DACS Talks

Within the interdisciplinary talk series **DACS Talks**, young DACStorE scientists present their recent findings.

The DACS Talks are hosted by the DACStorE Transformation Hub and are part of the NETs@Helmholtz Research School.

The talk will be recorded and published (+ PPT) on our website (www.dacstore-project.com).

Next Level Ramp Up of Direct Air Capture and Storage DACStorE

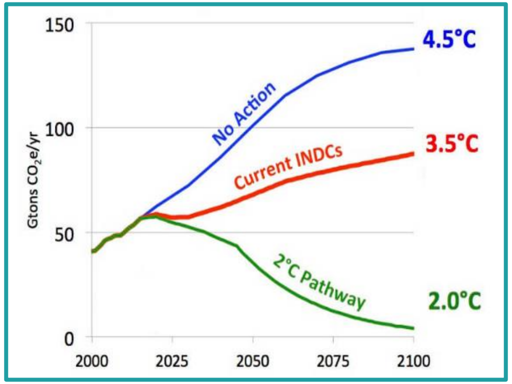
NETs@Helmholtz

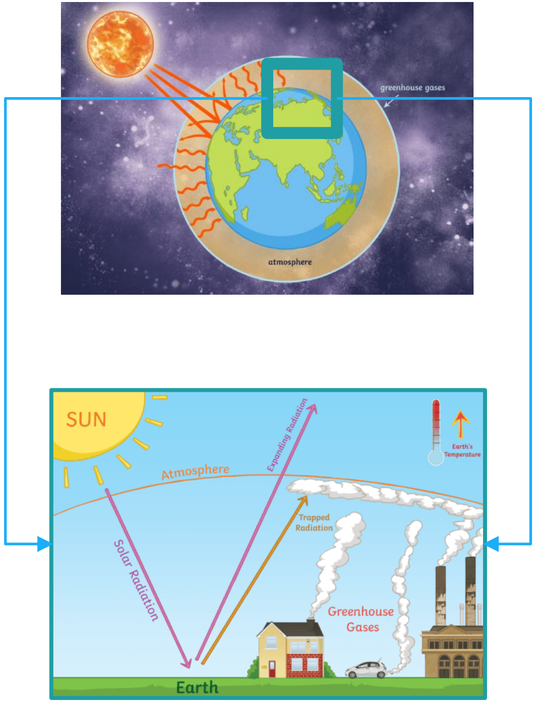
DACStorE Transformation Hub

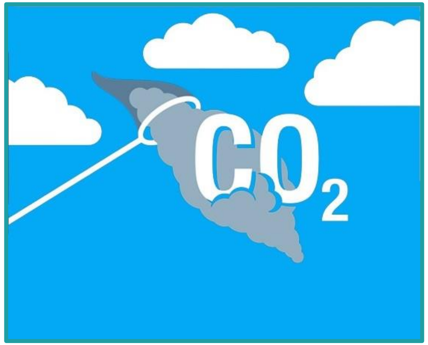
Introduction

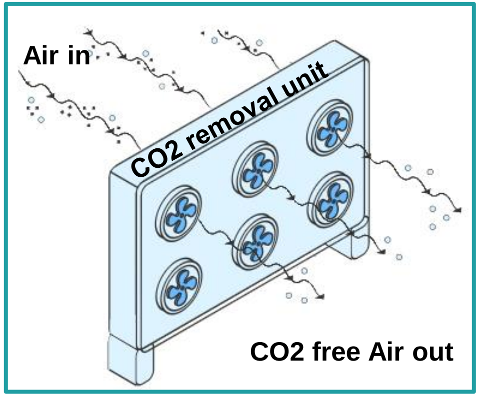
- Global Warming

- Why Direct Air Capture









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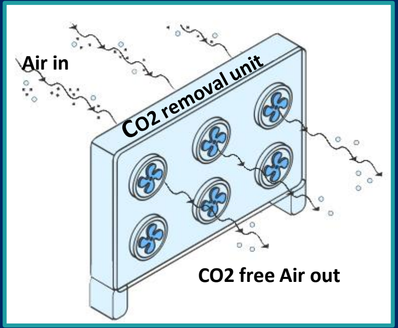
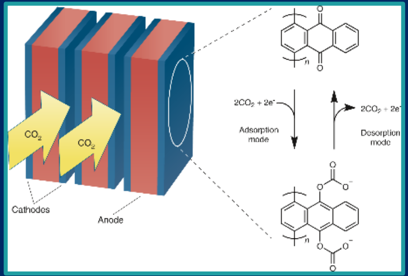
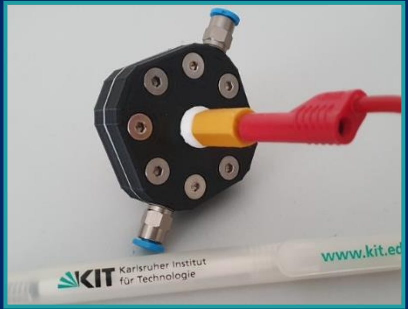
Direct Air Capture technologies



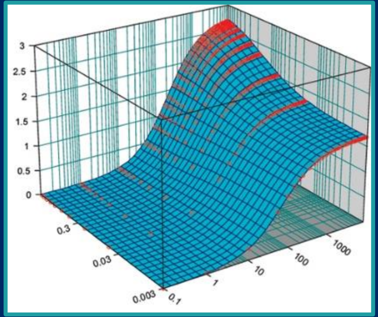
Electro-Swing DAC Principle



Proof-of-Concept Module



Modelling



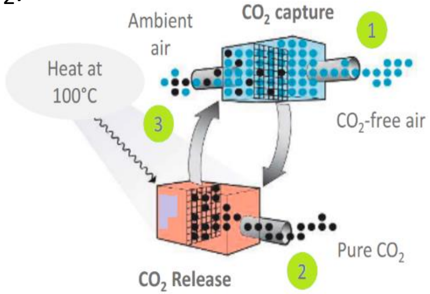
DAC technologies - Principles

➢ Temperature Swing Adsorption

- Low Temperature Technology (70-100°C)
- Cost estimation: 600$/t$CO_2$
- Required Energy : Heat (2000KWh/tCO_2)

& Electricity (650KWh/tCO_2)

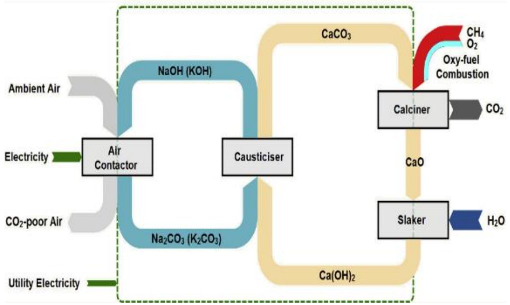
(ClimeWorks)



➢ Alkaline Gas Washing

- High Temperature technology: (800-950°C)
- High capacity to capture CO_2: (1milionTCO_2 / year)
- Required Energy: 5.25 GJ/tCO_2
- Cost estimation: 94 – 232 $/t$CO_2$

(Carbon Engineering)



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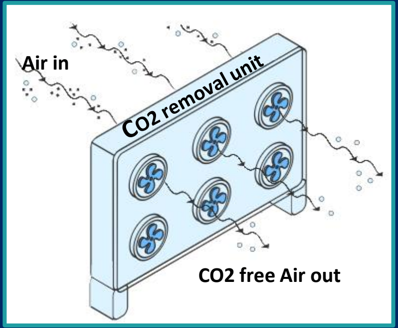

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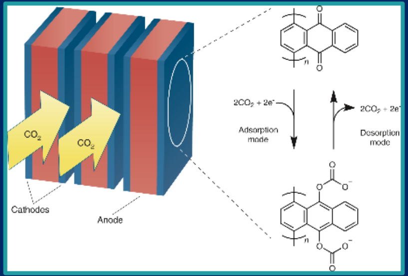

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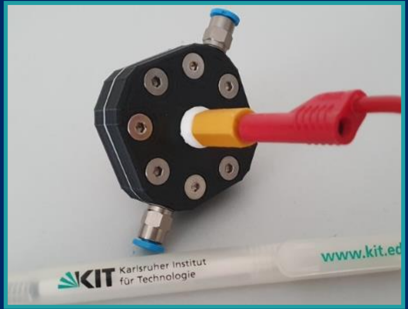
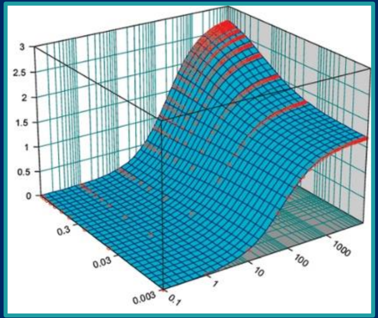
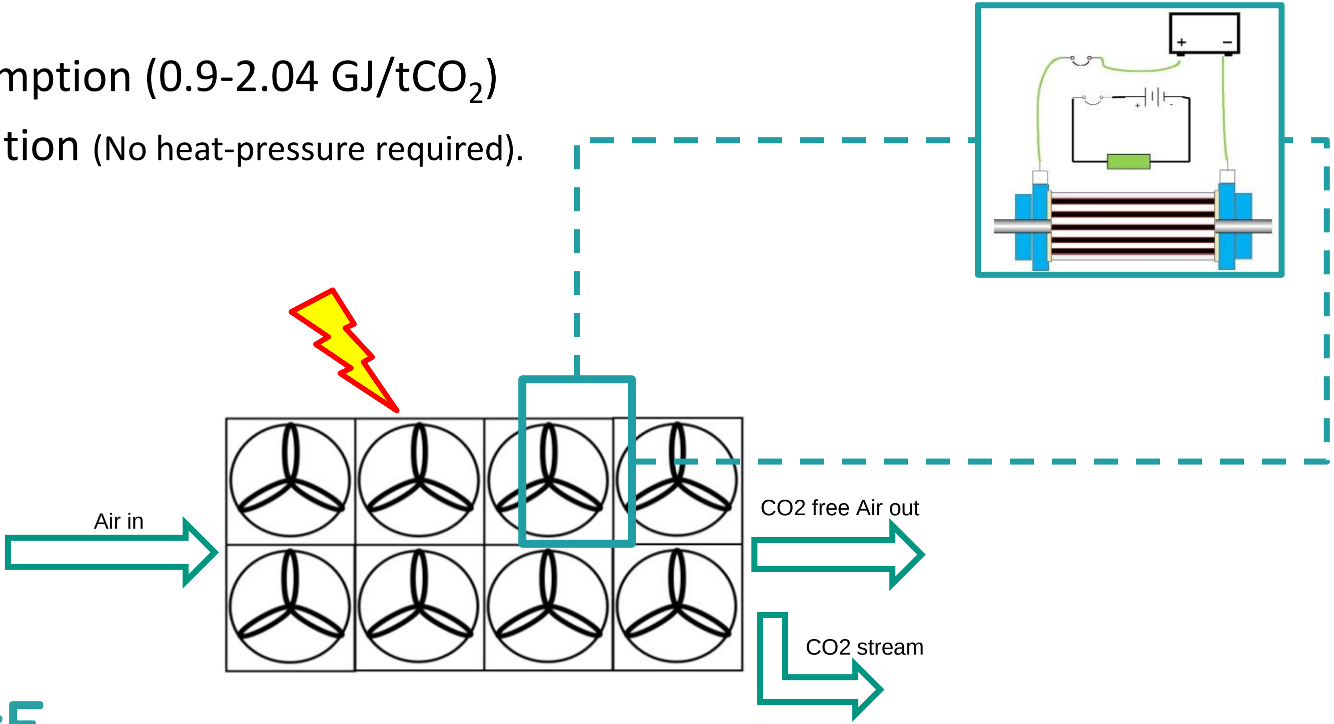


Modelling



Electro-Swing Approach for CO_2 Capture

- Low energy consumption (0.9-2.04 GJ/tCO_2)
- Electrical regeneration (No heat-pressure required).
- Cost effective [1]



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[1] https://doi.org/10.1038/s41560-020-0554-4

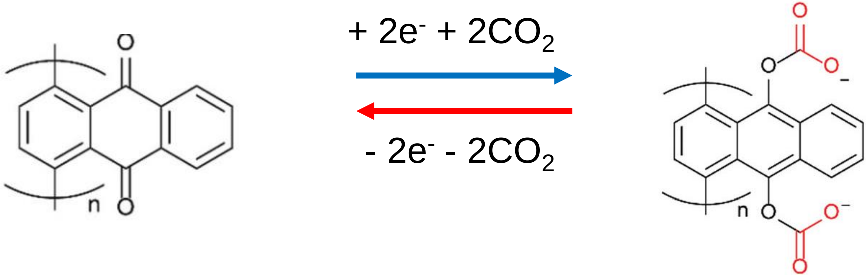
ESA-Fundmental

CO_2 adsorption → applying potential

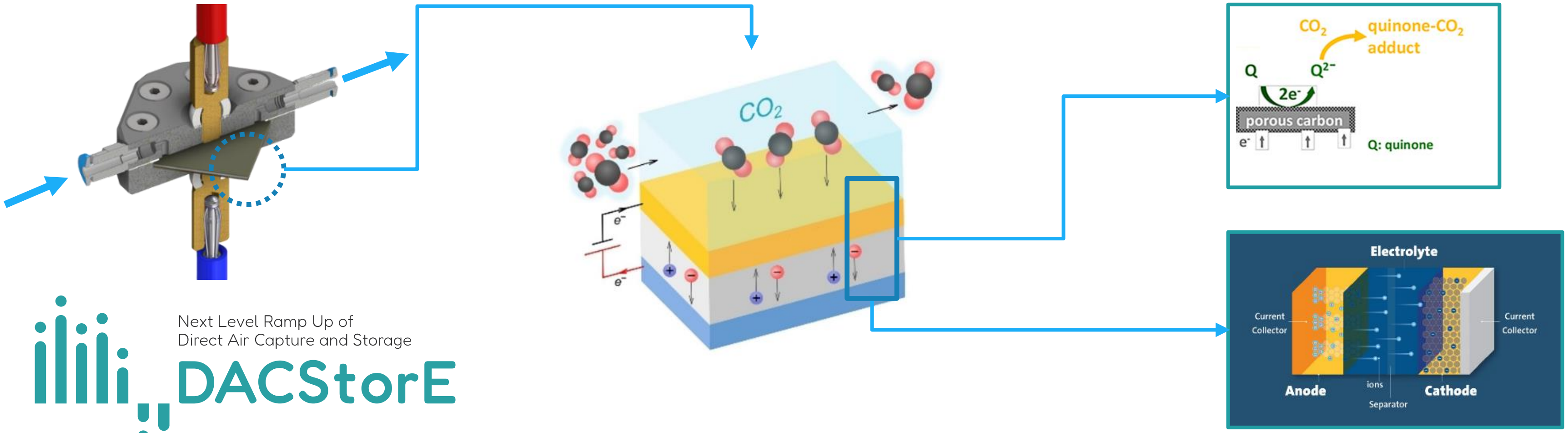
Negative

CO_2 desorption → reversing potential

Positive



Cross Section of the adsorption unit



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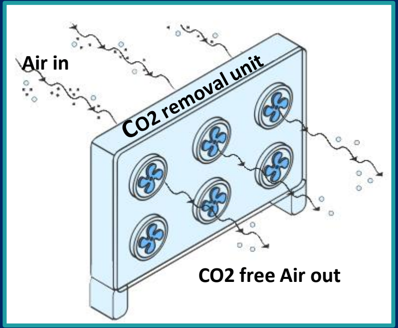
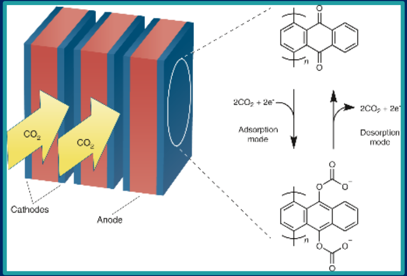
https://doi.org/10.1039/C9EE02412C

Agenda

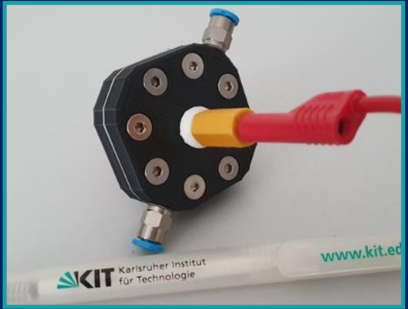
Direct Air Capture technologies



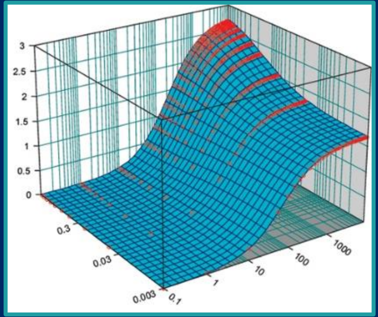
Electro-Swing DAC Principle



Proof-of-Concept Module

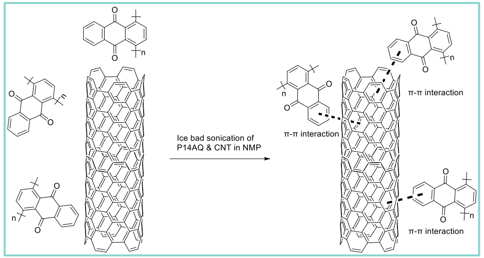


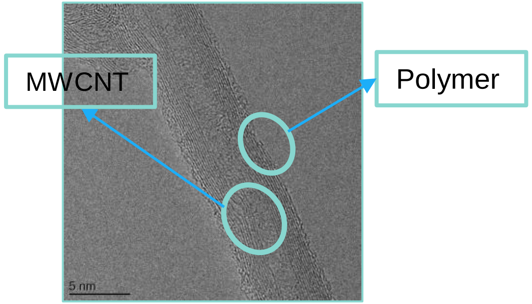
Modelling

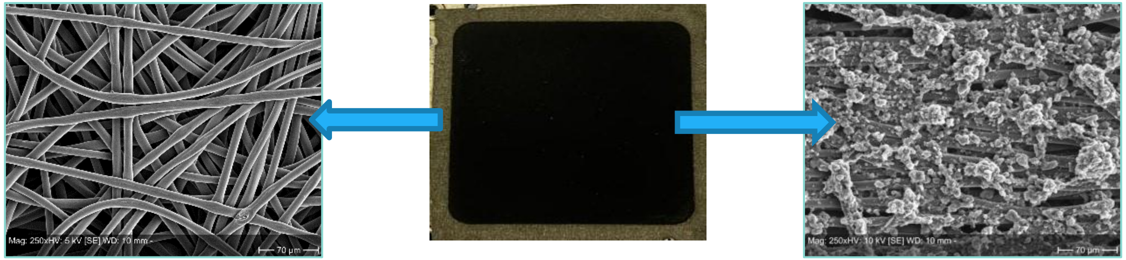


Proof-Of-Concept (*Electrode Fabrication*)

- Redox-Active Suspension
- Coating methods







Non-Coated part **Fabricated Electrode** **Coated part**

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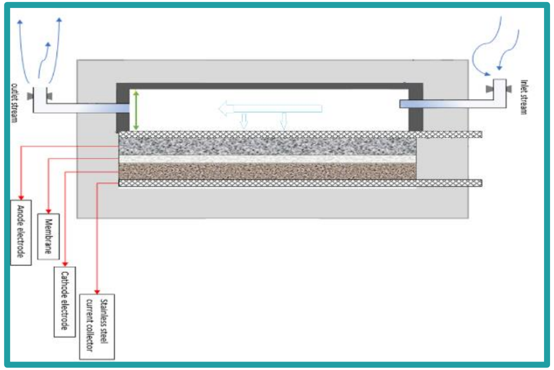
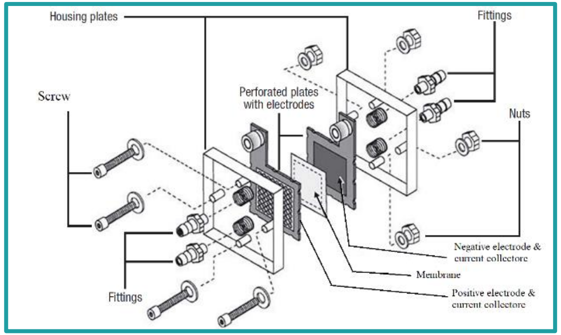
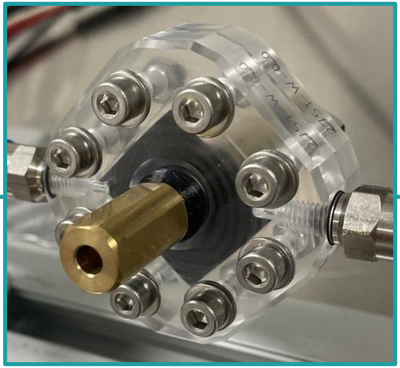
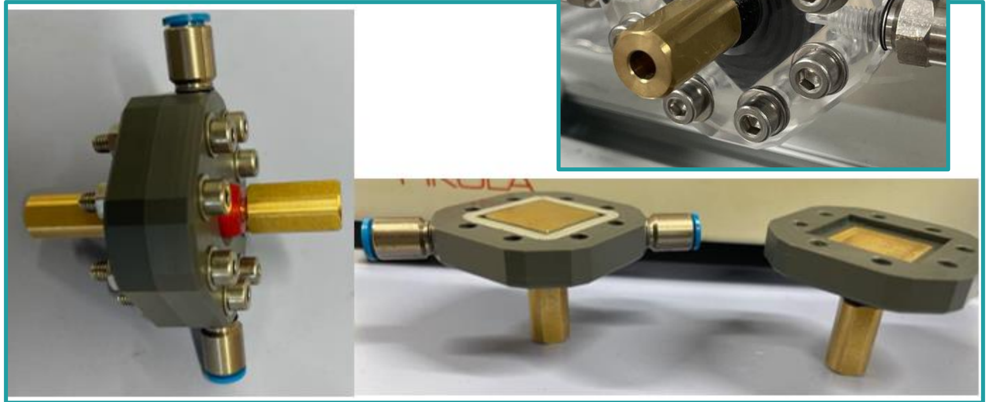
Proof-of-Concept (*Module Design & Construction*)

- The module comprised of several layers, and the device design incorporates a stepwise approach to avoid short circuits.









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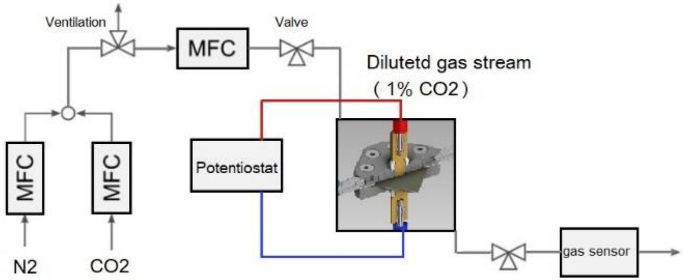
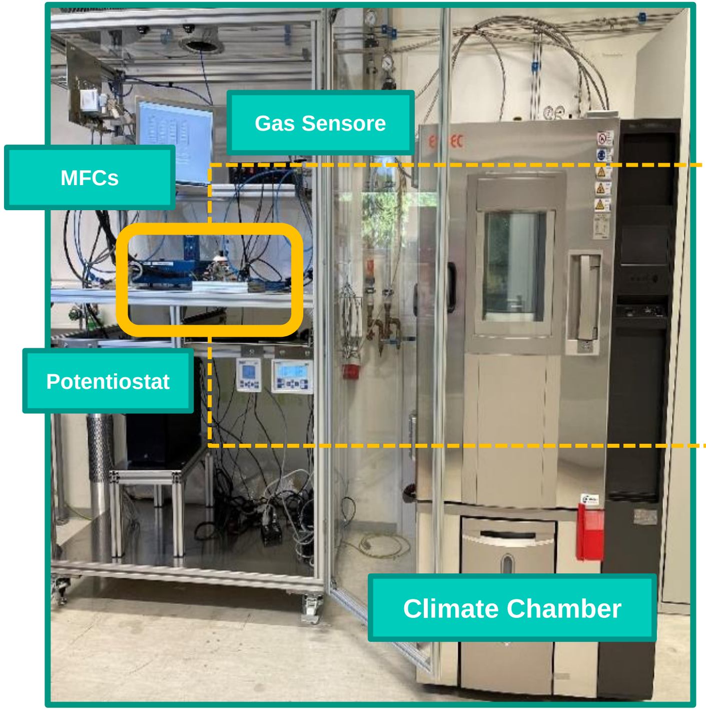
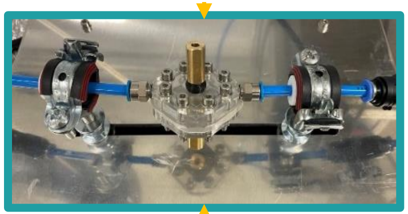
Proof-Of-Concept *(Set up)*

- Flow diagram.
- CO_2 is taken up by reduced polymer while the gas stream passes through the Module channel.







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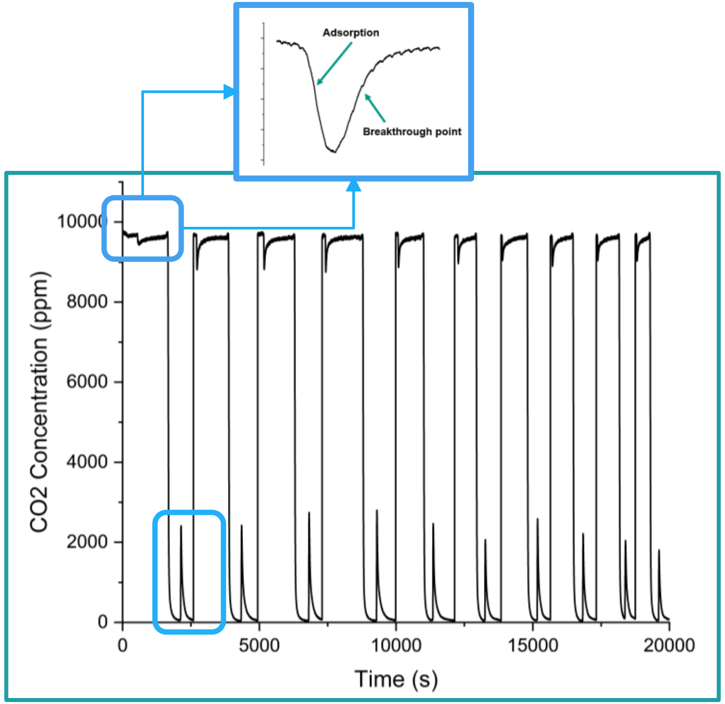
Proof-of-Concept (*Adsorption-Desorption experiments*)

- Capture-Release 10 cycles (*Adsorption- Flush- Desorption*)

Flow rate	Capture Voltage	Release Voltage
28 ml/min	-1,5 V	+1 V

$$\eta_{faraday} = \frac{n_{CO2} \times F}{Q}$$



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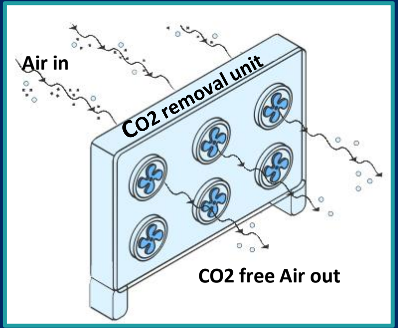
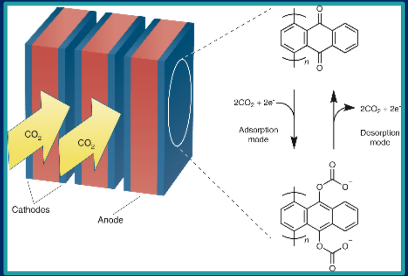
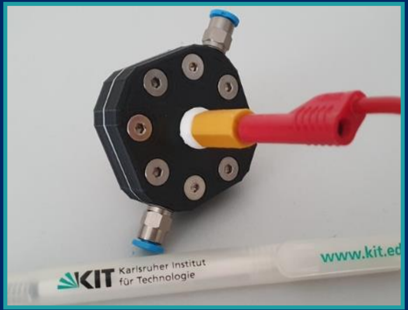
Direct Air Capture



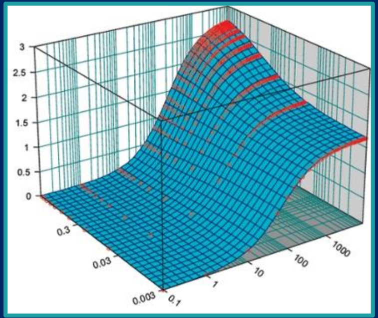
Electro-Swing DAC Principle



Proof-of-Concept

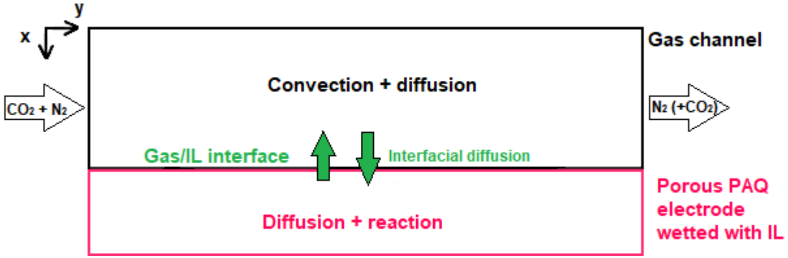


Modelling

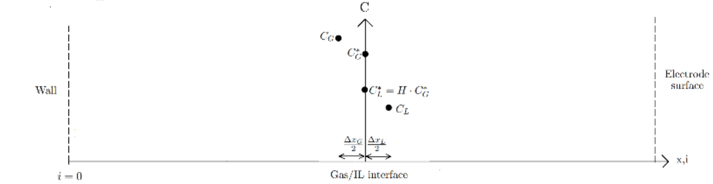


Modelling

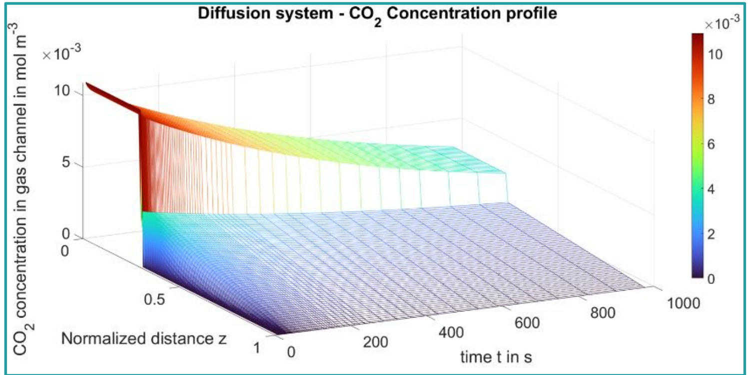
- Modelling: The modeling of the 2D instationary electrochemical system is implemented in MATLAB using finite differences and the method of lines found in *Schiesser et al. compendium*



	Gas phase	Liquid phase
Governing equation	$\frac{\partial C_G}{\partial t} = D_G \nabla^2 C_G$	$\frac{\partial C_L}{\partial t} = D_L \nabla^2 C_L$
Discretized form	$\frac{dC_G}{dt} = D_G \left(\frac{C_G(i+1) - 2C_G(i) + C_G(i-1)}{(\Delta x_G)^2} \right)$	$\frac{dC_L}{dt} = D_L \left(\frac{C_L(i+1) - 2C_L(i) + C_L(i-1)}{(\Delta x_L)^2} \right)$



	Wall	Gas/IL interface	Electrode surface
B.C	$D_G \frac{dC_G}{dx_G} = 0$	$\dot{n}_{in} = \dot{n}_{out}$ $D_G \frac{(C_G^* - C_G)}{\Delta x_G} = D_L \frac{(C_L - C_L^*)}{\Delta x_L}$	$\frac{dC_L}{dt} = r_{CO_2}$
Discretized form	$\frac{dC_G}{dt} = D_G \left(\frac{C_G(i+1) - C_G(i)}{(\Delta x_G)^2} \right)$	$\frac{dC_G}{dt} = \frac{D_G}{\Delta x_G} \left(\frac{C_G^* - C_G(i)}{\frac{\Delta x_G}{2}} - \frac{C_G(i) - C_G(i-1)}{\Delta x_G} \right)$ $\frac{dC_L}{dt} = \frac{D_L}{\Delta x_L} \left(\frac{C_L(i+1) - C_L(i)}{\Delta x_L} - \frac{C_L(i) - C_L^*}{\frac{\Delta x_L}{2}} \right)$	



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DACS Talks

<u>**Upcoming DACS Talks:**</u>

April: Simon Spiegel, KIT IFG
“tbd”

July: Robin Koch, KIT IMVT
“Early Business Cases for a fast industrialization of DACs technologies.”

September: Patrick Behr, FZJ IEK-1
“Design of porous solid sorbent for direct air capture.”

November: Lutong Lu, KIT IMVT
“Electrochemical CO2 capture with solid adsorbers based on electroactive polymers.”

DACS Talks

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