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The New C2 Value Chain from CO_2 Electrocatalytic Reduction

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Title project: Oxalic acid from CO_2 using Eletrochemistry At demonstratioN scale (OCEAN)

#EUGreenWeek

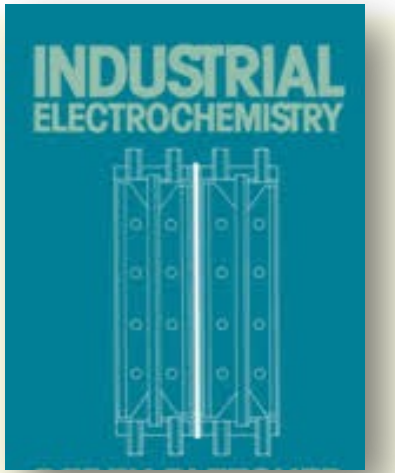
2021 PARTNER EVENT

SUN ERGY | FLOW PHOTO CHEM | SOLAR CHEM | SunCO2Chem | ocean | DECADE | ReCO2DE | European Commission

Objectives

- *Electrification chemical production* ⇨ **renewed interest in electrochemistry in industry** as a clean and carbon-neutral energy source to drive chemical reactions (⇨ ELECTROCATALYSIS).
  - Despite electrochemistry and electrosynthesis being known for decades, **application of electrocatalytic synthesis (starting from small molecules) in industry so far is limited**.
- → **demonstration of electrochemical processes to proof the industrial and economic feasibility**
  - Development integrated solutions for new value chains
- OCEAN overall objectives

1. provide a proof of the economic and industrial feasibility of the electrochemical technology to convert carbon dioxide
2. develop and demonstrate innovative electrochemical technologies to overcome current challenges in electrochemistry
3. Integration of the electrochemical technologies into industrial operations



This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 767798

Opportunities and challenges

***Electrocatalysis:* use electricity directly to drive chemical reactions**

- **use of less expensive starting materials** ⇨ electrochemistry opens the way to energetically restricted reactions, such as the conversion of CO_2 and H_2O to chemicals
- **less aggressive process conditions** ⇨ lower temperatures, reduced energy demand, less degradation of feed and/or product as well as equipment
- **potential to replace polluting chemical reactions with more environmentally friendly electrochemical reactions**, for example by *in situ generation* of reagents such as radicals.
- **fewer processing steps** ⇨ both synthetic and integration with separation / purification
- **Precise control of the oxidation or reduction level** by control of the electrode potential; this also opens the way to oxidations and reductions that require (very) mild conditions for high selectivity

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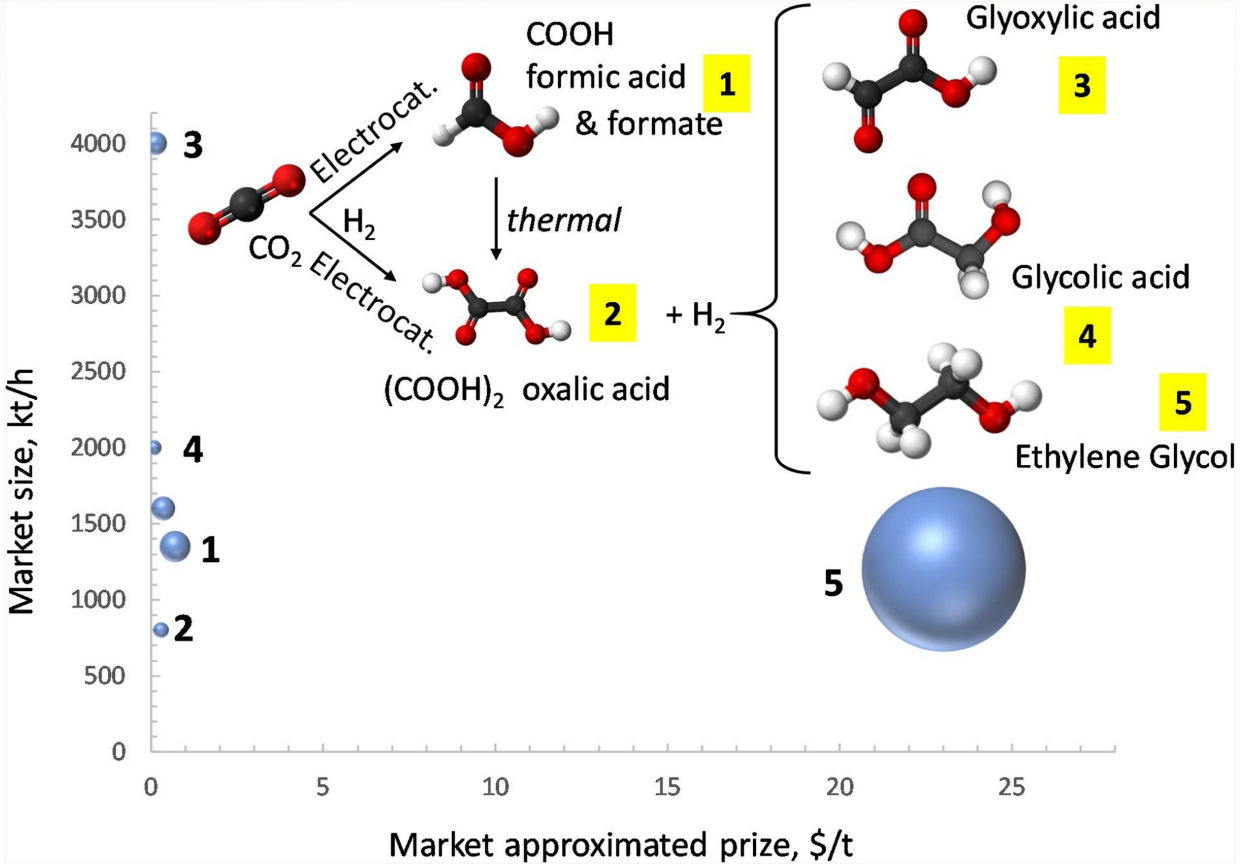
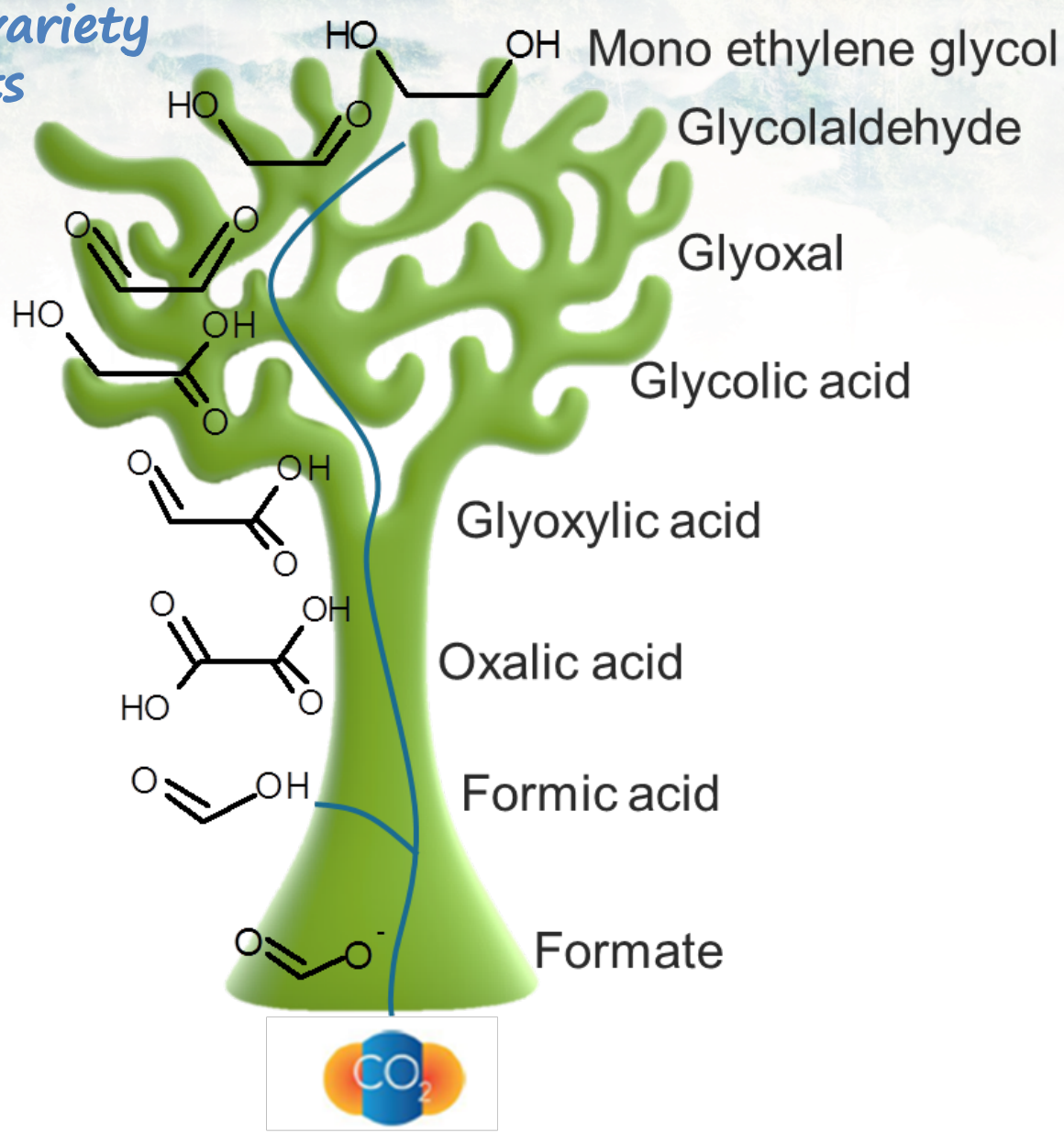
Value tree

Value tree: formic acid as starting compound for a variety of high value products





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Pert diagram of the activities in OCEAN

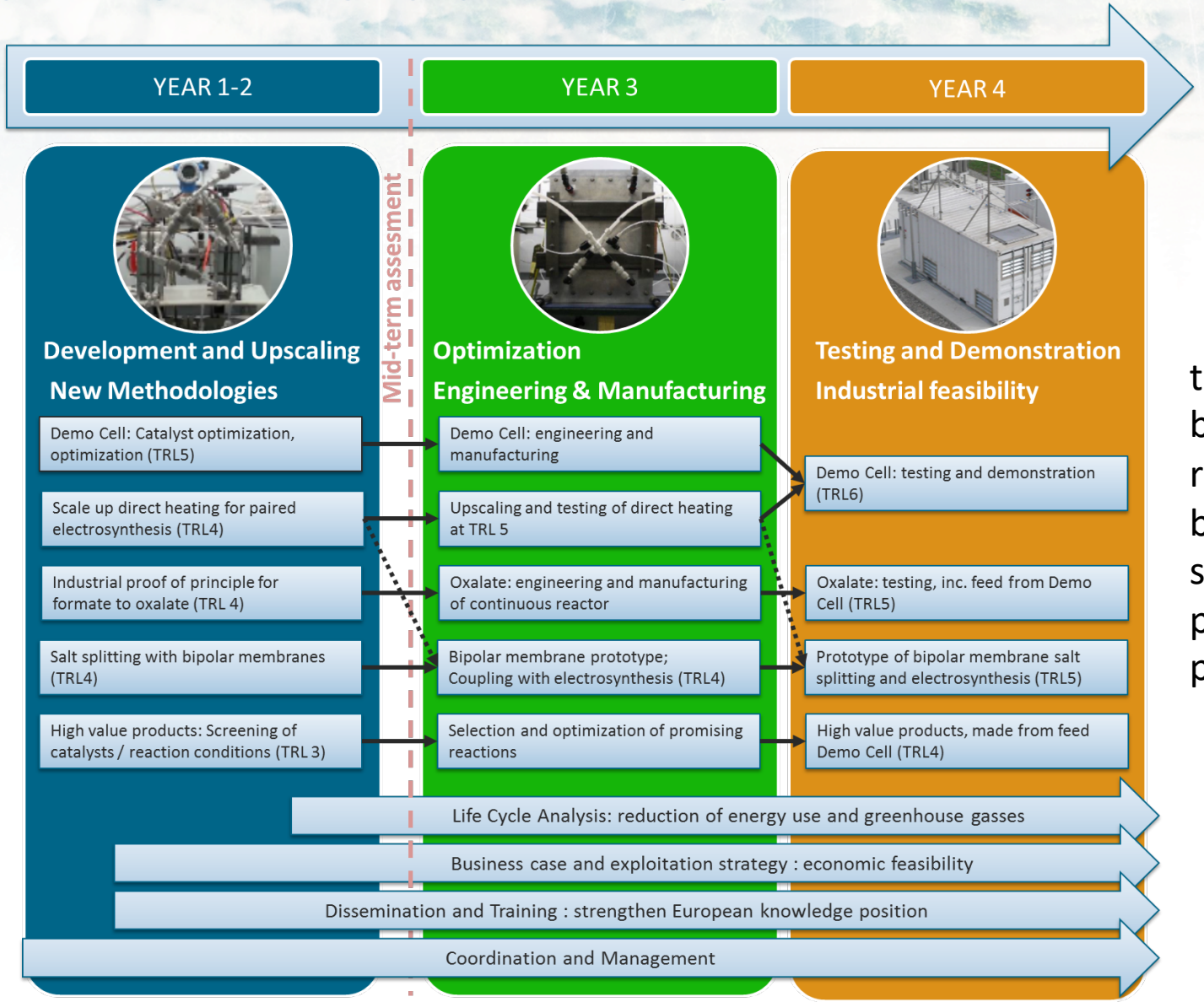
CO_2 to formate:
scale up from TRL 5 → 6-7

Formate to oxalate:
scale up technology

Electrochem. acidification

(electro)catalytic oxalic acid conversion to added value chem.

Dissemination



the reduction of CO_2 will be coupled to an anodic reaction, oxidizing a bio-based feedstock to a starting compound for the production of bio-based polymers

LCA
Business cases

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Role of the OCEAN partners

Trans-disciplinary approach

Partner name / acronym	Main role in the project in relation with competences
Avantium Chemicals BV / AVT	Demo Cell engineering, electrocatalyst optimization, process economics, project coordination
Gaskatel GmbH / GSKL	Upscaling of gas diffusion electrodes
Gensoric GmbH / GENS	Upscaling of the technology for temperature modulation function to match the kinetics of the anode with the cathode
Hysytech S.R.L. / HYS	Development/building of the reactor to convert formate to oxalate by calcination; manufacturing of the electrochemical cell
European Research Institute of Catalysis A.I.S.B.L. / ERIC	Development of electrocatalyst and comparison with chemocatalysts; project management
Fondazione Istituto Italiano di Tecnologica /IIT	LCA and process intensification: intensify the salt splitting step by employing a bipolar membrane
RWE Generation SE / RWE	Industrial demonstration; process economics
Universiteit van Amsterdam / UVA	Hydroformulation, hydrogenation and polymerization

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Demo cell (starting at TRL 5)

- Starting Demo TRL 5 setup for CO_2 to formate

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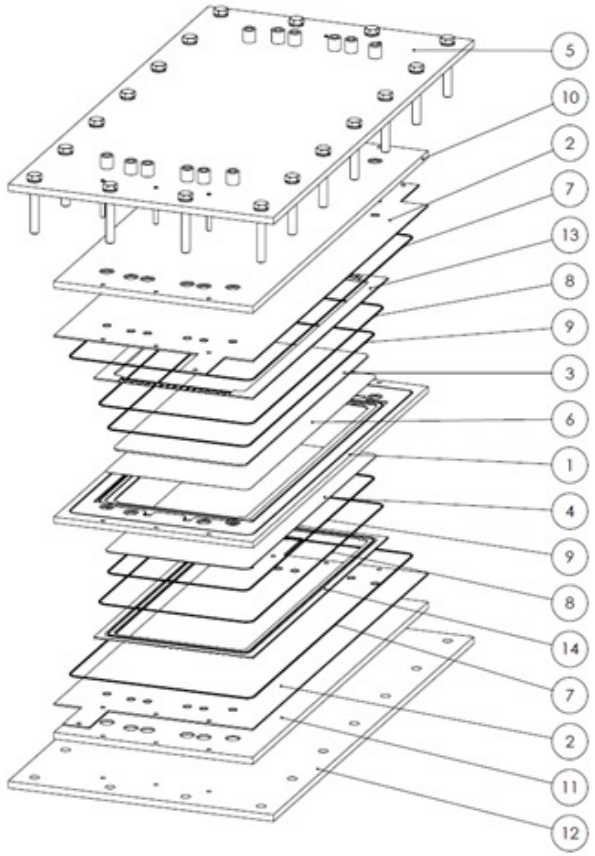
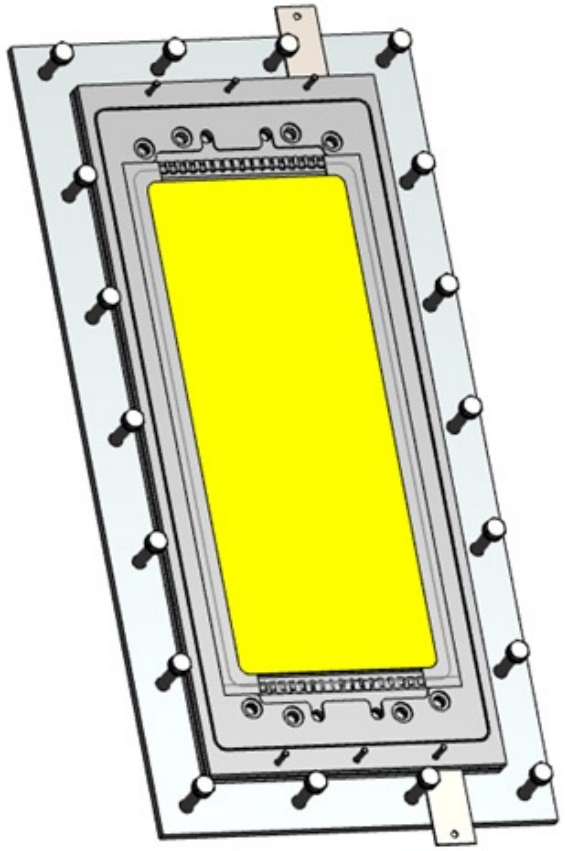
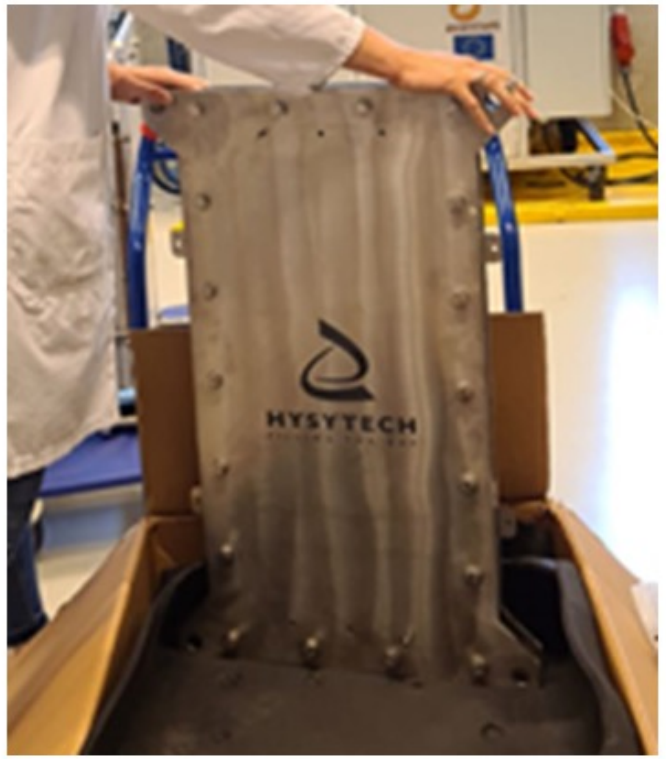
Scale-up of stacked electrocatalytic unit





0,4 m^2 electrode



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Container OCEAN Demonstrator

250 g/h CO_2 into formate

Now under testing under environmental relevant conditions at RWE

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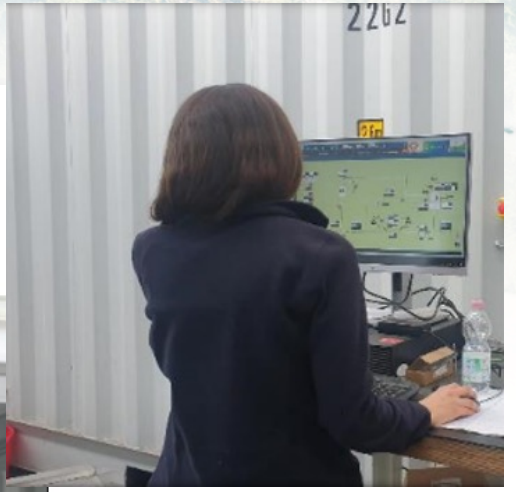
Inside view of the OCEAN demonstrator

1. Cathodic side (highlighted in **blue**)
2. Anodic side (highlighted in **green**)
3. Electrochemical Cell (highlighted in **orange**)
4. Electrics and control (highlighted in **purple**)



Fully automatized

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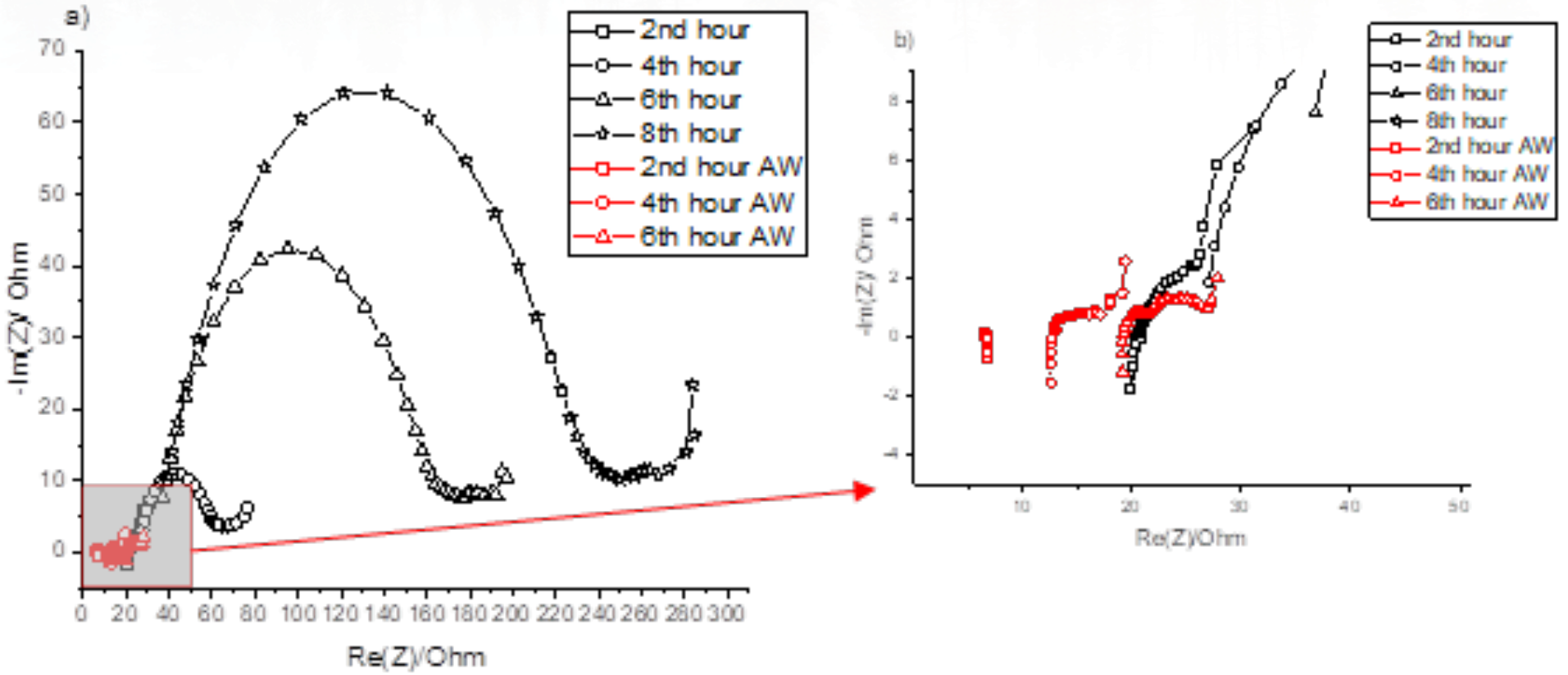
Integrated electrode monitoring by EIS

Electrochemical Impedance Spectroscopy (EIS)



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Prototype to convert oxalate to formate

the assembled unit, the electrical cabinet with the control interface and the gas analyzer to monitor the process

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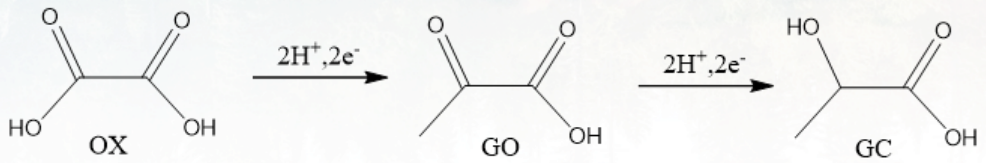
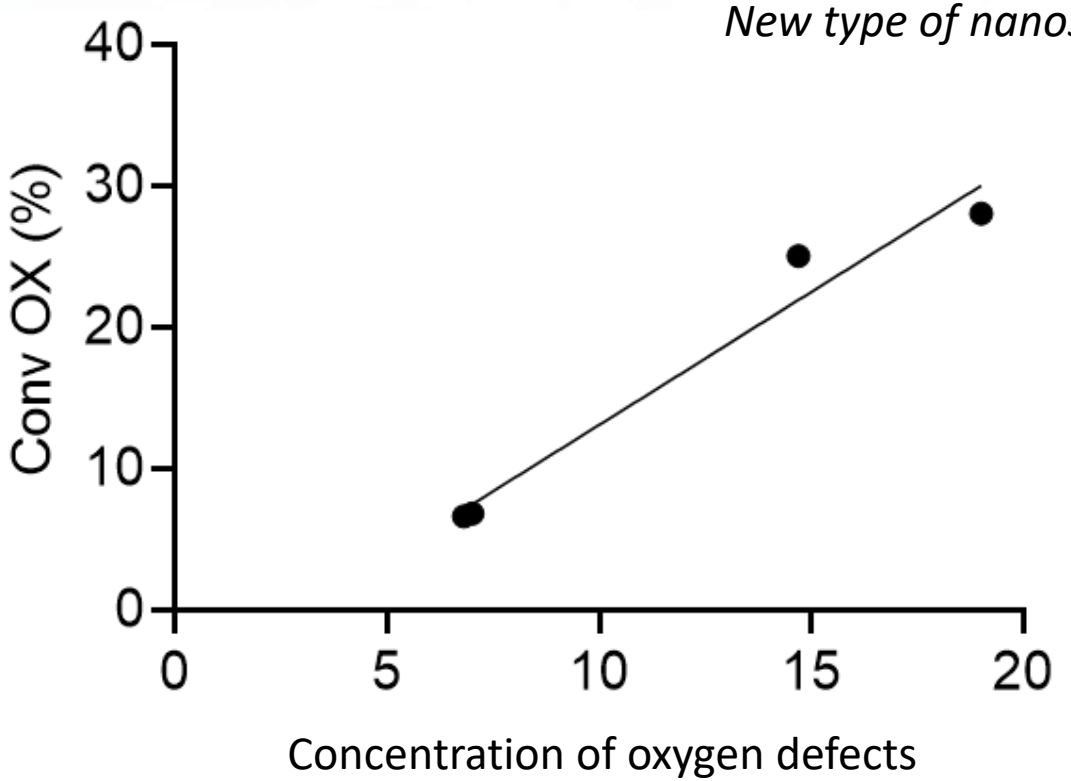
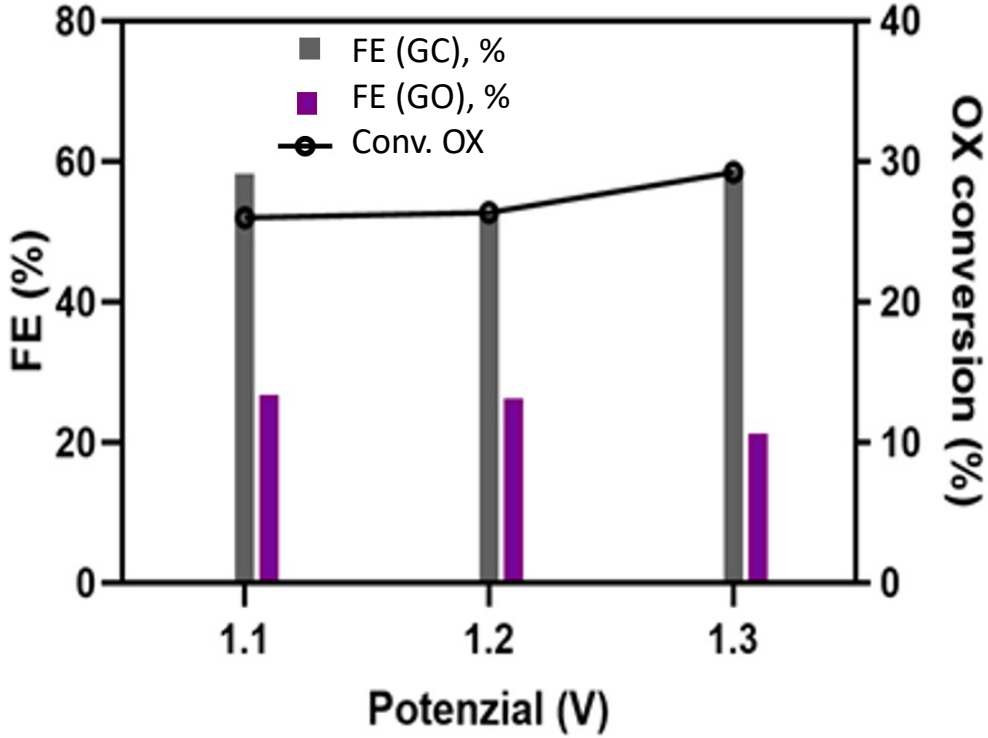
Electrocatalytic conversion oxalic acid



GO: glyoxylic acid
GC: glycolic acid

New type of nanostructured electrodes





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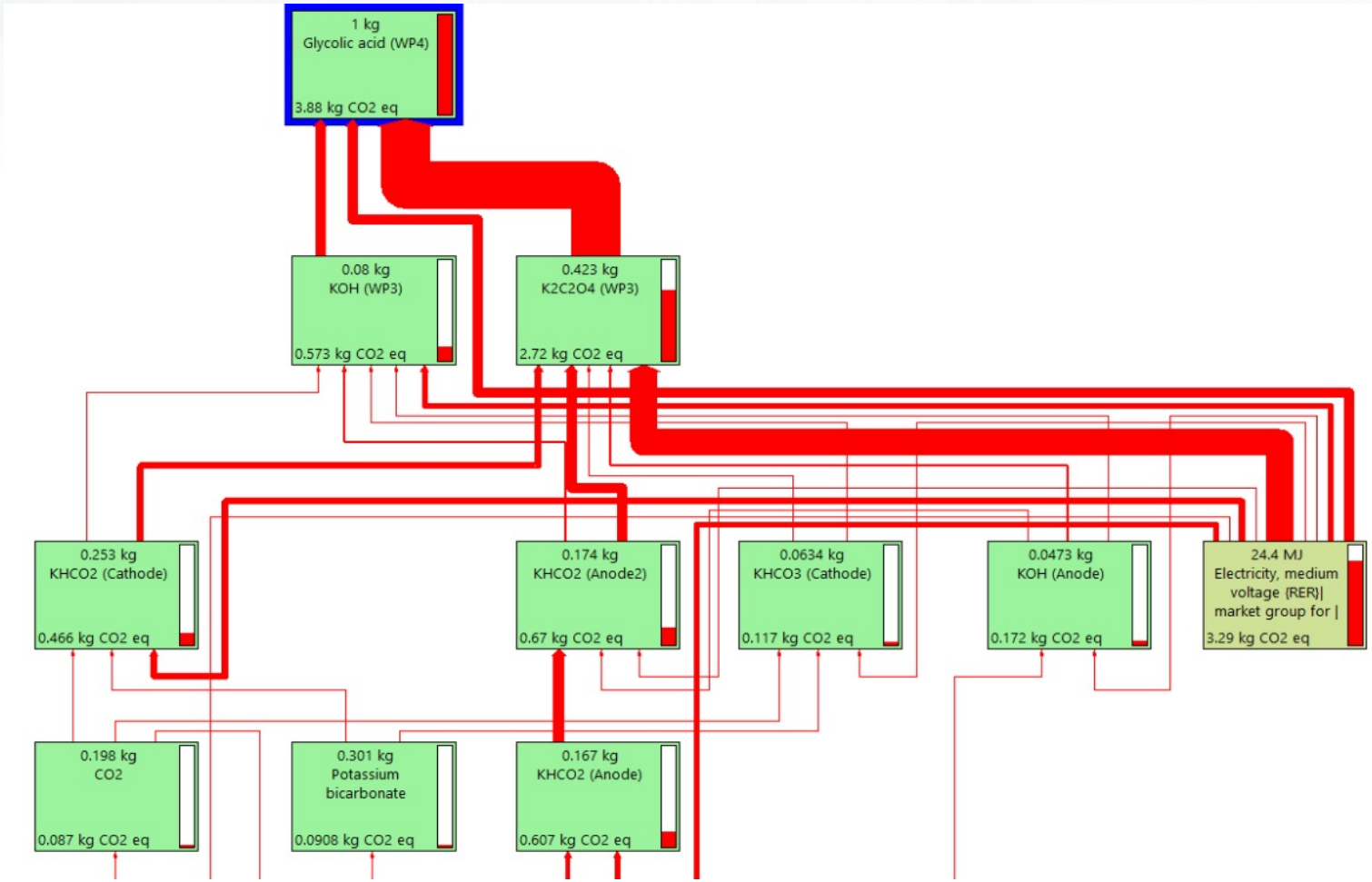
LCA of glycolic acid production



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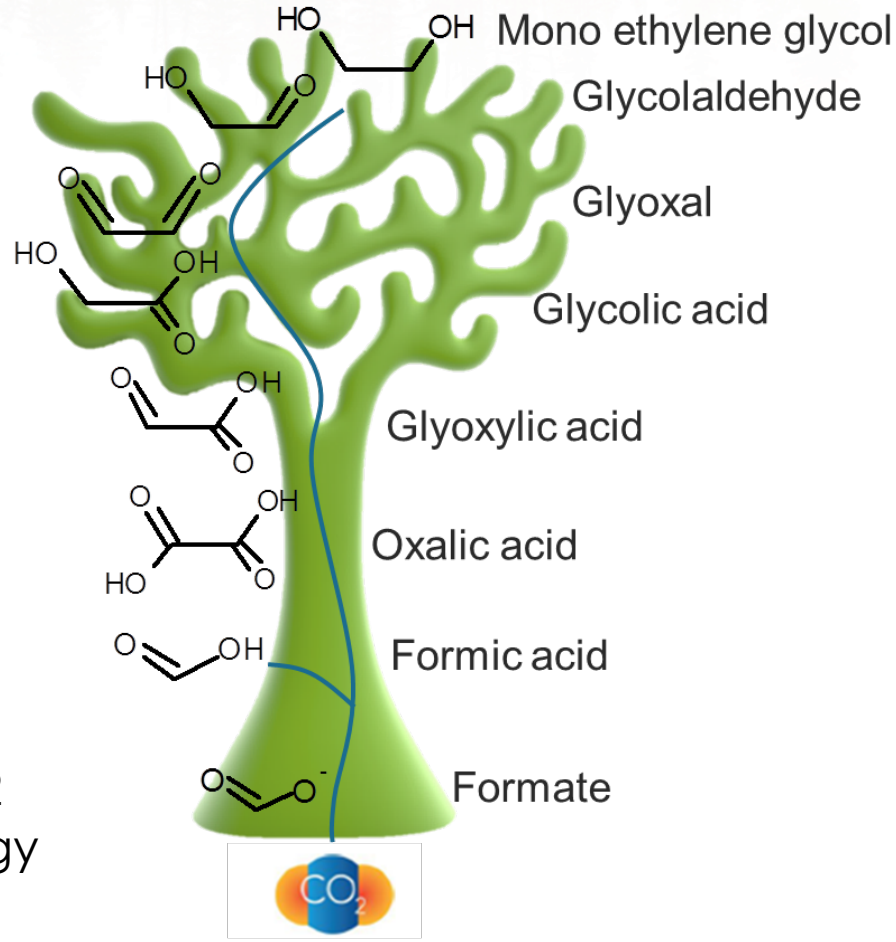
SUMMARY

OCEAN project: creating a new value chain for zero pollution C2 chemicals from CO_2

Our prototype

We create a new value tree from CO_2



OUR VISION: develop an advanced electrocatalytic prototype to produce C2 chemicals from CO_2 using renewable energy

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