



DistributEd Chemicals And fuels production from Carbon Dioxide

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Renewable energy to drive electrocatalysis



GREEN ENERGY

CO₂ REDUCTION

NO VEL PROCESS IN DUSTRY

ELECTROCATALYSIS

REACTIVE CATALYSIS

(e.g., electrons, holes, radicals)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under gran tagreemen t No. 86 2030



From linear to circular economy





re search and inno vation programme under gran t agreemen t No. 86 2030

* The Catalyst Review 4 (2021) 8-13 (part 1)



e-Refinery





from small and biobased molecules to a framework of chemical production (e-chemistry) alternative to that based on fassil fuels (cetrochemistry)



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DECADE H2020 Project



DistributEd Chemicals And fuels production From CO₂ in photoelectrocatalytic DEvices









Objective in DECADE project



• DECADE will develop a **novel photo-electrocatalytic (PEC) device** engineered to use waste CO_2 and bioalcohols as feeding inputs to synthetize valueadded products.





a novel (breakthrough) approach

ECADE





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Challenges in DECADE project



- A novel PEC concept engineered to form the SAME product on both sides of the cell, and avoid the formation of O_2 (common in H₂O splitting and CO₂ reduction approaches)
 - because in most of artificial leaf applications oxygen is a waste product (which reduces the effective overall efficiency)
- Integrate solar use in *biorefineries* (⇔ e-refinery)
- Develop flexible solutions with multiple markets (chemicals and fuels)
- Develop **compact** design PEC cells, with easier scalability to be used as **artificial leaves**
- Realize process intensification







Options to realize an artificial leaf







Enhance d efficiencies (higher current densities)
Higher stability

PV/EC









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DECADE specifications



• Input

- · (bio)ethanol and CO2 (biorefinery)
- PV/EC system
- Anode
 - Ethanol oxidative dimerization ⇒ ethylacetate

Cathode

- CO₂ reduction (to acetate) with its catalytic reaction with ethanol to form ethylacetate (**EA**)
 - also form at e formation and reaction with ethanol to form of ethylformate (EF)

Products and uses

• EA+EF mixture in ethanol used as green solvents and fuel additives







DECADE Consortium





Consortium partnership has a strong industrial character, but comprises top level scientists in the area and international collaboration with Japan to allow the best possible benchmarking for the novel approach developed





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ERIC-UniME activities in DECADE



- Design and construction of the lab-scale prototype
- The experimentation on the anodes and cathodes
- · Coupling with the PV cell
- Scale-up of the prototype



TRL = Technology Readiness Level



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ERIC-UniME activities in DECADE





* Curr. Opin. Green Sustain. Chem. 2022, 35:10060



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ERIC-UniME activities in DECADE

Lab-scale prototype



- Gas flow-through reactor
- Metal grid to diffuse the CO₂
- Gas and liquid products sampled from the reservoirs
- Compact design to minimize overpotential
- Obtained acetaldehyde, ethyl acetate, acetic acid, hydrogen and minor compounds





DECADE: Starts the TRL5 validation GOVO campaign

- Received in Messina the prototype by HYSYTECH
 - Improvement were made based on the comments of ERICuniME
- · First test campaign on the prototype developed by HYSYTECH carried out at the University of Messina
 - Provided good results regarding feed valorization.
- DECADE technology will be tested at MOTOR OIL headquarters for the TRL5 validation campaign
 - Use of real feed





M 51 General Assembly in San Servolo, Venice





Test with Scaled-up prototype before TRL5 validation

- Verification of stability and optimization of the system.
- Feed valorization test carried out at University of Messina, obtaining target products like ethyl acetate and acetaldehyde
- They were produced at both anode and cathode
- Obtained also hydrogen in the cathode part
- Future coupling with photovoltaic panel developed by Julich
- PV module will be delivered shortly under the indications requested by ERIC-uniME





Conclusions



DECADE project: develop next generation PEC devices to use CO_2 and bioethanol for the production of green chemicals and fuels





OUR VISION: Integrate solar use in biorefineries (=> e-refinery) for a new zero-pollution model of distributed production of chemic ds & fuels



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https://www.decadeproject.eu/

Thank you for your attention

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