FRANCE 2030

PROGRAMME DE RECHERCHE

DÉCARBONATION DE L'INDUSTRIE

PEPR SPLEEN

Pour la Décarbonation de l'Industrie

Directeurs de programme:

Fabrice Lemoine (CNRS et Université de Lorraine)
António Pires da Cruz (IFPEN)

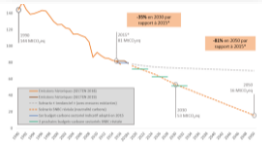
cnrs

ifp Energies nouvelles

4 décembre 2025

anr agence nationale de la recherche

France 2030
National Acceleration Strategy “Industry Decarbonisation”



- EU Fit for 55: Engagement towards carbon neutrality in 2050
- Industry represents **20%** of emissions in France
- National Low Carbon Strategy for industry: **-81%** emissions/2015

- France 2030 plan mobilizes **4.5 B€** for industry decarbonization:
  - **4.05 B€** for Green steel, chemistry and cement: Solutions deployment in industry
  - **405 M€** for Innovation and development of green technologies to support industry decarbonisation, including basic research to prepare the technologies of the future, including **70 M€** for basic research

PEPR in the National Acceleration Strategy

01

Competitive Industry

Ensure the emergence of competitive French industrial decarbonization solutions

02

Territorial Integration

Develop large-scale cross-cutting actions to demonstrate the feasibility of decarbonizing industrial areas (territorial synergies, carbon storage)

03

Regulation

Encourage and promote industry decarbonization (public procurement, standards, labels, regulatory barriers)

04

Research

PEPR SPLEEN

Prepare breakthrough decarbonization technologies of tomorrow to achieve carbon neutrality by 2050

05

Education and Training

Create and strengthen the training offer addressing the challenges of industrial decarbonization

France 2030: A continuum, from research to industry

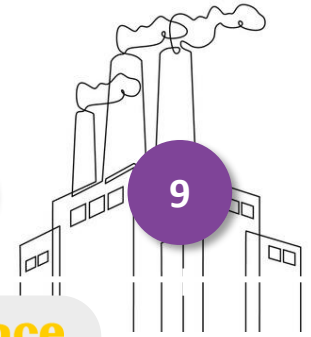
Research (PEPR SPLEEN) → Prematuration (premat CACTUS) → Maturation (mat CACTUS) → Industrialization & Marketing

Technology selection

Promising innovation projects

Transfer

1 2 3 4 5 6 7 8 9 TRL



PEPR SPLEEN

anr agence nationale de la recherche

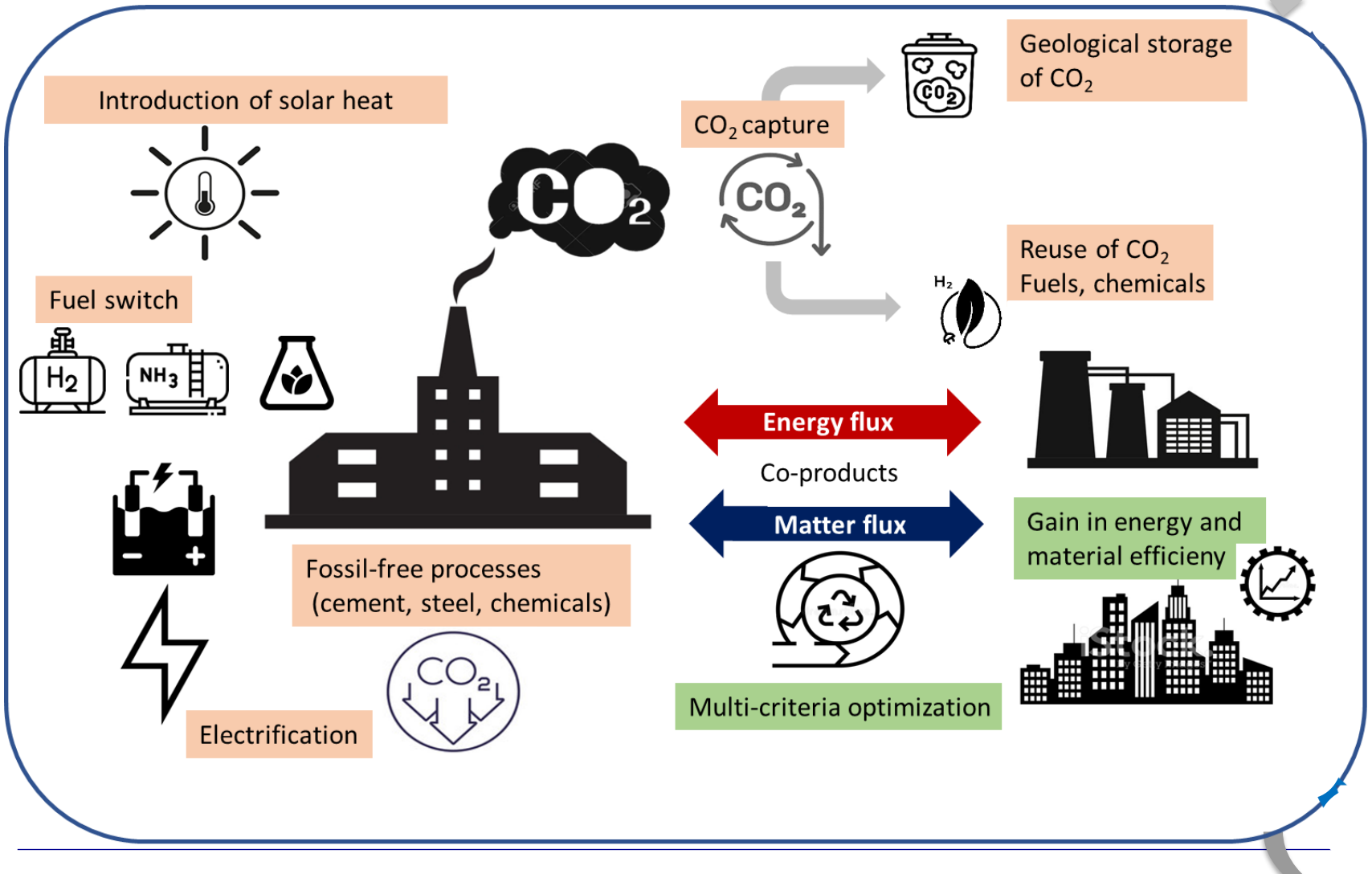
Prematuration & Maturation

ADEME — AGENCE DE LA TRANSITION ÉCOLOGIQUE

BANQUE des TERRITOIRES | Caisse des Dépôts Groupe

bpifrance

Industry Decarbonization - Major Research Challenges



- Governance
- Economy
- Legal Framework
- Public Policies
- Social & Environmental Impacts

PEPR SPLEEN: 21 On-going projects

AXIS 1

New prediction and monitoring tools

- DCARBO
- LCA SPLEEN
- ACT-4IE
- SPECULAR

AXIS 2

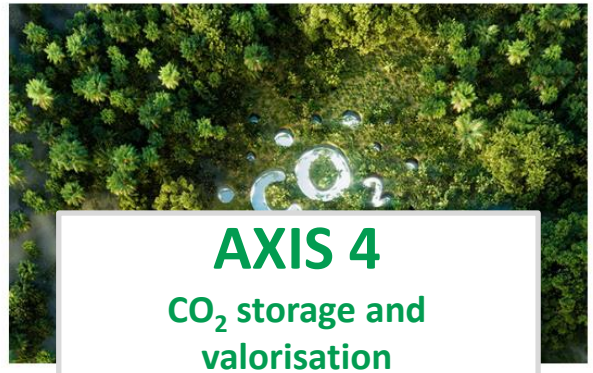
Integration of low carbon energy vectors, efficiency

- SHIP4D
- AMYABLE
- FROZEN
- REHEAT
- ATHENA
- REVCO2

AXIS 3

Process decarbonisation and intensification

- ECOCHEM
- PLASMA-N-ACT
- IMOSYCCA
- CATALPA
- OXY-3C
- NEWIRON



AXIS 4

CO_2 storage and valorisation

- POWER CO2
- COCCINELLE
- CARBIOCEM
- CARBONARA
- SESAME

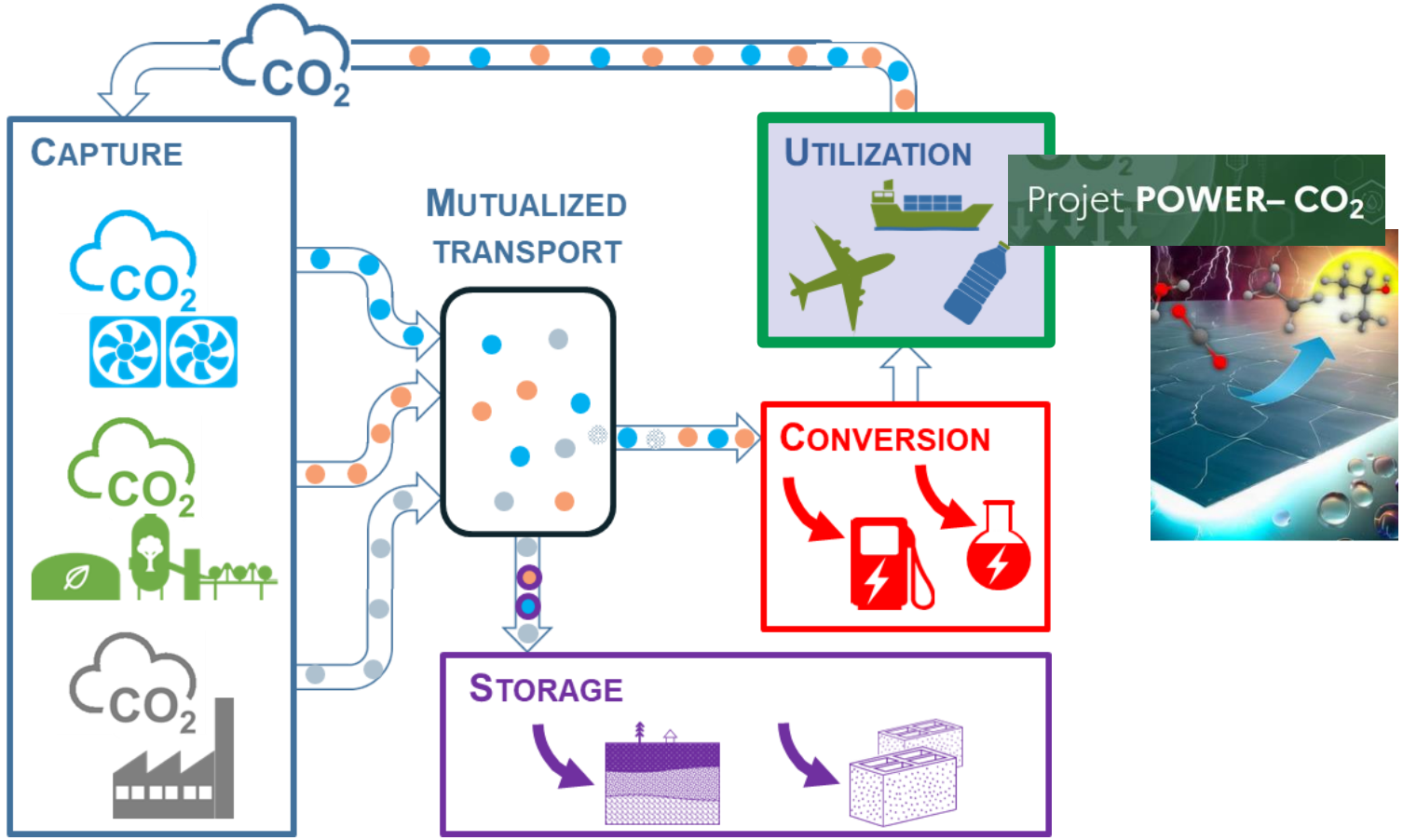
New projects expected in 2026!

Pathways to reach Carbon Neutrality

CO_2 nature:

- Atmospheric
- Biogenic
- Fossil (hard-to-abate)

- Atmospheric for Storage (negative emissions)
- Biogenic for Storage (negative emissions)
- Fossil for Conversion (until 2040)



RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

FRANCE 2030
PROGRAMME DE RECHERCHE
DÉCARBONATION DE L'INDUSTRIE

PEPR SPLEEN

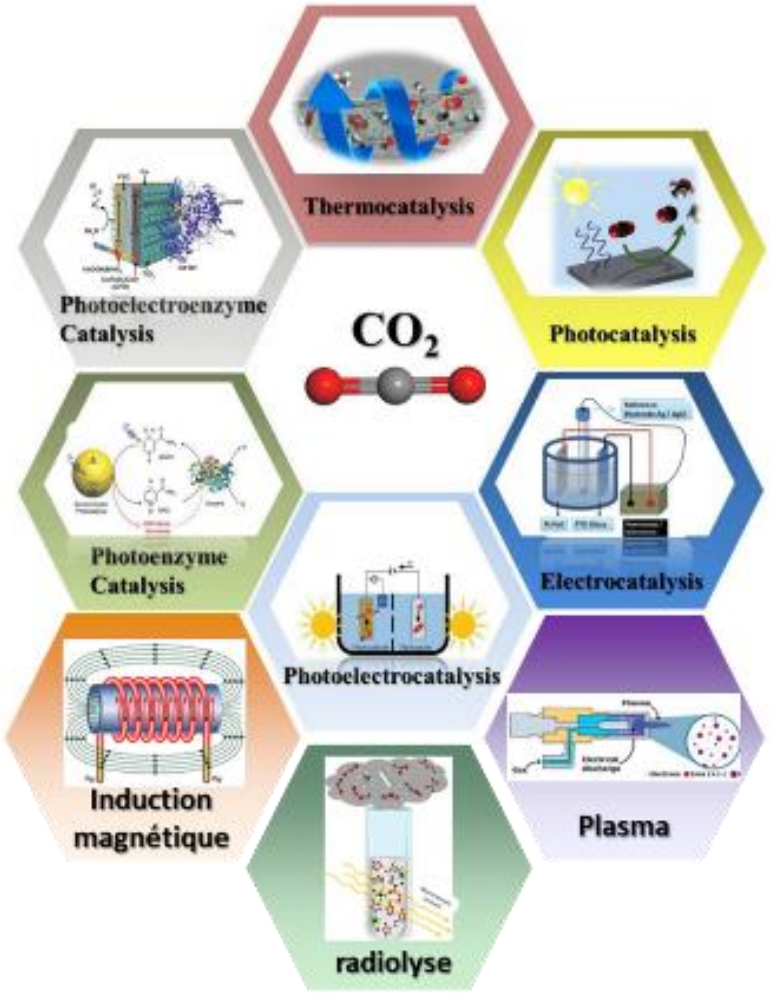
Projet Ciblé **POWER CO_2**

Alessandra Quadrelli (CNRS-IRCELyon), coordinatrice du projet ciblé

Audrey Bonduelle (IFPEN)

Christine Cavazza (CEA)

POWER CO_2 : Propulser la conversion du CO_2 en e-carburants, carburants solaires et synthons chimiques via des énergies renouvelables au-delà de l'état de l'art



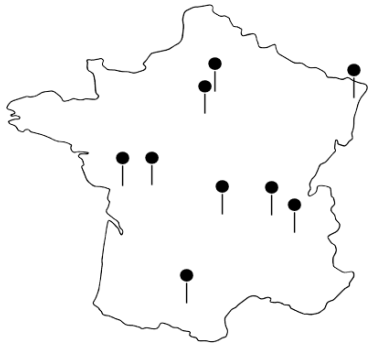
Objectifs et méthodologie :

→ Valoriser le CO_2 en utilisant des énergies bas-carbone

→ Stratégie autour de 3 axes :

1) **Electro**-(bio)-conversion du CO_2
2) Ingénierie de matériaux ou systèmes **photo-actifs**
3) Voies **d'activations non conventionnelles**
   telles que plasma, radiolyse, induction magnétique

8 partenaires institutionnels,
24 équipes de recherche,
+ de 70 permanents impliqués
28 thèses et post-docs



- CNRS
- CEA
- IFPEN
- SORBONNE U.
- U. Clermont F.
- MINES PARIS
- PARIS SACLAY
- INSA TOULOUSE

Paris
E-MOCA (CNRS- SU)
LCBP (CNRS - CdF)

Paris Saclay, Evry
IPVF (CNRS - U PSL - X - IPVF)
NIMBE *Lcme Lions* (CEA - CNRS)
JACOB (CEA – CNRS - Ud'E)
ICCMO (UPS - CNRS)
D'ALEMBERT (SU - CNRS)

Nantes
IMN Nantes (CNRS - Nantes U)
CEISAM Nantes (CNRS - Nantes U)

Poitiers
IC2MP (CNRS - U Poitiers)

Toulouse
LCC Smac Nos (CNRS)
LPCNO (INSA Toulouse - CNRS)

Strasbourg
ICPEES (CNRS - U Strasbourg)

Lyon & Clermont-Ferrand
IRCELYON *Ing & Catren* (CNRS - U. Lyon 1)
INL *i-Lum* (CNRS – ECL – INSA Lyon - U. Lyon 1)
IFPEN
UCA ICCF (UCF - CNRS)

Grenoble
DCM *Biocen* (CNRS/UGA)
LCBM *Solhycat & Bee* (CEA –CNRS UGA)
LITEN (CEA)

Marseille & PACA
BIP (CNRS/AMU)
Plateforme µ-algues (CEA Cadarache)
Mines Paris Tech PERSEE

Axe 1

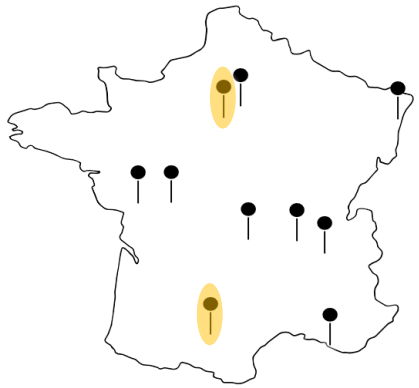
POWER CO_2 – fait marquant - « Electrocatalyse »

Post-doc A. Singh et D. Martin – M. Robert – J. Bonin – S. Bontemps

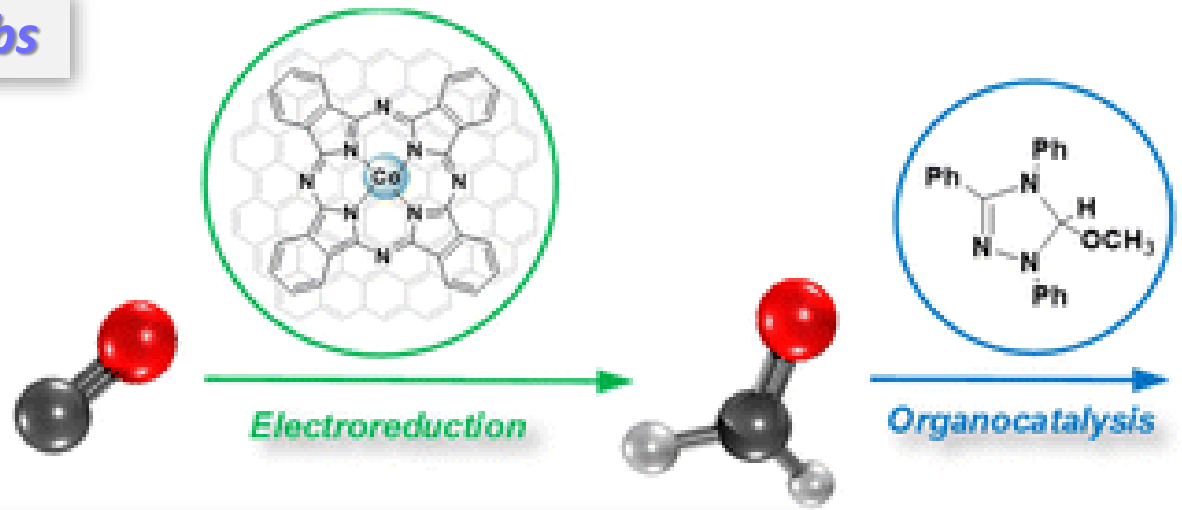
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

FRANCE 2030 PROGRAMME DE RECHERCHE DÉCARBONATION DE L'INDUSTRIE

Sous-projet Electrokrebs



Univ Paris Cité
LCC SMAC (CNRS)




Le Monde

Comment transformer du CO_2 et du monoxyde de carbone en sucres

Dans une étude publiée dans « Chemical Science » le 23 octobre, des chercheurs dévoilent la recette pour transformer des gaz nocifs en sucres. Une technique qui pourrait amener certaines productions vers la neutralité carbone.

JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY
pubs.acs.org/JACS
Communication

Molecular Electrochemical Catalysis of CO-to-Formaldehyde Conversion with a Cobalt Complex

Ajeet Singh, Afridi Zamader, Reza Khakpour, Kari Laasonen, Michael Busch, and Marc Robert*

Cite This: J. Am. Chem. Soc. 2024, 146, 22129–22133 Read Online

ACCESS | Metrics & More | Article Recommendations | Supporting Information

ABSTRACT: Formox, a highly energy-intensive process, currently serves as the primary source of formaldehyde (HCHO), for which there is a crucial and steadily growing chemical demand. The alternative electrochemical production of HCHO from C1 carbon sources such as CO_2 and CO is still in its early stages, with even the few identified cases lacking mechanistic rationalization. In this study, we demonstrate that cobalt phthalocyanine (CoPc) immobilized on multiwalled carbon nanotubes (MW-CNTs) constitutes an excellent electrocatalytic system for producing HCHO with productivity through the direct reduction of CO, the two-electron reduction product of CO_2. By carefully adjusting both the pH and the applied potential, we identified conditions that enable the production of HCHO with a partial current density of 0.64 mA cm^{-2} (17.5% Faradaic efficiency, FE) and a total FE of 61.2% for the liquid products (formaldehyde and methanol). A reduction mechanism is proposed.

Chemical Science

ROYAL SOCIETY OF CHEMISTRY

EDGE ARTICLE View Article Online View Journal

Check for updates

Cite this: DOI: 10.1039/d5sc06667k

All publication charges for this article have been paid for by the Royal Society of Chemistry

CO-to-sugars conversion from one-pot two-step electro-organocatalytic process

Ajeet Singh, †[a] David Martins-Bessa, †[b] Julien Bonin, *[a] Marc Robert *[ac] and Sébastien Bontemps *[b]

The conversion of C_1 molecules (single-carbon species) into C_n products (carbon chains) is a key challenge for developing sustainable chemical feedstocks to replace fossil resources. Carbohydrates, a vital class of complex polycarbon molecules, are mainly extracted from biomass, but *de novo* synthesis provides a complementary route to access rare and non-natural carbohydrates. Here, we report a fully integrated, one-pot two-step system converting carbon monoxide (CO) into carbohydrates. This process couples the electroreduction of CO to formaldehyde with the organocatalytic oligomerization of formaldehyde into C_{5-6} carbohydrates selectively. This work establishes a novel pathway to utilize CO as a building block for synthesizing complex carbon chains.

Received 29th August 2025
Accepted 22nd October 2025

DOI: 10.1039/d5sc06667k

rsc.li/chemical-science

anr

Axe 2

POWER CO_2 – fait marquant - « Photocatalyse »

M. Rivallan – post-doc A. Ricchebuono

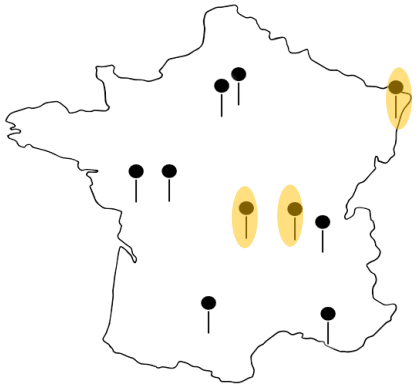
RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

FRANCE 2030 PROGRAMME DE RECHERCHE DÉCARBONATION DE L'INDUSTRIE

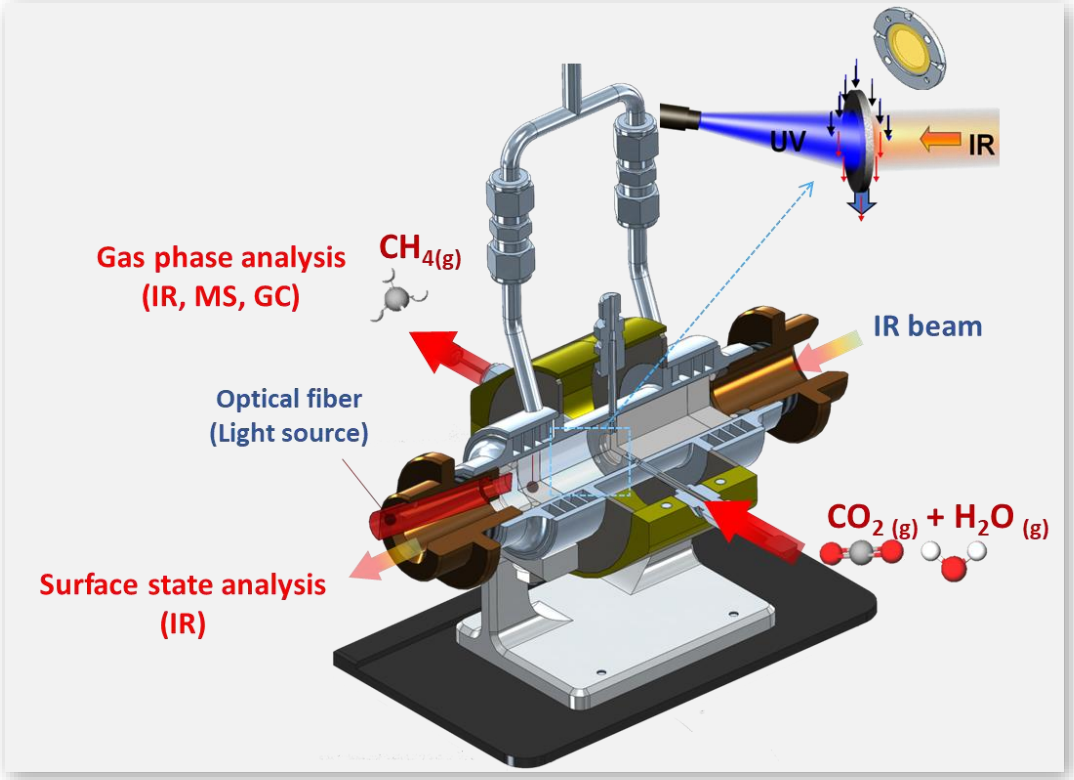
Sous-projet PLASMONS

Equipement : spectroscopie IR operando

$$CO_2 + H_2O + h\nu \rightarrow O_2 + H_2, CO, CH_4$$

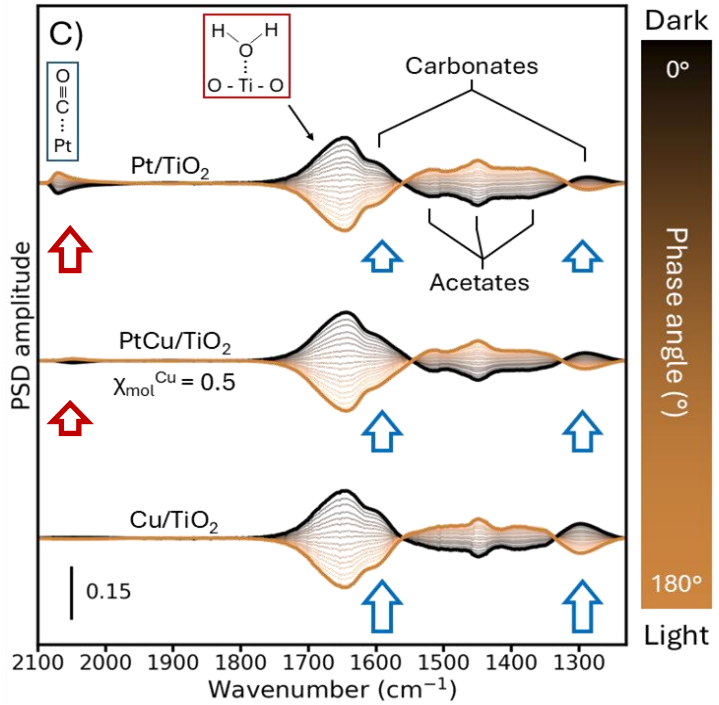


ICPEES (CNRS - U Strasbourg)
IFPEN
UCA ICCF (UCF - CNRS)



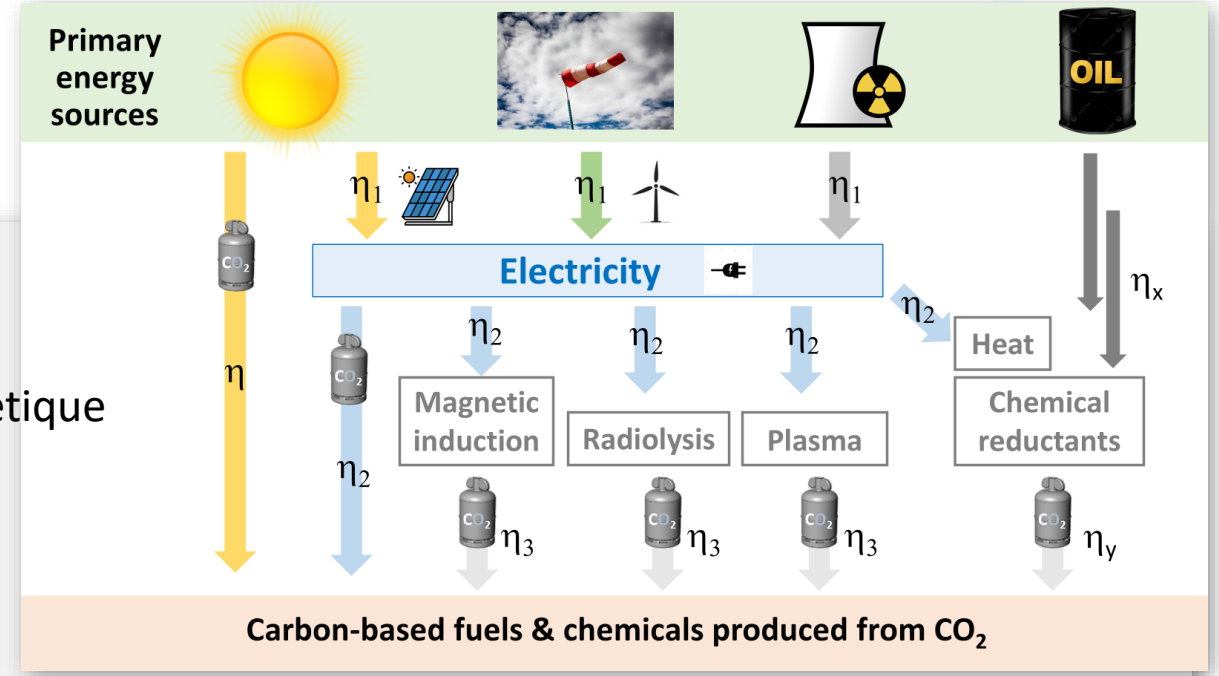
Objectifs :

Identifier les mécanismes et caractériser les intermédiaires réactionnels grâce à l'IR Operando de nouveaux matériaux PtCu /TiO_2 (ICPEES) et Bi/BiO_xF_y (ICCF), destinés à absorber un maximum de photons UV-Vis



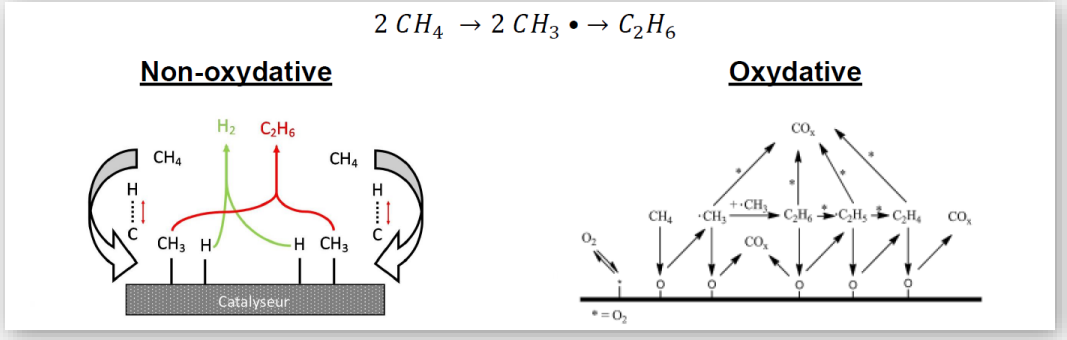
anr

POWER CO_2 – ses ateliers



- **2 ateliers organisés en 2024/2025 :**
  - Descripteurs communs pour définir l'efficacité énergétique
    - *Comparaison des technologies*
    - *Fiches à destination des étudiant.es*
    - *Cours en vidéo*
  - Etapes-clés de la formation de liaison C-C et de la construction d'architectures complexes à partir du CO_2
    - *Rédaction d'une revue multidisplinaire*

→ pour les catalyses homogène et hétérogène, photocatalyse, électrocatalyse, biocatalyse, plasma, radiolyse, magnétocatalyse



- **4 ateliers organisés en 2026/2027 avec ECOCHEM et le PEPR LUMA :**
  - Stratégies d'augmentation de l'efficacité énergétique en photoconversion du CO_2

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

anr agence nationale de la recherche

Find us on

https://www.pepr-spleen.fr/

contact@pepr-spleen.fr

PEPR SPLEEN

YouTube

FRANCE 2030

PROGRAMME DE RECHERCHE

DÉCARBONATION DE L'INDUSTRIE

We thank ANR for its support!