Development of a CO_2 capture strategy for power-to-gas systems

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Project insights
CarbonATE – biological methanation

Leadership:
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Swiss Federal Office of Energy SFOE

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As part of its commitment to sustainable energy transition, the European Union is focusing on the increased use of biomass. The power-to-gas (P2G) concept plays a pivotal role in this initiative by enabling the conversion of CO_2 from biomass systems with H_2 into biomethane, thereby facilitating a substantial decrease in overall emissions.

However, the path to CO_2 methanation is not without its challenges. Contaminants like O_2 and N_2, prevalent in industrial emissions, impose significant constraints on the viability of CO_2 sources for methanation. In addition, current CO_2 purification methods are costly and require a lot of energy. One approach to overcoming these challenges is through the application of an enzymatic method for CO_2 separation which promises to diminish both energy use and operational costs, allowing the use of 'impure' gas streams, such as those from biomass combustion or combined heat and power (CHP) plants. These alternative carbon sources could significantly enhance the role of biomass in the energy sector.

Federally supported European initiative

The CarbonATE project, backed by the Swiss Federal Office of Energy (BFE) and in collaboration with Austrian and Swiss partners, involved various objectives aimed at achieving the overall goal of producing sustainable and renewable energy sources based on different carbon sources. The project investigated the enzymatic capture of CO_2 using formate dehydrogenase and carbonic anhydrase, converting it into liquid forms for subsequent methanation by methanogenic archaea. This was not only to expand the raw material portfolio for biotechnological use, but also to provide an intermediate product for further conversion processes. Studies were conducted with microorganisms

Figure 1: Environmental Biotechnology Research Group's biological mechanisation laboratory setup in stirred-tank reactors (Photo by Frank Brüderli)

in various reactor types and at different scaling stages, using both pure and mixed cultures. The composition of the microbiome from the mixed cultures was examined depending on various process conditions, culminating in an economic assessment of the biomethanation process.

Technology with great potential

The project demonstrated that enzymatic CO_2 capture by formate dehydrogenase and carbonic anhydrase to liquid products, and the subsequent utilisation of the carbon compounds to produce methane through methanogenic archaea, can optimise biomethane production. These promising results illustrate the significant potential of this technology for the future generation of high-calorific gas on-site, even in smaller facilities. The generated gas could be integrated into existing networks or utilised within the transport sector, underscoring biomethanation's viability as a sustainable, independent energy solution from both an economic and environmental perspective. ■

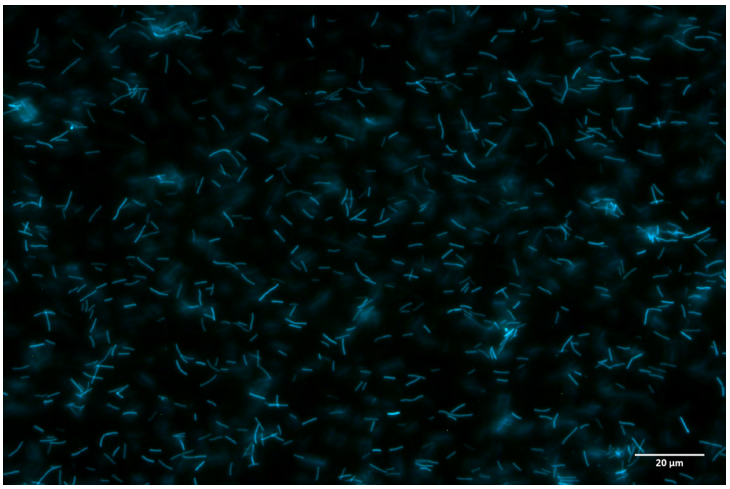

Figure 2: Fluorescence microscopy capture (40× magnification) of archaea during enrichment trials in a trickle-bed reactor (photo from Claudio Kalbermatten's 2022 master's thesis)

Breaking new ground in the biosynthesis of anthocyanins

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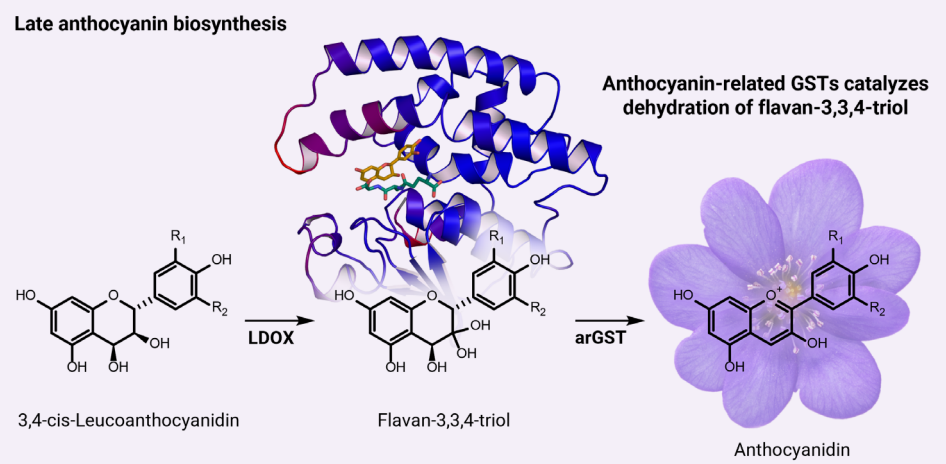
Anthocyanins are the source of the red, purple or blue colouration of most flowers, fruits and autumn leaves. Although the natural production of these pigments has been studied for a long time, anthocyanins have not yet been produced in cell factories. The Centre for Biocatalysis has made a significant breakthrough by identifying a previously unknown step in the biosynthesis of anthocyanins: the enzyme 'anthocyanin-related glutathione transferase', which was thought to act merely as a transport protein, plays a catalytic role in the biosynthesis process.

This enzyme facilitates the conversion of the penultimate intermediate via a dehydrating reaction. The missing enzyme was integrated into a yeast cell factory designed for anthocyanin production. Starting from the simple sugar glucose, the newly construced cell factory led to a dramatic increase in yield, producing anthocyanin levels which were 35 times higher than those achieved by cell factories lacking the crucial enzyme. These findings have been published in the journal *Nature Catalysis.*

Publication: Eichenberger, M., Schwander, T., Hüppi, S. et al. The catalytic role of glutathione transferases in heterologous anthocyanin biosynthesis. *Nat Catal* (2023). https://doi.org/10.1038/s41929-023-01018-y



Rebecca Buller and her team were able to show that the enzyme 'anthocyanin-related glutathione transferases', previously thought to be a transport protein, catalyses a key step in the biosynthesis of the pigments. Graphic © ZHAW / Eichenberger, M., Schwander, T., Hüppi, S. et al.

Development of small-molecule drugs for the treatment of leukemia

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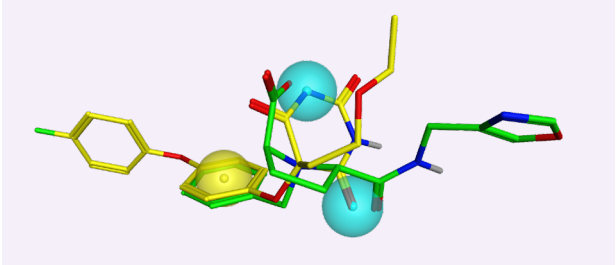
Acute myeloid leukemia (AML) is driven by leukemia stem cells that resist conventional chemotherapy and are the major cause of relapse. The incidence of AML ranges from three to five cases per 100,000 population. This translates to 40,000 and 20,000 newly diagnosed patients every year in Europe and in the USA, respectively (380,000 worldwide). Only very young and fit patients can undergo intensive curative treatment including allogenic transplantation. For more than 80 % of all AML patients, treatment is palliative and there is an urgent medical need to develop new treatments. In a project funded by Innosuisse, Michael Brand and Elias Bommeli from Rainer Riedl's medicinal chemistry research group at the Competence Center for Drug Discovery at the ZHAW Institute of Chemistry and Biotechnology, together with researchers from Inselspital Bern and University Bern (the research groups of Carsten Riether and Adrian Ochsenbein), have succeeded in developing a new class of small molecules that selectively target leukemic stem cells. Having patented the results, the research consortium now plans to develop the molecules into a drug for clinical treatment. ■



Pharmacophore model of drug-like small molecules targeting leukemia.