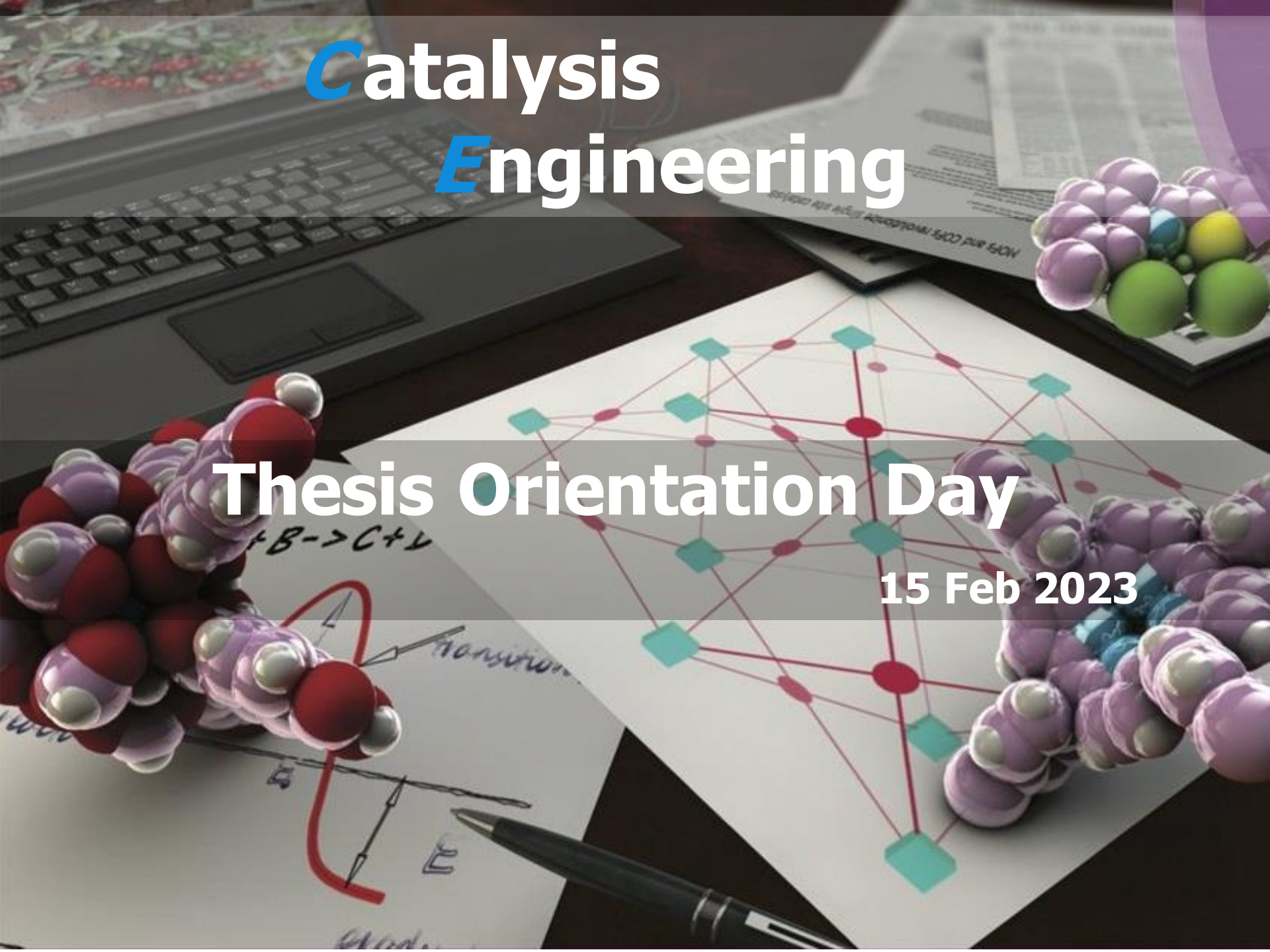
Catalysis Engineering

Thesis Orientation Day

15 Feb 2023



Catalysis Engineering

Atsushi Urakawa

Monique van der Veen

Atul Bansode

www. tudelft.nl/cheme/catalysis-engineering

Catalysis Engineering

Monique van der Veen

Projects at van der Veen Group

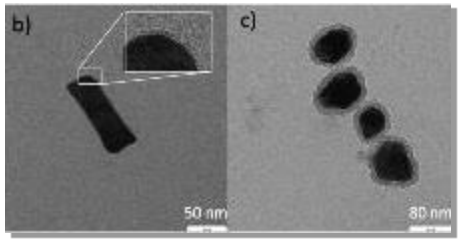
For more information go to:

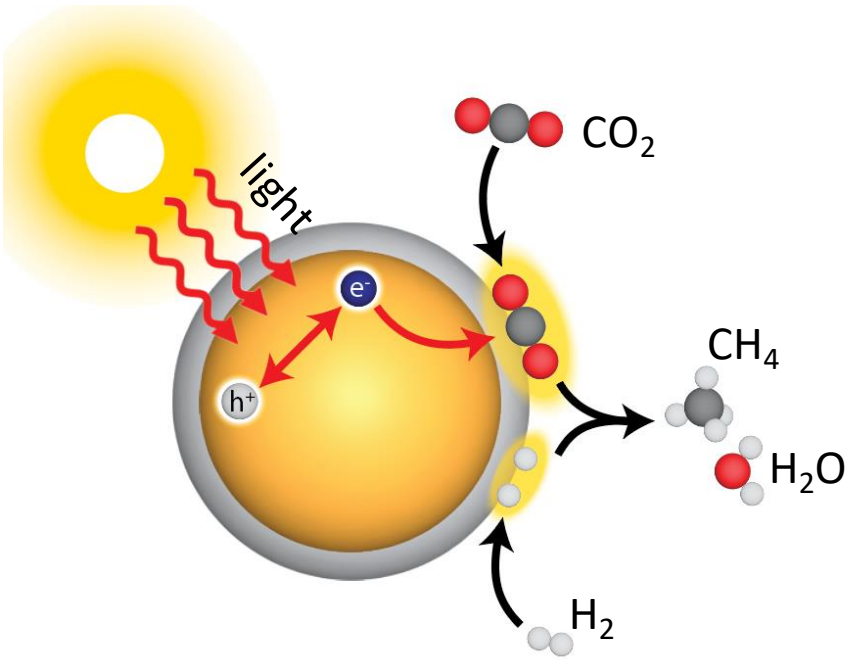
https://www.tudelft.nl/cheme/vanderveengroup


DOE EEN STAP TERUG
DOE EEN STAP NAAR VOREN
GOOI EEN
BIJL
EET EEN
BAL!

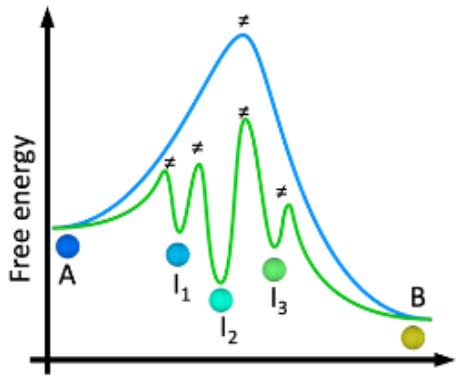
TU Delft

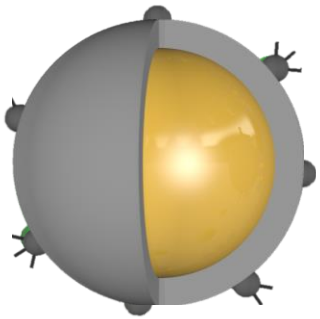
Theme 1:
CO_2 hydrogenation by plasmonic catalysis

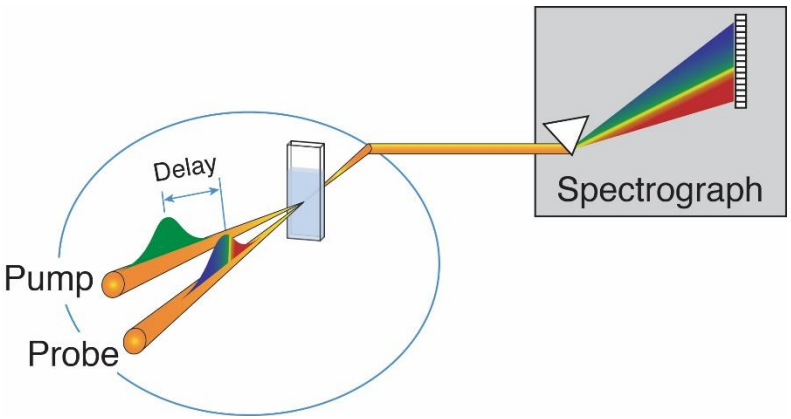




Project: Plasmonic NanoHEATers to Unravel Catalytic CO_2 Hydrogenation with Ultimate Time Resolution







Objectives:

- Initiate catalytic reactions by "normal" catalysts via ultrafast plasmonic **heating**
- Observe catalytic <u>intermediates</u> using ultrafast spectroscopy (picosecond resolution)

Contains:

- Catalysis, synthesis, ultrafast spectroscopy

Contact:
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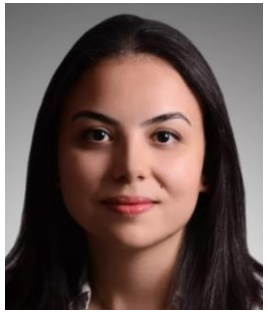
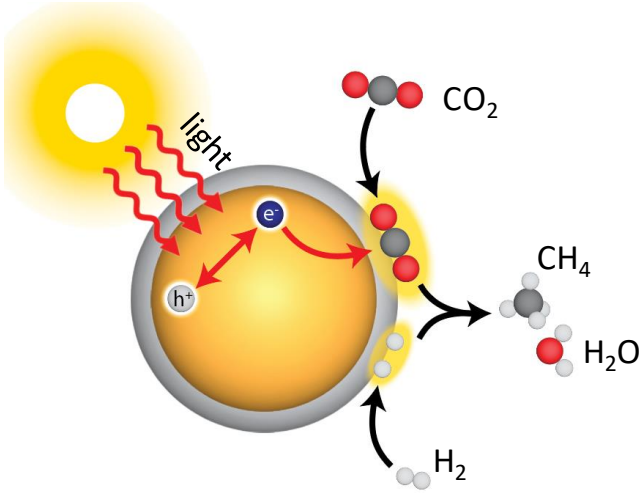


Project: Optimizing plasmon-assisted CO_2 conversion

Use the plasmonic particle directly as photocatalyst

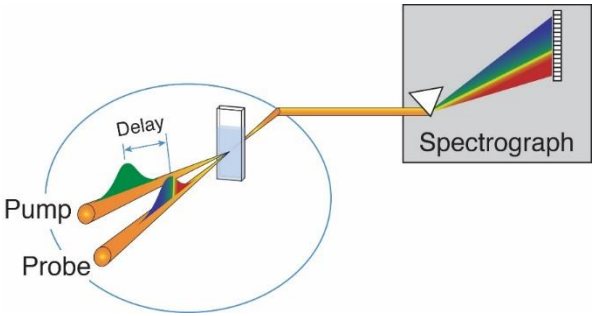


Plasmonic nanoparticles

- Excellent light absorbers
- Tuneable optical properties
- Steer specific reaction pathways

Ultrafast pump-probe spectroscopy

- Charge carrier dynamics
- Detect reaction intermediates
- 100 femtoseconds (10^{-13} seconds) timescale



Contact:
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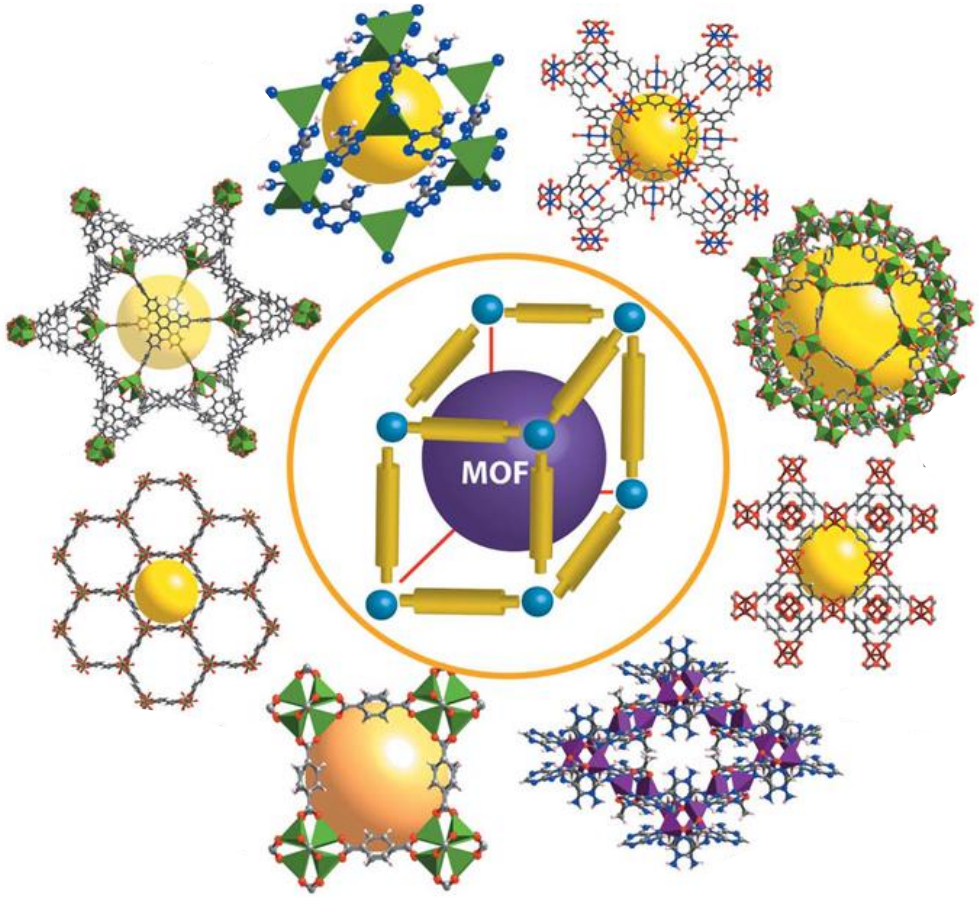
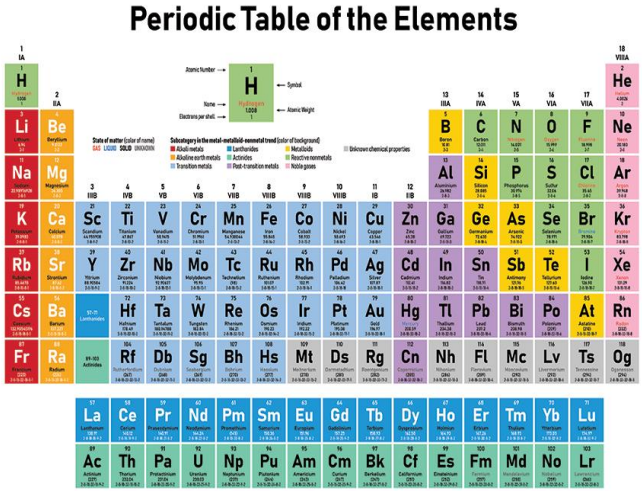
Theme 2:
Sensing and Separations

with nanoporous materials

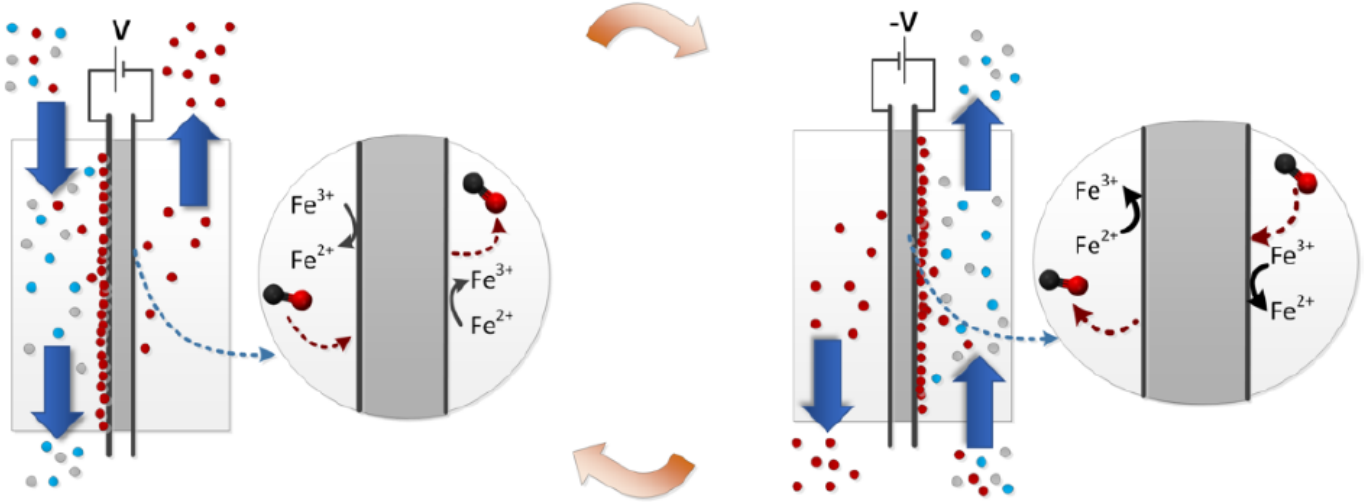




From: Augustus *et al. Am. J. Environ. Protection*. **2017**, 5(2), 61-67

Project: Redox-active materials for electric swing adsorption of CO

Removing CO from flue gasses from steel production can reduce global CO2 emission by 3 %!!



What we want to know

Which materials are suitable for electric swing adsorption of CO in industrial waste gas streams

What you will learn

Synthesis of nanoporous hybrid materials
Characterisation of to the structure and performance of the materials

Contact

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Project: Development of e-nose for the detection of veterinary disease

Xing *et al.* Chemistry Select 2020, 5(13), 3946

What we want to know

Which materials are selective for sensing disease specific odour components

How to print these materials onto sensor platforms

What you will learn

Synthesis and printing of metal-organic frameworks

Characterisation of to the structure and performance of the materials

Contact

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Catalysis Engineering

Atsushi Urakawa

Projects at Urakawa Group

Catalyst & Reaction Engineering

Contact: Atsushi Urakawa (A.Urakawa@tudelft.nl)

Thermo-catalysis

- CO_2 to methanol
- CO_2 to formates
- Integrated CO_2 capture & conversion
- Methane to C=C, CO (reacting with CO_2)
- Automotive catalysis

Electro-catalysis

- PEM electrolysis
- H_2 production
- Nitrogen oxides to ammonia

Photo-catalysis

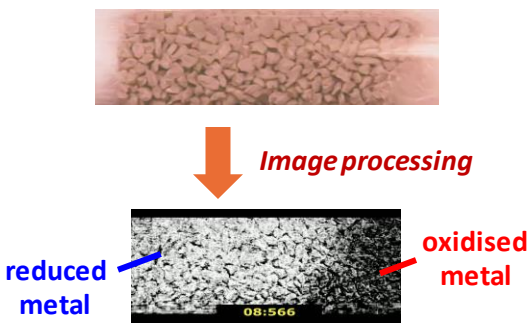
- H_2 production
- CO_2 reduction

Combining *operando* methodologies and kinetic study

Contact: Atsushi Urakawa (A.Urakawa@tudelft.nl)

Oxidation state

Visualisation

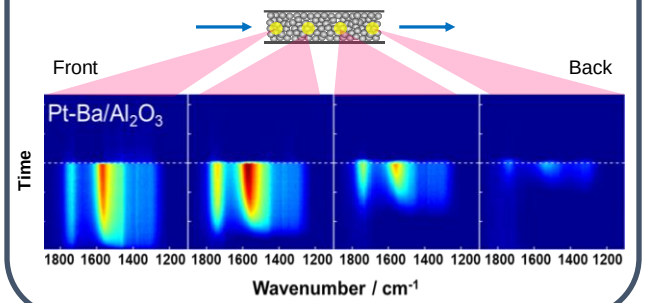


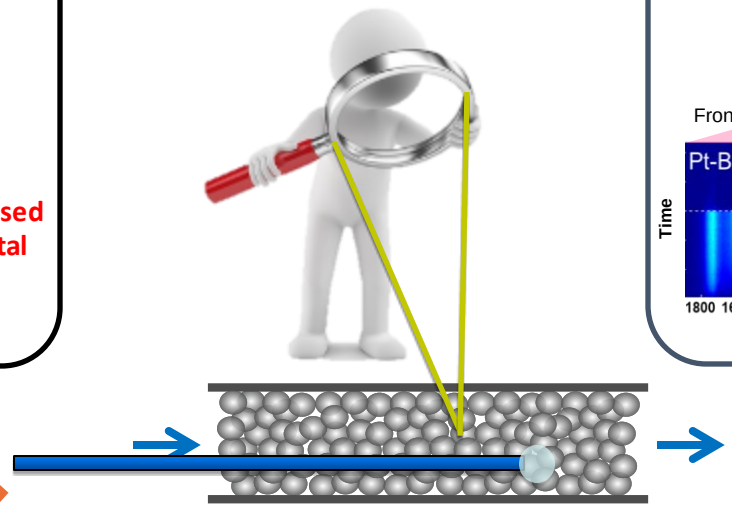
Surface/bulk chemistry

Spectroscopy

with *space- and time-resolution*

IR, Raman, X-ray, ...

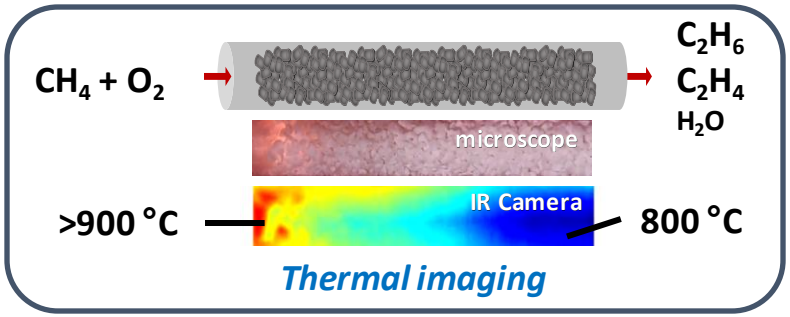




Fluid concentration

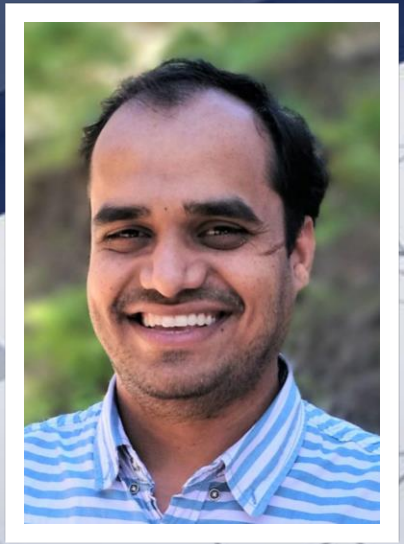
Space-resolved concentration profiling

Temperature



Thermal imaging

Catalysis Engineering



Atul Bansode

Projects at Bansode Group

Innovative catalytic processes and instrumentation

1. Green hydrogen

Hydrogen generation via Thermochemical Water Splitting

Material improvement through:

- Doping
- Support
- Structures ((core-shell) nanoparticles, 3D-ordered materials, etc.)

Methodology improvement through:

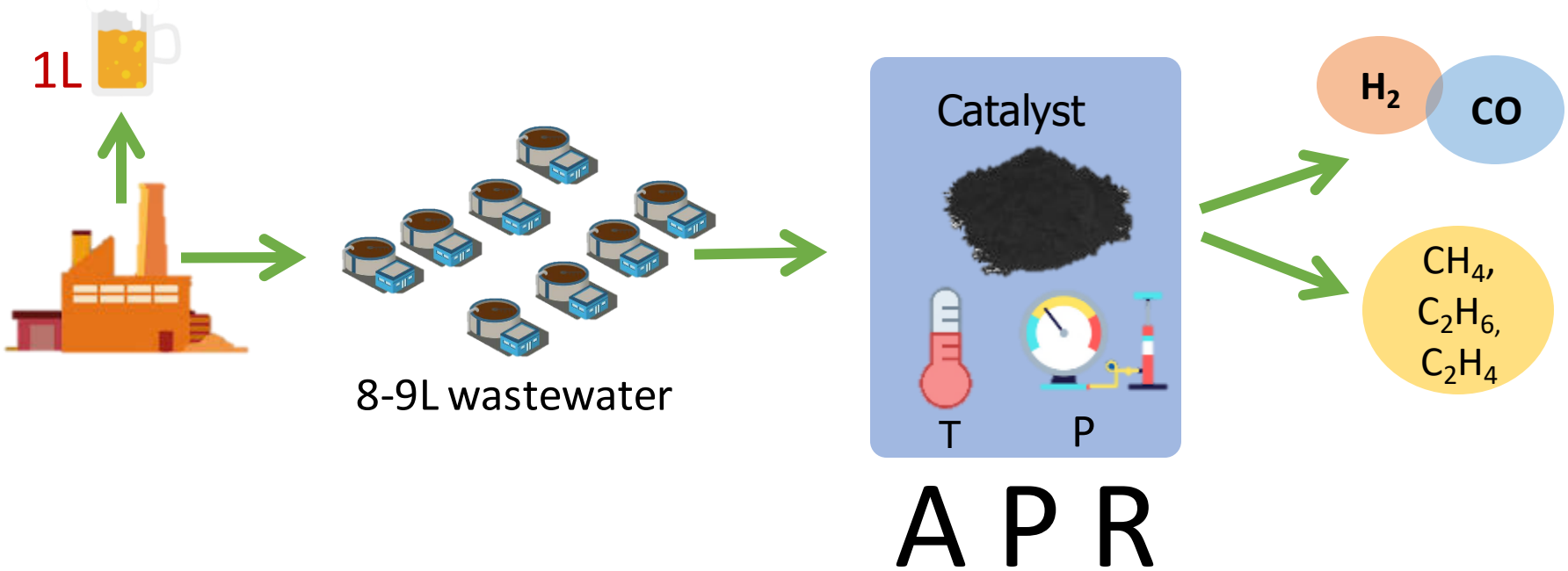
- Innovative instrumentation
- Operation modes
  - Temperature swing
  - Isothermal

Contact: (a.b.bansode@tudelft.nl)

Innovative catalytic processes and instrumentation

2. Waste to chemicals

Aqueous Phase Reforming**(APR)** of bio-wastes



Process improvement via :

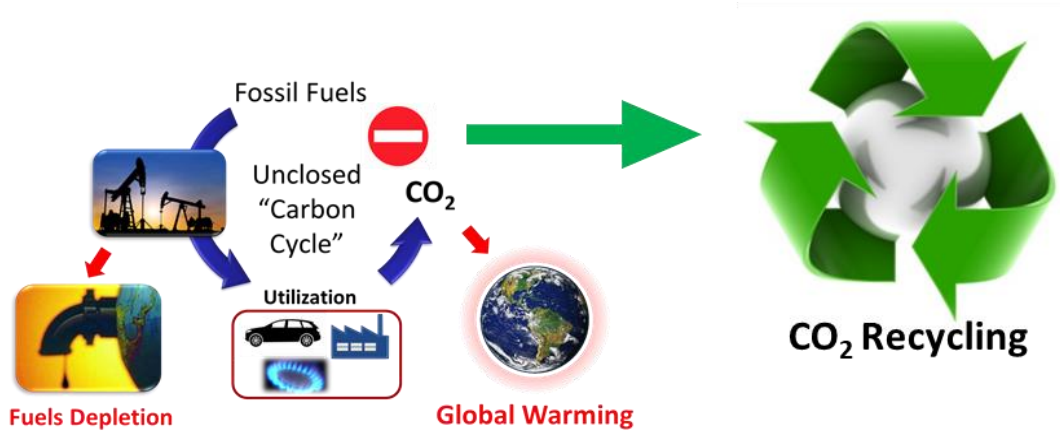
- ✓ New catalyst formulations
- ✓ Selective product formation
- ✓ Optimization of T, P and feed conditions
- ✓ Tuning of catalyst materials for better stability

Contact: (a.b.bansode@tudelft.nl)

Innovative catalytic processes and instrumentation

3. CO_2 conversion

CO_2 to higher alcohols (ethanol, propanol etc.)



Overall, what you'll learn:

- Development, synthesis and tuning of new materials
- Process optimization and hands on high pressure fixed bed reactors
- Characterization of material (BET Surface Area, XRD, SEM/EDS, …)
- GC-analysis
- Performance correlations

Contact: (a.b.bansode@tudelft.nl)

*C*atalysis *E*ngineering

After work: pizza, cake, BBQ, international dinner, Christmas dinner, cake, Friday drinks, and cake