CARE
IN PROCESS

CATALYSIS FOR RENEWABLES AND INNOVATIVE PROCESSES «CARE IN PROCESS»

site.unibo.it/catalysis-for-renewables-and-innovative-processes/en

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

WHO WE ARE

A fundamental research on catalysis and innovative materials and processes with a special focus on industrial collaboration and potential applications…

Prof.ssa Stefania Albonetti

Prof. Francesco Basile

Prof.ssa Patricia Benito

Prof. Fabrizio Cavani

Prof. Tommaso Tabanelli

Prof. Nikolaos Dimitratos

Prof. Giuseppe Fornasari

Dott. Andrea Fasolini

Dott. Alessandro Allegri

Dott. Jacopo de Maron

Prof Carlo Lucarelli (UnInsubria)

~ 20 PhD students and Post-doc Post-Doc Research Fellows

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

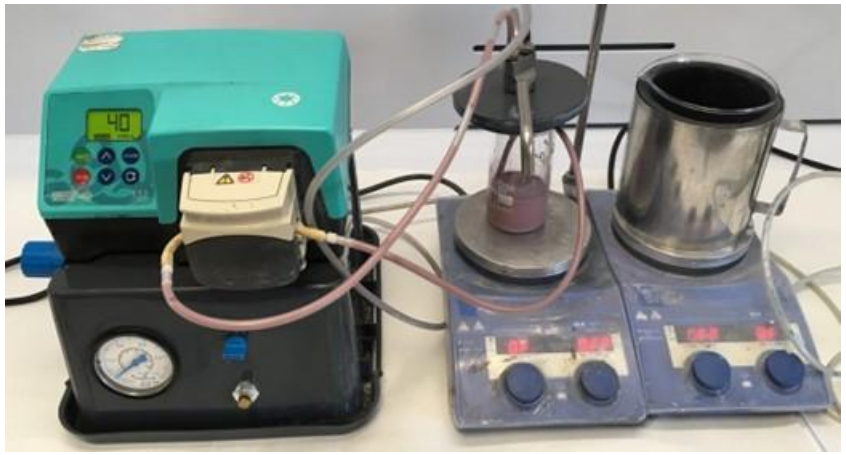
GENERAL APPROACH FOR ALL INTERNSHIPS

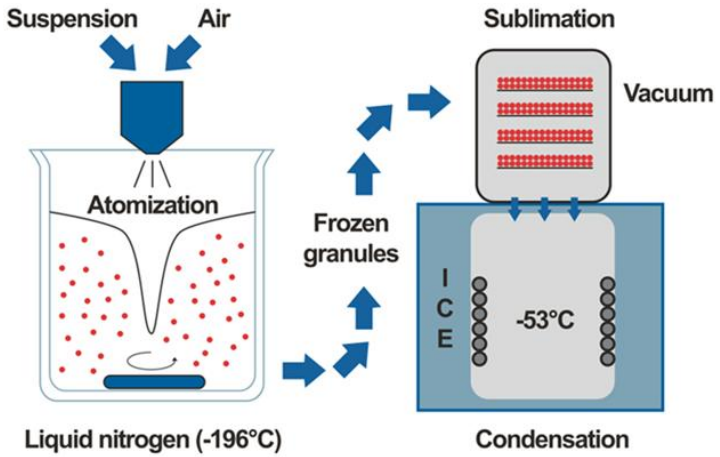
Catalyst Preparation

(Co-)Precipitation
Sol Gel
Microemulsion

Sol Immobilization
Incipient Wetness Impregnation

Spray-Freeze Drying

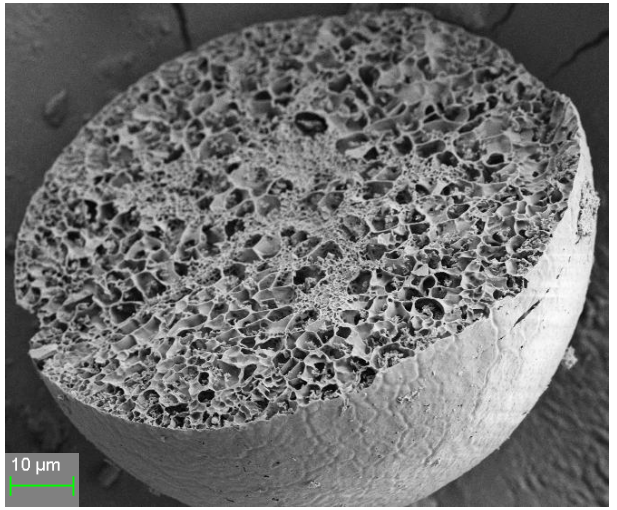




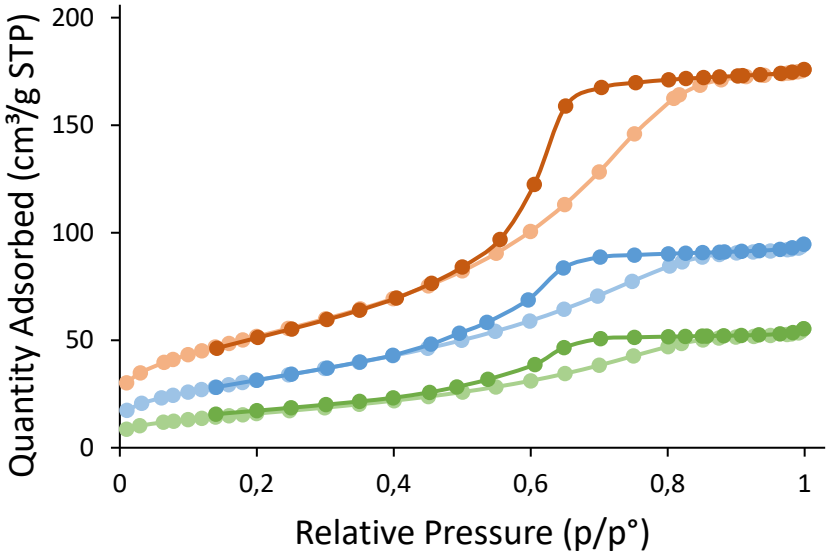
GENERAL APPROACH FOR ALL INTERNSHIPS

Catalyst Preparation → Catalyst Characterization

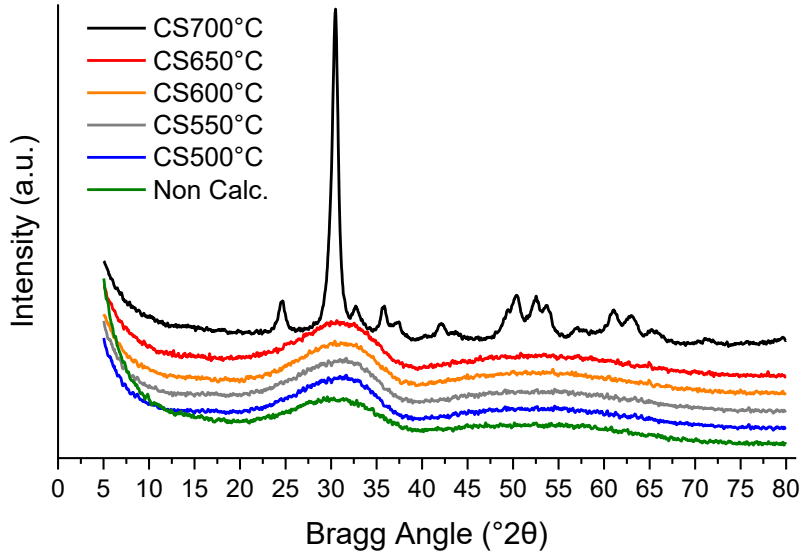
SEM



N_2 Adsorption-Desorption



XRD

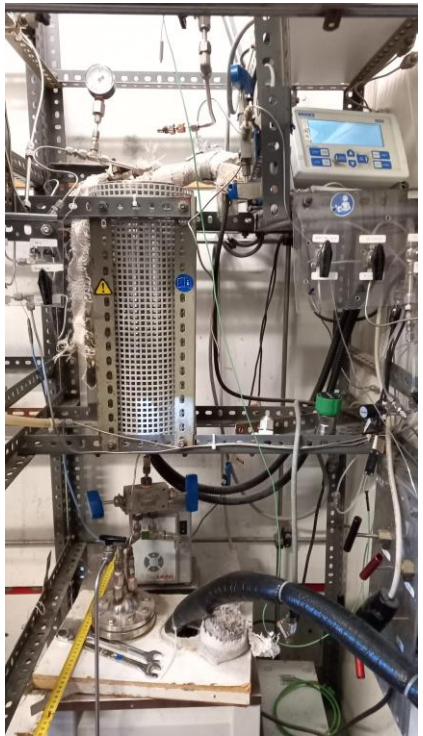


...and others like:
XRF, TPD-R-O,
(DR)UV-Vis, etc.

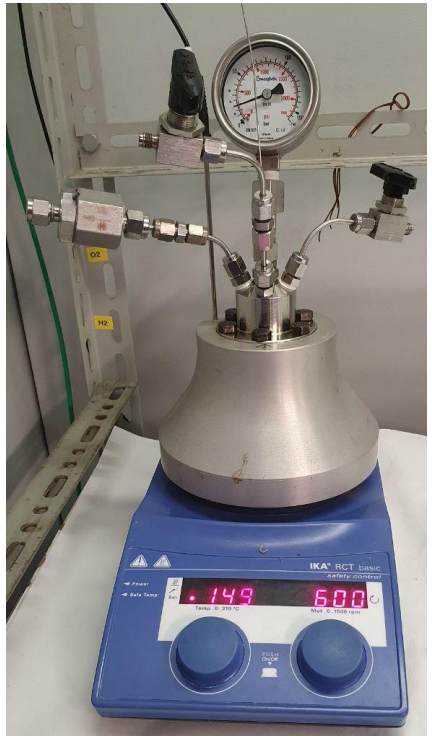
GENERAL APPROACH FOR ALL INTERNSHIPS

Catalyst Preparation → Catalyst Characterization → Catalytic activity

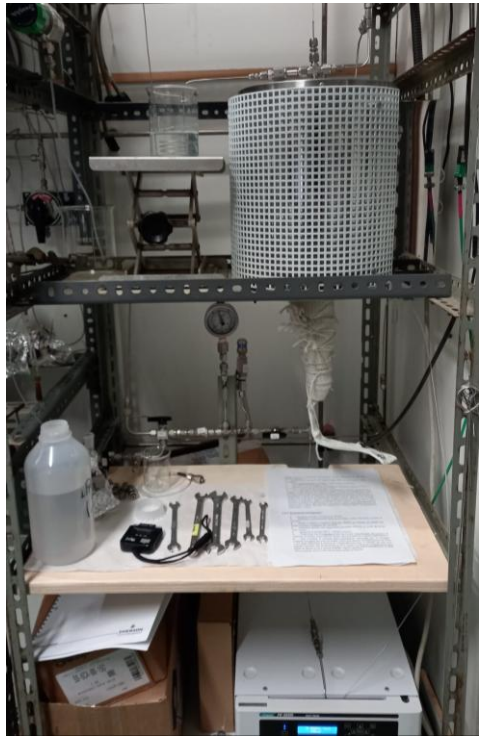
Gas Phase
Continuous Flow Reaction



Liquid Phase
Batch Reaction



Liquid Phase
Continuous Flow Reaction



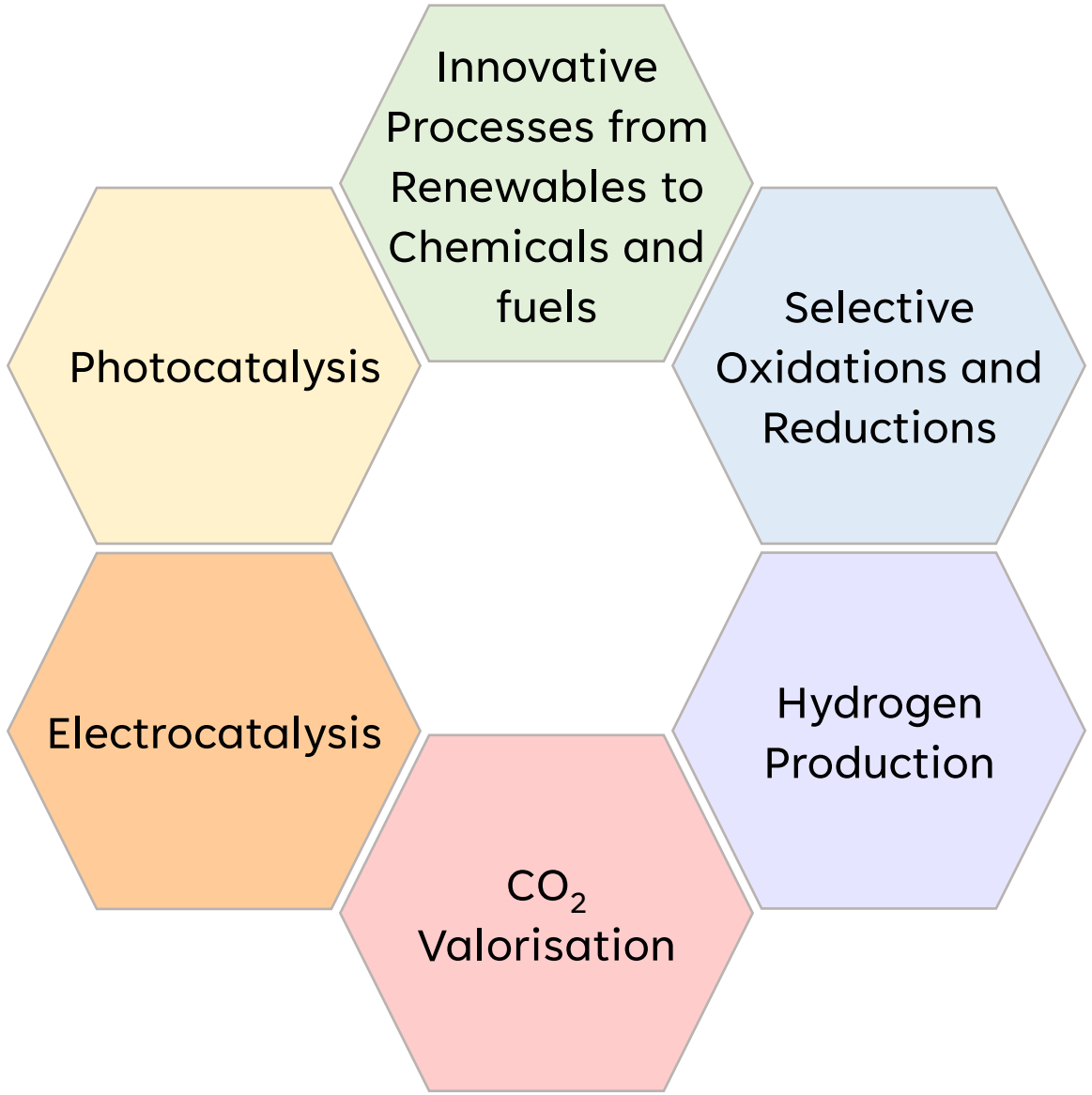
GENERAL APPROACH FOR ALL INTERNSHIPS

Catalyst Preparation → Catalyst Characterization → Catalytic activity → Reaction Outcome Analysis

Gas Chromatography (GC). Detectors: TCD, FID, MS

High-Pressure Liquid Chromatography (HPLC)

MAIN RESEARCH LINES



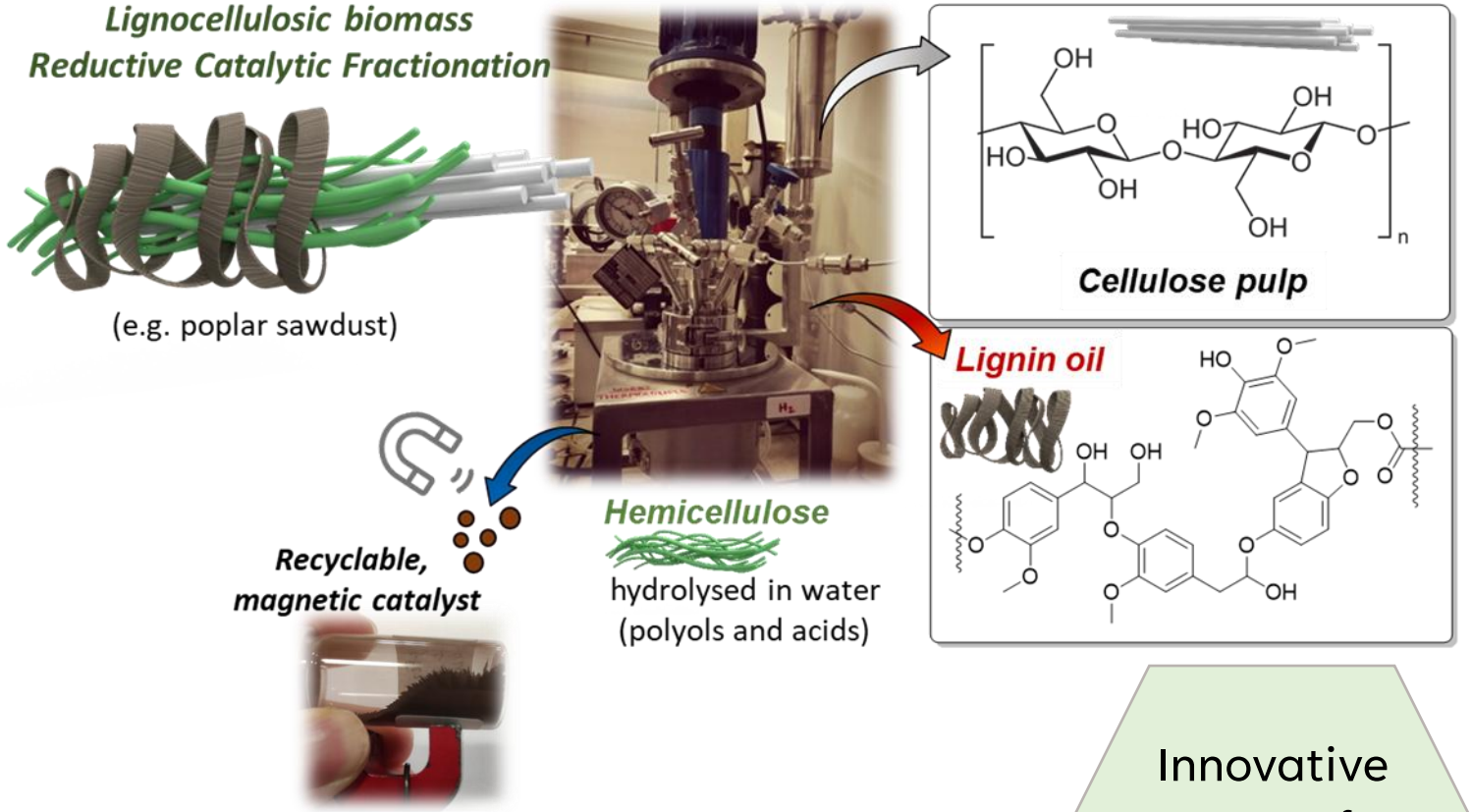
Direct valorisation and transformation of lignocellulosic biomass

Reductive Catalytic Fractionation of lignocellulosic biomass

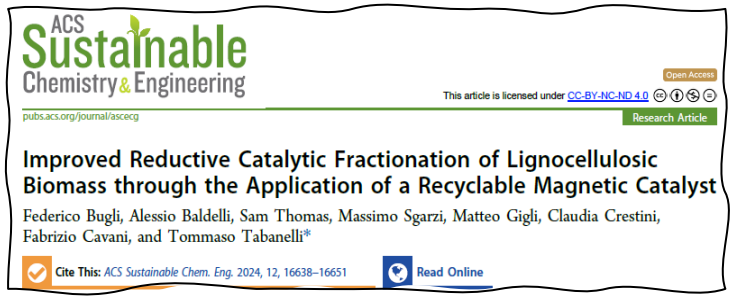
e.g. poplar, birch sawdust and others)

Mild ball milled biomass

Italian PRIN 2022 competitive project ***"ENCAPSULATE"***



Innovation via highly active, stable and recyclable magnetic catalysts



ACS Sustainable Chemistry & Engineering

pubs.acs.org/journal/ascecg

Research Article

Improved Reductive Catalytic Fractionation of Lignocellulosic Biomass through the Application of a Recyclable Magnetic Catalyst

Federico Bugli, Alessio Baldelli, Sam Thomas, Massimo Sgarzi, Matteo Gigli, Claudia Crestini, Fabrizio Cavani, and Tommaso Tabanelli*

Cite This: *ACS Sustainable Chem. Eng.* 2024, 12, 16638−16651

Read Online

Active on the:

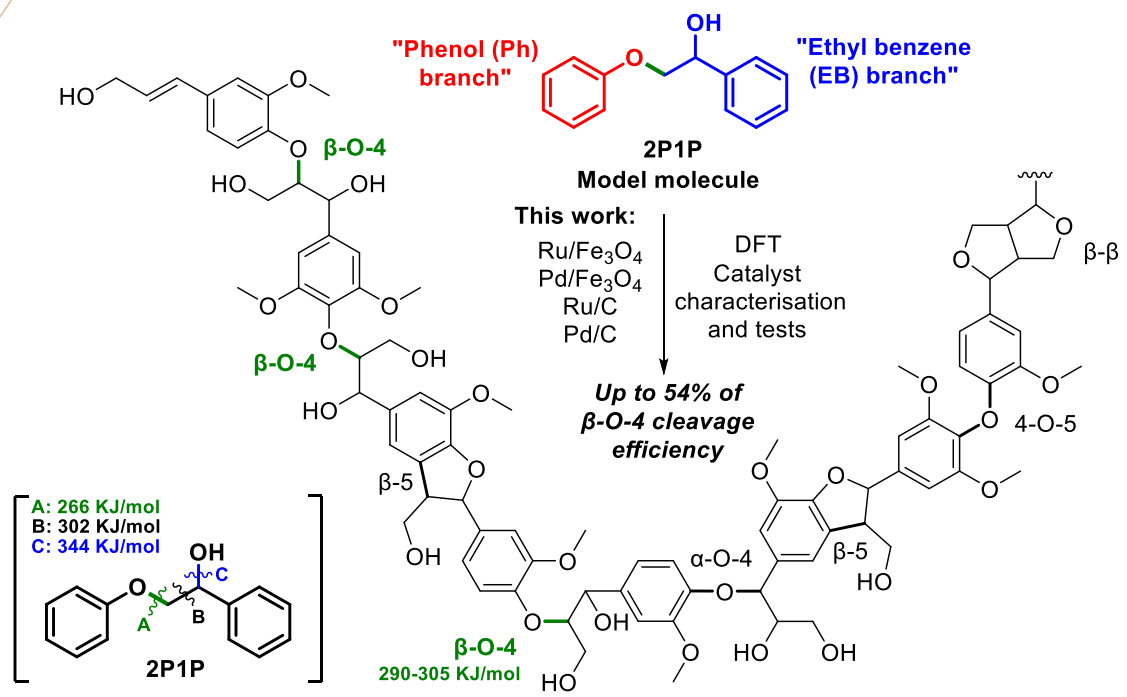
production of bio-based phenolics;

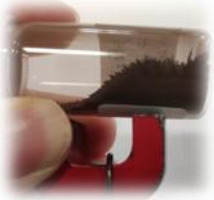
further valorisation of the highly delignified cellulose pulp for production of materials or for the production of sugars, polyols and other chemicals

Innovative Processes from Renewables to Chemicals

Ref: T. Tabanelli

Lignin depolymerisation and valorisation: the use of model molecules



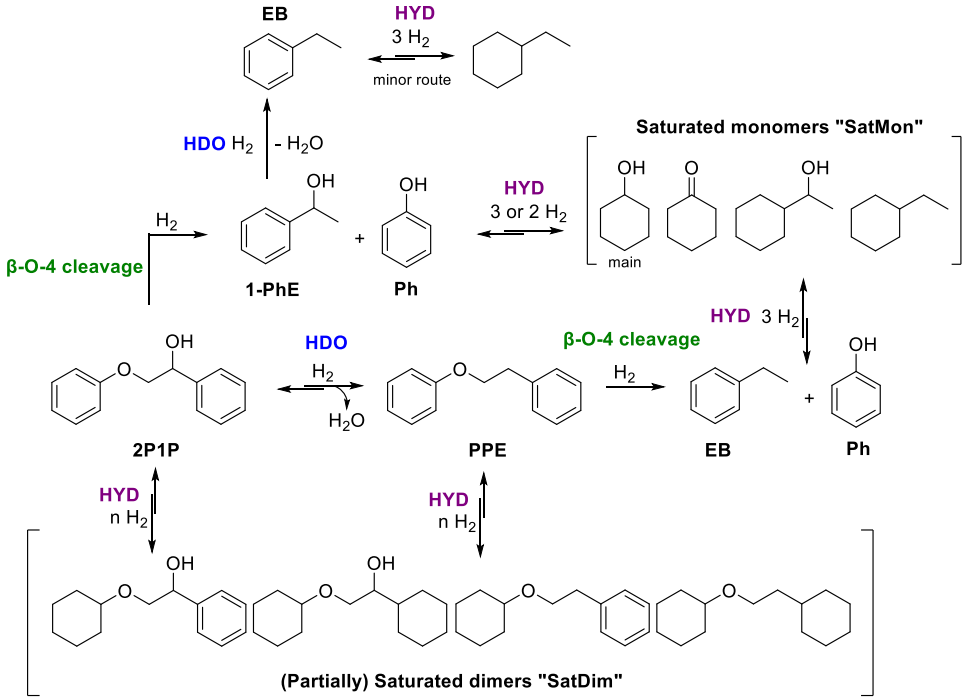


Hydrogenolysis

- Optimised catalysts with increased β-O-4 cleavage and hydrodeoxygenation (HDO) efficiencies, this way increasing the yields of deoxygenated aromatics;
- Limit the parasitic hydrogenation of the aromatic rings.

Investigation of alternative strategies based on bio-based glycols and CO_2 derived organic carbonates

Ref: T. Tabanelli



Innovative Processes from Renewables to Chemicals

CONTINUOUS-FLOW UPGRADING OF BIO-BASED ALCOHOLS: 1-BUTANOL

Bioalcohol

Gas-phase continuous-flow catalytic upgrading

Target **chemicals**

Blends in the **jet fuel** range

Dry
Calcine
Pellet
Reduce

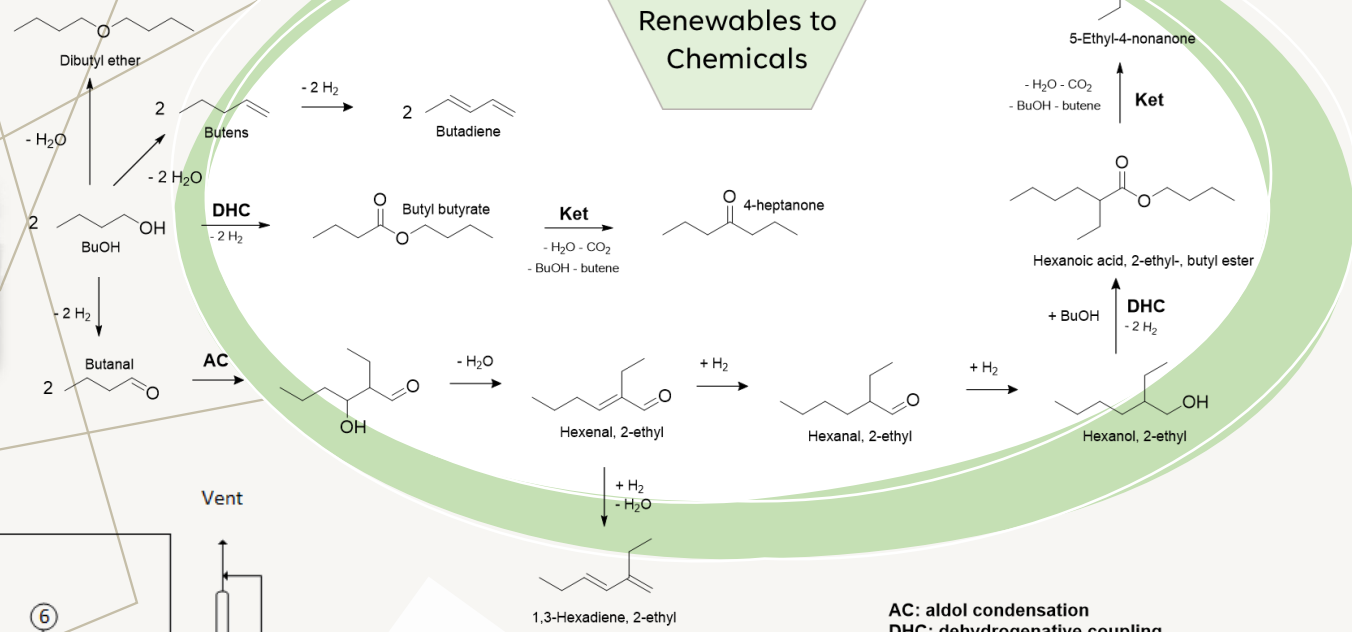
Cu precursor

ZrO_2

5%Cu/ZrO_2

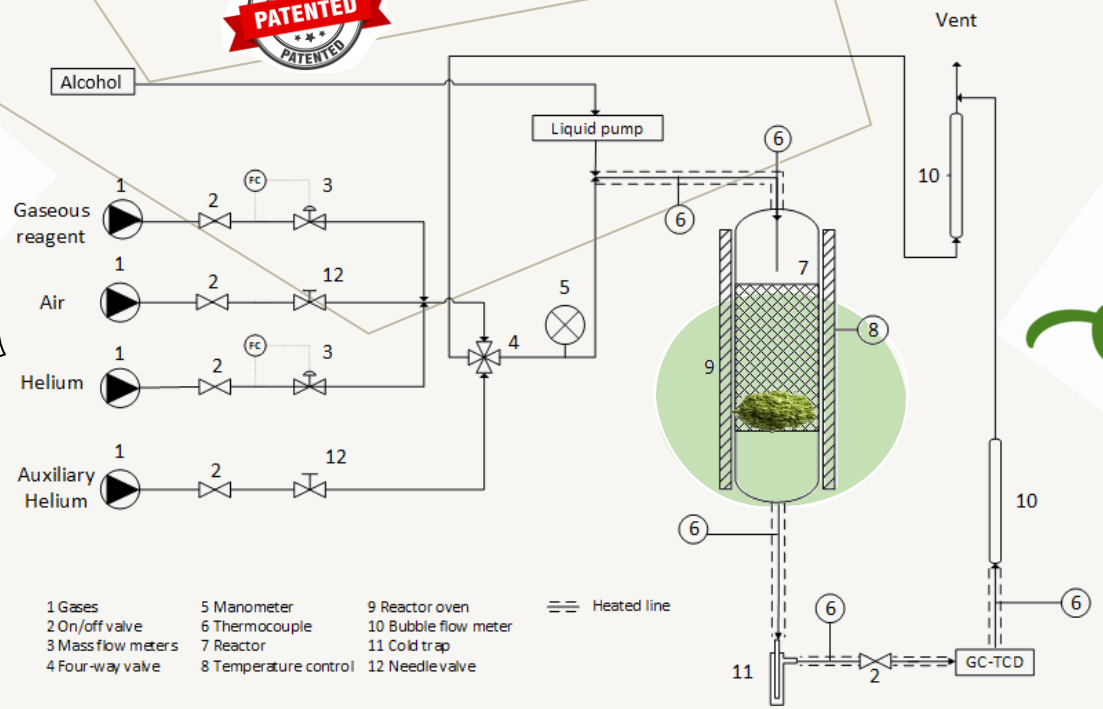
PATENTED

Innovative Processes from Renewables to Chemicals



AC: aldol condensation
DHC: dehydrogenative coupling
Ket: ketonization
CTH: catalytic transfer hydrogenation

Catalyst design optimisation



Ref: T. Tabanelli

Applied Catalysis B: Environment and Energy 349 (2024) 123865

Contents lists available at ScienceDirect

Applied Catalysis B: Environment and Energy

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

Ethanol to gasoline and sustainable aviation fuel precursors: an innovative cascade strategy over Zr-based multifunctional catalysts in the gas phase

Anna Gagliardi[a,b], Giulia Balestra[a,b], Jacopo De Maron[a,b], Rita Mazzoni[a,b,c], Tommaso Tabanelli[a,b,c,*], Fabrizio Cavani[a,b,c]

[a] Dipartimento di Chimica Industriale "Toso Montanari", viale Risorgimento, 4, Bologna 40136, Italy
[b] Center for Chemical Catalysis-C3, University of Bologna, viale del Risorgimento 4, Bologna, 40136, Italy
[c] Interdepartmental Centre for Industrial Research, Renewable Sources Environment, Sea, Energy (CIRI-FRAME), viale Risorgimento, 4, Bologna 40136, Italy

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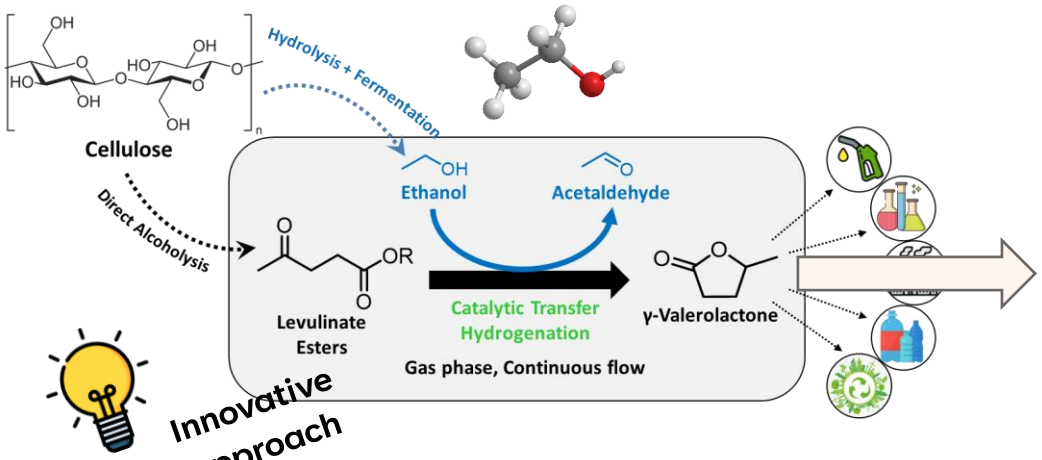
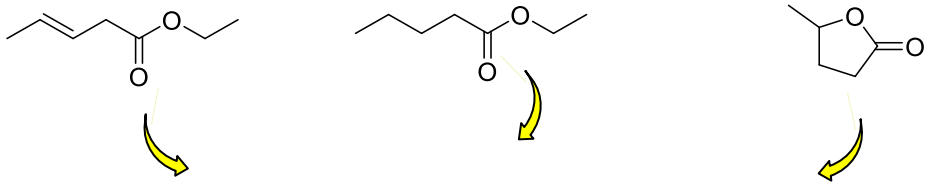
Innovative Processes from Renewables to Chemicals

Light alcohols activation in continuous-flow reactors

Continuous-flow Catalytic Hydrogen Transfer



Very high yield toward GVL, EP, and EV...
...completely bio-based



Innovative and stable catalysts based on mixed metal oxides

Catalyst synthesis, characterisation, catalytic tests, DFT calculation...
structure-activity relationship...toward C5 and **C7 esters**

Alternative strategies for the continuous-flow valorisation of these C5 esters and lactones via:

Ketonisation towards different types of products

PRIN 2020 LEVANTE project "LEvulinic acid Valorization through Advanced Novel Technologies" (Progetti di Ricerca di Rilevante Interesse Nazionale-Bando 2020, 2020CZCJN7).

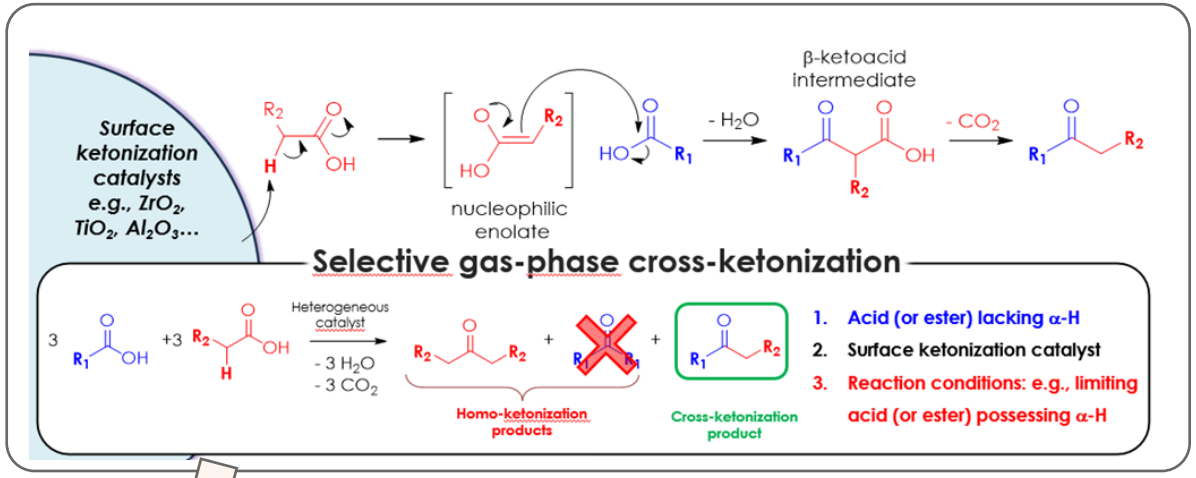
Molecular Catalysis 555 (2024) 113840;
Journal of Catalysis 428 (2023) 115177;
Current Opinion in Green and Sustainable Chemistry 2021, 29, 100449;
ACS Sustainable Chem. Eng. 2019, 7, 9937-9947;
ACS Sustainable Chem. Eng. 2019, 7, 8317-8330.

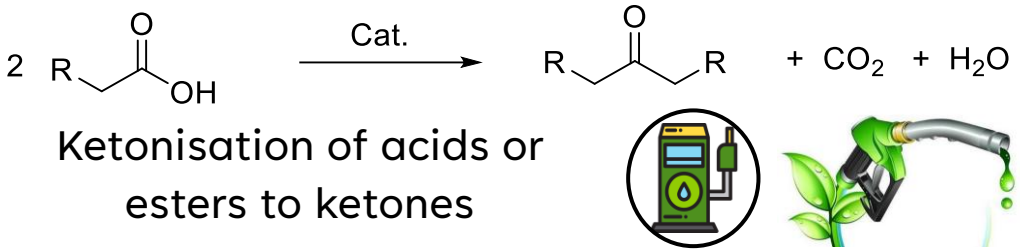
Ref: T. Tabanelli

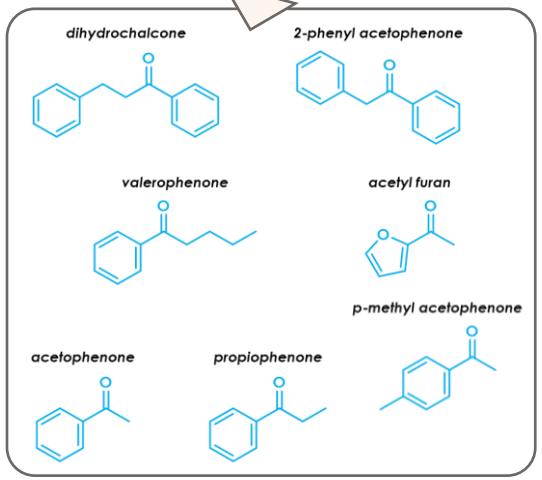
Innovative Processes from Renewables to Chemicals

Ketonisation towards different types of products

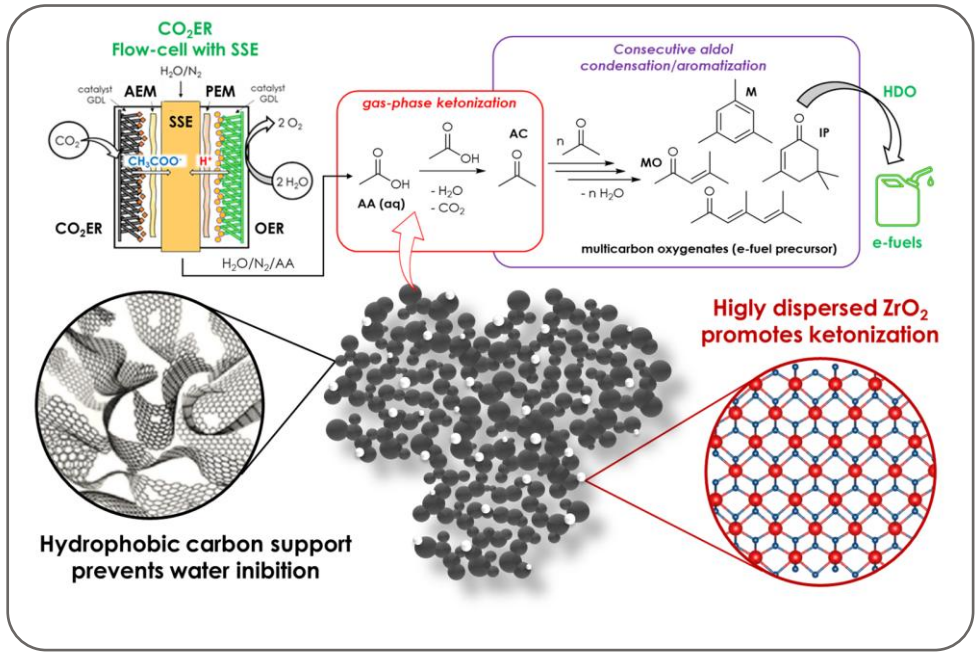
Chemical intermediates



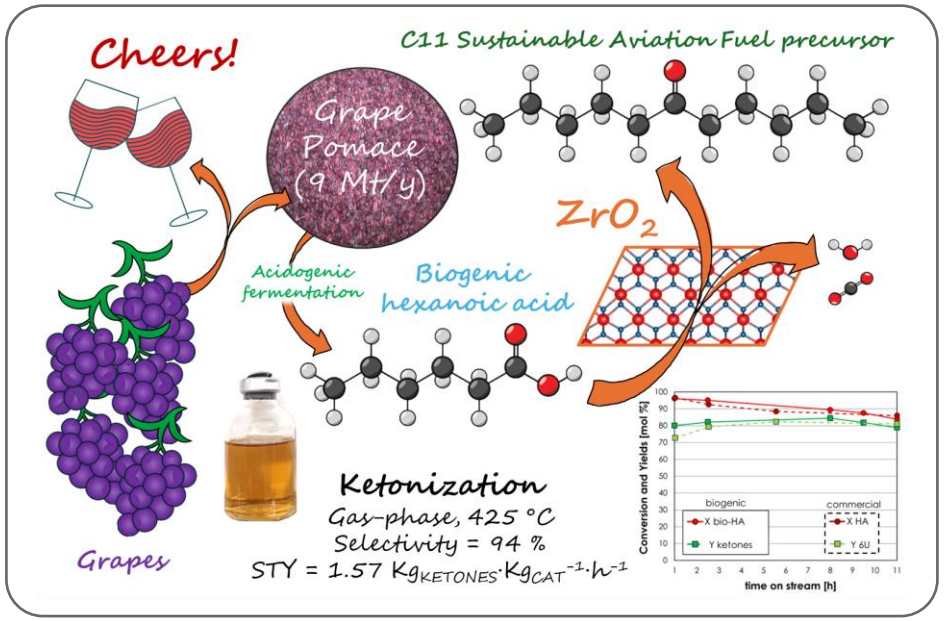




e-fuels



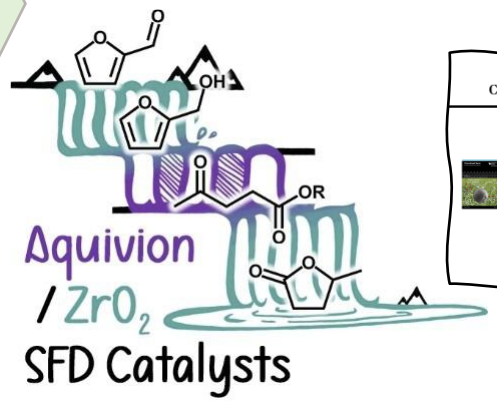
Sustainable aviation fuels



Ref: J. De Maron – T. Tabanelli

Innovative Processes from Renewables to Chemicals

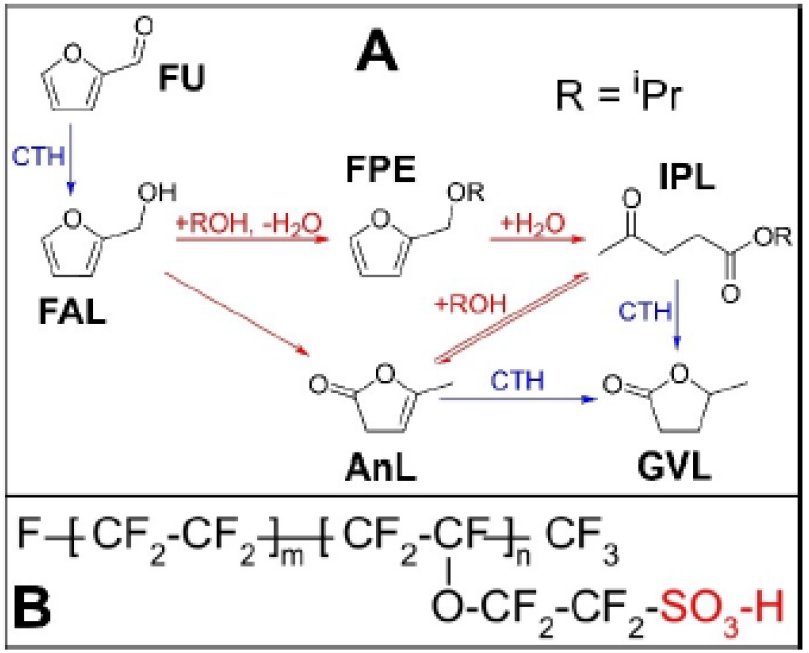
PRODUCTION OF GVL FROM FURFURAL



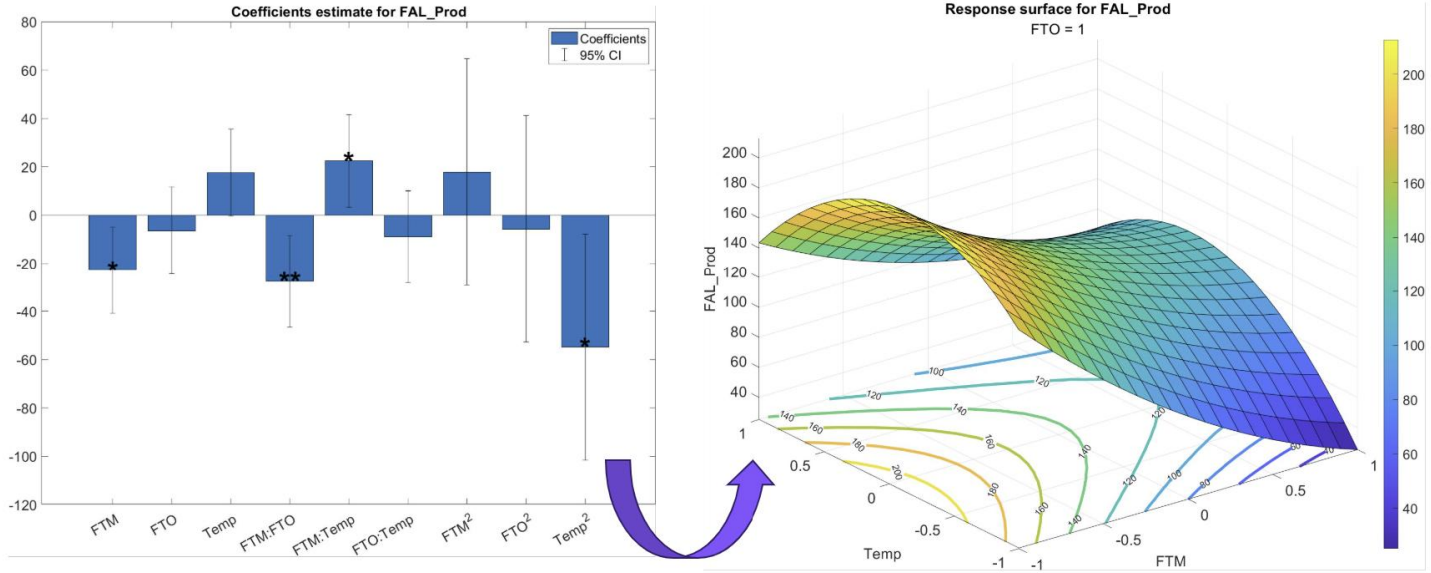
ChemSusChem | Research Article | doi.org/10.1002/cssc.202301683 | Chemistry Europe | www.chemsuschem.org

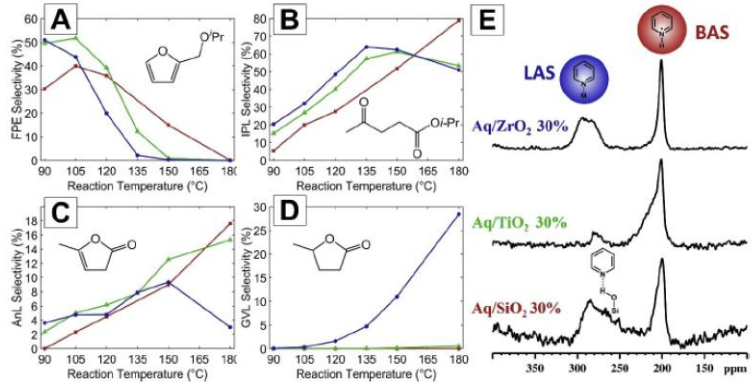
Aquivion-Based Spray Freeze-Dried Composite Materials for the Cascade Production of γ-Valerolactone

Alessandro Allegri,[a] Anna Saotta,[a] Francesca Liuzzi,[a] Enrica Gianotti,[b] Geo Paul,[c] Alice S. Cattaneo,[d] Claudio Oldani,[d] Andrea Brigliadori,[e] Ilaria Zanoni,[e] Giuseppe Fornasari,[a] Nikolaos Dimitratos,[a] and Stefania Albonetti*[a]



DoE and ML applied to research

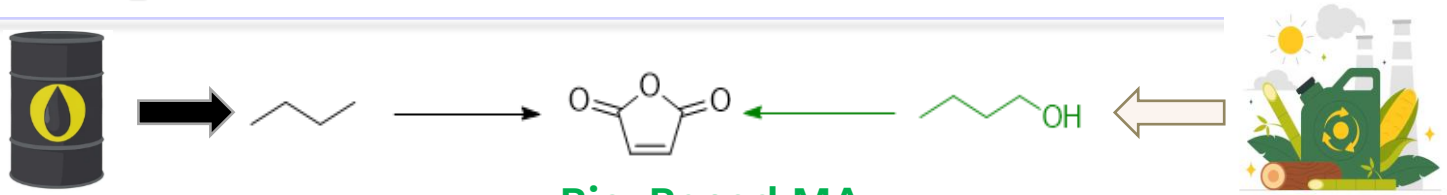




Ref: S. Albonetti – A. Allegri

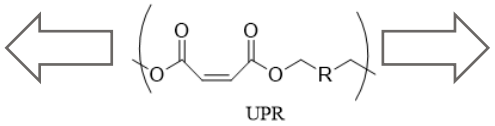
Selective Oxidations and Reductions

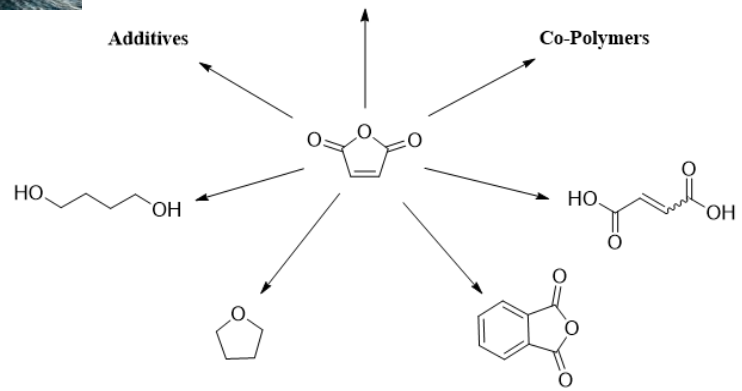
The development of an alternative route toward maleic anhydride

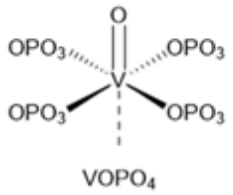


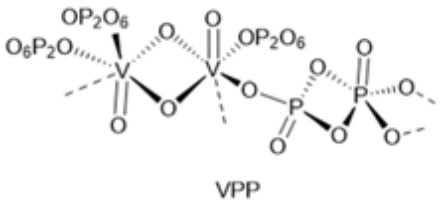
Bio-Based MA

Polynt

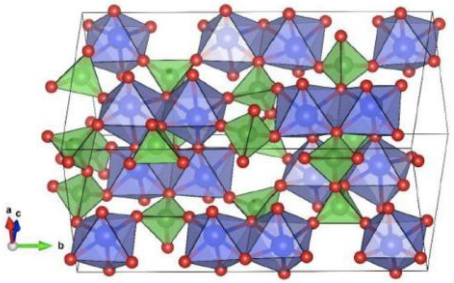






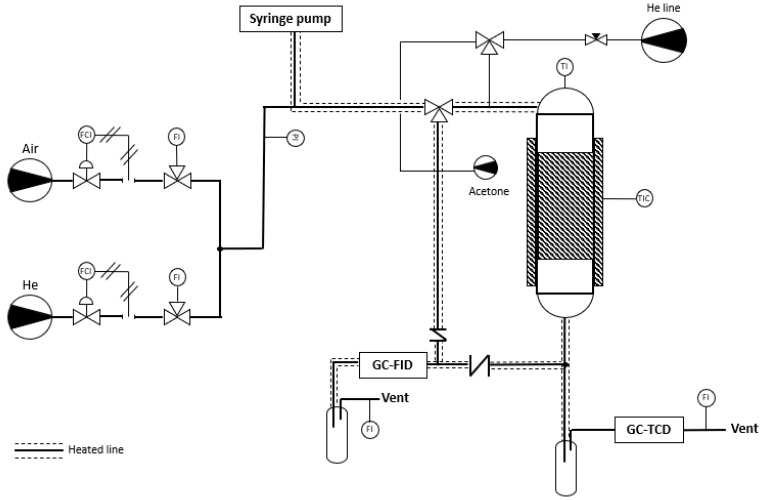


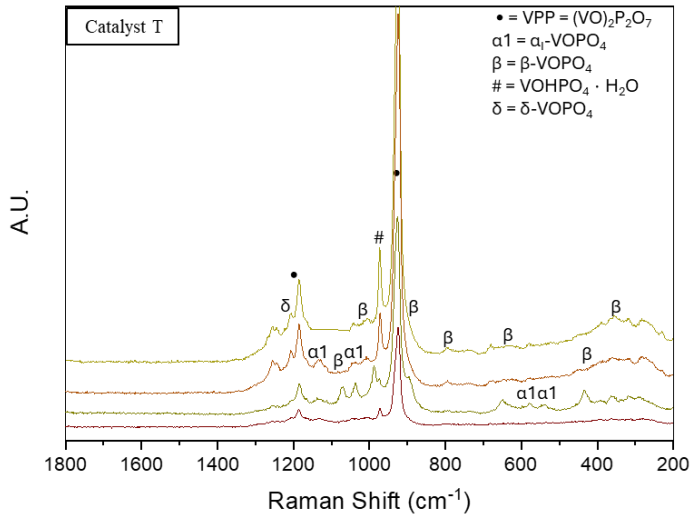
VPP structure:



Catalytic tests in a continuous-flow, fixed bed reactor;

Catalyst characterisation and reaction mechanism investigation also with in situ, in operando spectroscopy (in situ Raman)



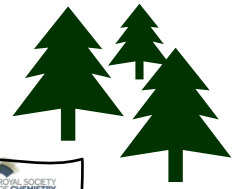


Ref: T. Tabanelli

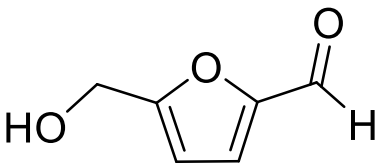
Selective oxidations and amination

RESEARCH LINES

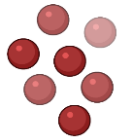
Biomasses



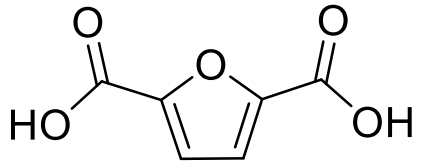
HMF



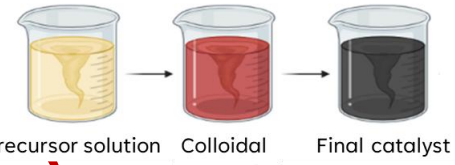
Gold NPs

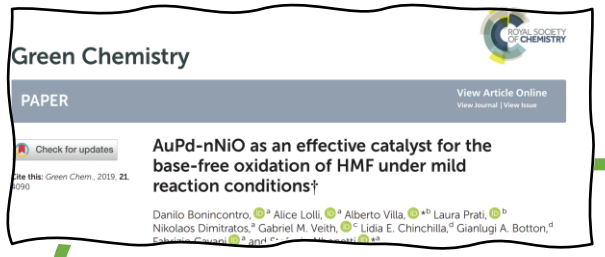


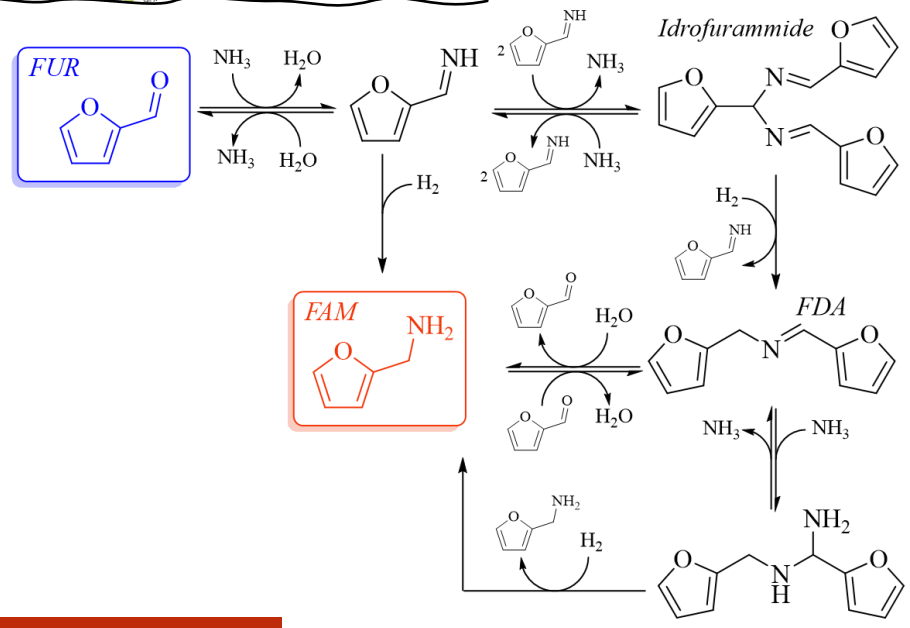
FDCA

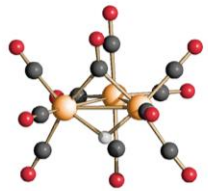


PEF

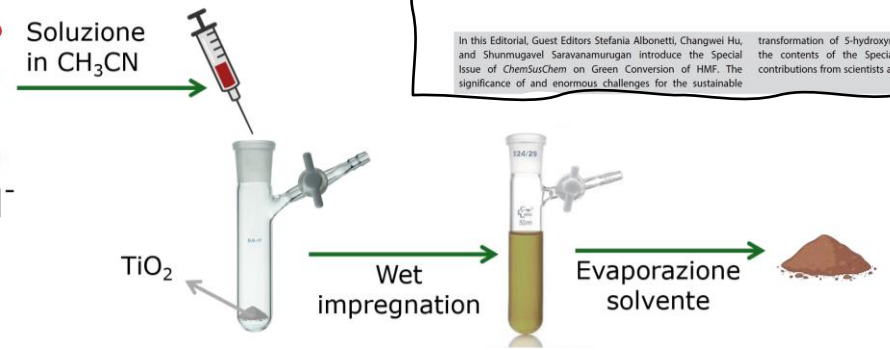


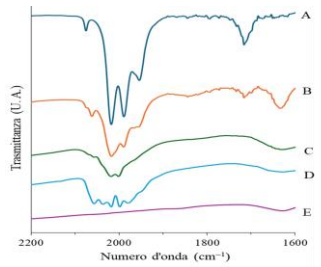


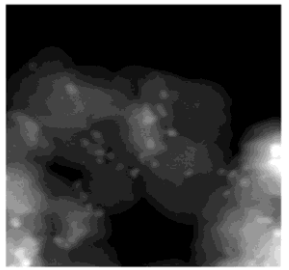


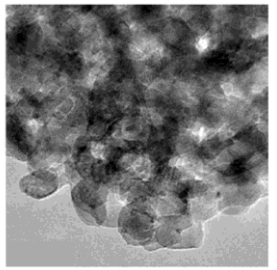


$[HRu_3(CO)_{11}]^-$









Ref: S. Albonetti – A. Allegri

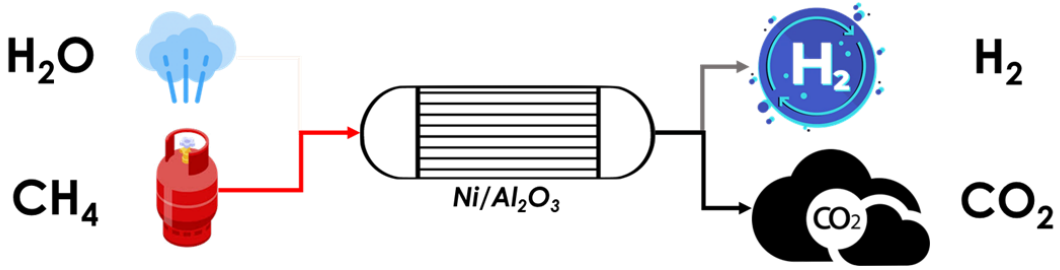
RESEARCH LINES

Hydrogen Production

Ref: F. Basile – A. Fasolini

Methane Steam Reforming

$$CH_4 + 2H_2O \rightleftarrows 4H_2 + CO_2 \quad \Delta H = 164{,}6\ kJ/mol$$

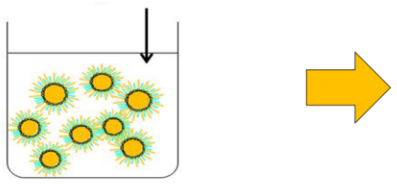


Methane oxy Reforming

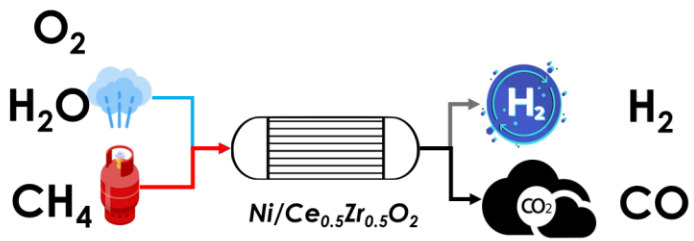
$$CH_4 + H_2O \rightleftarrows 3H_2 + CO \quad \text{endothermic}$$

$$CH_4 + 0.5O_2 \rightleftarrows 2H_2 + CO \quad \text{exothermic}$$

Microemulsion synthesis of catalysts



Gas phase catalytic tests



H_2 production from CH_4 cracking (progetto Europeo Storming)

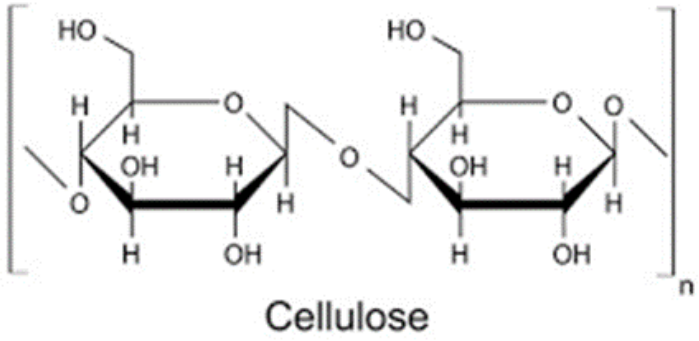
Ref: P. Benito – G. Fornasari

APR OF CELLULOSE AND OTHER POLYOLS

Hydrogen Production

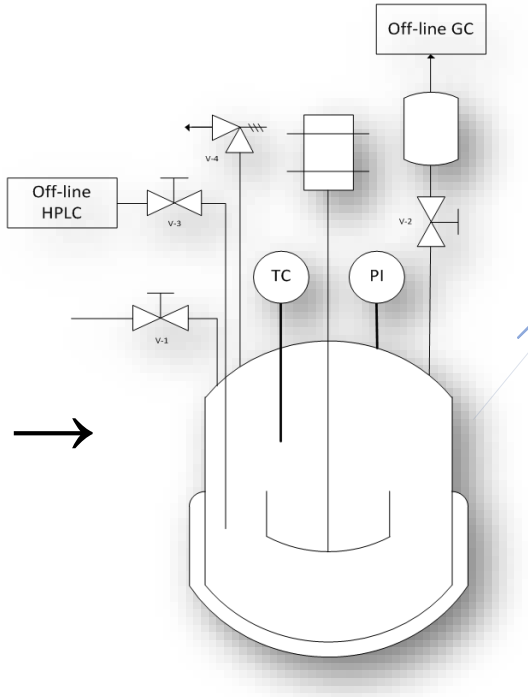
e.g., Glycerol: $C_3H_8O_3 + 3\ H_2O \rightarrow 7\ H_2 + 3\ CO_2$

In respect to the conventional steam reforming in the gas phase, the aqueous phase reforming require milder conditions and does not require a dry feedstock. Moreover, in these conditions the WGSR is favoured, and most CO is converted into CO_2 and H_2. Unwanted reactions lead to the formation of alkanes and alcohols.



Cellulose

$+ H_2O \rightarrow$



H_2

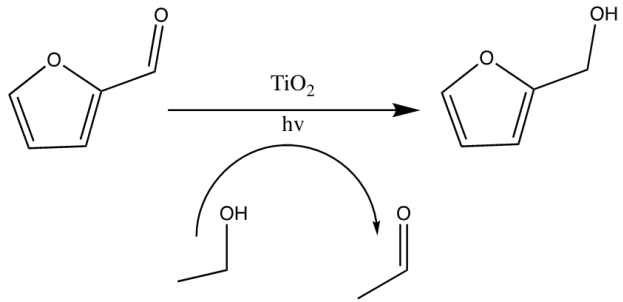
250 °C, autogenous pressure, Ni-catalyst,

Ref: F. Basile – A. Fasolini

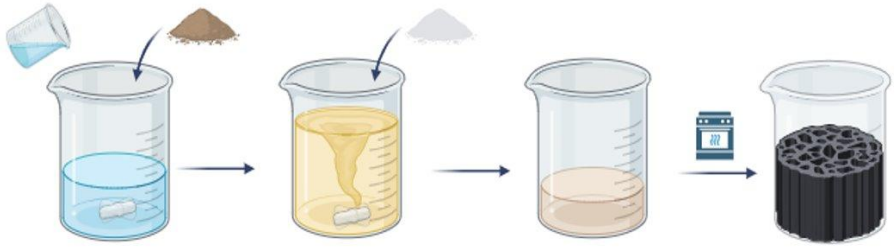
Fasolini et al., Hydrogen from Renewables: A Case Study of Glycerol Reforming, Catalysts 2019, 9, 722.
Fasolini et al., A Short Overview on the Hydrogen Production Via Aqueous Phase Reforming (APR) of Cellulose, C6-C5 Sugars and Polyols, Catalysts 2019, 9, 917.

RESEARCH LINES

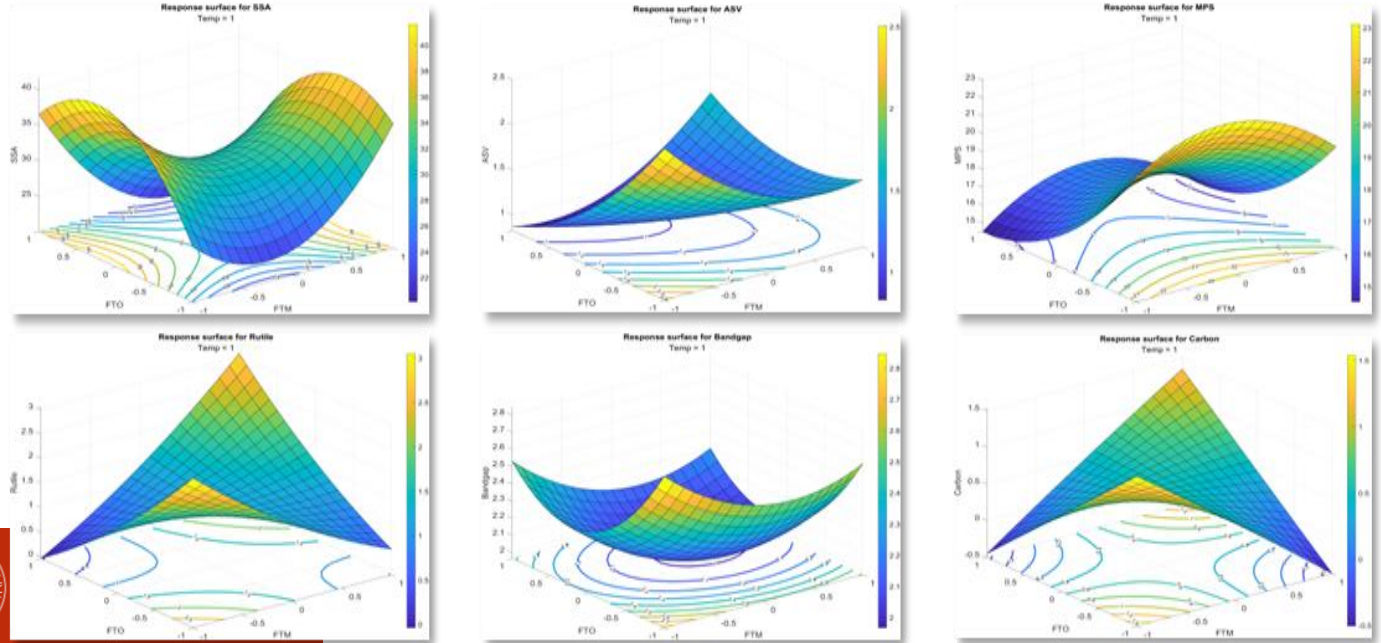
Photocatalysis



Photocatalysis synthesis

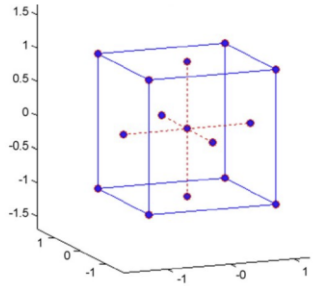


DoE and ML applied to research



DoE chemometric study

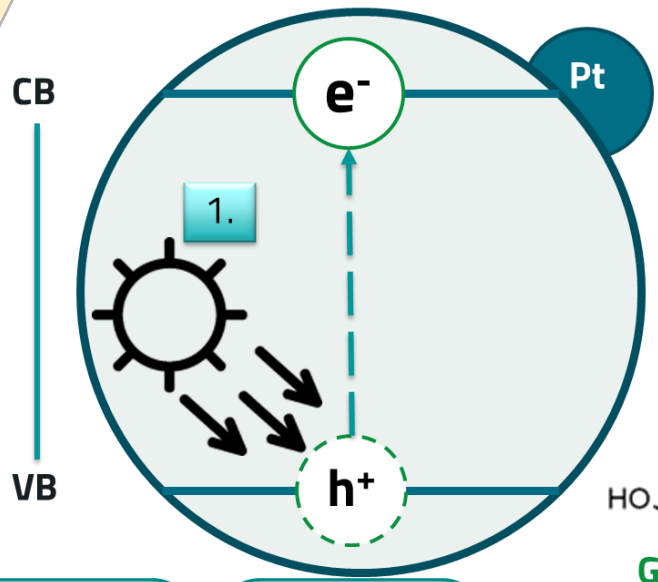
factors	-	0	+
F/M	0,4	0,8	1,2
F/O	0,5	1	1,5
T °C	400	475	550



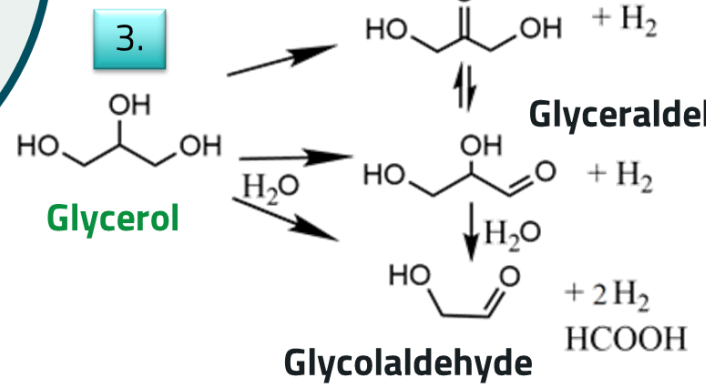
Ref: N. Dimitratos – A. Allegri - Albonetti

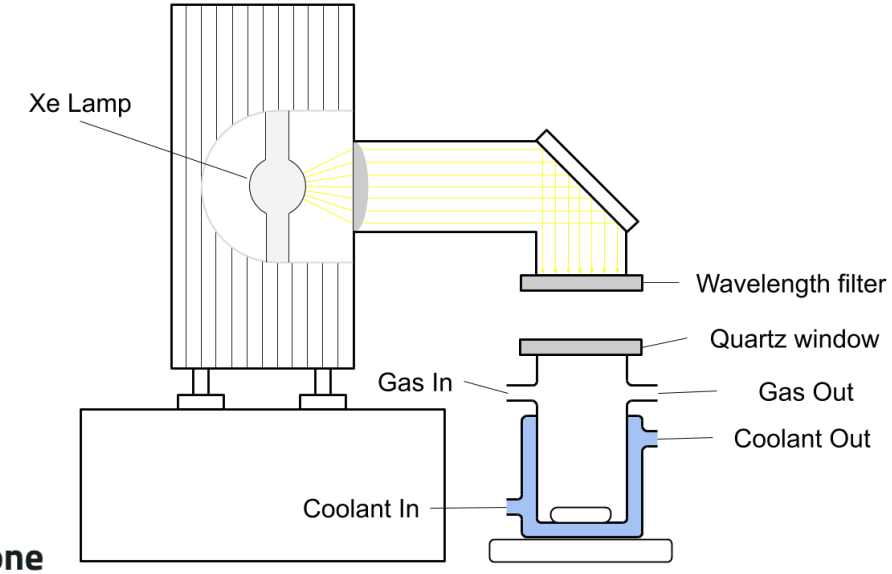
RESEARCH LINES

Photocatalysis



2. $2H^+ \rightarrow 2H_2$

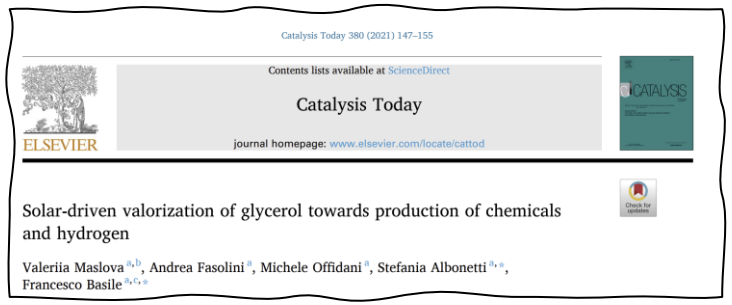




1. Renewable Energy Source

2. Hydrogen production

3. Valorization of **glycerol** towards production of chemicals


Catalysis Today 380 (2021) 147–155

Contents lists available at ScienceDirect

Catalysis Today

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

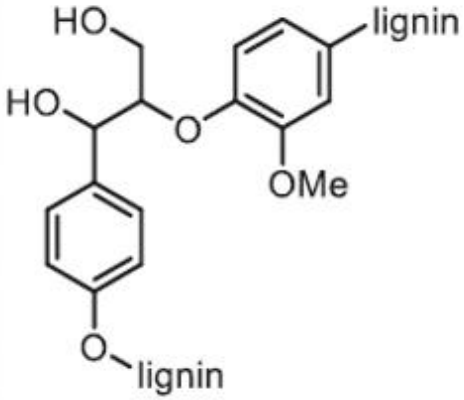
Solar-driven valorization of glycerol towards production of chemicals and hydrogen

Valeriia Maslova, Andrea Fasolini, Michele Offidani, Stefania Albonetti, Francesco Basile

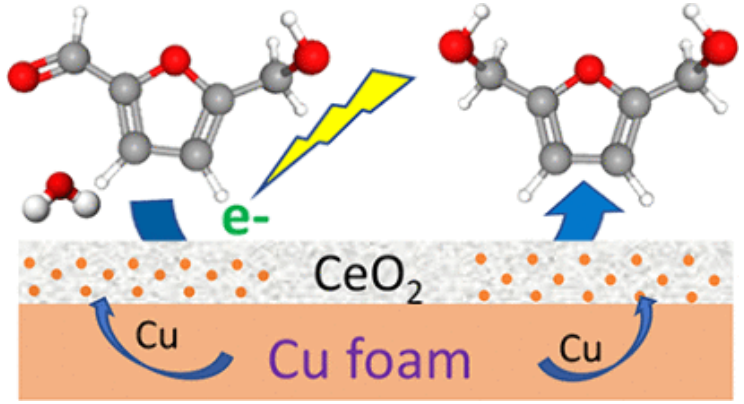
Ref: F. Basile – A. Fasolini

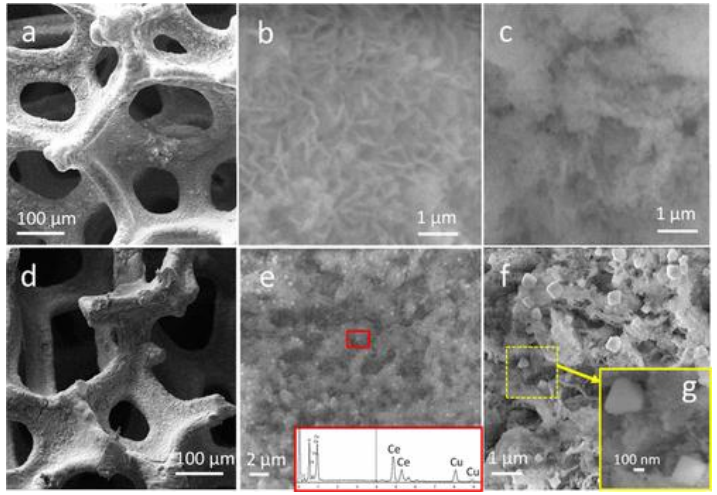
RESEARCH LINES

Electrocatalysis

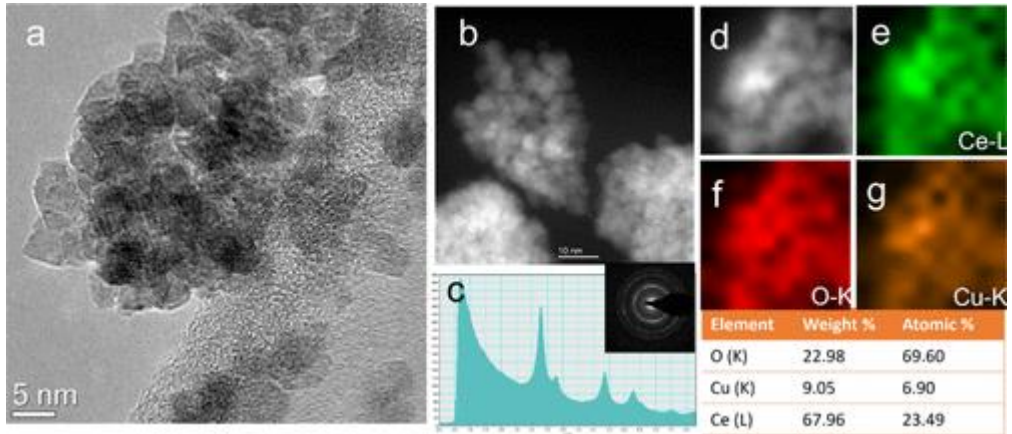


Vanillin





Ref: P. Benito – G. Fornasari

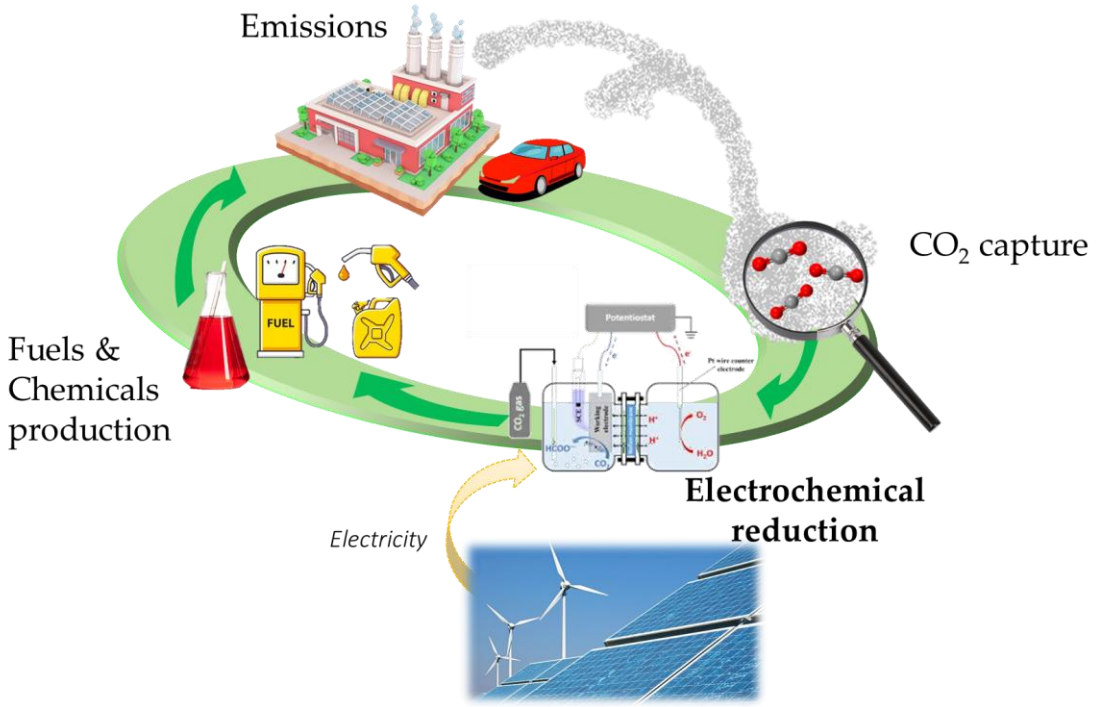


RESEARCH LINES

In Collaboration with the research group of Prof. Erika Scavetta

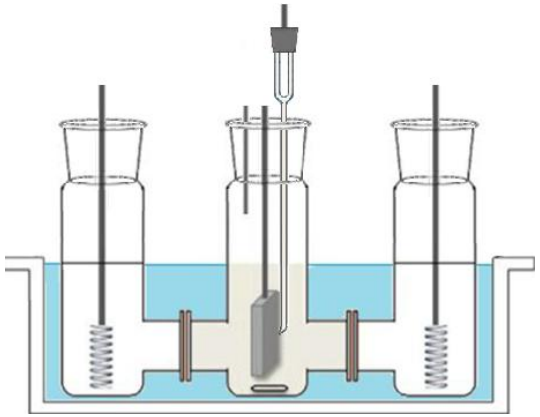
Electrocatalysis

CO_2 Valorisation

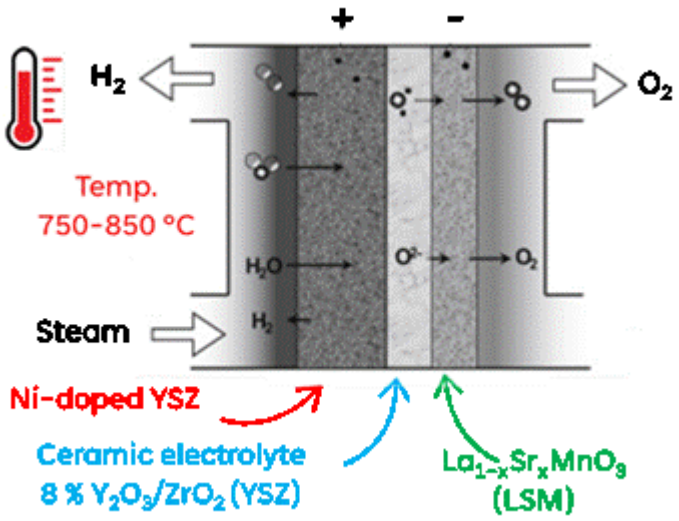


Ref: F. Basile – A. Fasolini

CO_2 — Cat → **Acetic acid**

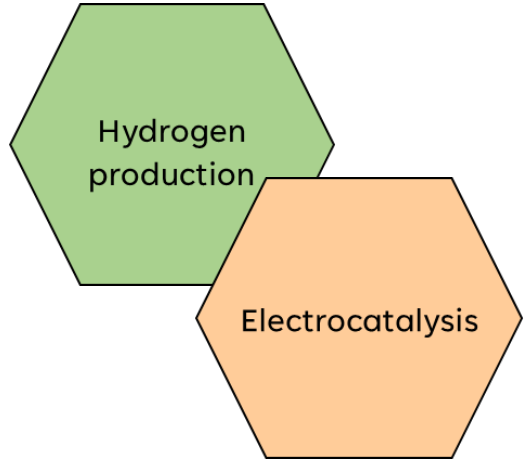


HIGH TEMPERATURE ELECTROLYSIS IN **SOEC** CELLS



Anode: $2\ O^{2-} \rightarrow O_2 + 4\ e^-$

Cathode: $2\ H_2O + 4\ e^- \rightarrow 2\ H_2 + 2\ O^{2-}$



Advantages

- non PGM electrodes (e.g., Pt, Pd, Ir, Ru)
- High efficiency, low potential

Challenges

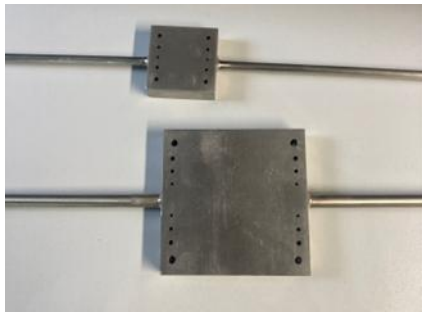
- Early research & development stage (PEM = commercial)
- Lower current densities than PEM and AEM

Probostat

Test di button cell da 1.5 cm di diametro

Single cell

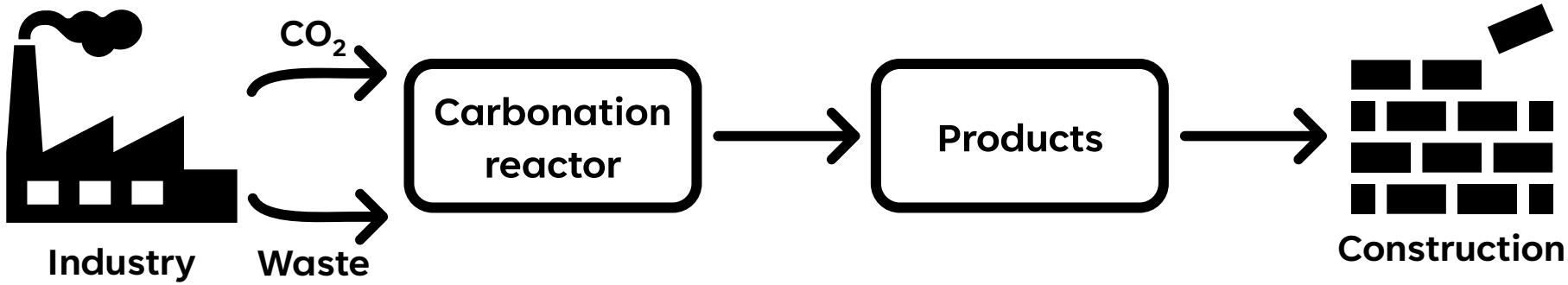
Test di Celle da 25cm^2 e 100 cm^2

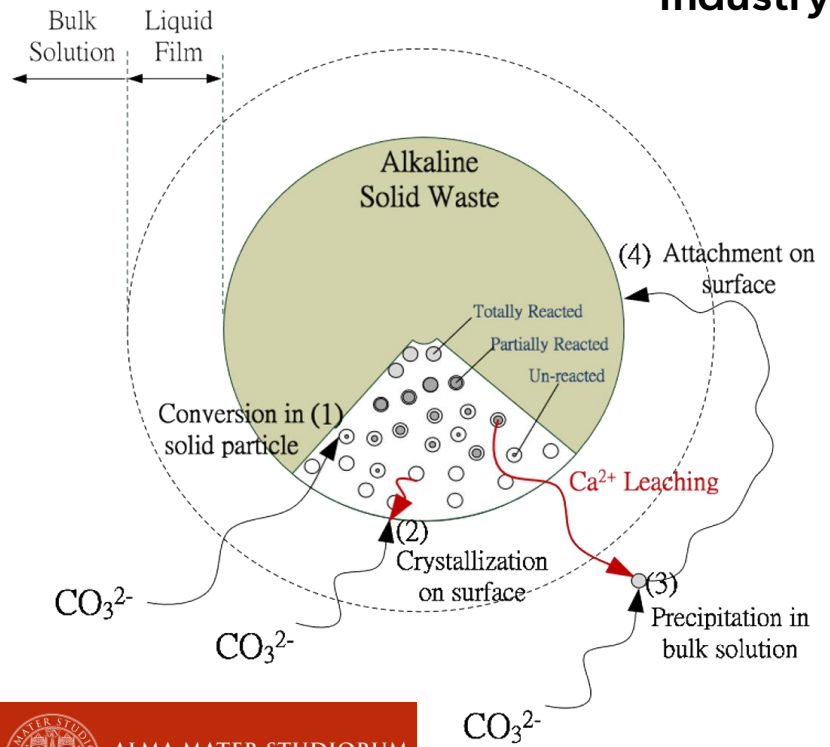


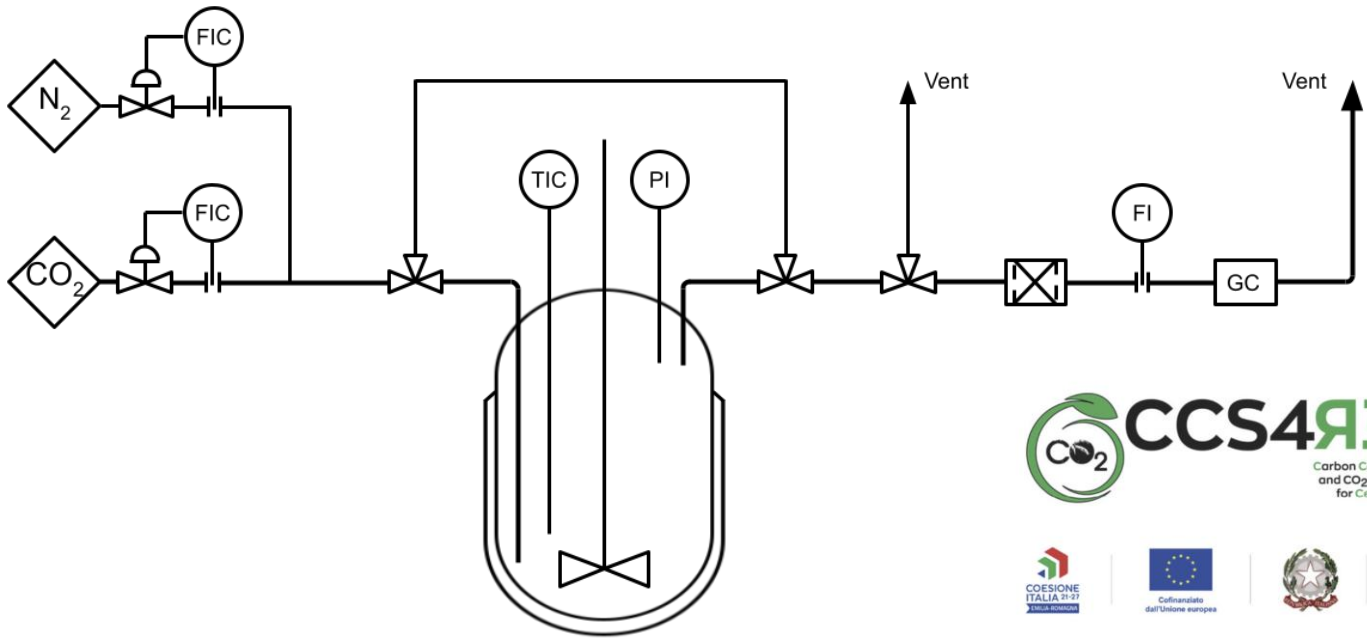
Ref: F. Basile – A. Fasolini

Mineralization of CO_2 in basic waste

CO_2 Valorisation







Ref: S. Albonetti – A. Allegri

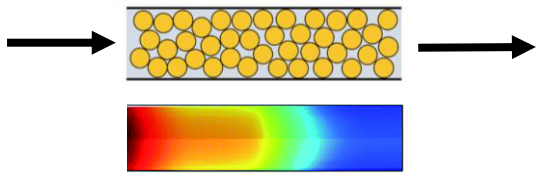
Project- Carbon Capture Storage and CO_2 mineralization for Ceramic Industry

CO_2 hydrogenation to MeOH, dimethyl ether or alkanes

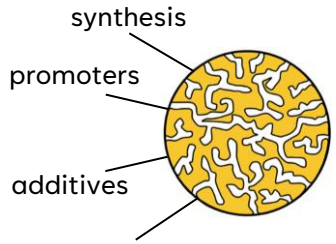
CO_2 Valorisation

Testing and process optimization

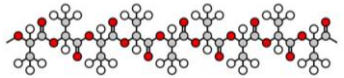
T, P, H_2/CO_2 ratio, WHSV



Novel catalyst



Polymers & resins



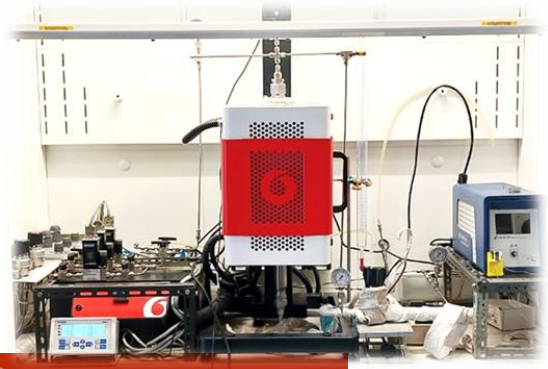
pharma
chemicals
cosmetics

Sustainable marine fuel

Methanol

Ref 1 – P. Benito – G. Fornasari
Ref 2 - F. Basile – A. Fasolini

Small-scale plant in Bologna
+
5-grams scale plant in Marina di Ravenna
P = 40 bar

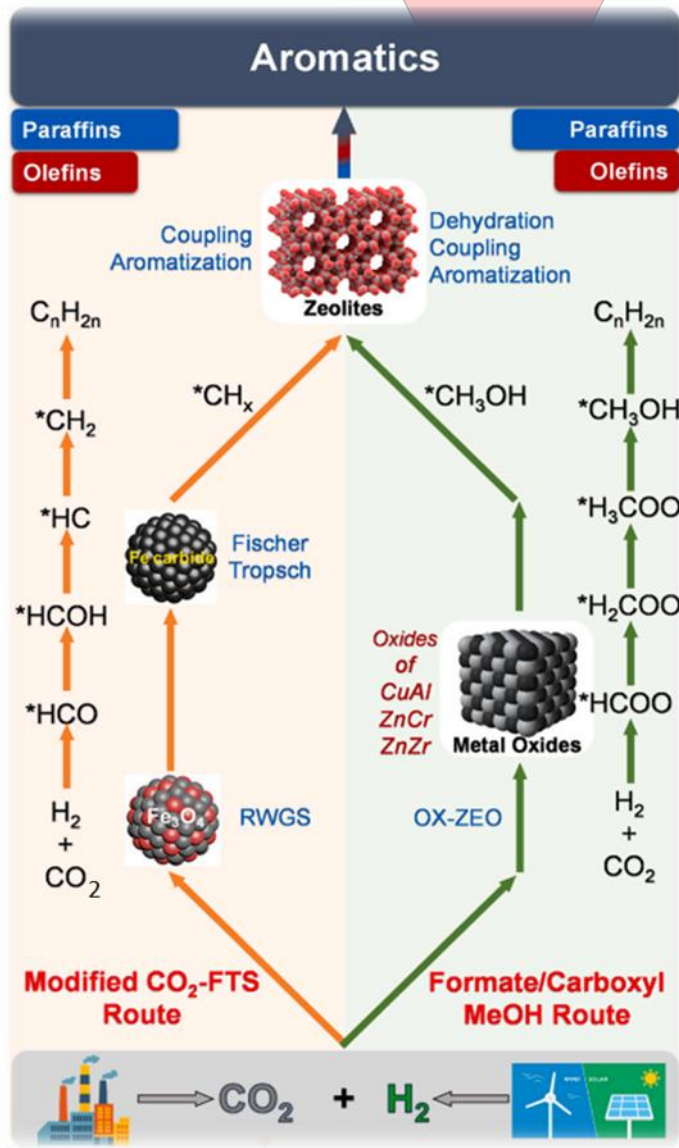


CO_2+ H_2

Dimethyl ether

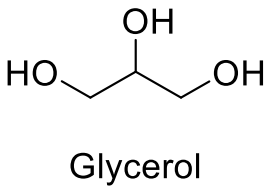
Alternative diesel fuel

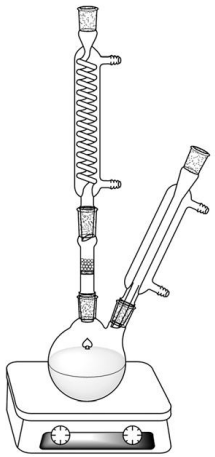
Sustainable aviation fuels

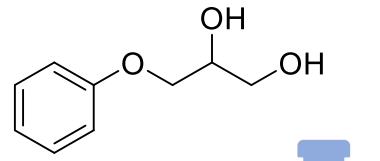


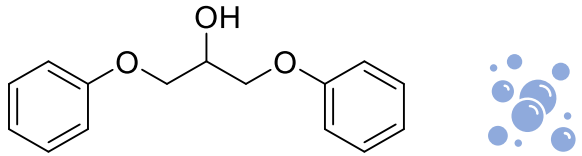
RESEARCH LINES

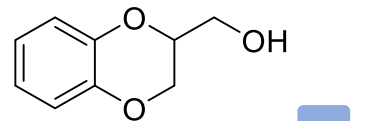
CO_2 Valorisation

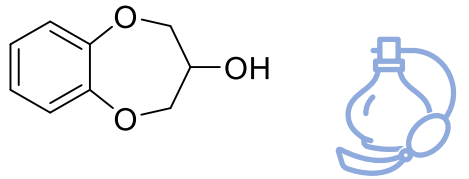

Glycerol + CO_2 → Glycerol Carbonate









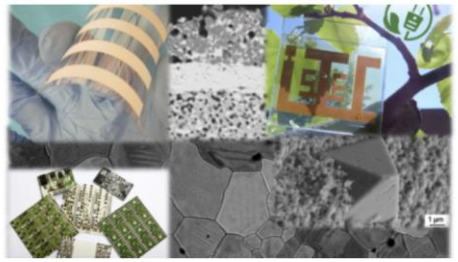


Ref: T. Tabanelli

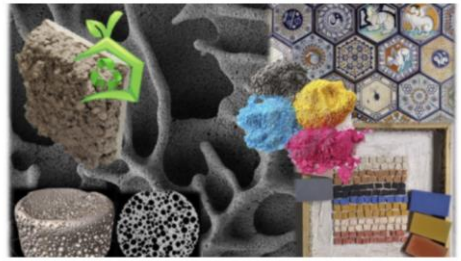
CNR ISSMC | Istituto di Scienza, Tecnologia e Sostenibilità per lo Sviluppo dei Materiali Ceramici

Collaboration with CNR-ISSMC

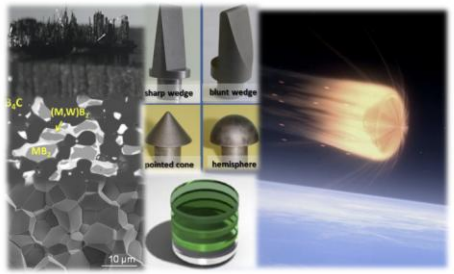
Nanotecnologie e nanosafety



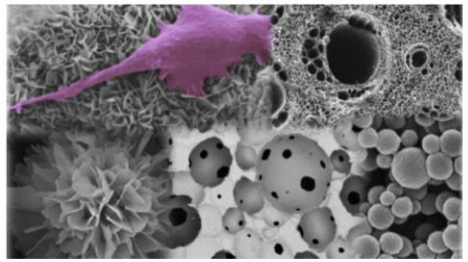
Energia e meccatronica



Ambiente, edilizia e patrimonio culturale



Materiali per applicazioni estreme



Salute e benessere

https://www.issmc.cnr.it/

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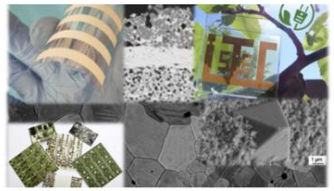
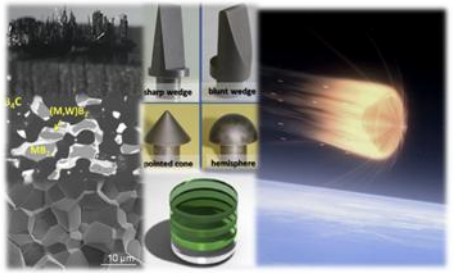
Collaboration with CNR-ISSMC

Nanotecnologie e nanosafety



Energia e meccatronica



Materiali per applicazioni estreme

Journal of Environmental Management 304 (2022) 114187

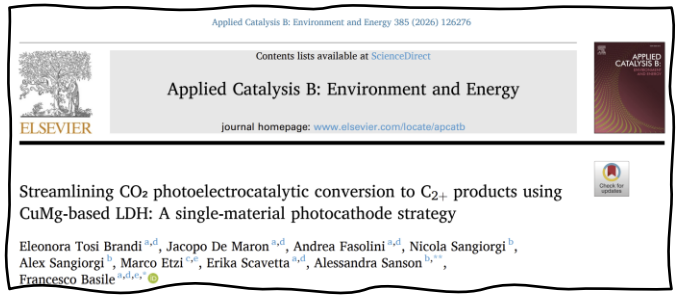
Contents lists available at ScienceDirect

Journal of Environmental Management

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

Chlorella vulgaris meets TiO_2 NPs: Effective sorbent/photocatalytic hybrid materials for water treatment application

M. Blosi [a,*], A. Brigliadori [a,**], I. Zanoni [a], S. Ortelli [a], S. Albonetti [b], A.L. Costa [a]



Applied Catalysis B: Environment and Energy 385 (2026) 126276

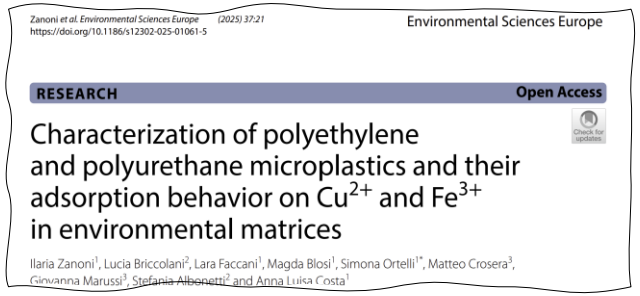
Contents lists available at ScienceDirect

Applied Catalysis B: Environment and Energy

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

Streamlining CO_2 photoelectrocatalytic conversion to C_{2+} products using CuMg-based LDH: A single-material photocathode strategy

Eleonora Tosi Brandi [a,d], Jacopo De Maron [a,d], Andrea Fasolini [a,d], Nicola Sangiorgi [b], Alex Sangiorgi [b], Marco Etzi [c,e], Erika Scavetta [a,d], Alessandra Sanson [b,**], Francesco Basile [a,d,e,*]



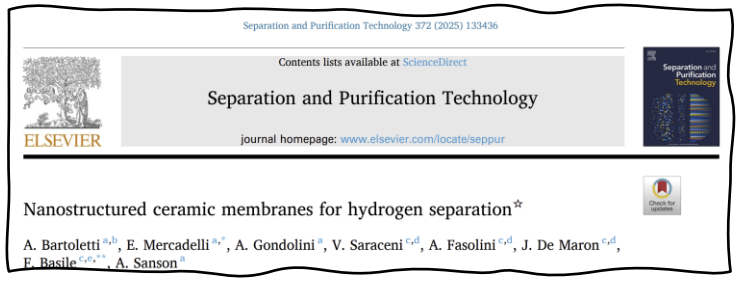
Zanoni et al. Environmental Sciences Europe (2025) 37:21
https://doi.org/10.1186/s12302-025-01061-5

Environmental Sciences Europe

RESEARCH Open Access

Characterization of polyethylene and polyurethane microplastics and their adsorption behavior on Cu^{2+} and Fe^{3+} in environmental matrices

Ilaria Zanoni[1], Lucia Briccolani[2], Lara Faccani[1], Magda Blosi[1], Simona Ortelli[1*], Matteo Crosera[3], Giovanna Marussi[3], Stefania Albonetti[2] and Anna Luisa Costa[1]



Separation and Purification Technology 372 (2025) 133436

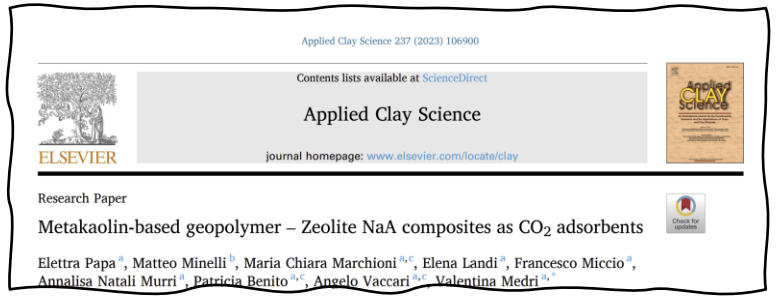
Contents lists available at ScienceDirect

Separation and Purification Technology

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

Nanostructured ceramic membranes for hydrogen separation☆

A. Bartoletti [a,b], E. Mercadelli [a,*], A. Gondolini [a], V. Saraceni [c,d], A. Fasolini [c,d], J. De Maron [c,d], F. Basile [c,e,**], A. Sanson [a]



Applied Clay Science 237 (2023) 106900

Contents lists available at ScienceDirect

Applied Clay Science

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

Research Paper

Metakaolin-based geopolymer – Zeolite NaA composites as CO_2 adsorbents

Elettra Papa [a], Matteo Minelli [b], Maria Chiara Marchioni [b,c], Elena Landi [a], Francesco Miccio [a], Annalisa Natali Murri [a], Patricia Benito [a,c], Angelo Vaccari [a,c], Valentina Medri [a,*]

Ref: P. Benito - S. Albonetti – F. Basile

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

CNR ISSMC | Istituto di Scienza, Tecnologia e Sostenibilità per lo Sviluppo dei Materiali Ceramici

Tematiche specifiche per tesi 2026/2027 con CNR-ISSMC

1. Sviluppo di materiali **adsorbenti e fotocatalitici** a base di **calcioferriti** per la **degradazione e rimozione di inquinanti persistenti** (metalli pesanti, molecole organiche, PFAS) da matrici acquose.
2. Sintesi di materiali **adsorbenti ibridi** a base di **nanofasi ceramiche, biopolimeri e microalghe** per il **trattamento di acque contaminate** da metalli pesanti, inquinanti organici e PFAS.
3. Progettazione di **rivestimenti nanostrutturati** idro/oleofobici "PFAS-free" su **supporti tessili** per lo sviluppo di finissaggi eco-sostenibili.
4. Sviluppo di **rivestimenti nanostrutturati conduttivi** su substrati tessili per l'integrazione di proprietà elettroniche e la realizzazione di e-textiles.

Riferimento S. Albonetti

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5. Sintesi di nanomateriali con proprietà **antimicrobiche** per il contrasto della proliferazione batterica e della resistenza agli antibiotici (in collaborazione con l'Università Statale di Milano).
6. Sistemi di **incapsulamento e granulazione di composti bioattivi** (polifenoli, oli essenziali) derivanti da scarti marini o dell'industria alimentare per applicazioni in packaging/cosmetica/agricoltura.
7. Strategie di **rimediazione colloidale** per la **cattura e rimozione di micro e nanoplastiche** mediante processi di destabilizzazione e flocculazione controllata.

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Tematiche specifiche per tesi 2026/2027 con CNR-ISSMC

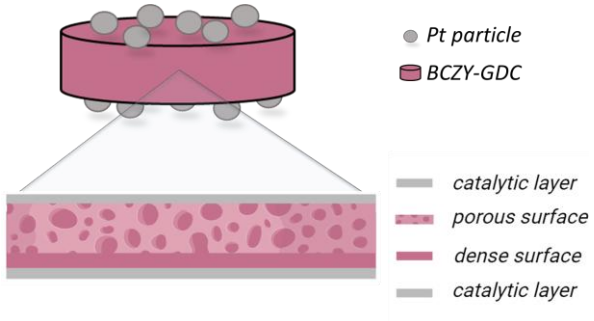
1. Development of **low temperature electrolytic materials** for solid oxide cell.
2. Design specific **piezoelectric nanomaterials** aimed at enhancing microalgal photosynthesis.
3. Development of **ceramic components** for Na-based all **solid-state batteries**.

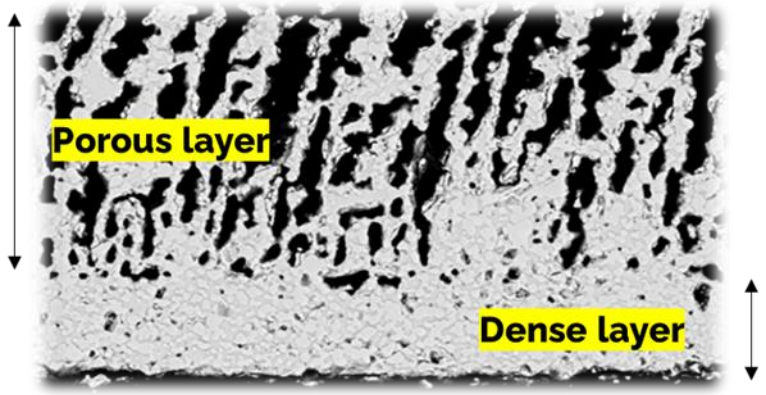
Ref: S. Albonetti

CERAMIC MEMBRANES FOR HYDROGEN PRODUCTION AND PURIFICATION

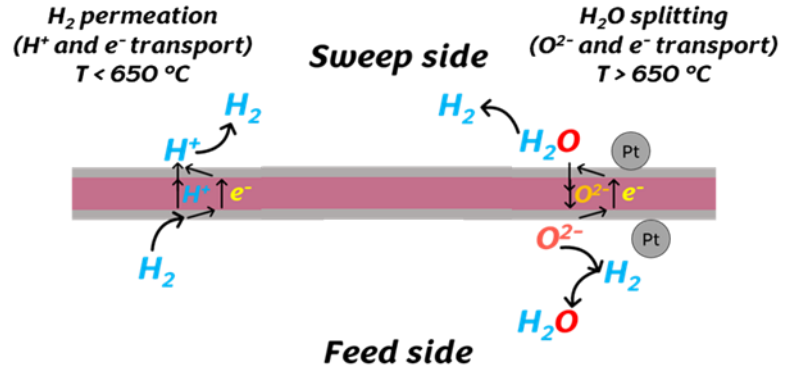
Hydrogen production

$BaCe_{0.65}Zr_{0.20}Y_{0.15}O_{3-\delta}$ – $Gd_{0.2}Ce_{0.8}O_{2-\delta}$





The coupling H_2 membarne separation low temperature methane reforming creates a driving force that push the equilibrium towards products, allowing to increase H_2 yields above the theoretical limit predicted by the reaction equilibrium



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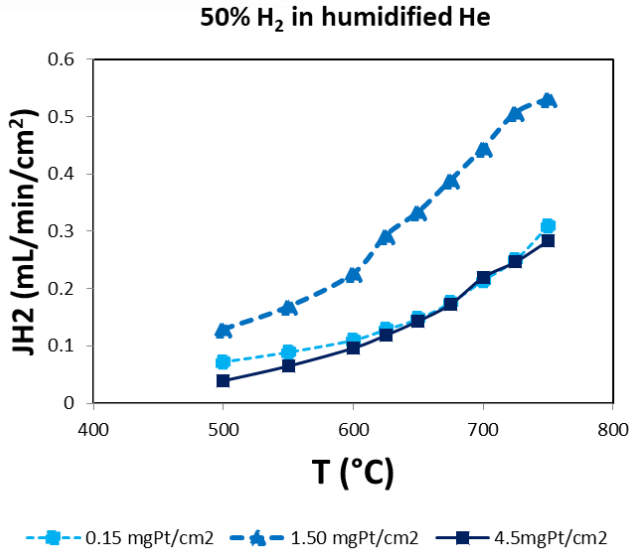
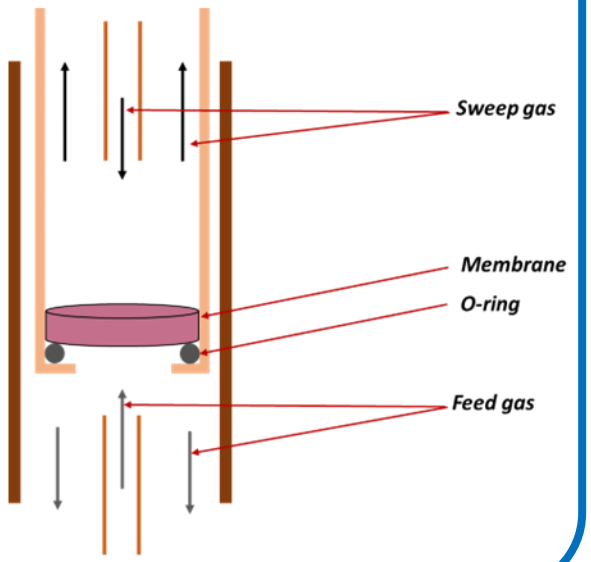
CARE IN PROCESS

Testing in membrane reactor





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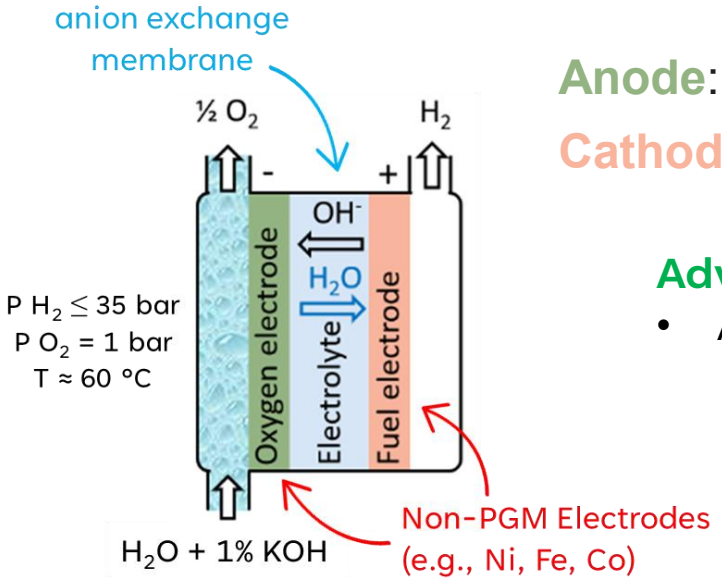
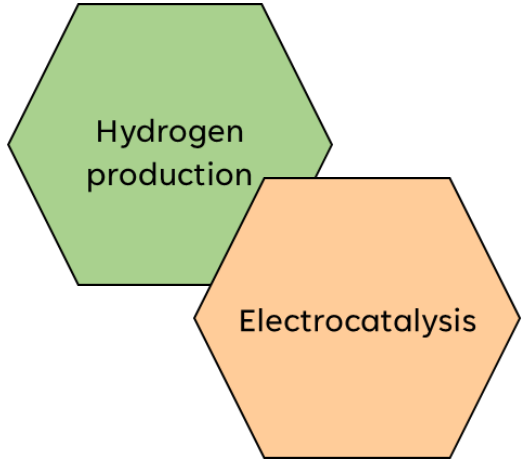
LOW TEMPERATURE ELECTROLYSIS IN **AEM** CELLS



Anode: $4\ OH^- \rightarrow O_2 + 2\ H_2O + 4\ e^-$ (+ 0.4 V)

Cathode: $4\ H_2O + 4\ e^- \rightarrow 2\ H_2 + 4\ OH^-$ (- 0.83 V)

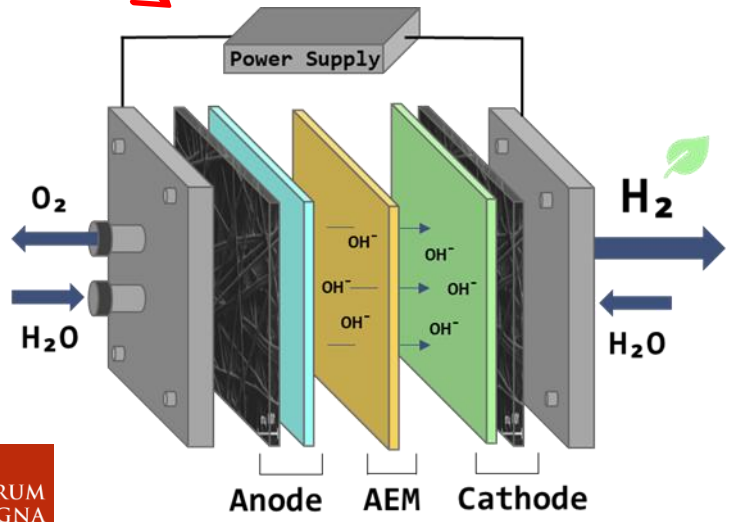


Advantages

- Avoid PGM electrodes (e.g., Pt, Pd, Ir, Ru) required by PEM

Challenges

- Early research & development stage (PEM = commercial)
- Lower current densities than PEM



Possible internships:

- *Development of electro-catalyst and gas diffusion electrode (GDL) systems; study of cell resistances and fluid dynamics*
- *Development of a device characterized by the deposition of the catalyst directly on the AEM membrane for H_2 production at high pressures*

CATALYSIS FOR RENEWABLES AND INNOVATIVE PROCESSES «CARE IN PROCESS»

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