PhotoElectroCatalytic Device for Sun-Driven CO_2 conversion into Green Chemicals

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4th June 2021

#EUGreenWeek

2021 PARTNER EVENT

SUNERGY · FLOW PHOTO CHEM · SOLAR CHEM · SunCO2Chem · ocean · DECADE · RECODE · European Commission

SunCO2Chem Consortium

14 partners from 8 European countries

6	3	1	3	1
Research institutions	R&D SMEs	Standardisation body	Chemical industries	EU International Cooperation partner

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cnrs advancing the frontiers
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This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 862192.

The European Chemical Industry

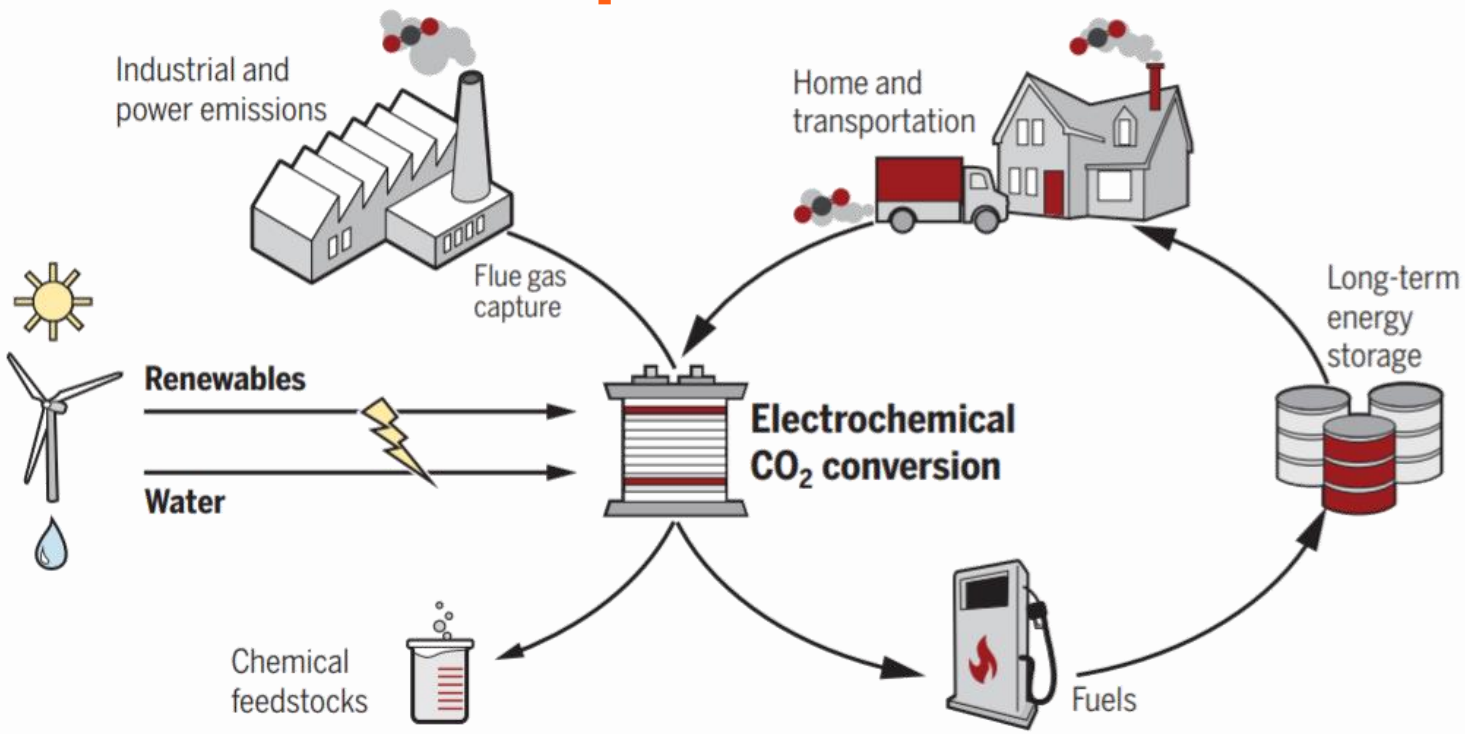
Transition towards low-emission energy technologies

30
giatons of CO_2 emitted yearly

95%
Chemicals based on fossil fuels

The Chemical Industry is the third larger greenhouse gas emitter in Europe, with over 30 $GtCO_2$ yearly.

Renewable electrochemical conversion of CO_2



Images from: De Luna et al., *Science*, **2019**, 364, eaav3506

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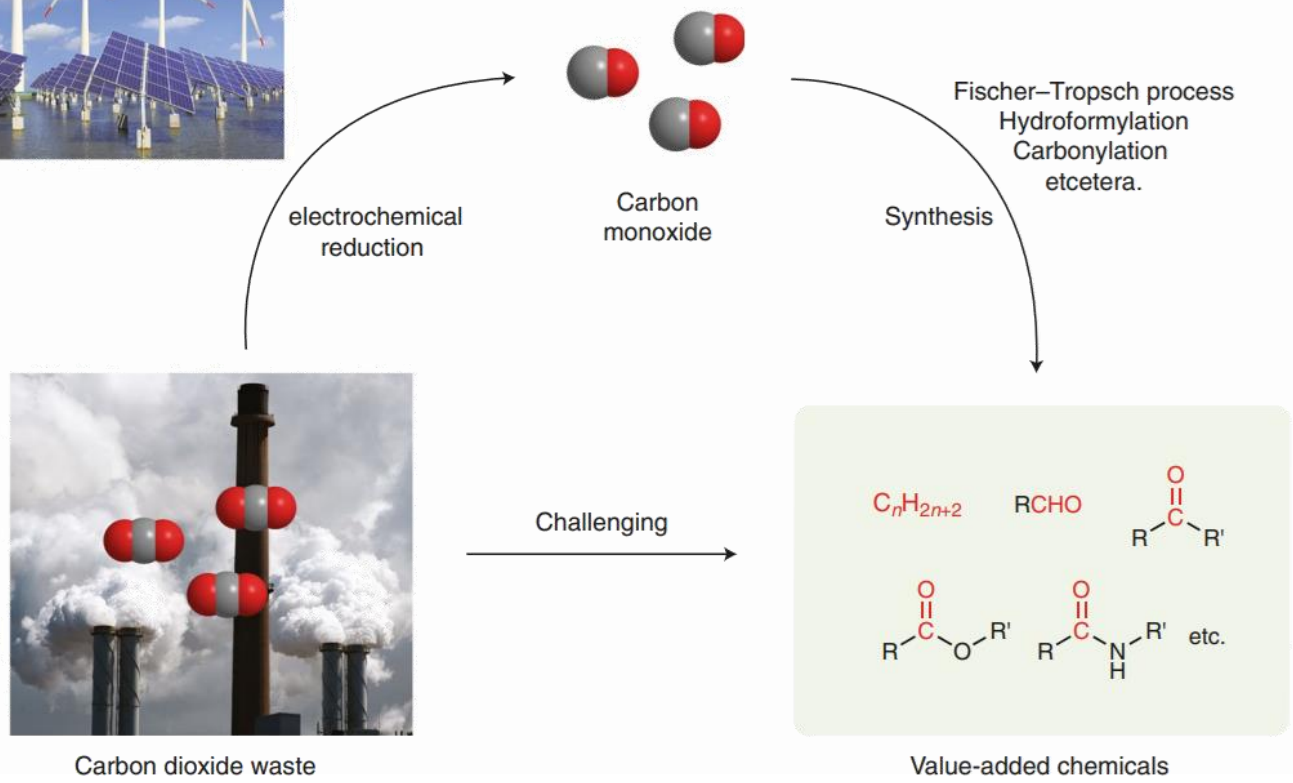
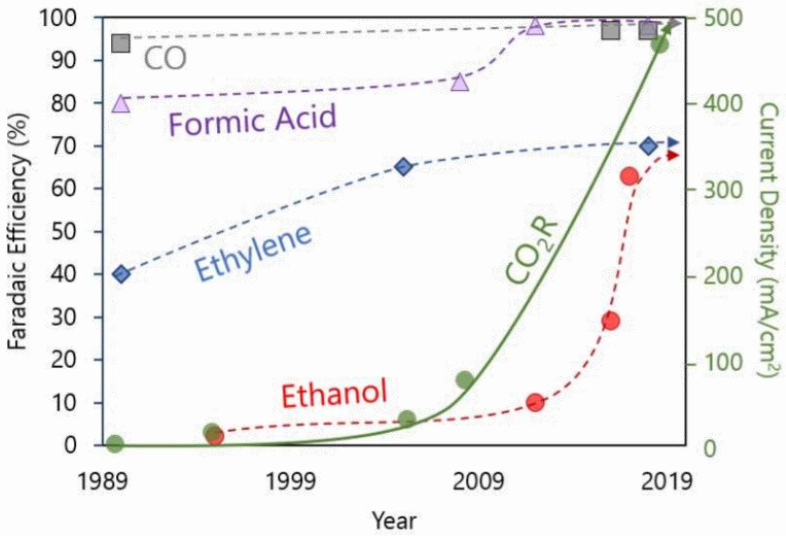
Sequential pathways to higher chemicals *via* CO electrosynthesis

CO as C1-building block for introducing carbonyl functionalities



Parameters	Chemical	Electrochemical
	RWGSR	Heterogeneous
Temperature	High	Low
Pressure	High	Low
Solvent SHE classification	NMP(H)	Water(R)
CO production rate	High	Moderate to high
Controlled CO generation	Poor	Good
Scalability	Good	Good



Enhanced selectivity and conversion efficiencies *versus* higher energy density products

Troels Skrydstrup, Nature Catalysis, **2018**, 1, 244-254

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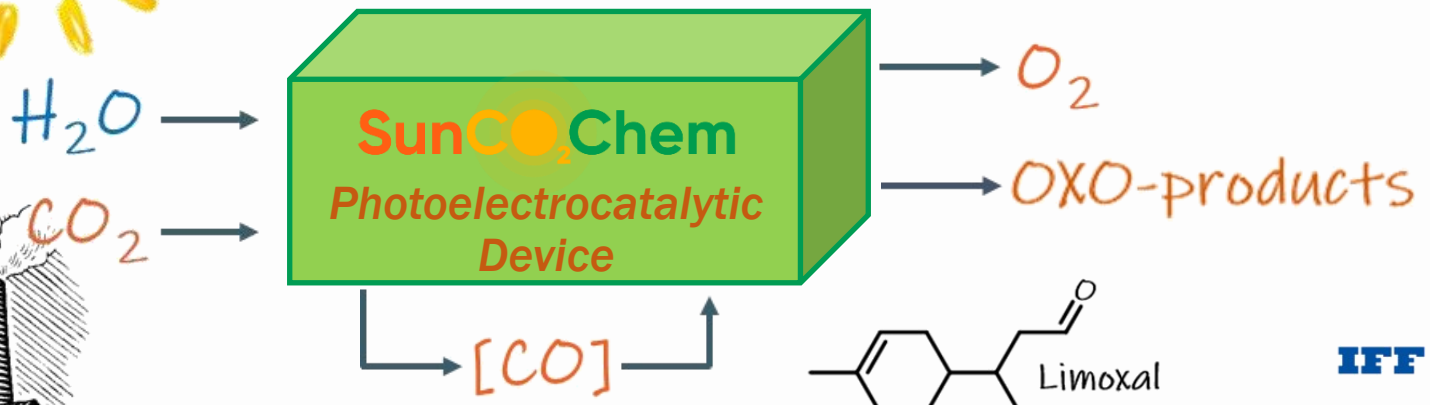
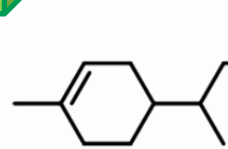
SunCO2Chem Concept

SUN-driven production of energy and high-value chemicals

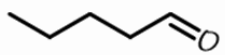
- The project develops a photoelectrocatalytic tandem reactor (TPER) to manufacture **valuable chemical oxo-products from renewable energies** based on **CO_2, H_2O and solar energy.**

Integrated artificial leaf-type device for solar harvesting, CO_2 capture and organic chemical production





IFF



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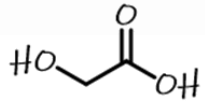

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TPER COMPONENTS

- Hybrid photocathode for CO_2 conversion to oxo-products
- Photoanode for water oxidation
- Transparent bipolar membrane (TBM)
- CO_2 capture and concentration stage

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SunCO2Chem Objective

Three sustainable oxo-products produced from CO_2

- Oxo-products **produced from the use of CO_2** as a renewable carbon source, in comparison to actual routes based on fossil fuels.

GLYCOLIC ACID
Hydroformylation of formaldehyde

Building block applied in dying and tanning, flavoring preservative and emulsion additive.

VALERALDHEYDE
Hydroformylation of Butene
(DOW waste by-product)

Building block applied as food flavouring, in resin and rubber products

LIMOXAL ™
Hydroformylation of limonene

Building block applied as a perfuming agent, in personal care and house cleaning products

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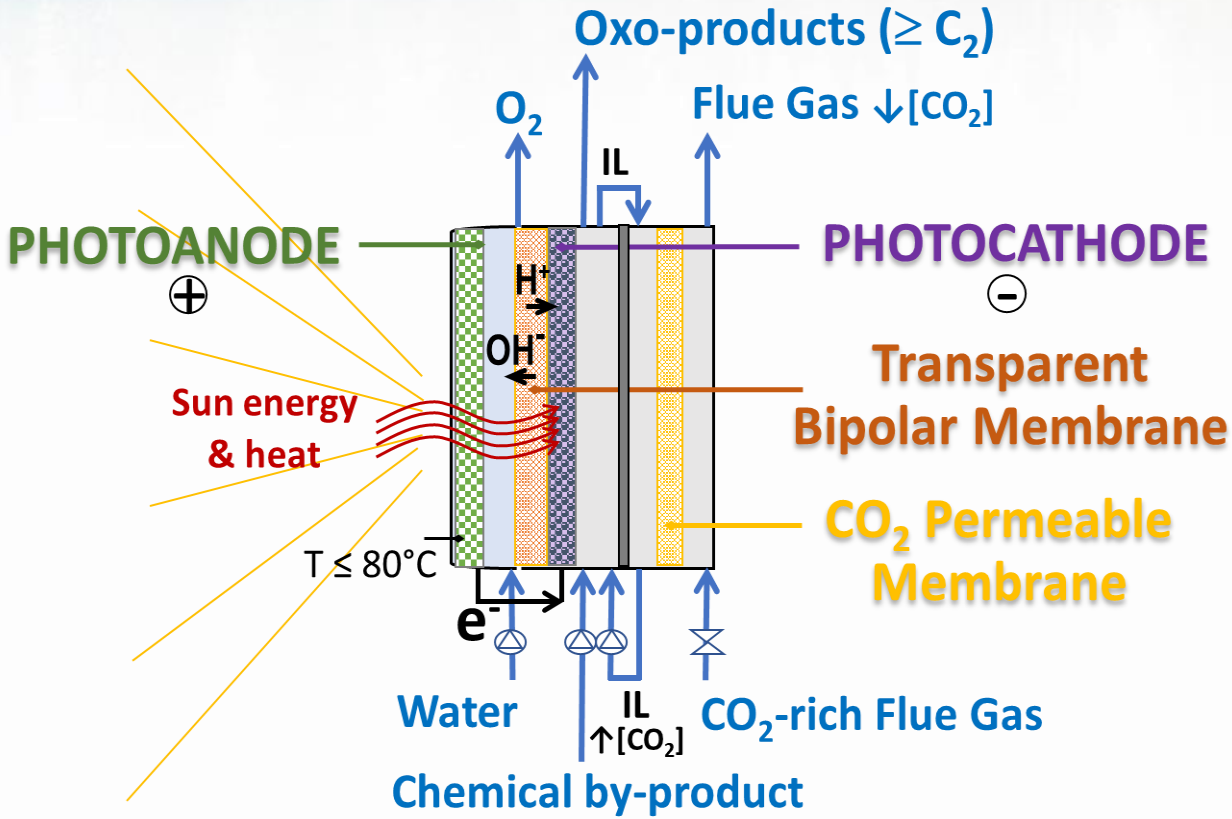
SunCO2Chem TPEC Device



Three-chamber configuration:

ANODIC CHAMBER

- Water oxidation to O_2

CATHODIC CHAMBER

Photo- and *non*-photoassisted coupled reactions

- Selective PEC CO_2 reduction to CO
- CO-hydroformylation of OXO-products

Ionic Liquids electrolytes

MEA *via* a transparent bipolar membrane

Low-cost PV solar cells to boost internal photo-voltage

FLUE GAS & CO_2 CAPTURE CHAMBER

- CO_2 capture from flue gas stream with an asymmetric polysulfone membrane
- CO_2 concentration in Ionic Liquids

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SunCO2Chem Project Phases

TRL 3

Development of materials and components of the TPER cell

Upscaling, testing and validation of the TPER device

Integration and optimisation of materials and components

Socio-economic and environmental impact assessment

TRL 5

WP1
PEC Cell Materials Development

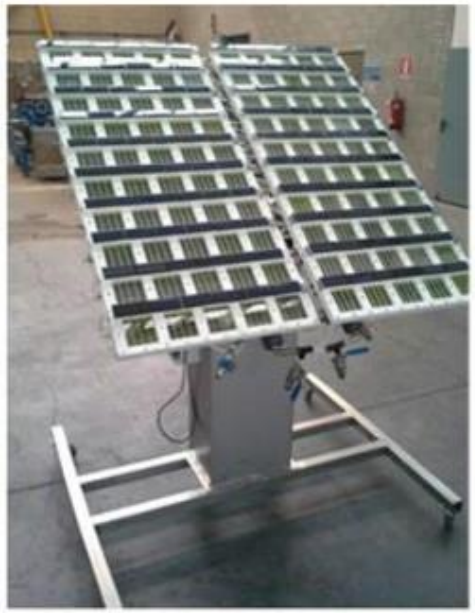
WP2
CO_2 Capture and Concentration Materials Development

WP3
TPER Components Integration

WP4
Design, assembling and testing of final TPER prototype

WP5
Impact Assessment

WP6
Exploitation and Dissemination



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TPER (1m^2) will be validated at the production facility of IFF

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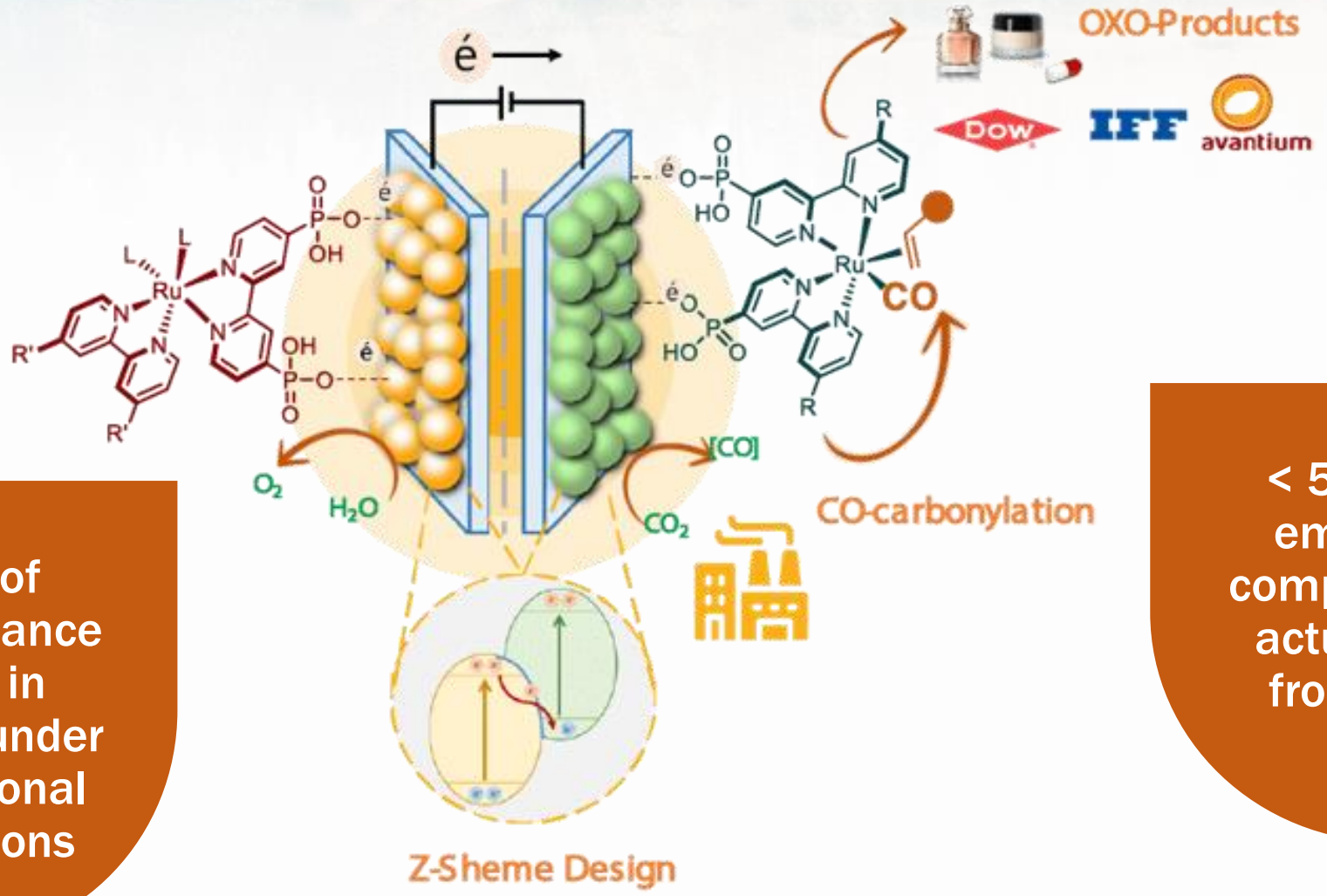
SunCO2Chem Technical Challenges

Overall sunlight to chemical conversion CO efficiency > 10%



Loss of performance < 5% in 1000h under operational conditions

< 50% CO_2 emissions comparable to actual route from fossil fuels

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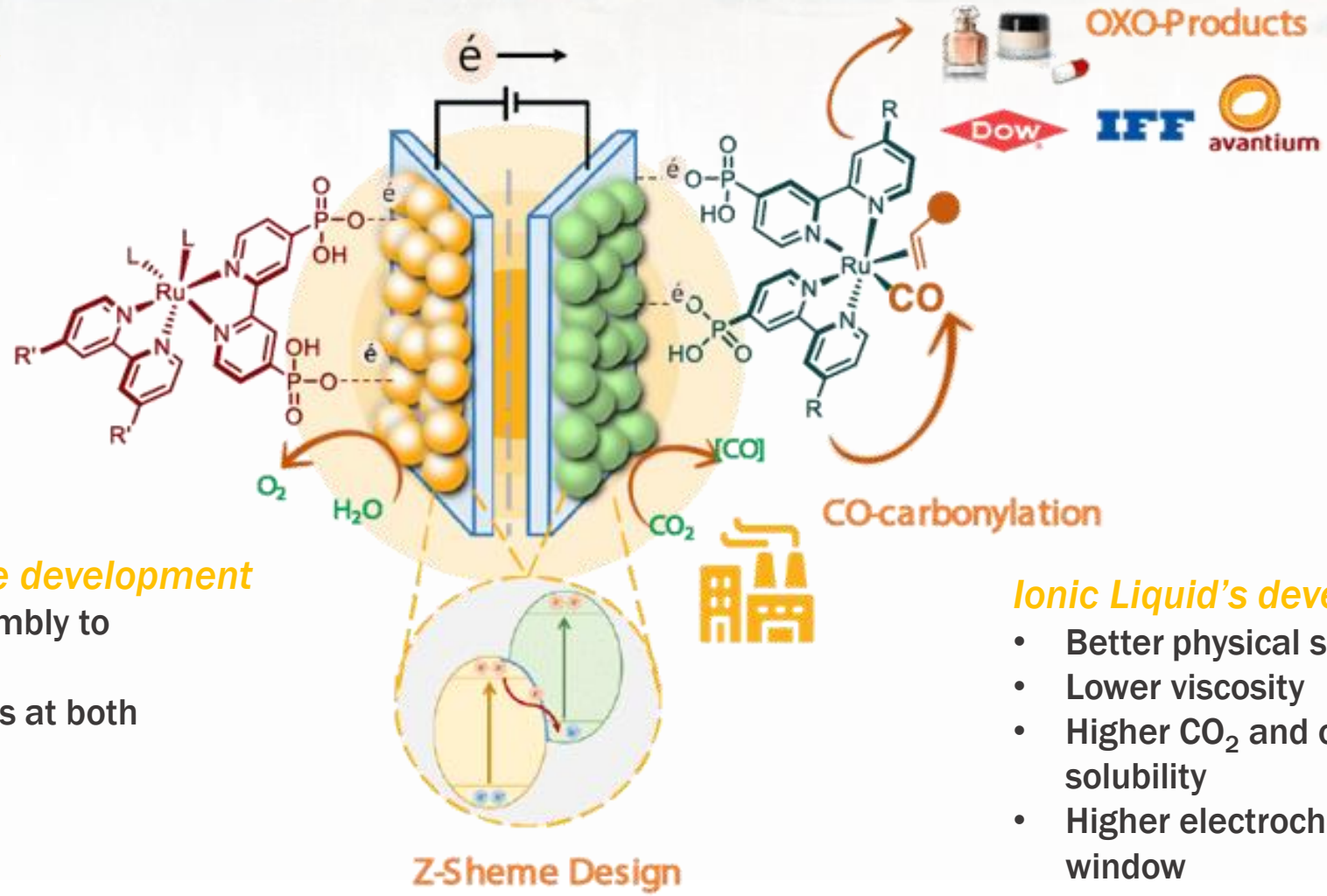
SunCO2Chem Approach

Photo-electrodes development

Multi-heterojunction photoelectrodes for Z-scheme mimicking:

- Metal oxide nanoparticles
- Molecular organometallic chromophores
- Molecular catalysts for water oxidation, CO_2 reduction and hydroformylation



Transparent bipolar membrane development

Bipolar Membrane-electrode assembly to maximize catalyst performance:

- Constant pH and ionic gradients at both compartments
- Use of different electrolytes

Ionic Liquid's development

- Better physical sorption
- Lower viscosity
- Higher CO_2 and organic reagent solubility
- Higher electrochemical stability window

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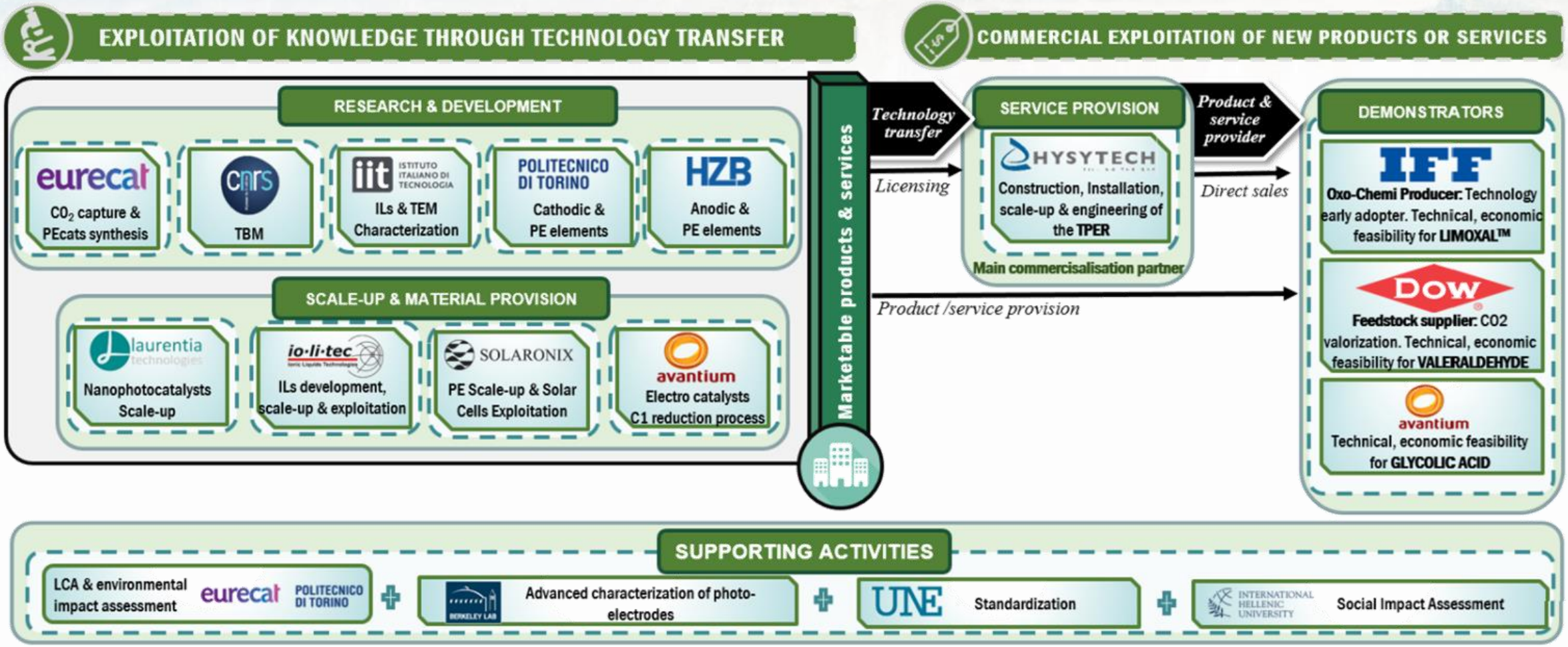
SunCO2Chem Route to Market



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SunCO2Chem Team

A project coordinated by: eurecat

Thank you!

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DECADE

RECODE

European Commission