Auf morgen bauen.

Direct CO_2 electroreduction from cement flue gas – Options and Opportunities

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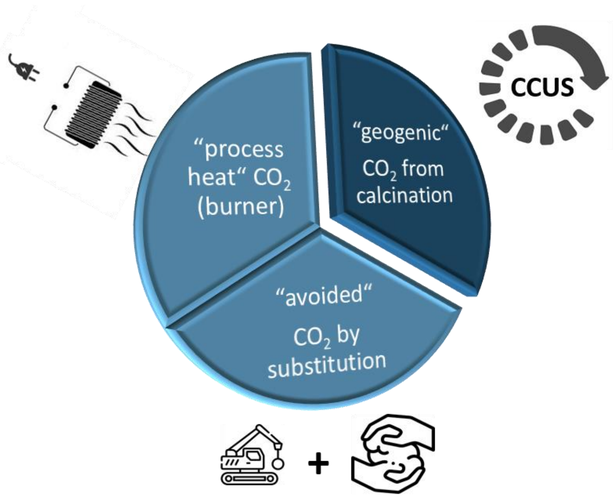
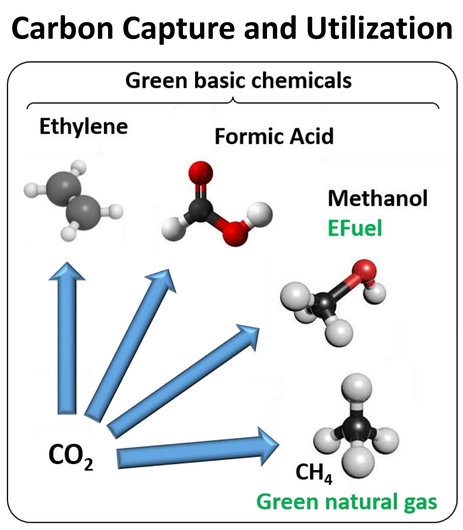
Introduction

Here we show **direct carbon capture & electrolysis** from cement flue such to enable intensified *lean* carbon processing from flue gas to value-added chemicals. As such Rohrdorfer poses an energy-efficient CO2-reduction and de-fossilation pathway based on renewable energy. CO_2 in flue gas will hereby be captured by an absorber medium, which is in addition used as catholyte in a custom-designed electrolyzer cell; by that, the energy-intense thermal desorption can be eliminated thus reducing the CO_2 footprint significantly. Central innovation of direct carbon capture & electrolysis is the catholyte medium that absorbs and transports large amounts of CO_2 to the electrode for direct use. Here, we elucidate the merits of such process and compare it with the state-of-the-art, further discuss the needs for the electrolyzer cell and the most promising absorber/catholyte media that ensure high performances at maximum cycling stability.

Roadmap for cement companies

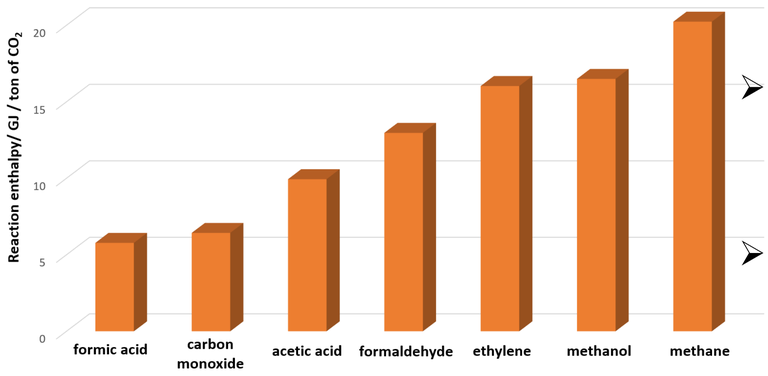




- **Cement industries** account for **7-8%** of the **worldwide CO_2 emission**
- **1/3 of the CO_2 emissions** need CCU or CCS
- For the climate goal (1.5°C) we need to cut the emissions by **7% each year**

➡ Fast innovations in **CO_2 reduction technologies**

CO_2 electroreduction products



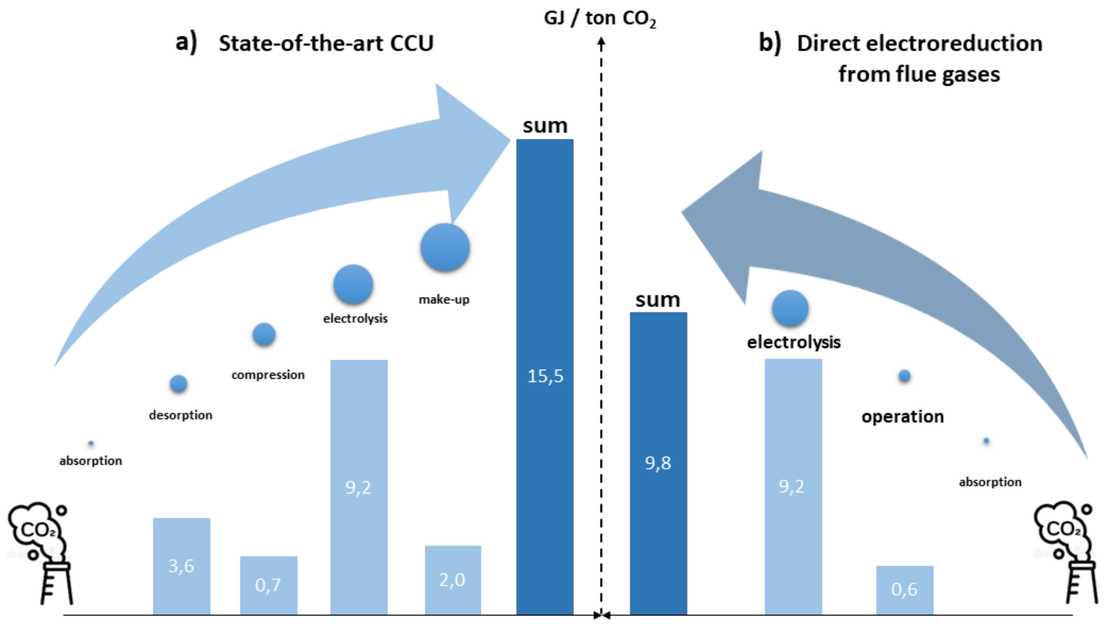
- CO and formic acid (FA) have the **lowest reaction enthalpy** per ton of CO_2
- **FA** has the **highest normalized market price** ($ per electron)

- **Limited market** for CO and FA
- Literature reveals already **high FE** and **current densities** for **FA** and **CO**

Market parameters of CO_2 reduction products			
Product	**Global Production [Mt/year]**	**Market Price [$/ton]**	**Normalized market price [$/electron] * 10^3**
methanol	110	580	3.1
ethanol	77	1000	3.8
ethylene	140	1300	3
n-propanol	0.2	1430	4.8
CO (syngas)	150	60	0.8
CO	-	600	8
formic acid	0.6	740	16.1
Data according to [1]			

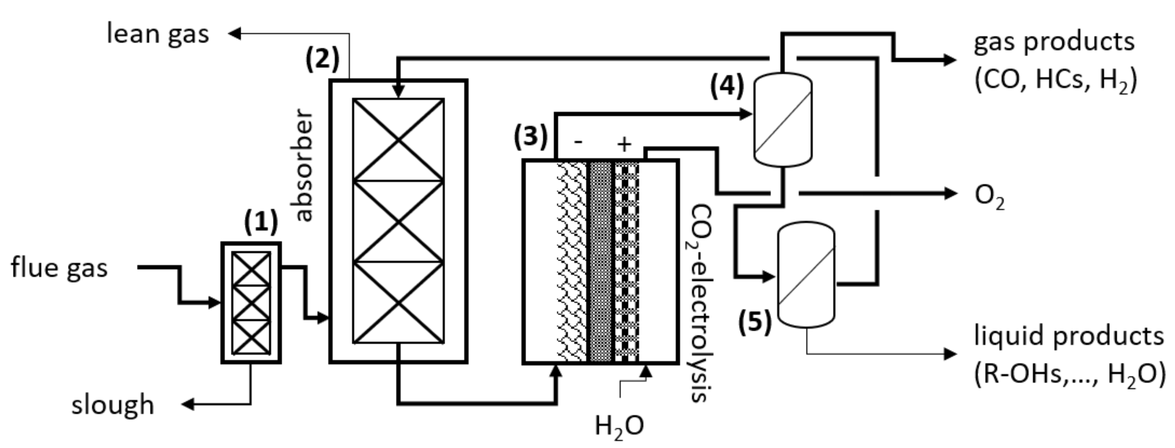
➡ **FA** and **CO** only viable products for a **cost** and **energy efficient CO_2 reduction**

Energy demand



➡ **Decrease of energy demand by a third**

Simplified Overview



1. Pretreatment flue gas
2. Absorber
3. CO_2-Electrolyser
4. Gas separation
5. Liquid product separation (destillation)

➡ Simplified scheme for the **direct CO_2 capture and electroreduction**

Mutual optimization of absorber media and electrolyzer cell

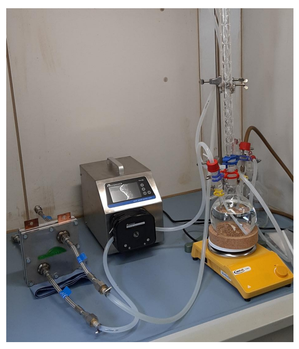
Requirements of the absorber/catholyte media:

- Cycling and degradation stability
- High CO_2 solubility
- Minimal membrane diffusion

Best options:

- Amines
- Organic Acids
- Ionic Liquids

➡ **Best electrolyte dependent on cell setup**



- **Electrolyte** and **cell** need to be **optimized mutually**
- **TRL: 2-3 –** research needed
- **Start of project: October**

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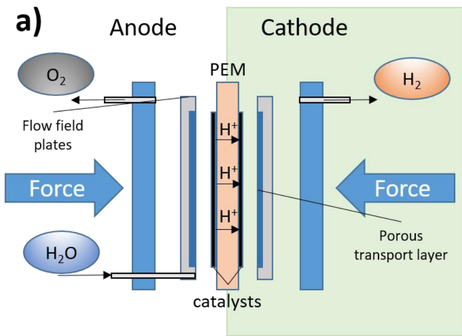

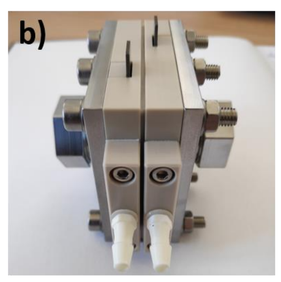

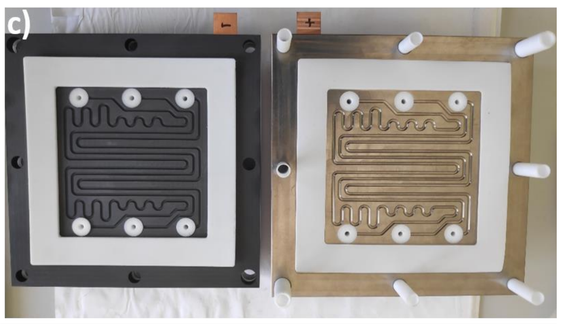

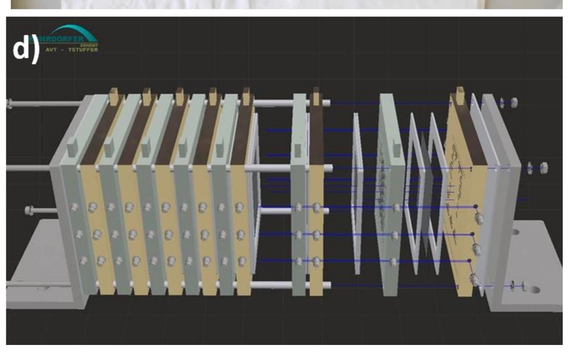

a) Electrolyzer cell based on **PEM cell**. Upscaling process with a **catalyst surface** of **b) 4 cm², c) 100 cm² and d) 1000 cm².**

Absorber/catholyte media — **Combination** — **Scale up electrolyzer cell**

[1] A. Gawel et al., Electrochemical CO2 reduction - The macroscopic world of electrode design, reactor concepts & economic aspects, *iScience*, vol. 25, no. 4, p. 104011, **2022**, doi: 10.1016/j.isci.2022.104011.

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