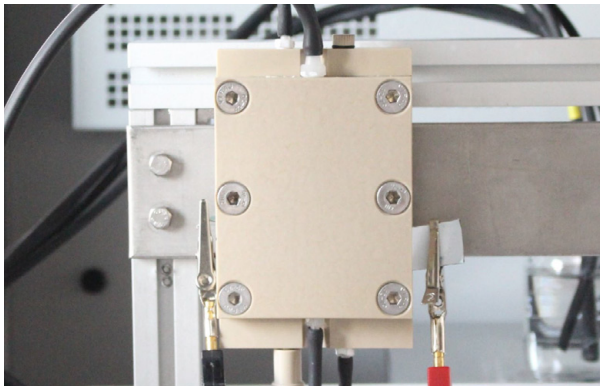
"GAMES" expands the process window of microbial electrosynthesis.

Diverse Processes and Products

By the cooperation of the SME Gaskatel GmbH, ifn Forschungs- und Technologiezentrum GmbH, and three application-oriented research organizations (DECHEMA-Research institute Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, and Technical University Mittelhessen-University of Applied Sciences), innovative solutions for the transformation of CO_2 into bio-based products of the chemical industry will be developed in

the course of the project GAMES. Among the desired project results are particularly:

- the development of a universal test rig,
- new gas diffusion electrodes for the transformation of CO_2 into formiat in biological media,
- new processes and reactors for the production of bio-based chemicals,
- use of CO_2 and electrical energy as cheap substrates for fermentations,
- new added value for biogas plant operators, as well as
- the continuous extension of the process window of microbial electrosynthesis for the production of biopolymers and basic chemicals.



First prototype of a flat plate reactor.

Funding initiative
CO_2 as a sustainable source of carbon – Pathways to industrial utilization (CO_2-WIN)

Project title
GAMES – Gas Diffusion Electrodes for Coupled Microbial-Electrochemical Syntheses from CO_2

Duration
01.04.2021–31.03.2025

Funding code
033RC031A-E

Funding volume
1,300,000 Euro

Contact
Prof. Dr.-Ing. Dirk Holtmann
Technical University Mittelhessen-University of Applied Sciences
Competence Center for Sustainable Engineering and Environmental Systems
Wiesenstrasse 14
35390 Giessen (Germany)
Phone: +49 641 3092579
E-mail: dirk.holtmann@lse.thm.de

Project partner
DECHEMA-Research institute; Gaskatel GmbH; Helmholtz-Zentrum für Umweltforschung GmbH – UFZ; ifn Forschungs- und Technologiezentrum GmbH

Internet
co2-utilization.net

Published by
Bundesministerium für Bildung und Forschung/
Federal Ministry of Education and Research (BMBF)
Division Resources, Circular Economy; Geosciences
53170 Bonn, Germany

May 2021

Editing and layout
Project Management Resources and Sustainability
Project Management Jülich (PtJ), Forschungszentrum Jülich GmbH

Photo credits
p. 1: Technical University Mittelhessen University of Applied Sciences
p. 2: DECHEMA-Research institute