Reactor design for microbial electrosynthesis from CO_2

PhD	Oriol Cabau-Peinado
Supervisors / promotors	Dr. Ludovic Jourdin Dr. ir Adrie J.J. Straathof
Institute	Delft University of Technology, Department of Biotechnology, Bioprocess Engineering Section
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Project Description

Earth's biosphere and human society are being threatened by climate change and the inevitable depletion of fossil resources. This challenge to modern civilisation can be overcome by migrating towards a complete circular economy, recycling and eliminating waste to create a closed-loop system.

A technology that has the potential to overcome the aforementioned issues is microbial electrosynthesis (MES). This technology relies on the ability of electroactive microorganisms to accept electrons from an electrode and use them to catalyse the reduction of carbon dioxide into industrially relevant products (i.e. alcohols, carboxylic acids). Renewable electricity powers the technology, effectively storing electrons into chemicals of interest. To date, MES reactors have been based on the H-type electrochemical cell system. These reactors are rather simple and were mainly used to investigate the fundamentals of the technology. However, the use of non-optimized lab-scale reactors and a lack of knowledge on both the limiting steps of the system and its performance at a larger scale is impeding the technology to make a leap towards its full-scale implementation.

Therefore, to push MES to an industrial level, a deep understanding of all factors that limit reactor efficiency and a clever way to overcome scalability issues must be combined and applied during the design part. In this context, this PhD project aimed to design, develop, and assess novel process configurations and operations to overcome process limitations and produce value added chemicals with bioelectrochemical systems using CO_2 as sole carbon feedstock. Both experimental and mathematical approaches have been used to tackle this challenge.

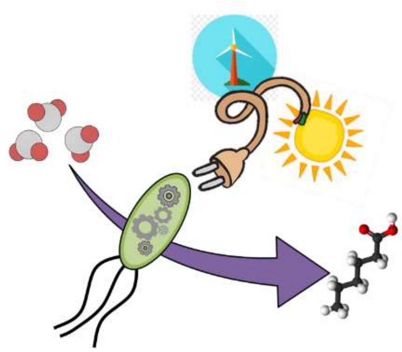

Figure: Schematic representation of MES from CO_2 to valuable organics using renewable energy and minimal amount of water (green oval represents a microorganism)

Dissertation

Towards upscaling of microbial electrosynthesis reactors (2024)

Publications

1. O. Cabau-Peindao, A.J.J. Straathof, L. Jourdin (2021) A general model for biofilm-driven microbial electrosynthesis of carboxylates from CO2. Frontiers in Microbiology, 12 | Article 669218. https://doi.org/10.3389/fmicb.2021.669218
2. M. Winkelhorst, O. Cabau-Peinado, A.J.J. Straathof, L. Jourdin (2023) Biomass-specific rates as key performance indicators: A nitrogen balancing method for biofilm-based electrochemical conversion. Frontiers in Bioengineering and Biotechnology 11, 1096086. https://doi.org/10.3389/fbioe.2023.1096086
3. O. Cabau-Peinado, M. Winkelhorst, R. Stroek, R. de Kat Angelino, A.J.J. Straathof, K. Masania, J.M. Daran, L. Jourdin (2024) Microbial electrosynthesis from CO_2 reaches productivity of syngas and chain elongation fermentations. Trends in Biotechnology 2509, 1-16 https://doi.org/10.1016/j.tibtech.2024.06.005