Extracellular pathways and fluxes in bioelectrochemical CO_2 reduction to organics

PhD-student: Marijn Winkelhorst, Msc.
Promotor: Dr. Adrie Straathof
Supervisor: Dr. Ludovic Jourdin
Institute: Delft University of Technology, Department of Biotechnology, Bioprocess Engineering section
Project term: March 2019 – March 2023
Financed by: TU Delft

Description

Global climate change due to anthropogenic fossil fuel consumption, resource scarcity and dependency on foreign influences are primary triggers to transition to a biobased and circular economy. This means that not only energy has to be produced from renewable sources but also fuels, chemicals, feed, food and pharmaceuticals. Electrochemical technologies such as water splitting for hydrogen production and CO_2 reduction are being researched to answer this challenge.

Microbial electrosynthesis (MES) is an emerging novel technology in which microorganisms that are able to use (renewable) electricity, via an electrode (cathode), act as biocatalyst to convert CO2 to valuable chemicals (see figure). This technology potentially has many advantages such as no net CO_2 emissions (when renewable electricity is used), low water footprint, large product variety, high electron recovery and long life time of the catalyst (years). Most research focuses on producing acetic acid from CO_2, but recently CO_2 elongation to longer chained carboxylic acids (butanoic and hexanoic acid) has been demonstrated.

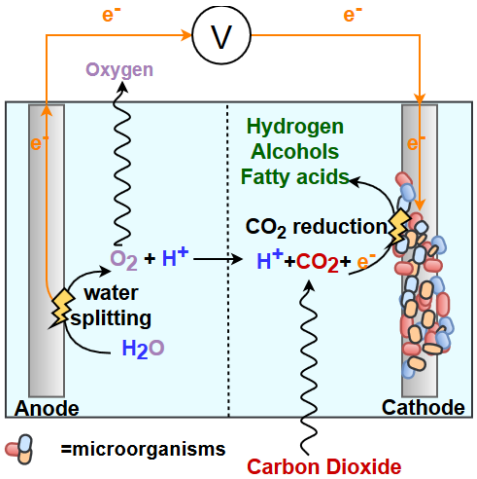

Figure 1: schematic overview of MES

Since MES is an emerging technology, many fundamental mechanisms (such as electron and carbon fluxes, see figure 2) are still unknown. Unravelling these mechanisms will allow to overcome process limitations on microscale as shown in figure 3.

In my PhD research I aim to give insights on what and how (bio-, electro-, and/or bioelectro)-catalytic processes occur and what limits performance of CO2 reduction to organics by MES at the µm to cm-scale (i.e. electrode-biocatalyst scale). Both experimental and mathematical approaches will be exploited to provide answers to the research questions.

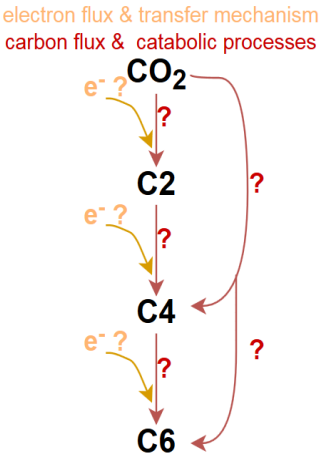

Figure 2: unkown fluxes processess in bioelectrochemical CO2 reduction to longer chained organics

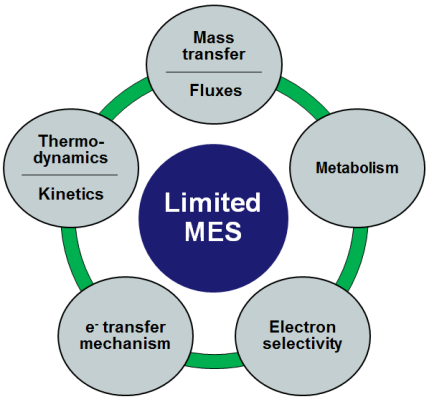

Figure 3: potential limitations in MES on microscale