Producción de syngas en un módulo electroquímico para su posterior utilización con H_2 renovable en la producción de combustibles sintéticos

Syngas production by electrochemical reactor as a key step in the production of alternative fuels

Thursday 26 October 2023

L. Martinez[1], E. Bernad[1], J. Sánchez-Laínez[1], V. Gil[1,2], J. Gurauskis[2,3], R. Burato[3], NC Rosero-Navarro[4], R. Nakazato[4], K. Tadanaga[4]

[1]Fundación Hidrógeno de Aragón, Spain

[2]Fundación ARAID, Spain

[3]INMA, CSIC, Spain

[4]Hokkaido University, Japan

4AirCRAFT-Air Carbon Recycling for Aviation Fuel Technology

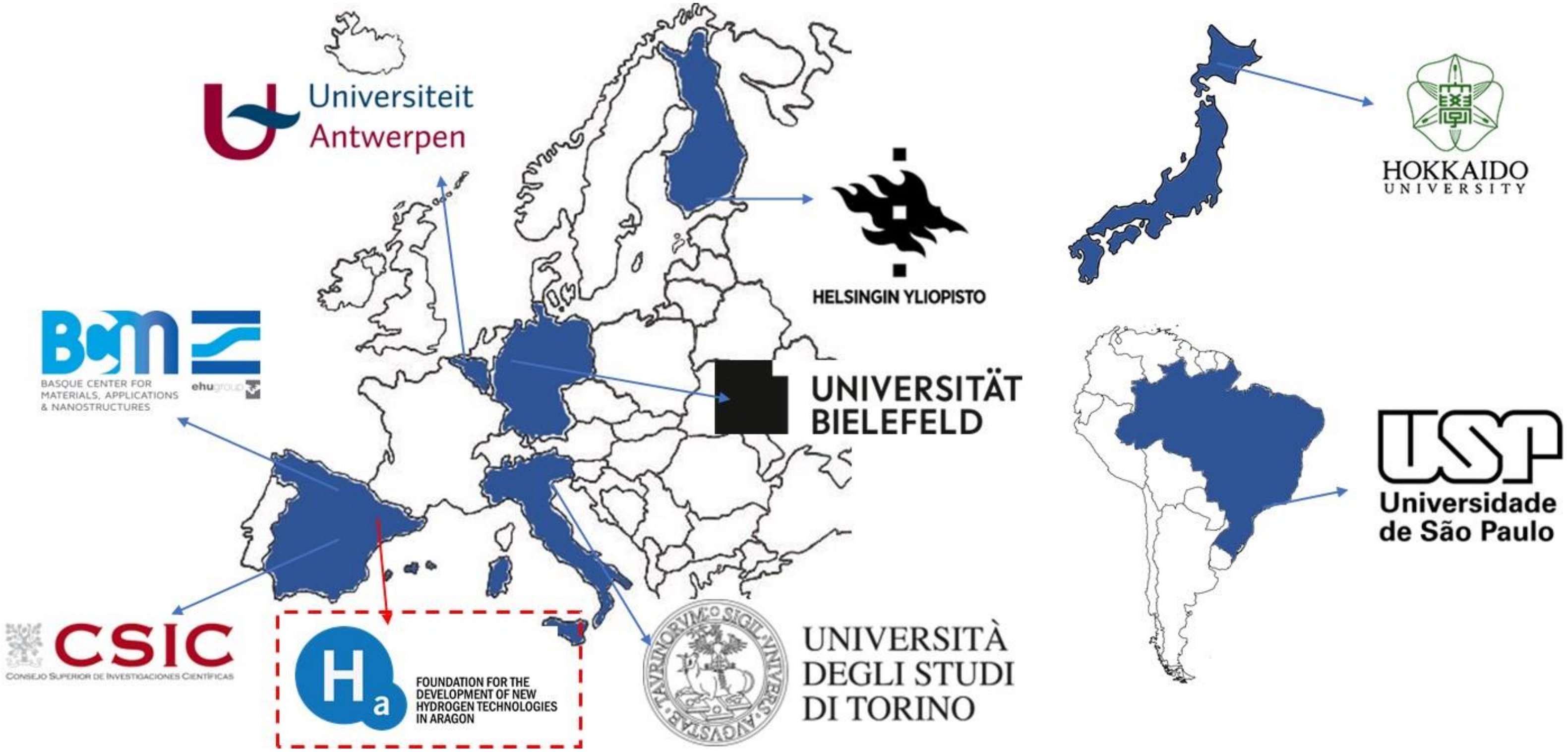
- **Funding Programme:** H2020-EU.3.3.3. – Alternative fuels and mobile energy sources
- **Topic:** LC-SC3-RES25-2020 – International cooperation with Japan for Research and Innovation on advanced biofuels and alternative renewable fuels

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022633.

This work is supported by Japan Science and Technology Agency (JST) under Grant Agreement No JPMJSC2102.

This project is developed in the frame of a Mission Innovation Challenge supported by The Sao Paulo Research Foundation (FAPESP) under Grant No. 2022/04751-0

4AirCRAFT Consortium



Coordination: Aragon Hydrogen Foundation (FHa, Spain)

FUNDACIÓN PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGÍAS DEL HIDRÓGENO EN ARAGÓN

araid FUNDACIÓN AGENCIA ARAGONESA PARA LA INVESTIGACIÓN Y EL DESARROLLO

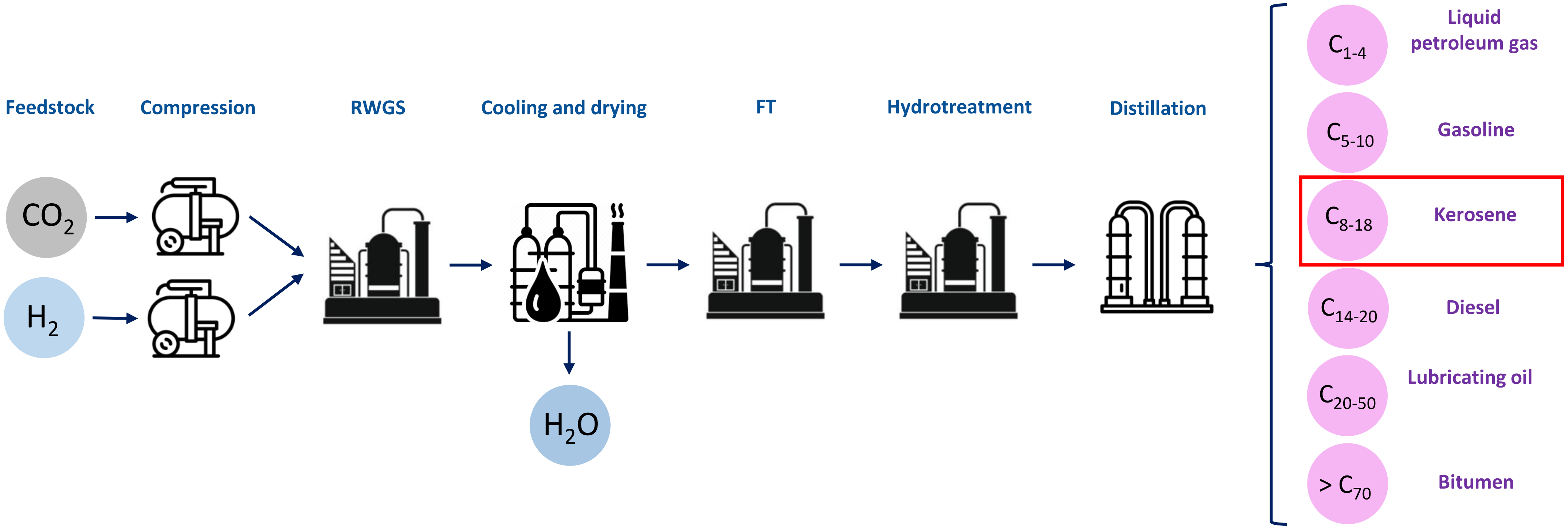
vgil@hidrogenoaragon.org

Advisory Panel group

- Sustainable fuels producers
- Petro-chemical industry
- Chemical industry
- CO_2 producers
- Logistics, Ports, etc.

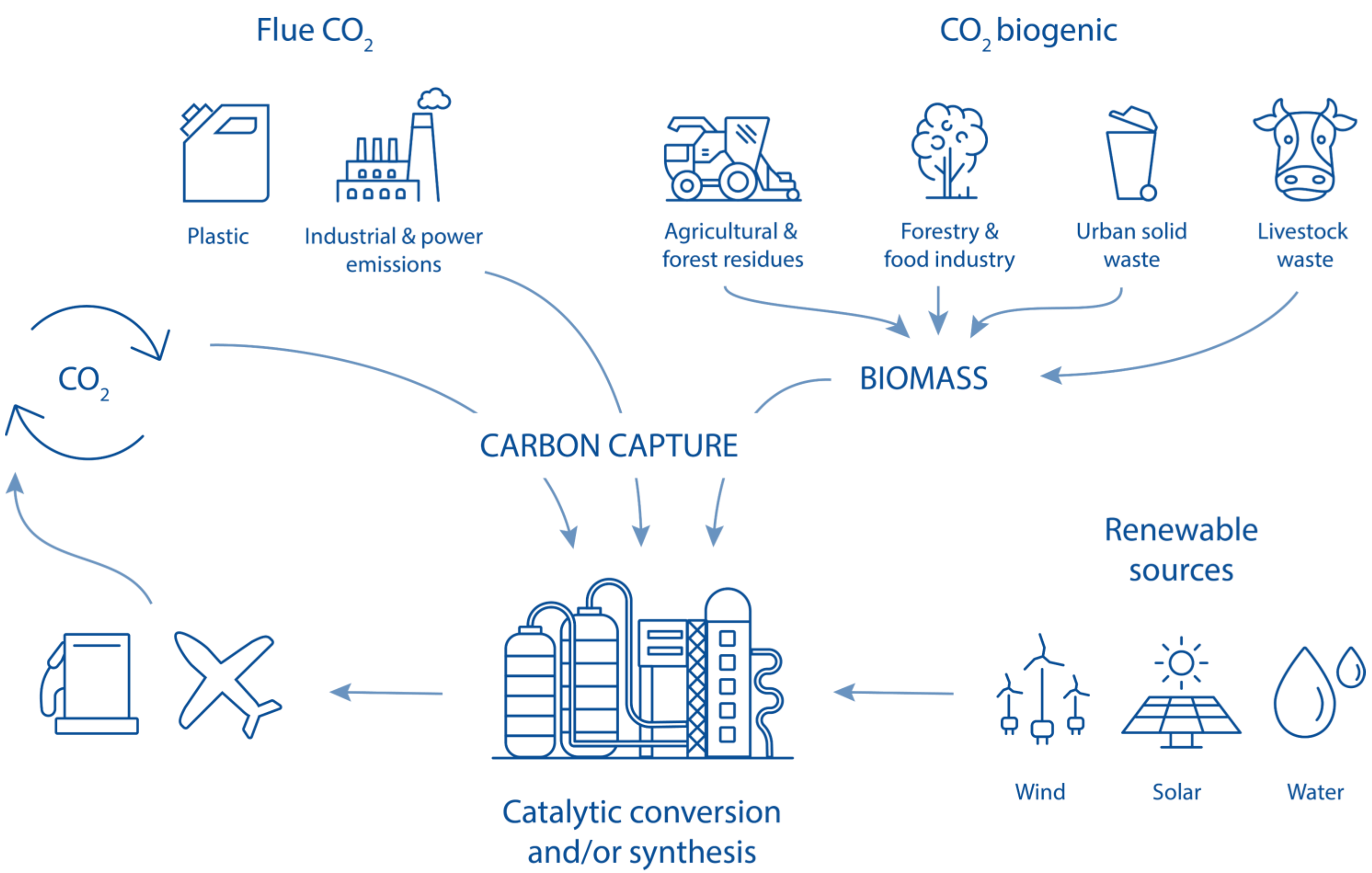
What is our motivation?

SAF production approach based on ASTM D7566



Unfortunately, **conventional technologies** often suffer from **low selectivity control** and **conversion** while **lacking energy efficiency**.
Therefore, **new technology** solutions are required, in which the **rational design of catalytic materials** is a must.

4AirCRAFT Approach



Unfortunately, **conventional technologies** often suffer from **low selectivity control** and **conversion** while **lacking energy efficiency**.

Therefore, **new technology** solutions are required, in which the **rational design of catalytic materials** is a must.

4AirCRAFT Approach

Water and carbon dioxide from biomass and industrial sources

Greener, milder and intensified liquid fuel production routes

Direct aviation use, storage and distribution in the existing infrastructures

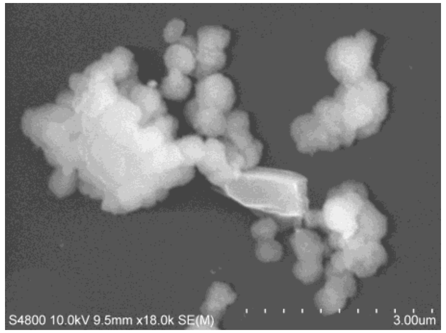
Hybrid cascade reactor technology - CO_2 conversion to long-chain hydrocarbons at mild conditions

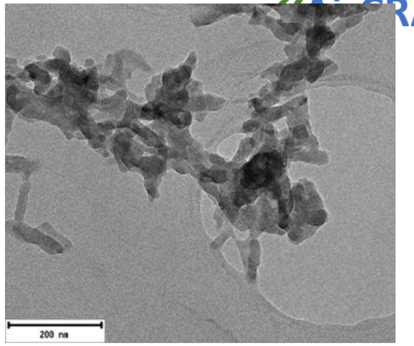
Proof of the concept → TRL3

4AirCRAFT – Research Activities

Materials

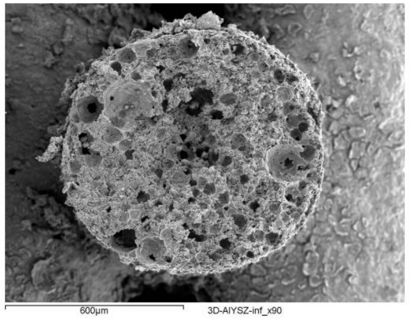
- Electrocatalyst
- Chemocatalysts
- Bio- and Biomimetic catalysts





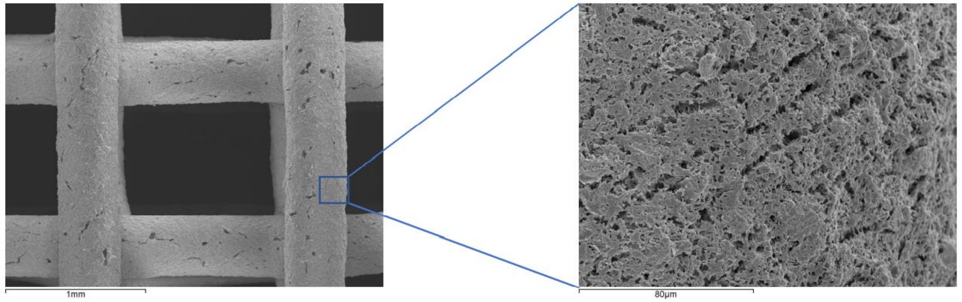
Components

- Membranes and Electrodes
- Advanced Catalysts Carriers
  MOFs and nano→meso→macro strctured and functionalized scaffolds)



Reactor

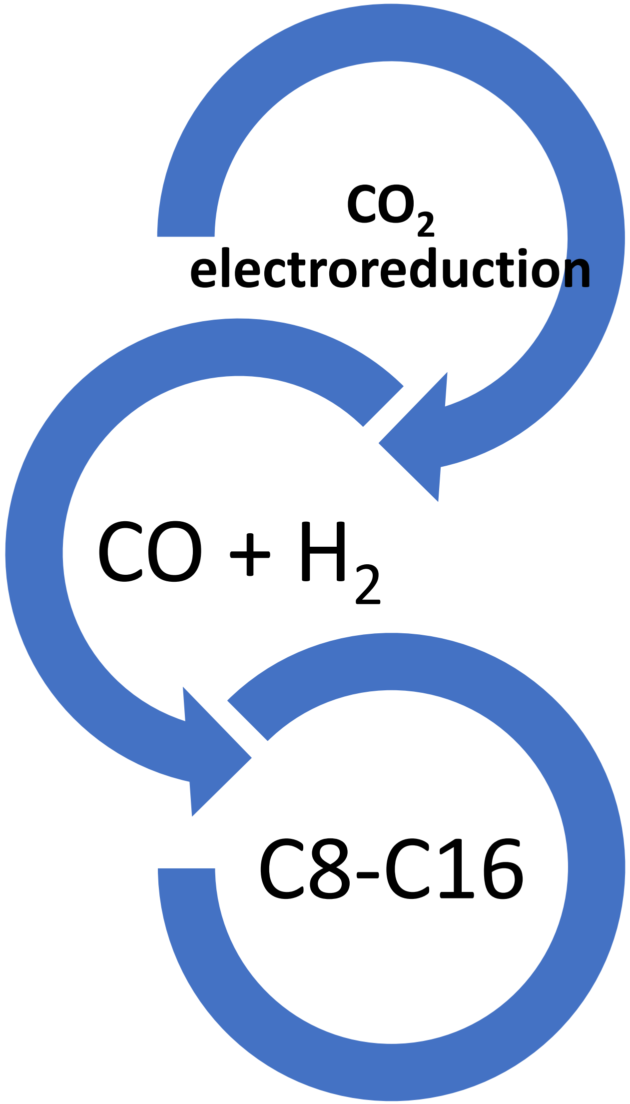
- Reactor design-Process Intensification
- Structural and mechanistic investigations
- Proof of the concept and Life Cycle Assessment



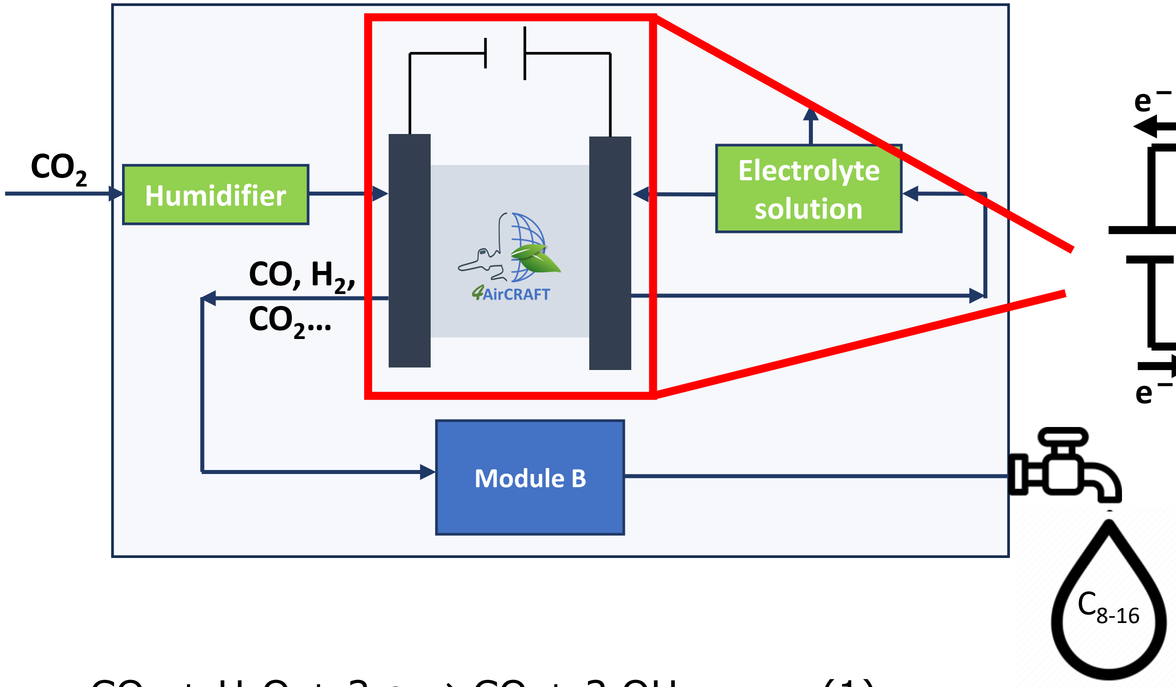
4AirCRAFT

Air Carbon Recycling for Aviation Fuel Technolog

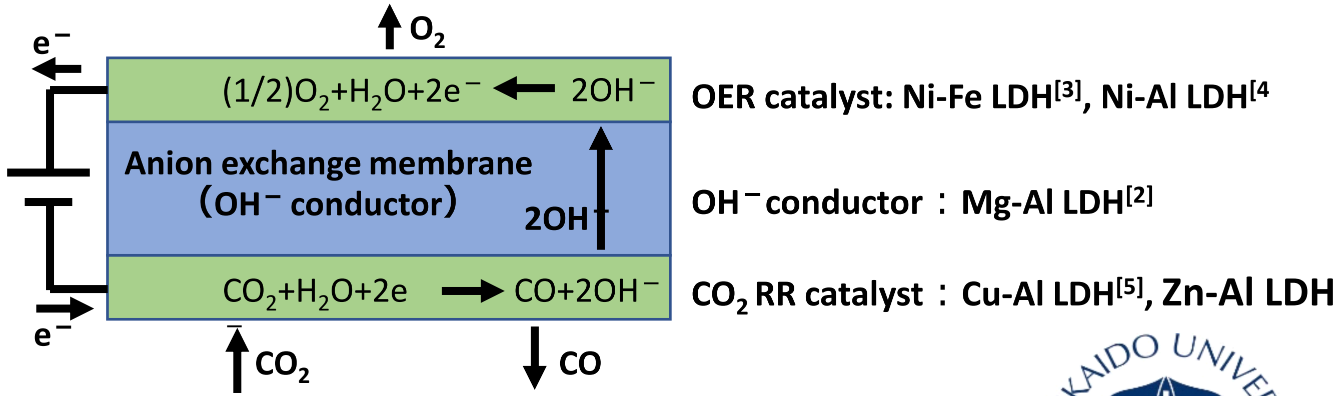
Preliminary results strategy “syngas mediated”



4AirCRAFT cascade reactor – key step CO production



Electrochemical cell using an anion exchange membrane



$$CO_2 + H_2O + 2\,e^- \rightarrow CO + 2\,OH^- \qquad (1)$$

$$2\,OH^- \rightarrow H_2O + 2\,e^- + (1/2)\,O_2 \qquad (2)$$

$$CO_2 \rightarrow CO + (1/2)\,O_2 \qquad (3)$$

K. Tadanaga et al. J Asian Ceram Soc. **2023**, 11.3, 406

LDH (Layered Double Hydroxide)

- Variety of metal combination[1]
- Large surface area [1]
- High OH- conductivity [2]
- Stability in alkaline solution [2]

[1] C. I. Ezeh et al., *Ultrason. Sonochem.* ***2018***, *40, 341.*
[2] K. Tadanaga et al., *Adv. Mater.* ***2010***, *22, 4401.*
[3] D. Zhou et al., *Chem. Soc. Rev.* ***2021***, *50, 8790.*
[4] M. Li et al., *J. Mater. Sci.* ***2019***, *54, 9034.*
[5] K. Iwase et al., *ChemSusChem* ***2022***, *15, e202102340.*

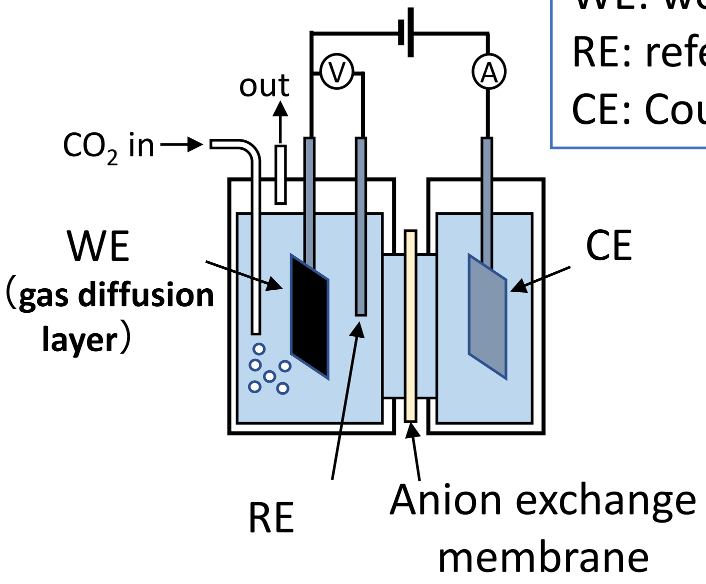
Prof. K. Tadanaga

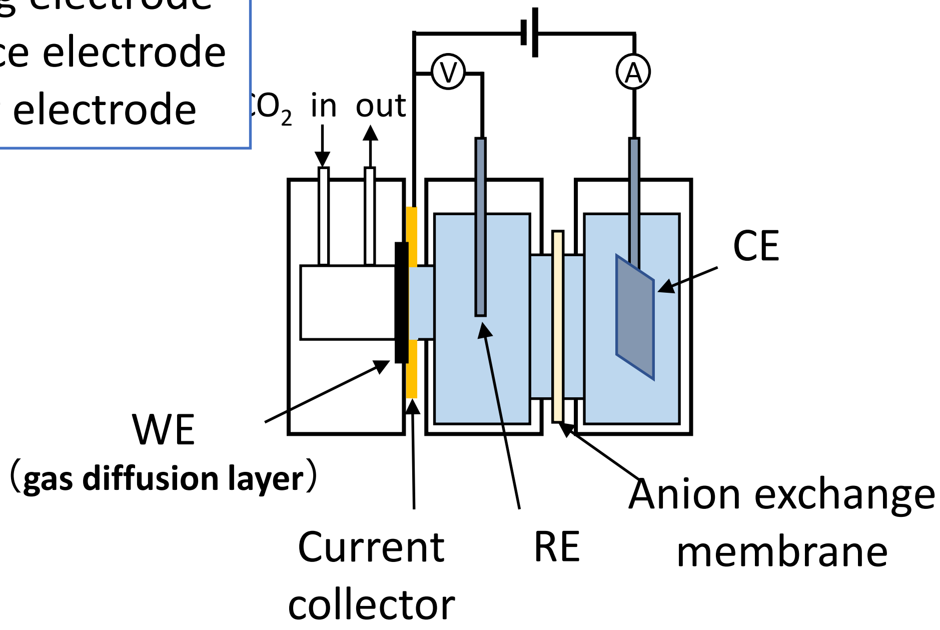
Electrocatalyst performance - Cell configuration for CO_2 reduction reaction (CO_2RR)

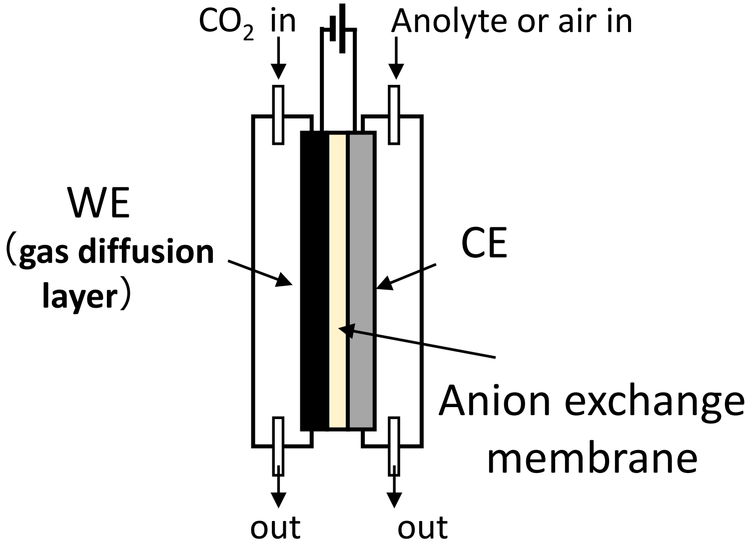
4AirCRAFT

2-compartment cell → 3-compartment cell → Zero gap cell

WE: working electrode
RE: reference electrode
CE: Counter electrode







Dissolved CO_2RR

- ✓ **Factors to limit the CO2 RR reaction**
  Saturation concentration of CO_2 (33 mM)
  Diffusion rate of CO_2
  Limit of electrolyte because of dissolution of CO_2

Gaseous- CO_2RR

- ✓ Increase in reaction efficiency using gas
- ✓ Configuration is rather easy

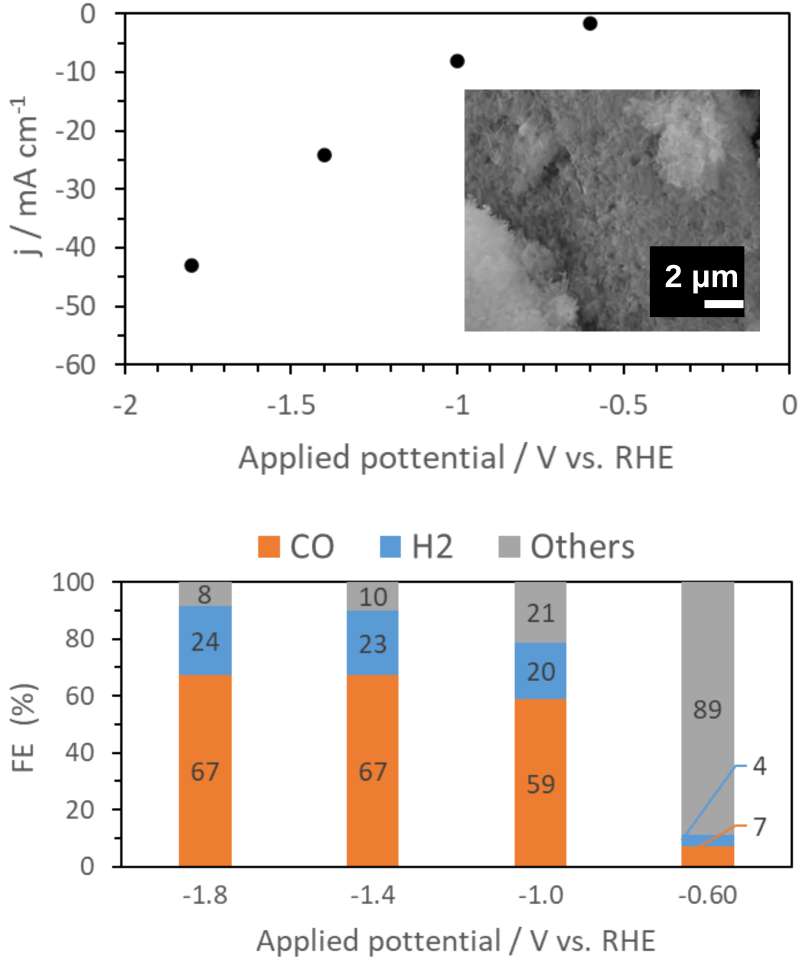
Practical gaseous CO_2RR

- ✓ Reduction of cell resistance using MEA (membrane electrode assembly)

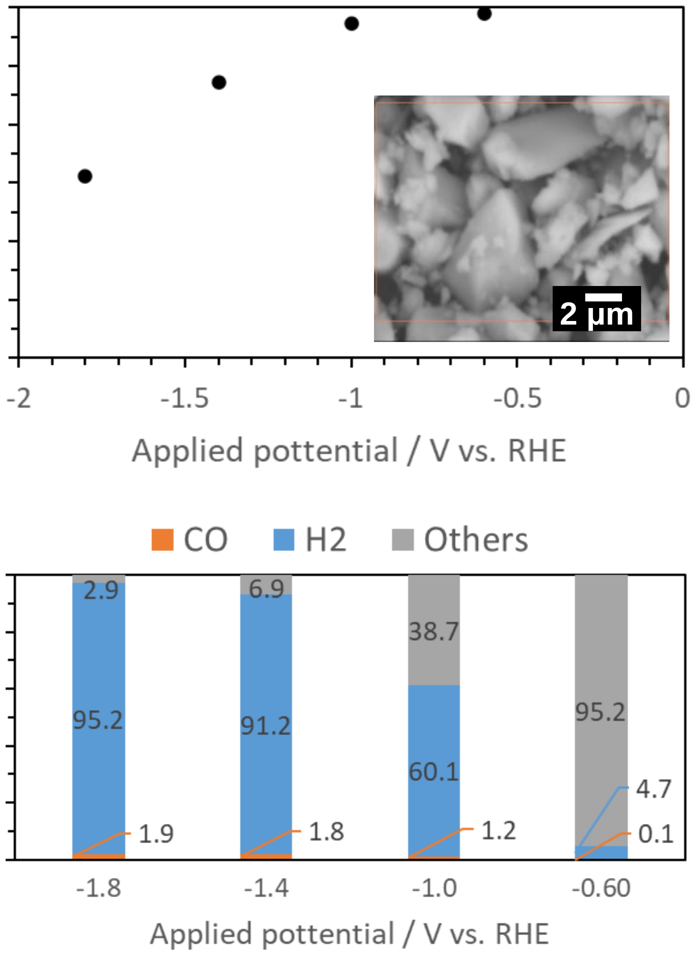
Gaseous CO_2RR activity

2-compartment cell test

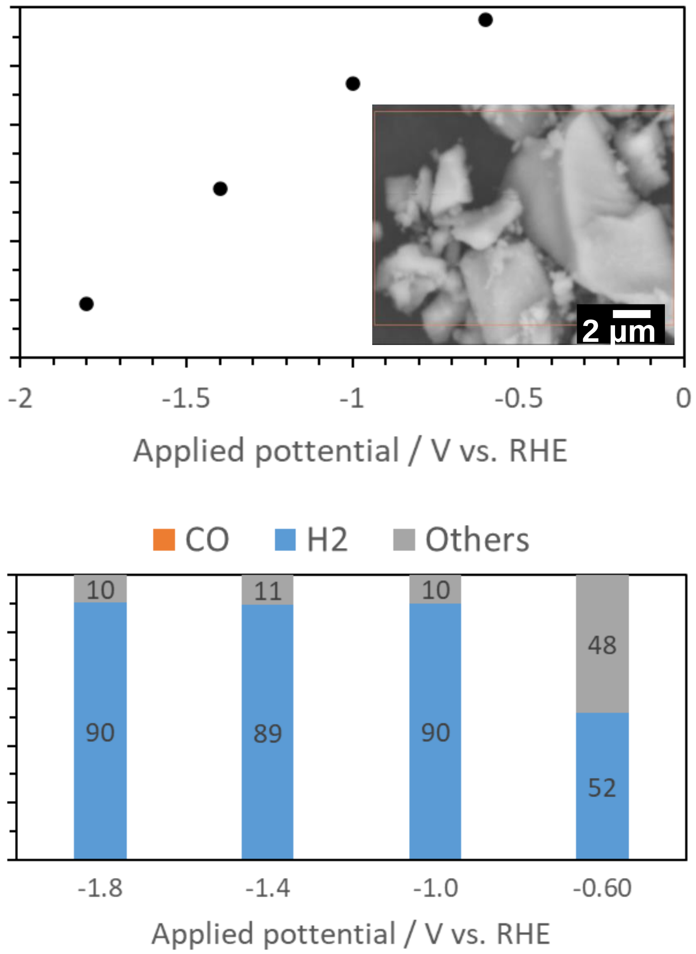
Zn-Al LDH



Ni-Al LDH

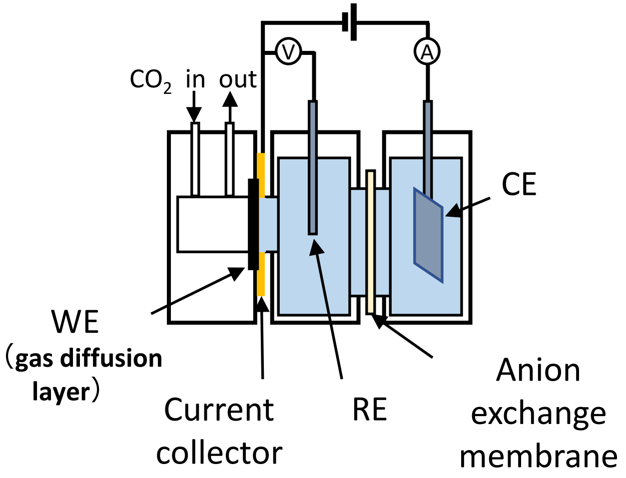


Ni-Fe LDH



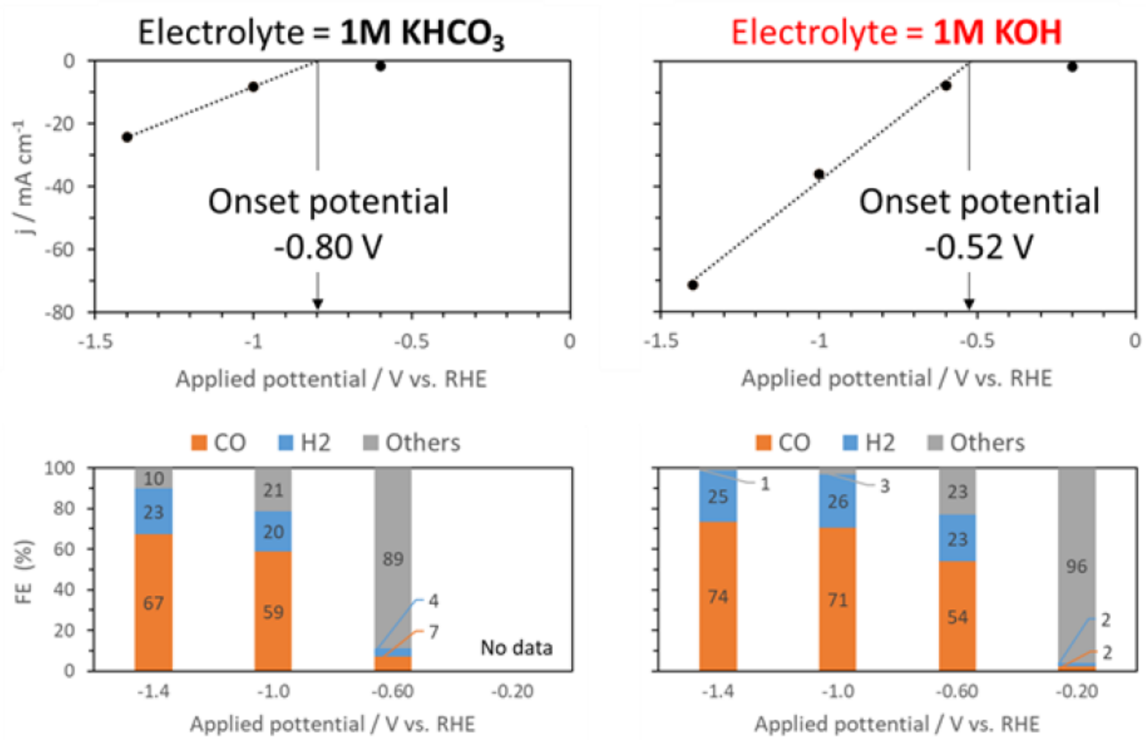
Gaseous CO_2RR activity

3-compartment cell test



Gaseous- CO_2RR

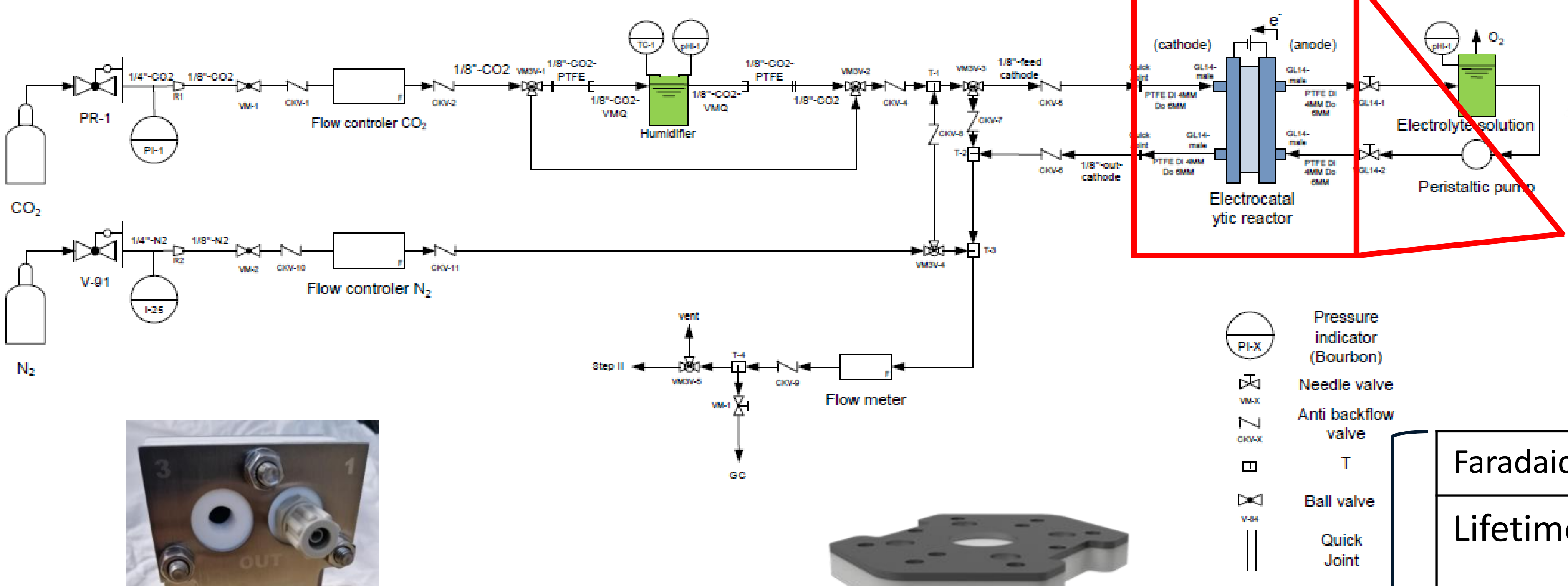
- ✓ Increase in reaction efficiency using gas
- ✓ Configuration is rather easy

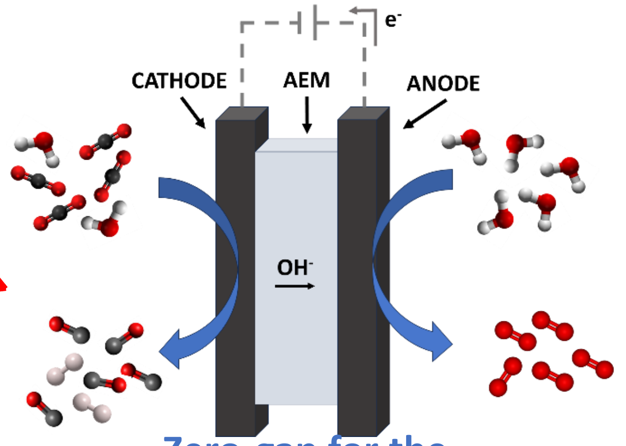


C. I. Ezeh *et al.*, *Ultrason. Sonochem.* **2018**, *40*, 341; K. Tadanaga *et al.*, *Adv. Mater.* **2010**, *22*, 4401; D. Zhou *et al.*, *Chem. Soc. Rev.* **2021**, *50*, 8790; M. Li *et al.*, *J. Mater. Sci.* **2019**, *54*, 9034; K. Iwase *et al.*, *ChemSusChem* **2022**, *15*, e202102340.

CO2RR Test Bench

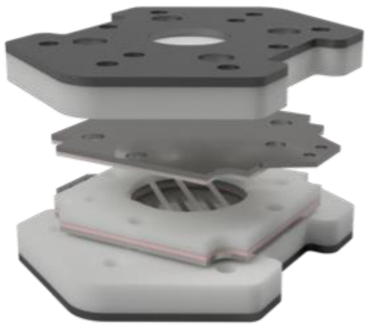
Zero-gap cell



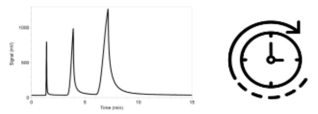


Zero-gap for the CO2RR

Commissioning module – single cell



Initial module design – single cell

Faradaic efficiency	FE
Lifetime studies	
LCA	
TEA	€

4AirCRAFT

Conclusions

✓Zn-based catalyst with CO_2 affinity achieves up to 77% of selectivity for CO evolution and 94% for CO + H_2.

✓Design and construction of a test bench to carry out tests and monitoring carbon dioxide flues.

✓Customizable electrochemical cell.

✓Use of non-precious metal as catalysts.

✓Development of a stage with great potential for the synthesis of industrial chemical processes.

Financial support from the T13-23R (the Aragón Government).

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101022633.

This work is supported by Japan Science and Technology Agency (JST) under Grant Agreement No JPMJSC2102.

This project is developed in the frame of a Mission Innovation Challenge supported by The Sao Paulo Research Foundation (FAPESP).

www.4aircraft-project.eu