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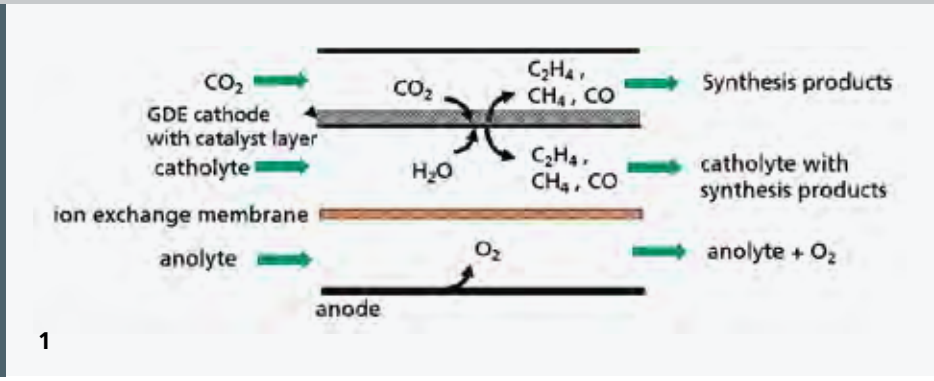

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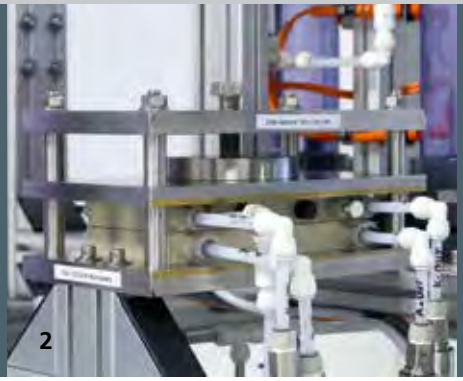
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# ELECTROLYTIC SYNTHESIS

1 *Schematic representation of the electrosynthesis of base chemicals from $CO_2$ and water.*
2 *Electrolytic cell with 130 $cm^2$ electrode area.*

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Using electric energy for the production of chemicals is becoming of increasing strategic importance since it addresses two current challenges: First, the trend towards renewable energy sources leads to fluctuations in the availability of electrical energy with periods of excess current and insufficient concepts for storage. Second, many industrial processes require base chemicals, which leads to high efforts and costs for purchase and storage. Further, carbon-based chemicals like ethylene are up to now mainly synthesized from imported fossil resources. To tackle these challenges, Fraunhofer IGB develops electrolytic processes which enable the local on-demand production of base chemicals from water, $CO_2$ waste streams, or oxygen from air. Core component of the technology is an electrolytic cell with integrated gas diffusion electrode (GDE). At the GDE, oxygen or $CO_2$ is electrochemically reduced to the desired product. The cell enables also the combination of the typically cathodic electrosynthesis process with anodic reactions, e.g. process water treatment by advanced oxidation processes (AOP).

Apart from the scalable electrolytic cells with currently approx. 130 $cm^2$ electrode area, Fraunhofer IGB has developed and built a demonstration unit with fully automatic process control. The unit enables the transfer of results from laboratory scale into a first industry-relevant scale with reliable results on flow-through mode operation and scale-up.

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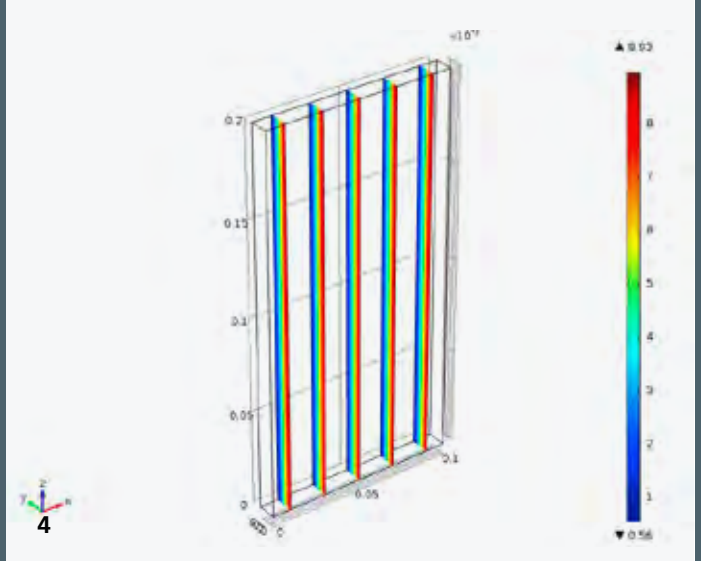

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## Performance characteristics

- The electrolytic synthesis processes require only electrical energy, water, and pressurized air or $CO_2$
- Local on-demand production of the required chemicals: No need for transport or storage
- Intermitting production enables the use of renewable energy sources and excess current
- Valorization of exhaust gases, especially $CO_2$
- Electrolytic cells:
  - Electrode area (GDE) currently approx. 130 $cm^2$
  - Scalable by electrode area and stacking
  - Acid and base resistant: pH 1 – 14
  - Gas volume flows up to 300 L/h
  - Fluid volume flows up to 100 L/h
  - Possible inlet pressure up to 3 bar
  - Inlet temperature up to 60°C
  - Option for flow-through and semibatch operation
- Demonstrator unit:
  - Fully automated process control
  - Flexible mobile system
  - Option for integrated pH control
  - Controlled extraction and analysis of products generated in gas and fluid compartment

## Application areas

- Synthesis of carbon-based base chemicals from $CO_2$ and water (e. g. ethylene, formic acid)
- Production of $H_2O_2$ from air oxygen and water
- Combination with process water treatment (e.g. electro-oxidation for COD removal)

## Our equipment

- Electrolytic cells with approx. 130 $cm^2$ electrode area
- Mobile, flexible demonstrator unit with fully automatic process control
- Chemical and technical laboratories
- In-house analytical laboratory
- SOLIDWORKS® CAD software for construction of cells and complete units
- COMSOL Multiphysics® simulation software for process modelling

## Our service offers

- Conception and development
- Electrolytic cells for a wide range of applications
- Material flow management
- Analytics and characterization
- Customer- and application-specific solutions (process, technology, system)
- Simulation and modelling
- Process analysis and optimization
- Process-, technology- and prototype development
- Design from small up to industrial scale
- Process and plant design
- CAD und construction
- Process- und system integration
- Transfer of results from laboratory scale into demonstration scale and continuous flow-through operation
- Screening of electrodes, catalyst materials and gas diffusion electrodes
- Testing of longterm stability of electrodes and catalysts
- Economic evaluation

## Reference projects

- Fraunhofer lighthouse project »Electricity as a Raw Material« Further information: *www.igb.fraunhofer.de/electricity-as-a-raw-material*
- CELBICON – Cost-effective $CO_2$ conversion into chemicals via combination of Capture, ELectrochemical and BIochemical CONversion technologies, EU (grant agreement no. 679050) Further information: *www.igb.fraunhofer.de/en/celbicon*

3 *Fully automated demonstrator unit.*

4 *Simulation (COMSOL Multiphysics® Software) of the electrolyte potential inside the electrolytic cell.*

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