Rheticus – Specialty Chemicals from CO2

Submission from Evonik

The innovation.

Humanity needs to reduce carbon emissions in order to limit the effects of climate change. Simultaneously, carbon is needed as the backbone of many chemical products such as plastics, fuels or cosmetic products. Currently, this carbon is still mainly derived from finite fossil resources and these products will release CO2 into the atmosphere if they decompose or are incinerated at the end of their lifecycle. These issues can be addressed by using CO2 as a feedstock for the production of circular specialty chemicals.

Plants use photosynthesis to produce carbohydrates from CO2 and sunlight to support their growth. Inspired by nature, Evonik's scientists started to investigate a similar approach for the synthesis of value added chemicals. Sunlight can be harvested by photovoltaics to provide energy to power chemical processes in which molecular hydrogen is produced. Together with hydrogen, CO2 can be used by bacteria to produce base chemicals for the specialty chemicals industry. Evonik and Siemens Energy call this process 'artificial photosynthesis.' The microorganisms employed in this process only require a small fraction of the provided feedstocks for sustaining their own life. Consequently, the overall process is vastly more efficient than natural photosynthesis due to its higher energy conversion rate and a much lower water consumption.

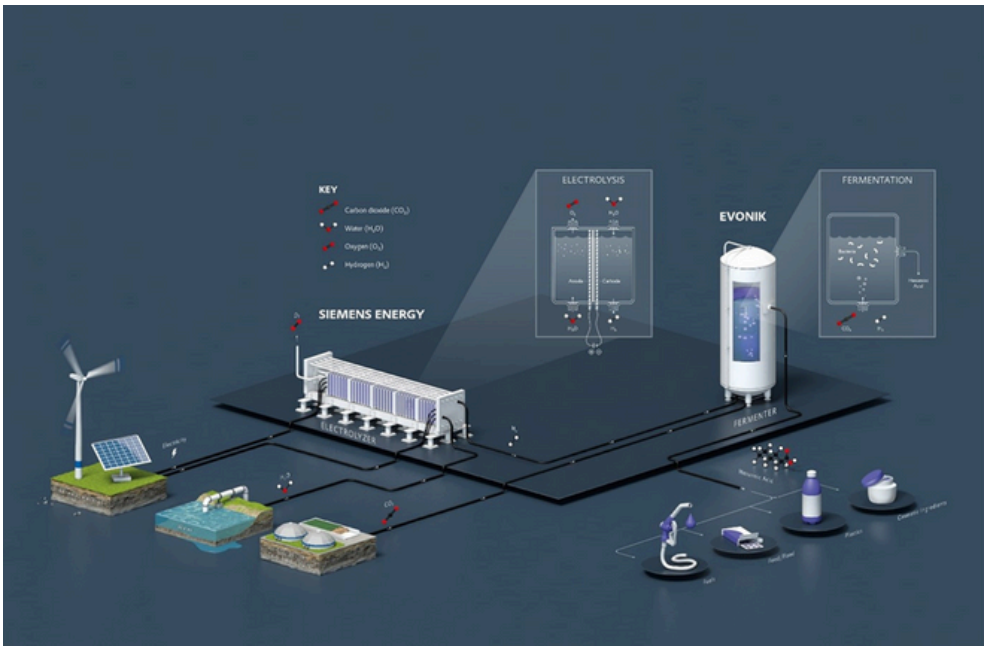
Currently, Evonik is pioneering this technology in a pilot plant in Marl (Germany) where hexanoic acid is produced from CO2 and molecular hydrogen. After isolation and further processing, hexanoic acid can be used for a wide variety of applications such as cosmetics, cleaning agents, lubrication, and cooling. For future diversification, many other organic platform chemicals are in reach to be produced in this process as well. This will help to provide the chemical industry with a wide pallet of CO2-based chemicals.

The benefits.

In addition to recycling and use of biobased materials, experts agree that net-zero emissions in 2050 can only be achieved through harnessing CO2 as a raw material (1, 2). Up to 25% of all carbon required for chemicals and materials will have to be derived from so called “CO2-to-X" processes. However, only methanol and ethanol are currently available for further chemical processing on an industrial scale.

With its hexanoic acid pilot plant, Evonik is a leading innovator in the CO2-to-Chemicals technology. The pilot plant already demonstrated a solar conversion efficiency higher than the current practice of using agriculturally derived fuel plants. Even better, without needing any arable land, this technology will significantly contribute to defossilization without competing with food and feed production.

Scalability of the process will be demonstrated by upscaling to a 2000-5000 ta demonstration plant. The products will be marketed to sectors that already seek more sustainable solutions, such as the cosmetics and automotive industries (e-vehicles). The establishment of this new chemical platform has the potential to replace many fossil-based products. The current project is aimed to drive forward and expand the knowledge gained from the publicly funded KOPERNIKUS and RHETICUS projects (BMBF).



Additional materials:

Haas, T., Krause, R., Weber, R. et al. Technical photosynthesis involving CO2 electrolysis and fermentation. Nat Catal 1, 32–39 (2018). https://doi.org/10.1038/s41929-017-0005-1 https://www.nature.com/articles/s41929-017-0005-1

More information:

- Rheticus
- About Rheticus

Copernicus projects

For a climate-friendly industry: Rheticus research project (video)

How to turn carbon dioxide into green chemicals (video)

(1) McKinsey, Sustainable feedstocks: Accelerating recarbonization in chemicals, 2023.

(2) vom Berg, C. and Carus, M. 2023: Making a Case for Carbon Capture and Utilisation (CCU) – It Is much more than just a Carbon Removal Technology. Renewable Carbon Initiative (ed.), Hürth 2023.