BioRECO$_2$VER

Thermophilic CO_2 bio-electro recycling for continuous acetate production

Laura Rovira-Alsina, Elisabet Perona-Vico, Lluís Bañeras, Jesús Colprim, M. Dolors Balaguer, Sebastià Puig

Okinawa, 07st - 10th October 2019

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 760431.

Concrete

is the most widely used man-made material in existence


Water

Okinawa

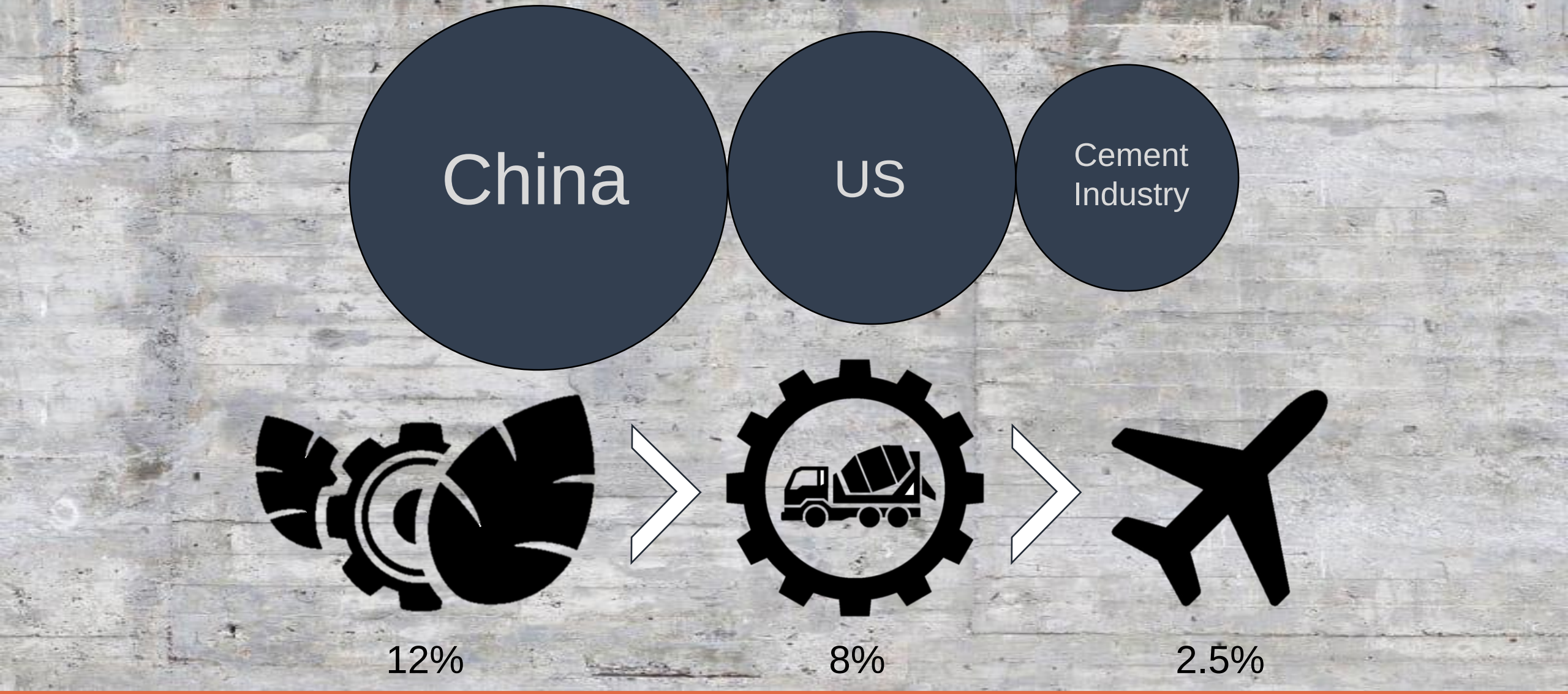
Source: Japanupdate.com/Hana-block is Okinawa's original wall art

A building wall made of 'hana blocks.'

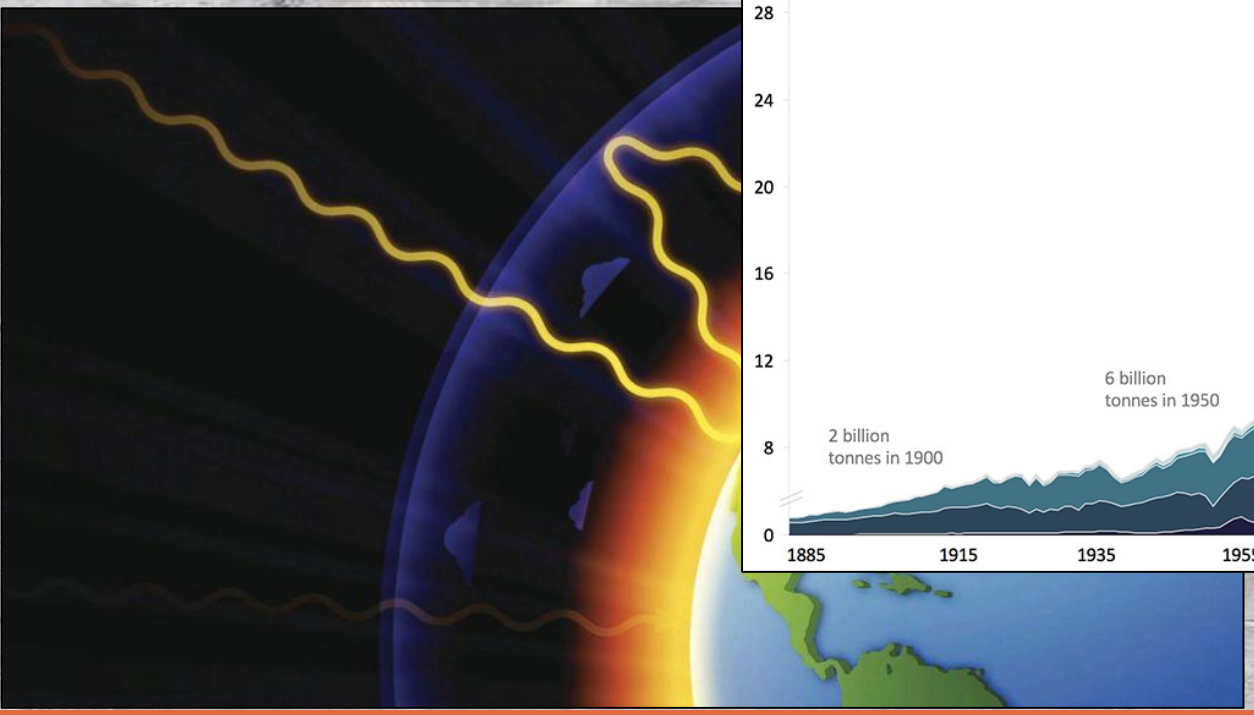
For foreigners, or even visiting mainland Japanese, the most striking feature in Okinawa is the use of concrete for almost anything. Most buildings here are made of concrete, and so are utility poles and even benches, tables and guardrails in parks and other public areas.

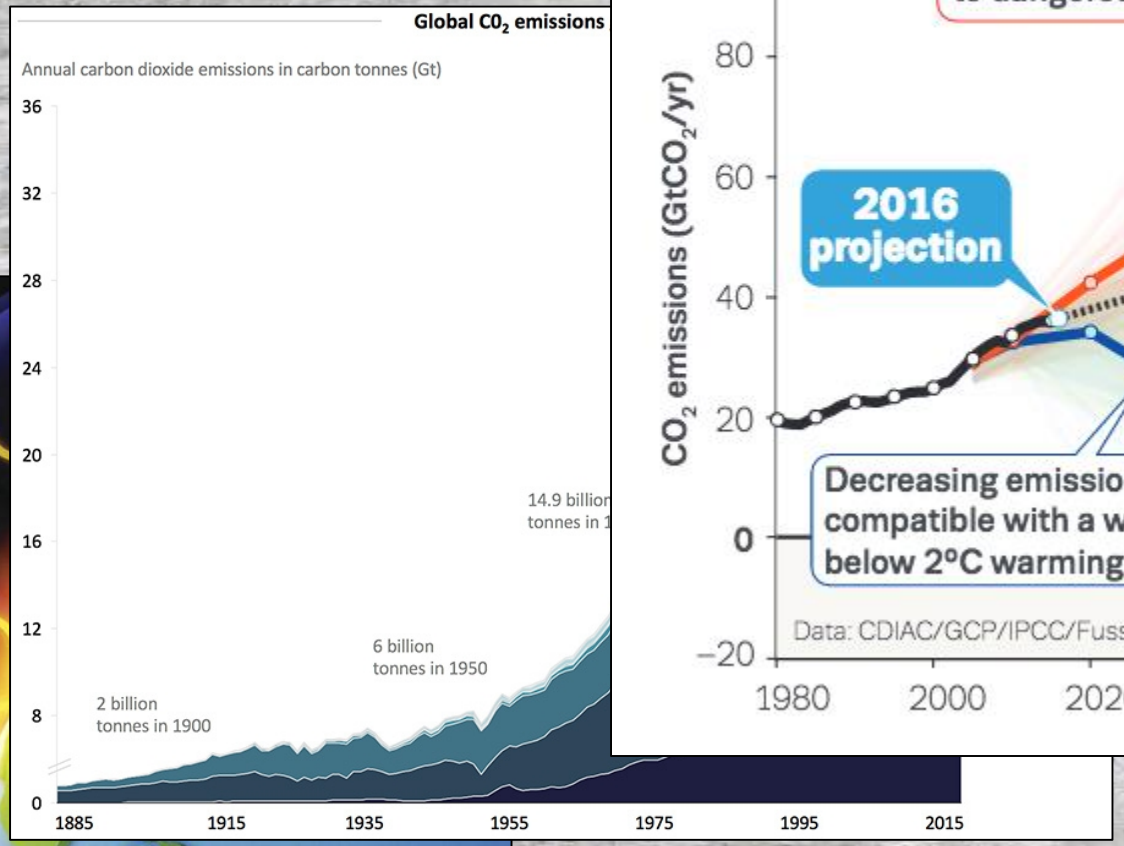
Cement

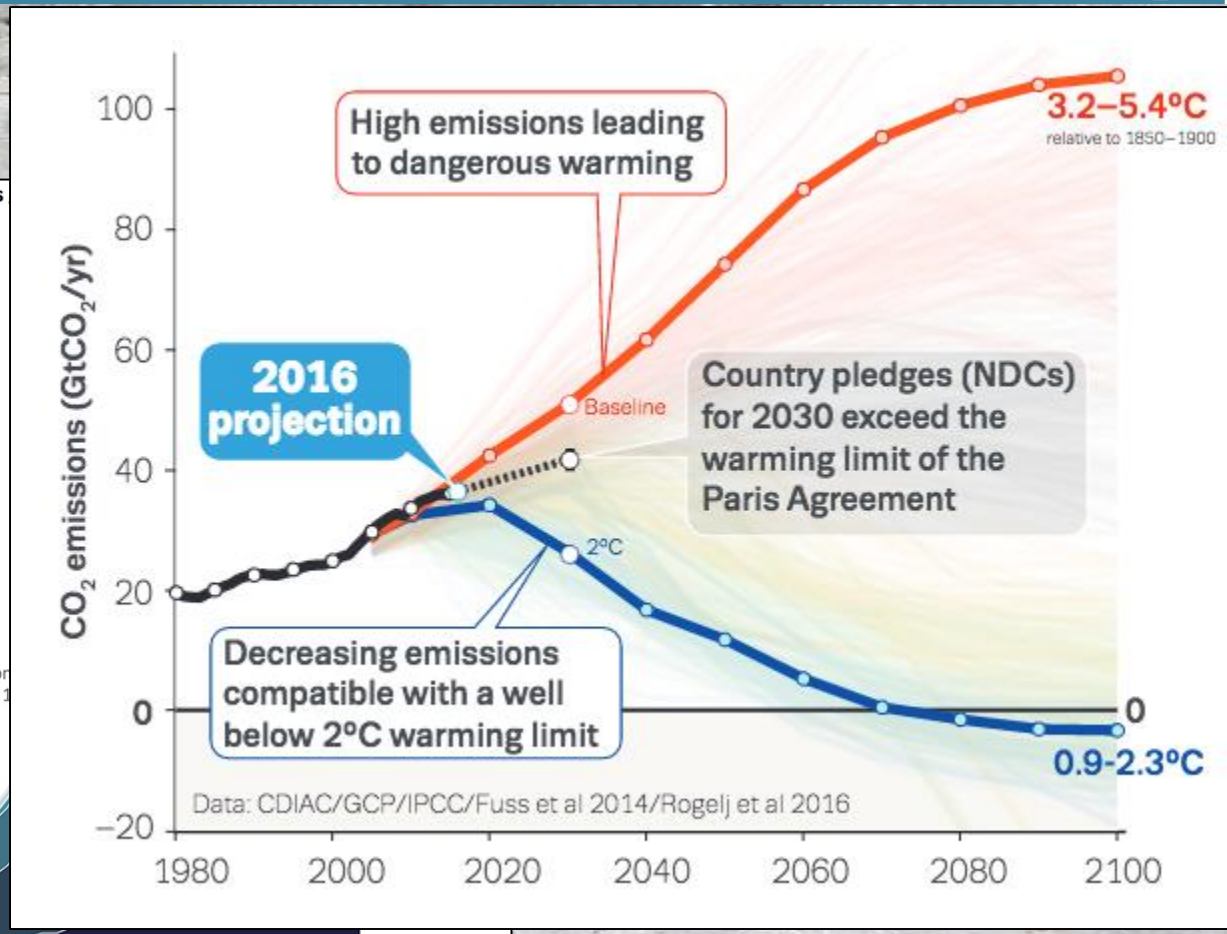
Concrete – C footprint



CO_2 concerns







MET for CO_2 reduction

Bioresource Technology 228 (2017) 201–209

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Tracking bio-hydrogen-mediated production of commodity chemicals from carbon dioxide and renewable electricity

Sebastià Puig [a,*], Ramon Ganigué [a,b], Pau Batlle-Vilanova [a,c], M. Dolors Balaguer [a], Lluís Bañeras [d], Jesús Colprim [a]

Bioelectrochemistry 117 (2017) 57–64

Contents lists available at ScienceDirect

Bioelectrochemistry

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Microbial electrosynthesis of butyrate from carbon dioxide: Production and extraction

Pau Batlle-Vilanova [a,b], Ramon Ganigué [a,c], Sara Ramió-Pujol [a,d], Lluís Bañeras [d], Gerard Jiménez [a], Manuela Hidalgo [e], M. Dolors Balaguer [a], Jesús Colprim [a,*], Sebastià Puig [a]

ARTICLE

Unravelling the factors that influence the bio-electrorecycling of carbon dioxide towards biofuels

R. Blasco-Gómez,[a] S. Ramió-Pujol,[b] L. Bañeras,[b] J. Colprim,[a] M. D. Balaguer[a] and Sebastià Puig.*[a]

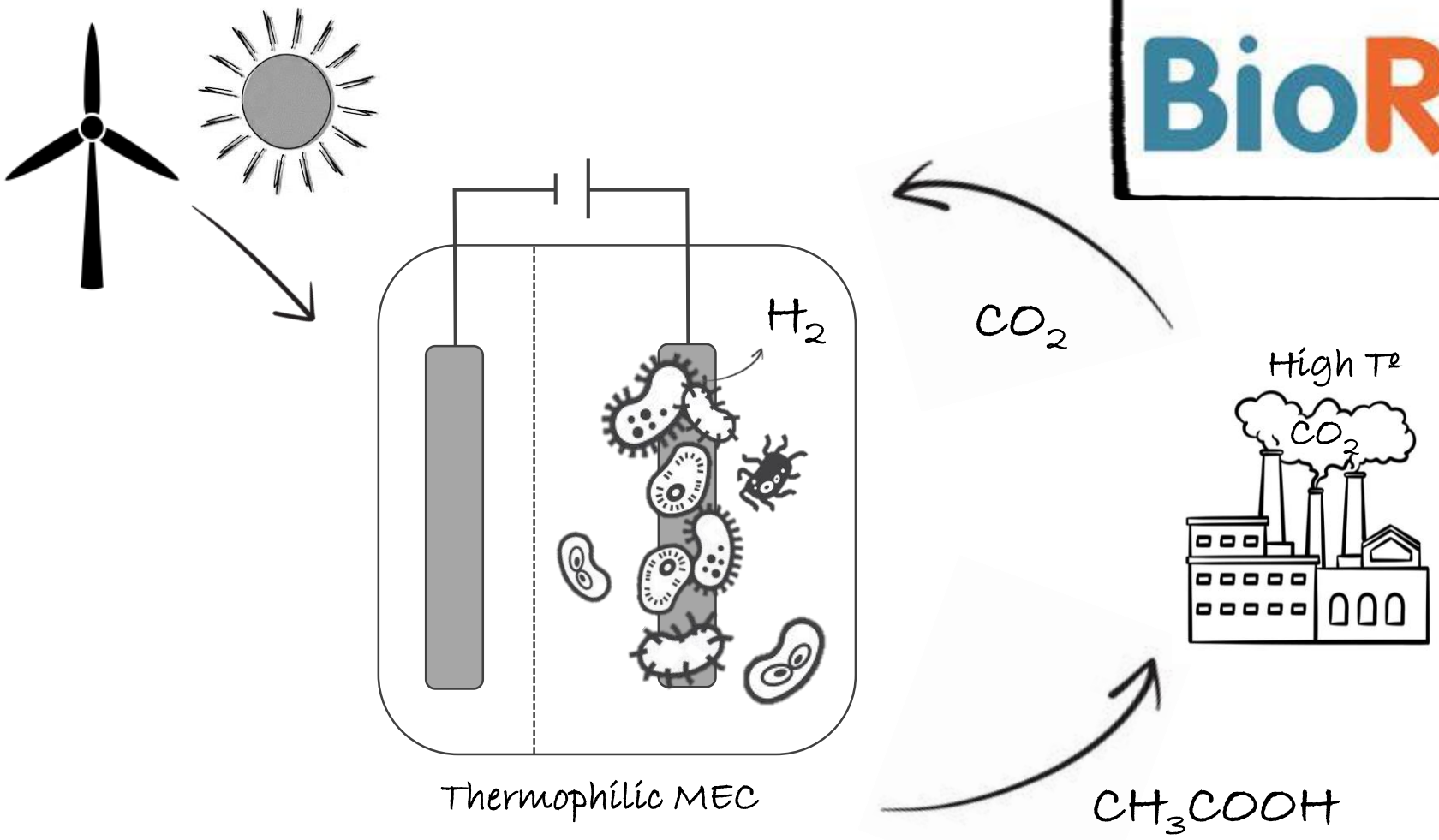
Accepted 00th January 20xx

ble Chemistry

Recent advances in industrial CO_2 electroreduction

Oriol Gutiérrez Sánchez[1,2,a], Yuvraj Y. Birdja[1,a], Metin Bulut[1], Jan Vaes[1], Tom Breugelmans[1,2] and Deepak Pant[1]

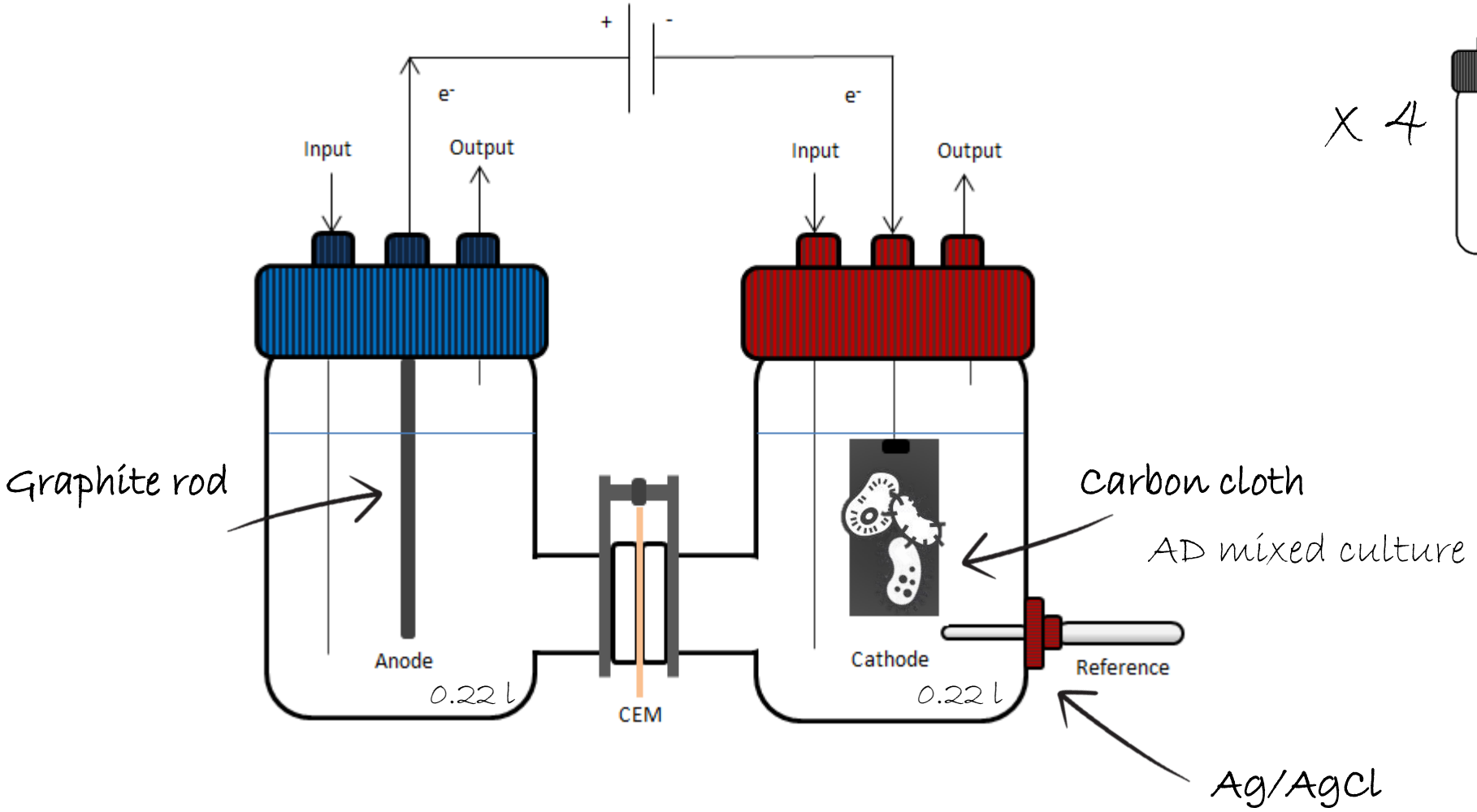
AIM of the study

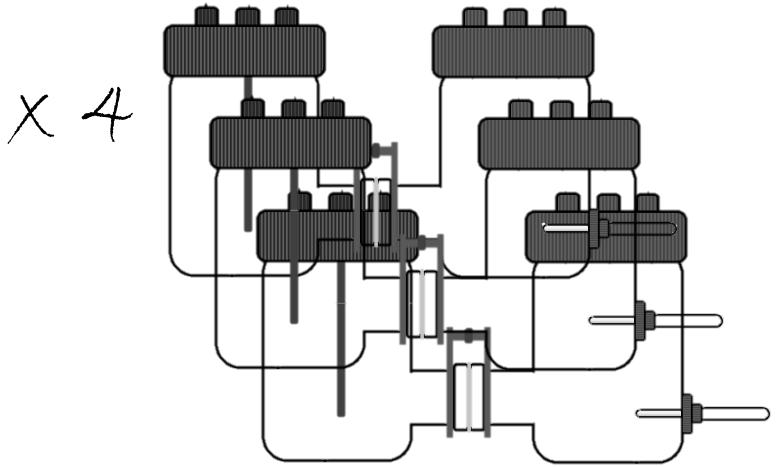


High T°

- Higher reaction rates
- Less risk of contamination
- More product specificity

Configuration



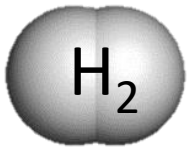


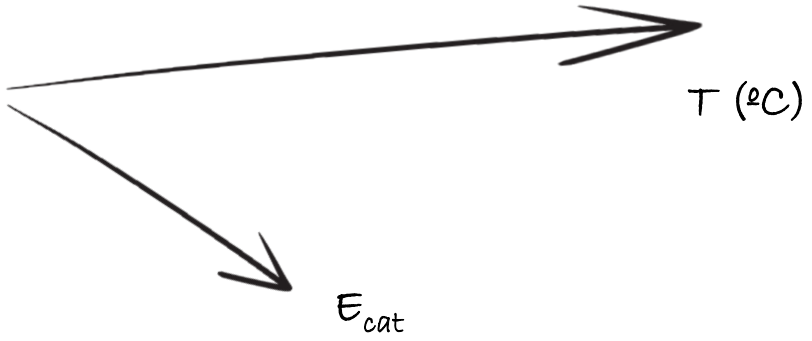
Preliminary tests are always needed

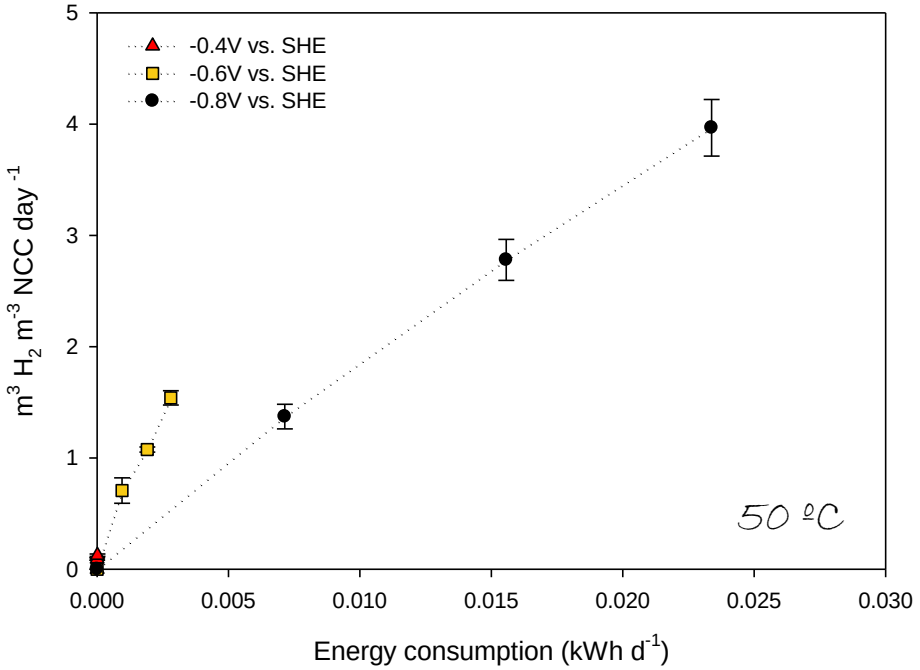
Pre-characterization

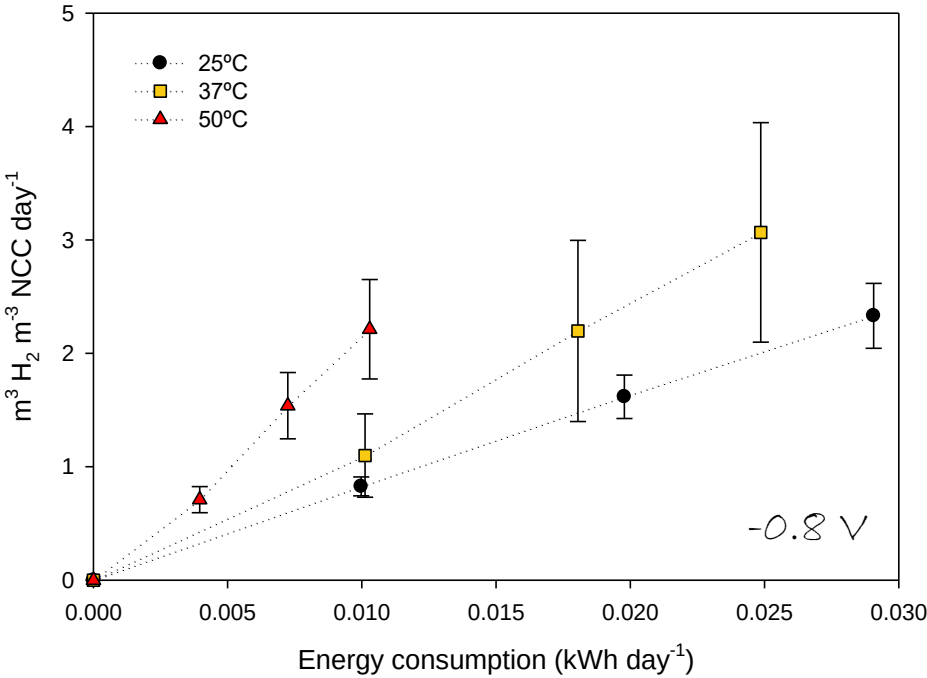
Abiotic tests

T (ºC)	E_{cat} (V vs. SHE)
25	
37	-0.8
50	-0.6
	-0.4







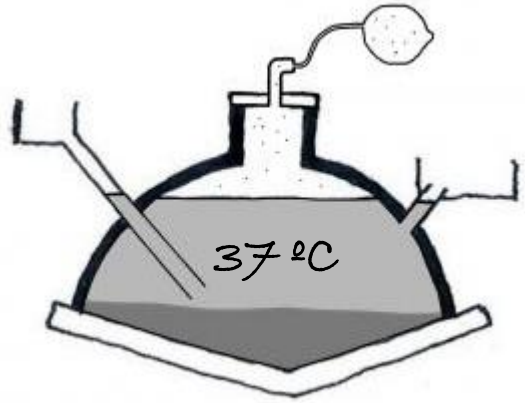


Operational conditions

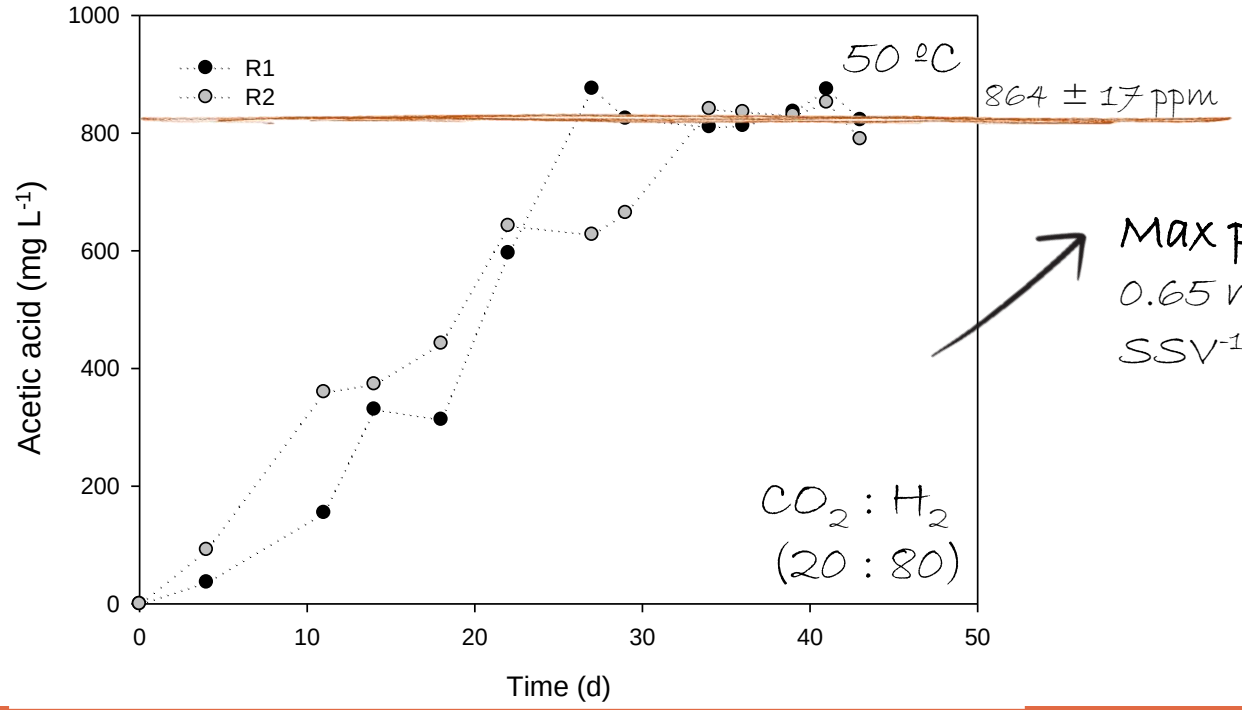
- 50 ºC
- -0.6 V vs. SHE

Pre-characterization

AD
mixed culture

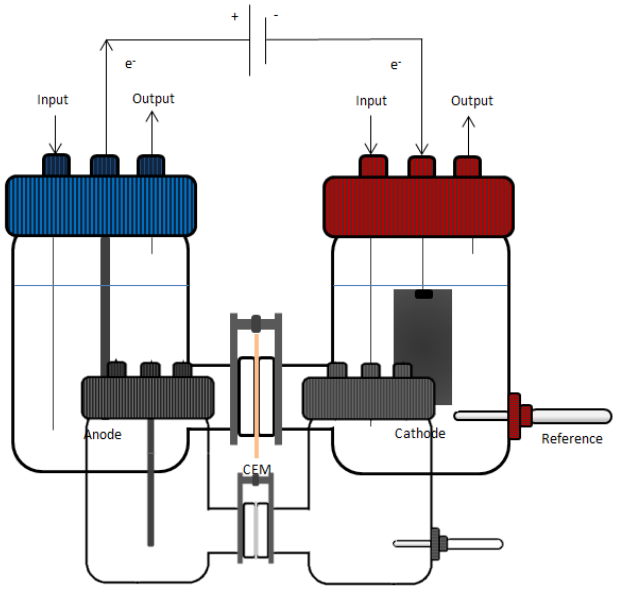


- Robust
- Mesophilic
- Fully available



Max prod. rate:
0.65 mg acetate mg SSV^{-1} day^{-1}

Long-term acetate production

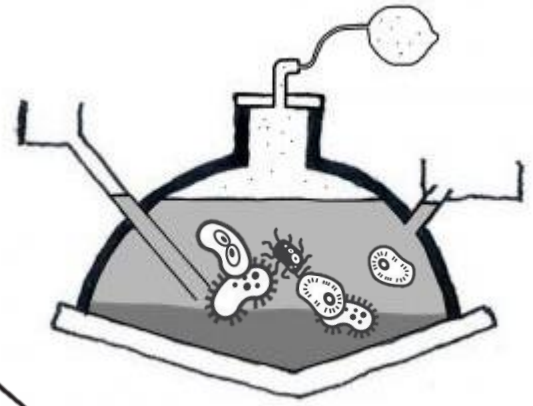


Reactor 1

Reactor 2

1:4 dilution

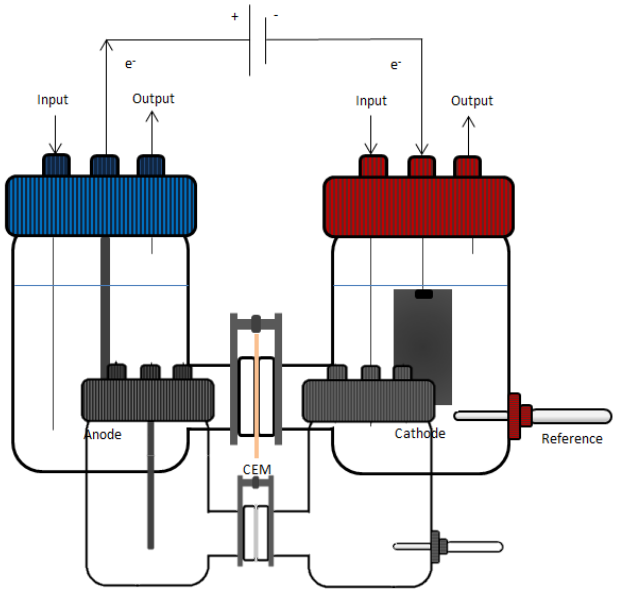
67 days



AD

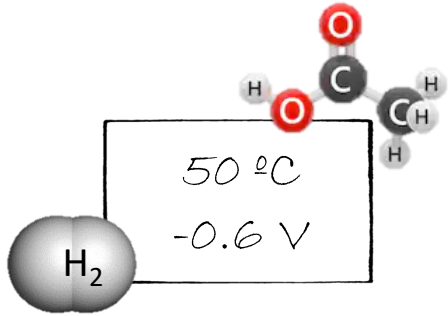
mixed culture

1:20 dilution

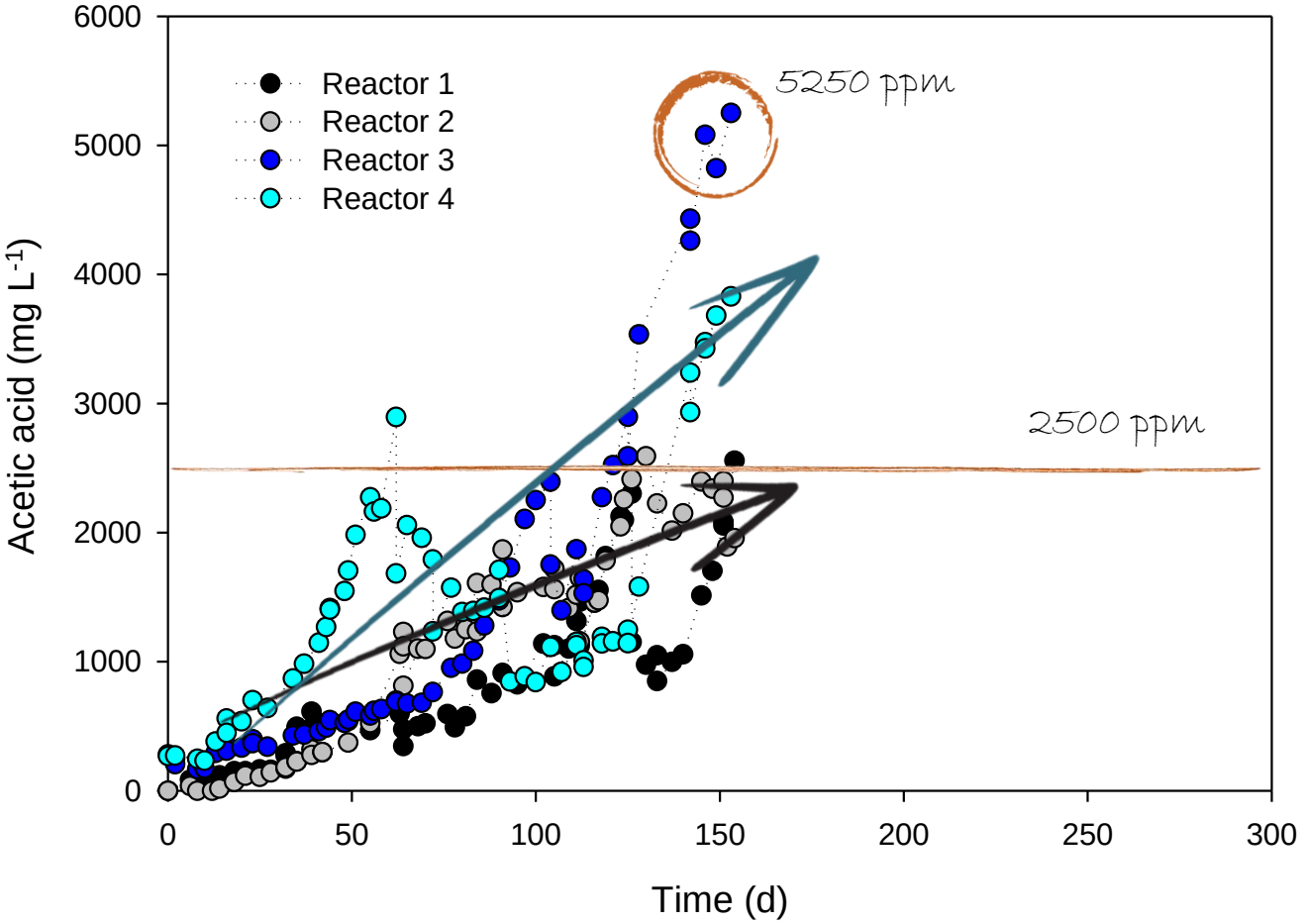


Reactor 3

Reactor 4



Long-term acetate production



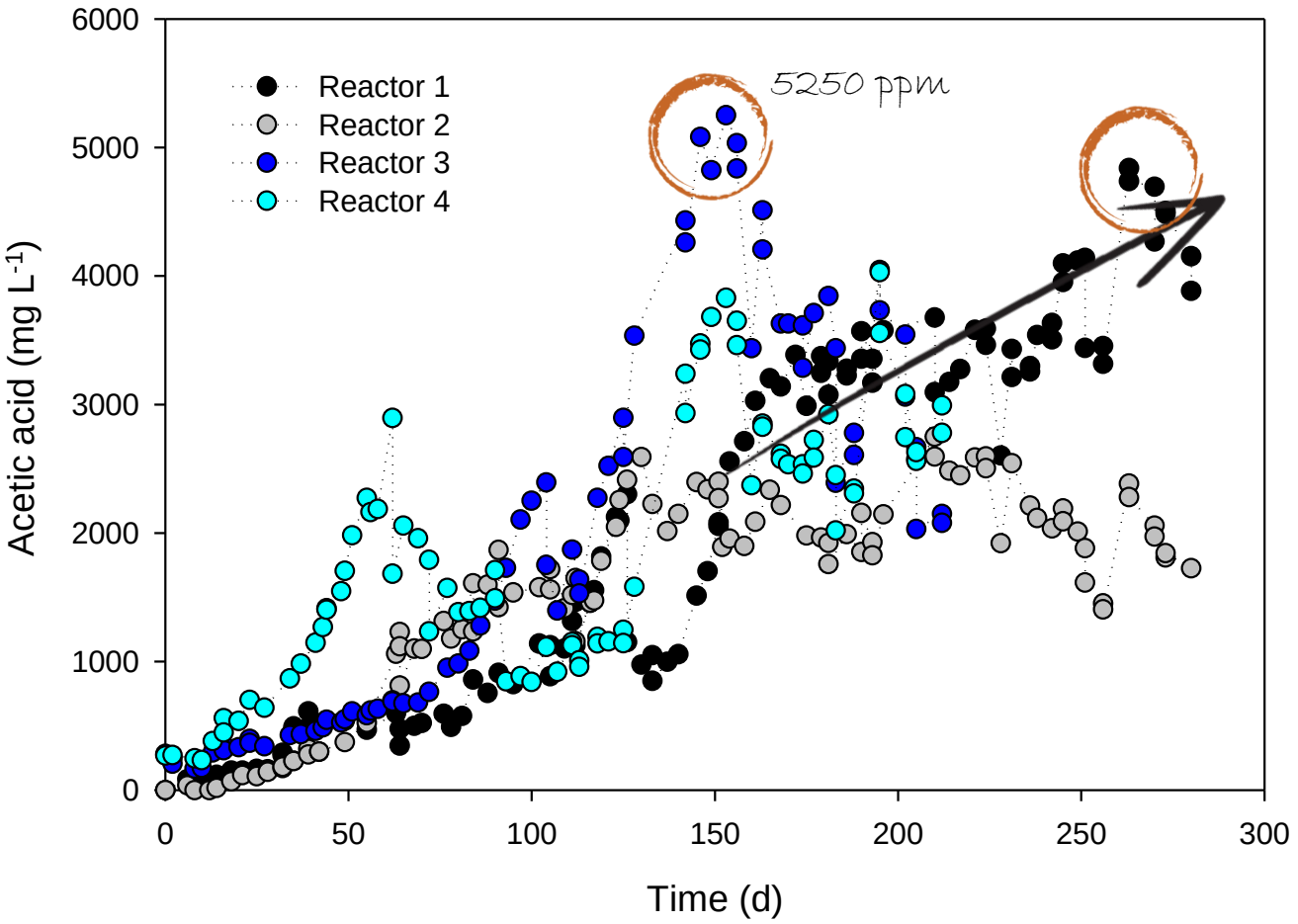
Max production rate

468 mmol acetate m^{-2} d^{-1}

Coulombic efficiency

80-90%

Long-term acetate production



Max production rate

468 mmol acetate m^{-2} d^{-1}

Coulombic efficiency

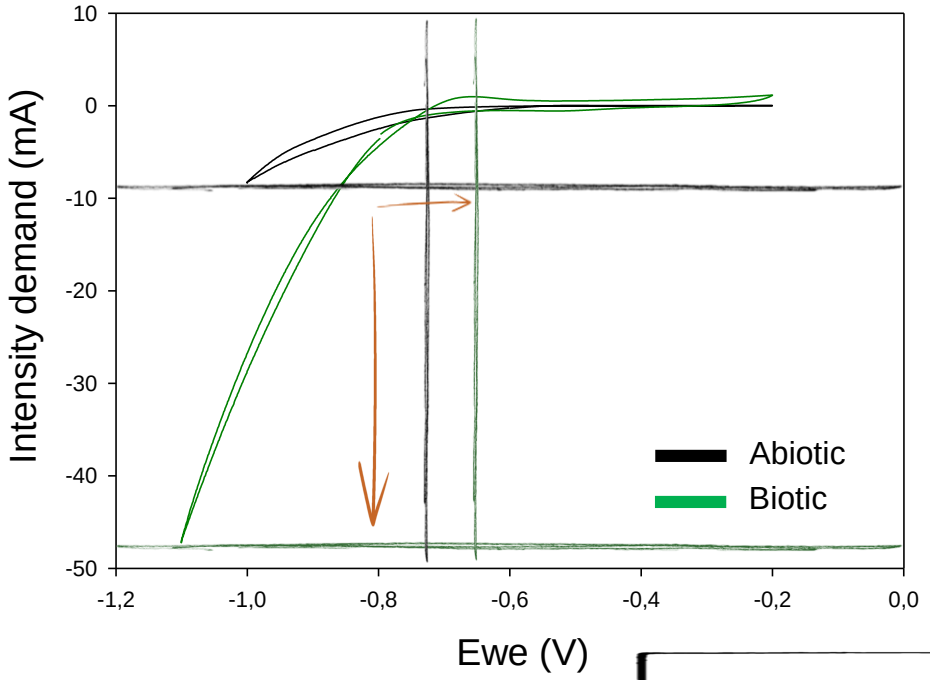
80-90%

Because sometimes it is not enough

Tracking parameters

Bio-Hydrogen production

Time 0 vs. 40 days

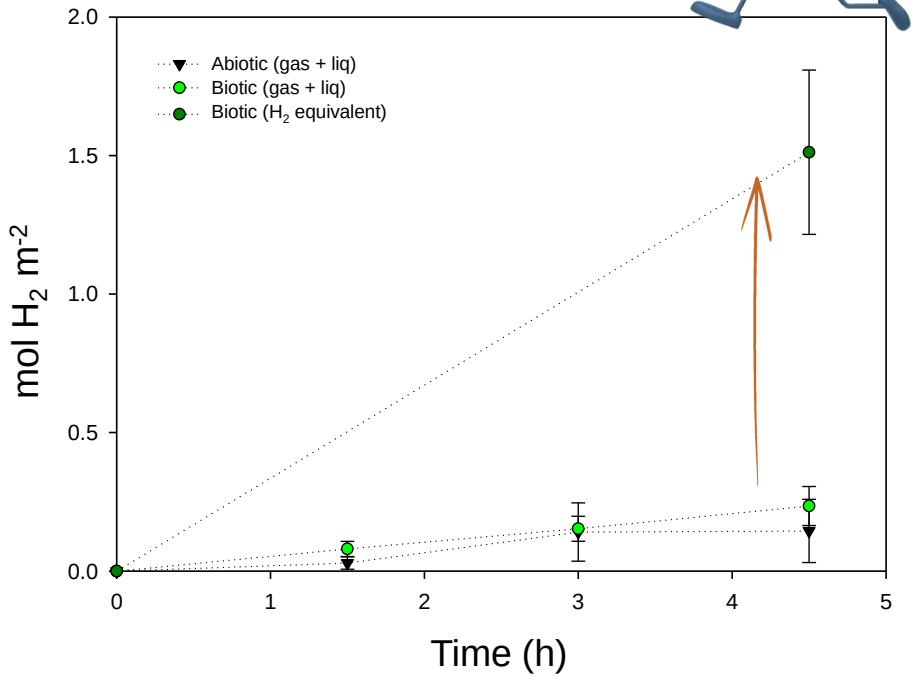


$2\,CO_2 + 4\,H_2 \longrightarrow Acetate + H^+ + 2H_2O$

$\Delta G^{0'}_{55ºC} = -74.56\ KJ\ mol^{-1}$

The key mediator

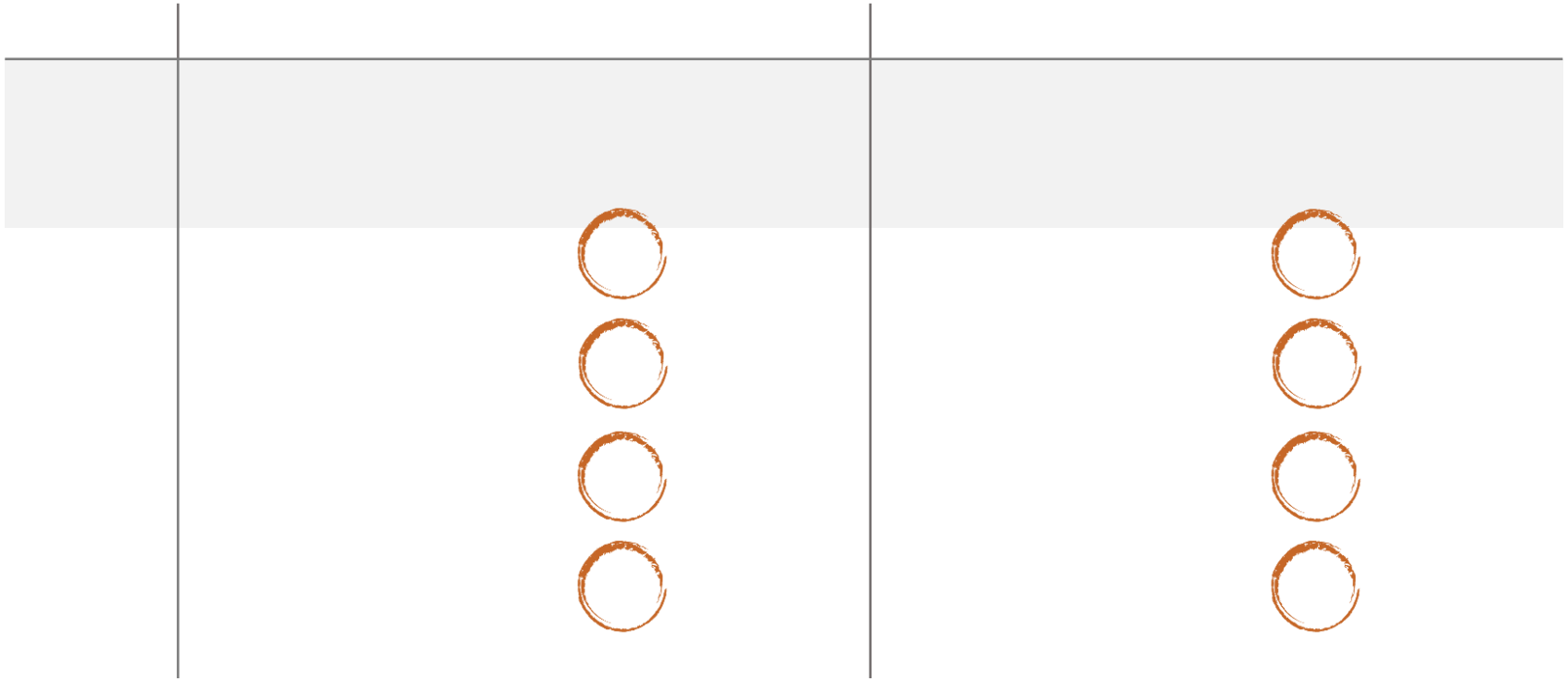
H_2 mediated inorganic carbon transformation



Tracking parameters

Fresh medium replacement ↑ Product formation velocity

Nutrients addition?



Improvement

HT1 → 63.49 mmol Ac^- $m^{-2}d^{-1}$

HT2 → 89.39 mmol Ac^- $m^{-2}d^{-1}$

HT3 → 148.33 mmol Ac^- $m^{-2}d^{-1}$

HT4 → 161.18 mmol Ac^- $m^{-2}d^{-1}$

~Hac → +Prod. Rate

+Hac → +Prod. Rate

~~Problem~~

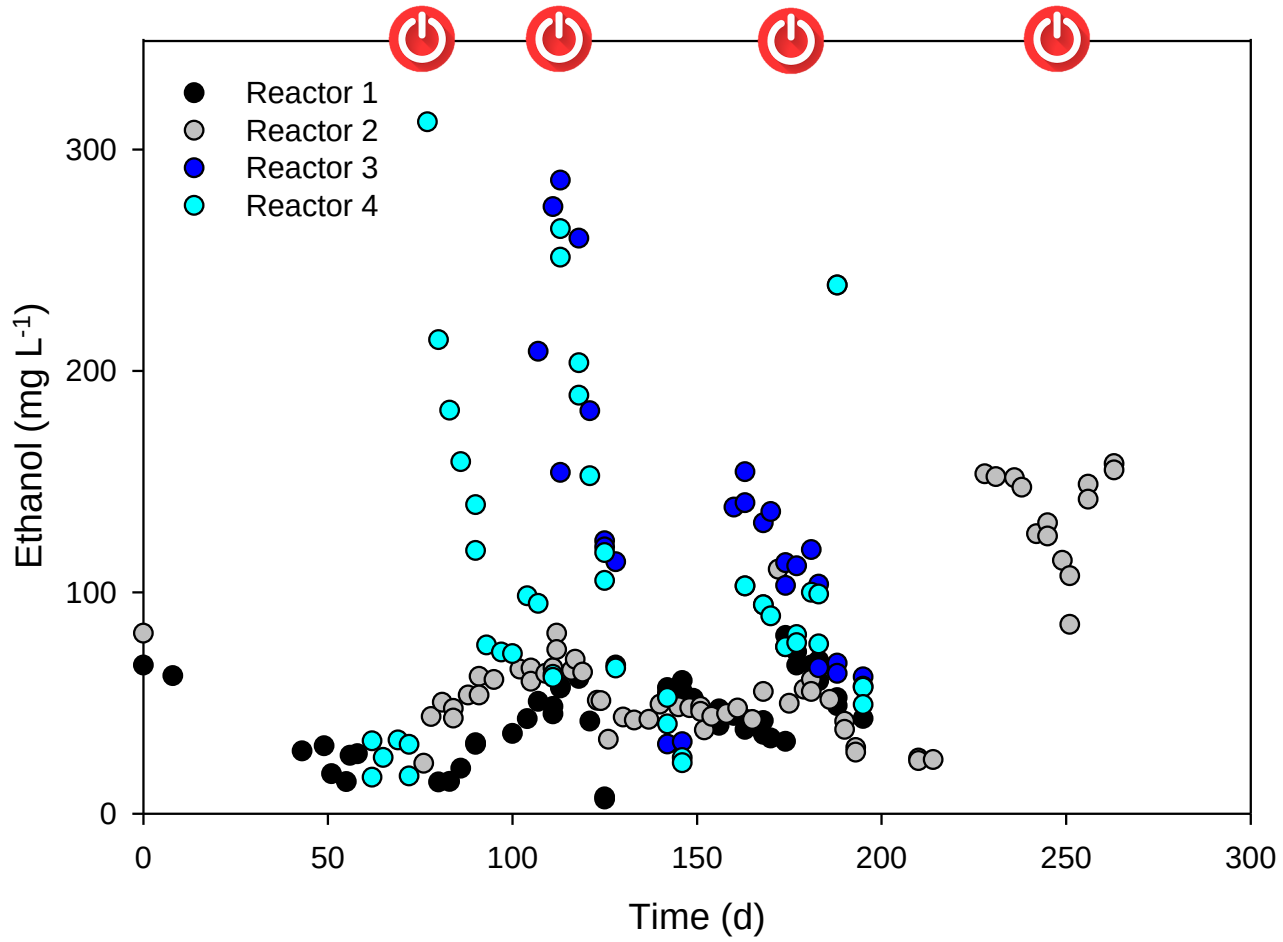
Opportunity

Tracking parameters

Transient ethanol formation

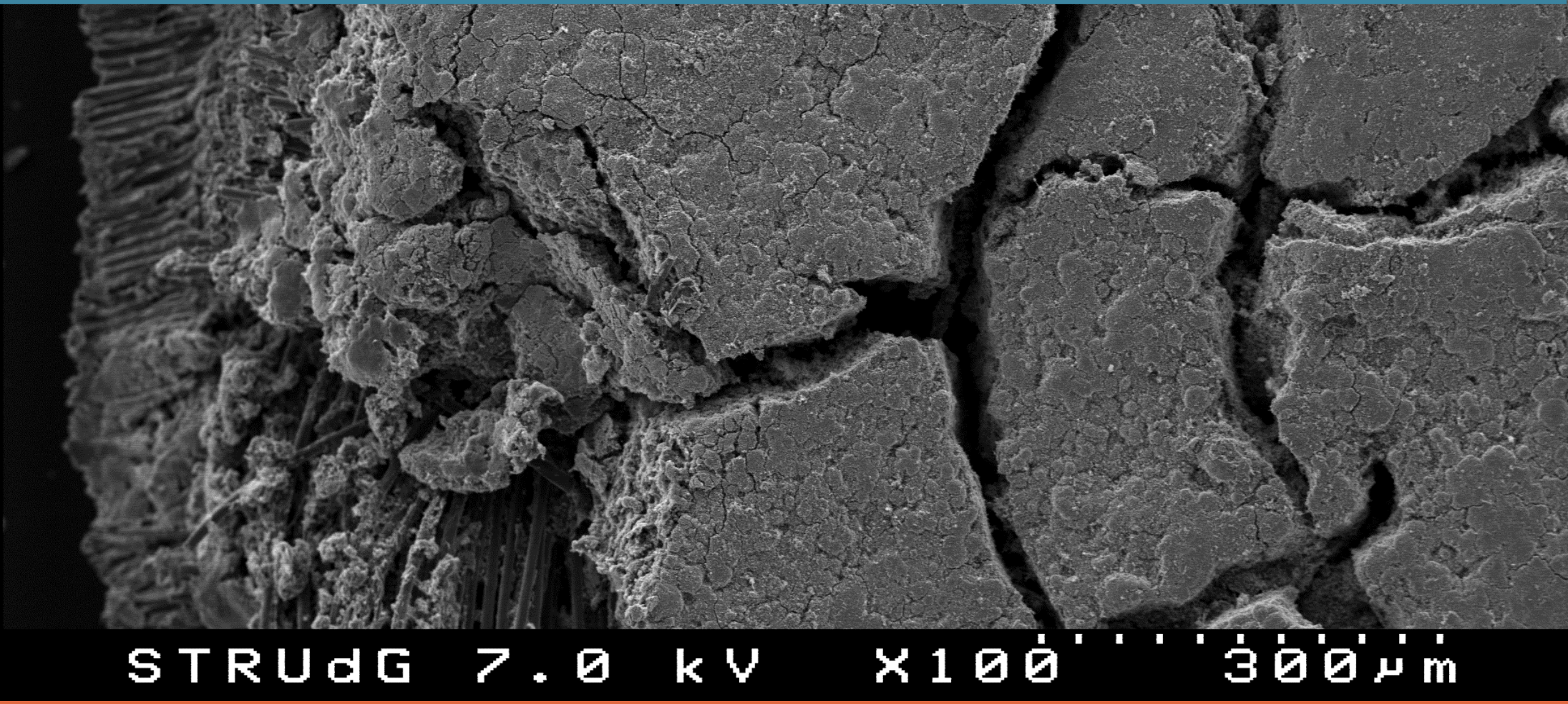
$$Acetate + H^+ + 2H_2 \longrightarrow Ethanol + H_2O$$

$$\Delta G^{o\prime} = -9.1\ kJ\ mol^{-1}$$

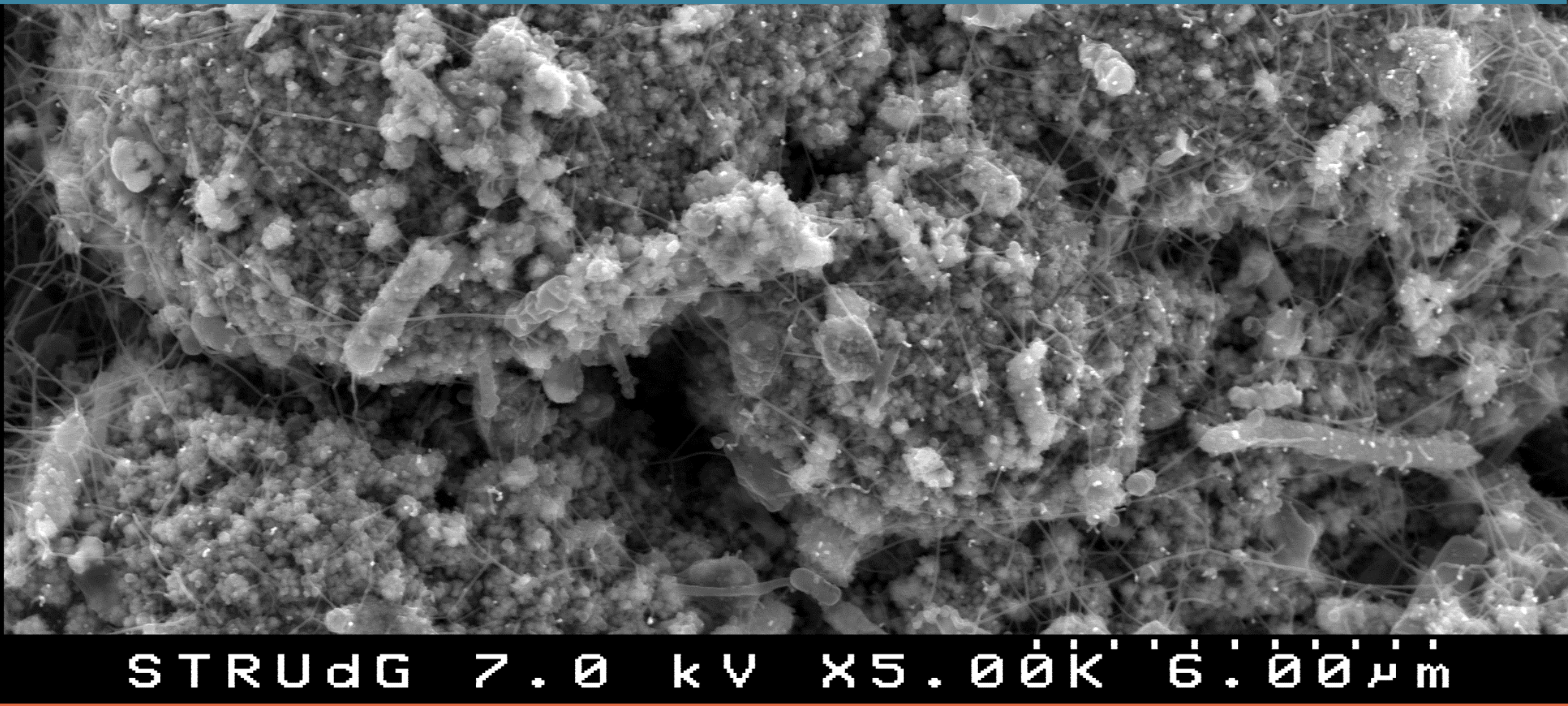


Blasco-Gómez et al., 2019

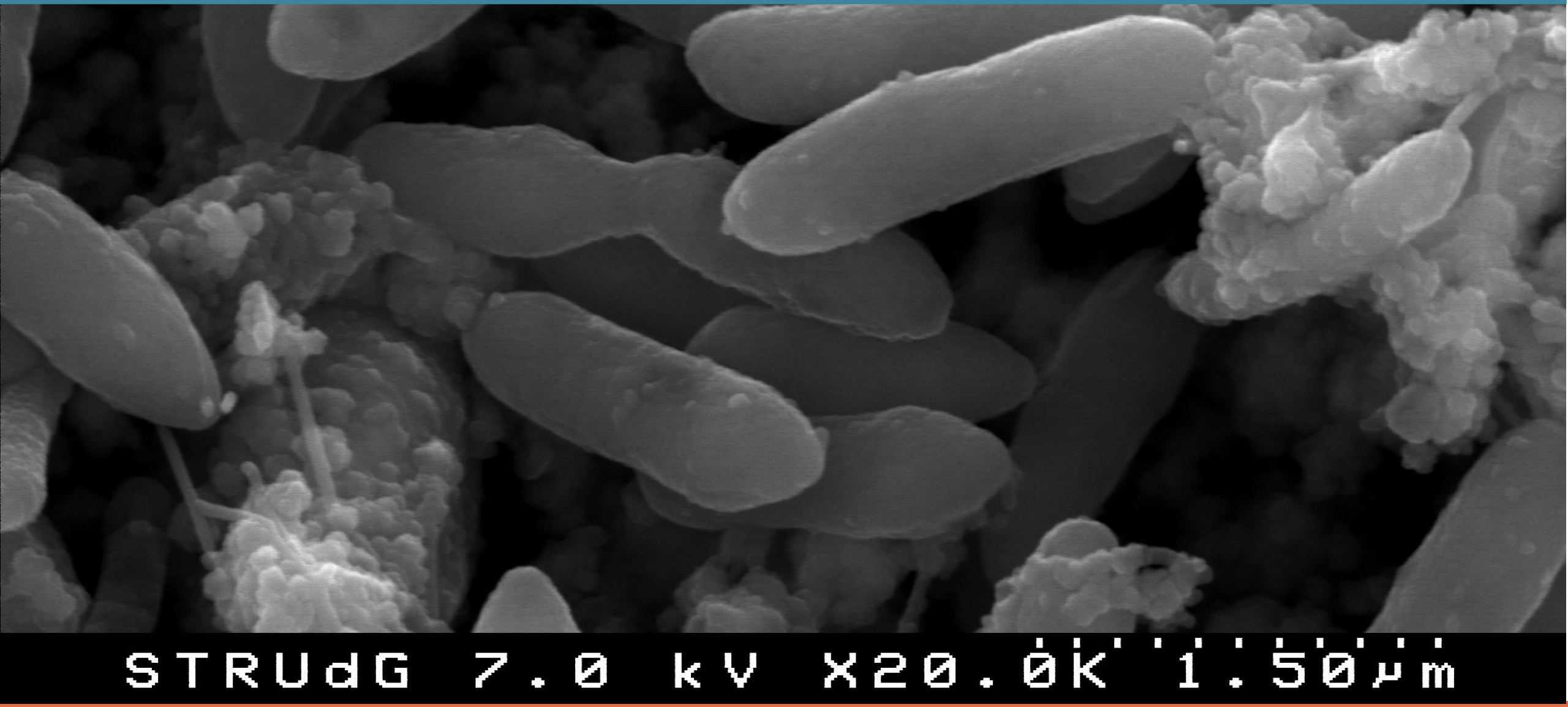
Microbial community analysis



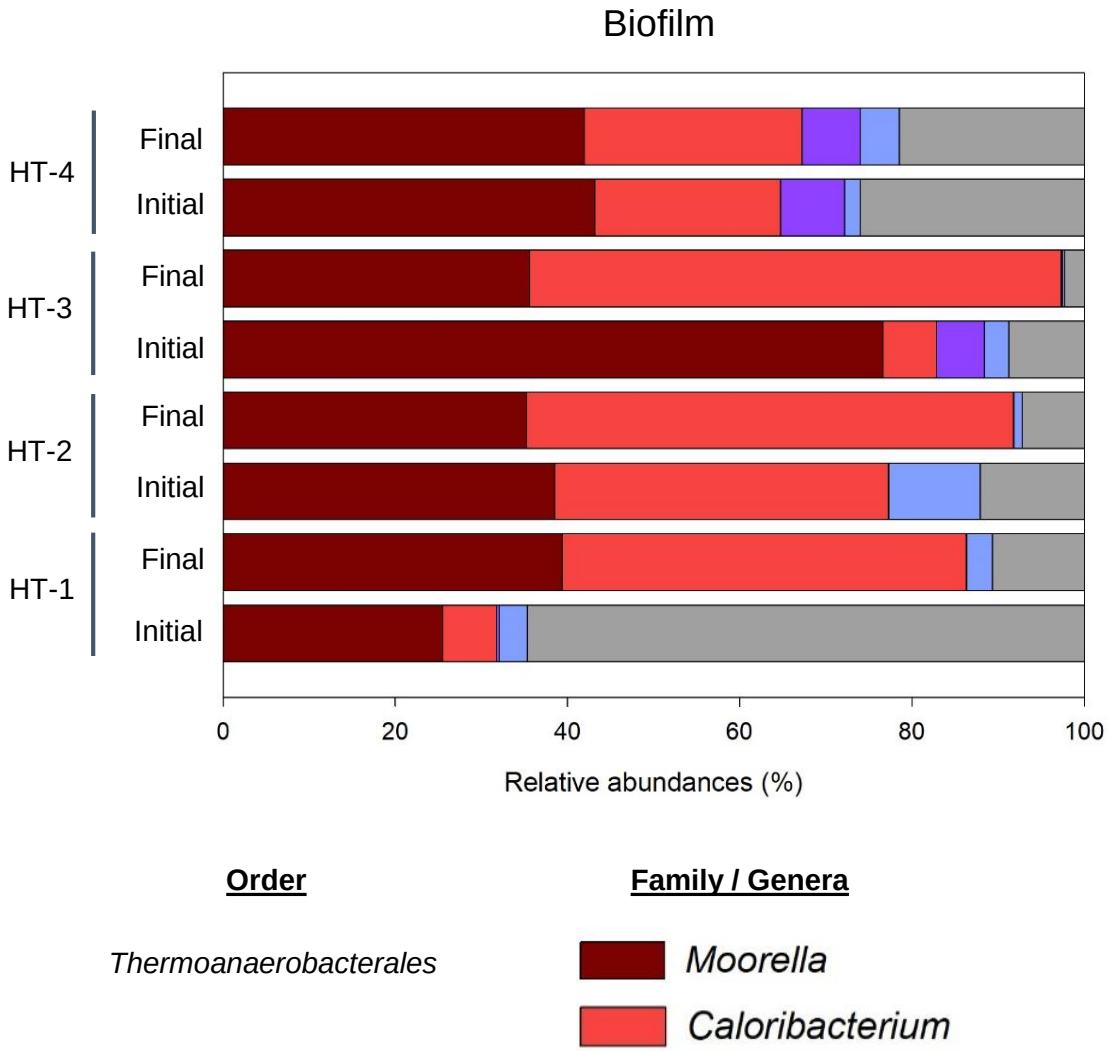
Microbial community analysis



Microbial community analysis



Microbial community analysis



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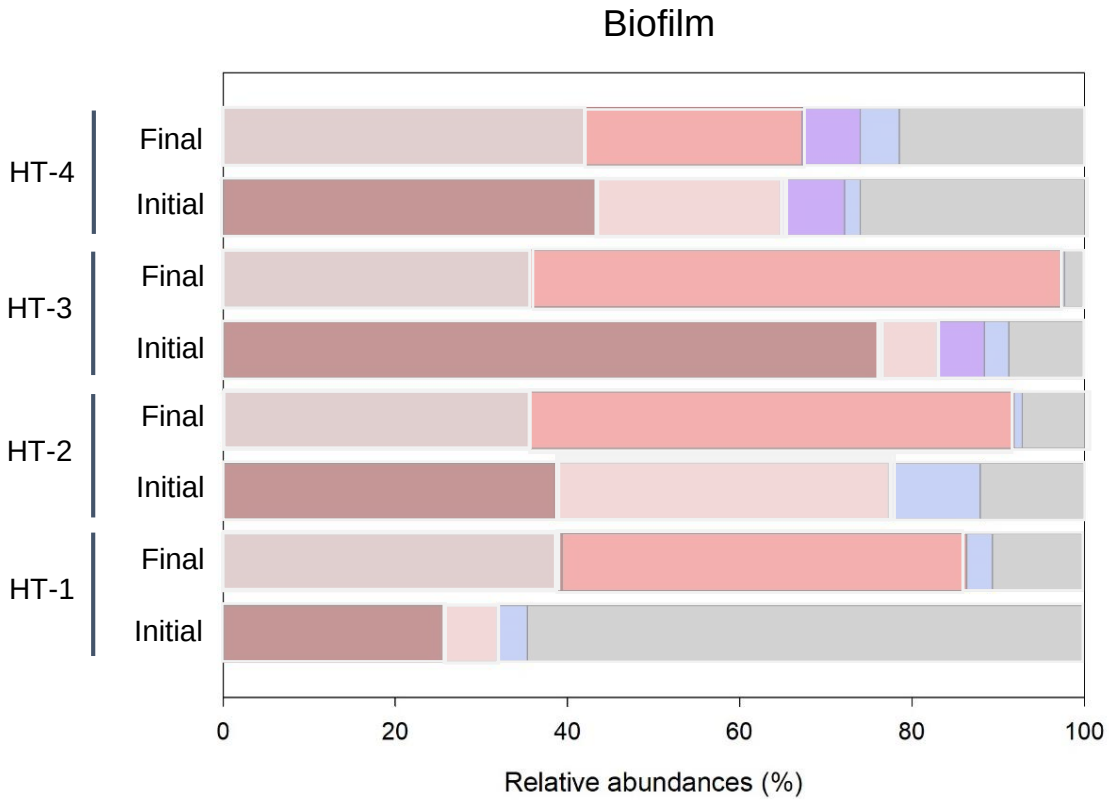


Order

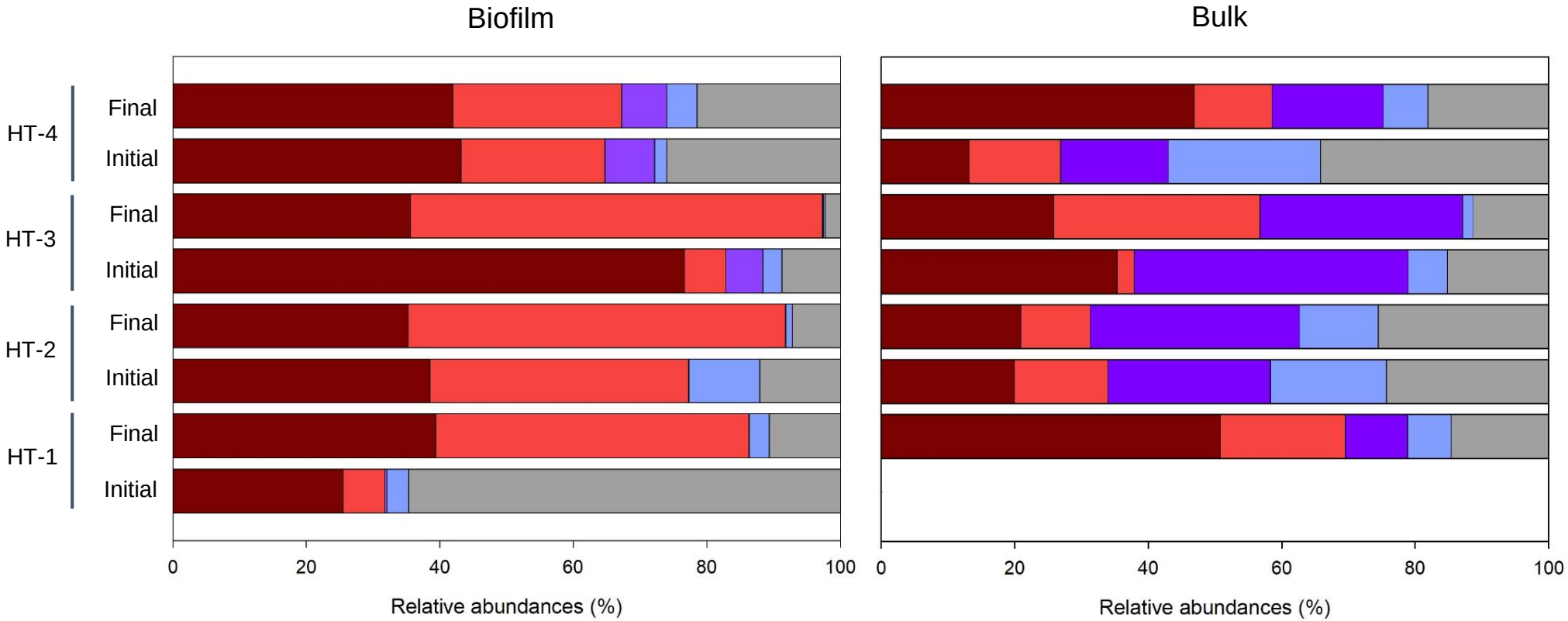
Thermoanaerobacterales

Family / Genera

Moorella

Caloribacterium

Microbial community analysis



And... What now?

E&E NEWS

CLIMATE

Cement Producers Are Developing a Plan to Reduce CO_2 Emissions

Without action, the industry could jeopardize the Paris Agreement's global climate target

By Chelsea Harvey, E&E News on July 9, 2018

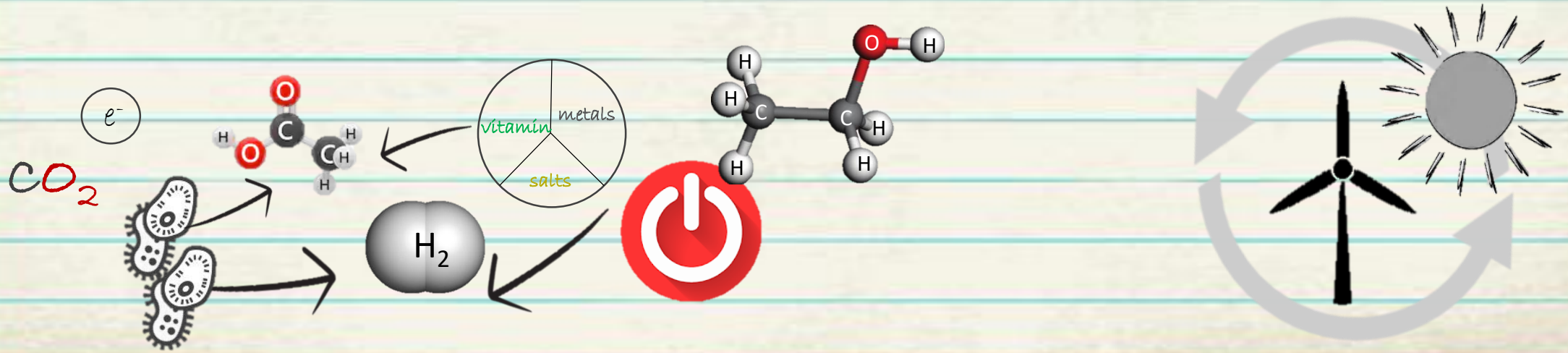
- **Increasing energy efficiency**
- **Substituting fossil fuels with other energy sources**
- **Using additives to develop a large range of products**
- **Implementing MET on-site**

NEW!

New perspectives

CO_2 at high temperature can be electrically reduced by a microbial mixed culture to synthesize organic compounds

- Microorganisms enhanced H_2 production rates
- Nutrients renovation was necessary to keep high production rates
- Ethanol appeared after periods of power disconnection



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Thank you for your attention!

Questions or comments?

UdG lequia ECO-INNOVATIVE ENVIRONMENTAL SOLUTIONS

laura.rovira@lequia.udg.cat

Okinawa, 07st - 10th October 2019

Horizon 2020
European Union Funding
for Research & Innovation

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