Catalysis Engineering

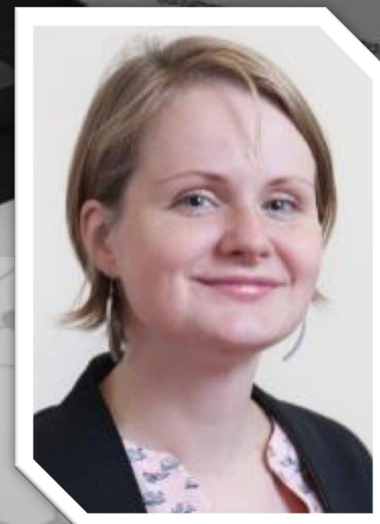
Thesis Orientation Day

28 November 2018

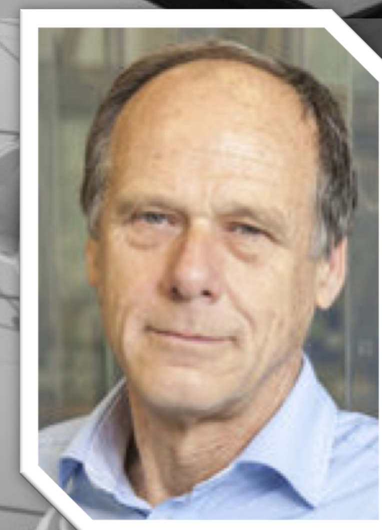
Catalysis Engineering

Atsushi Urakawa

Freek Kapteijn



Monique
van der Veen

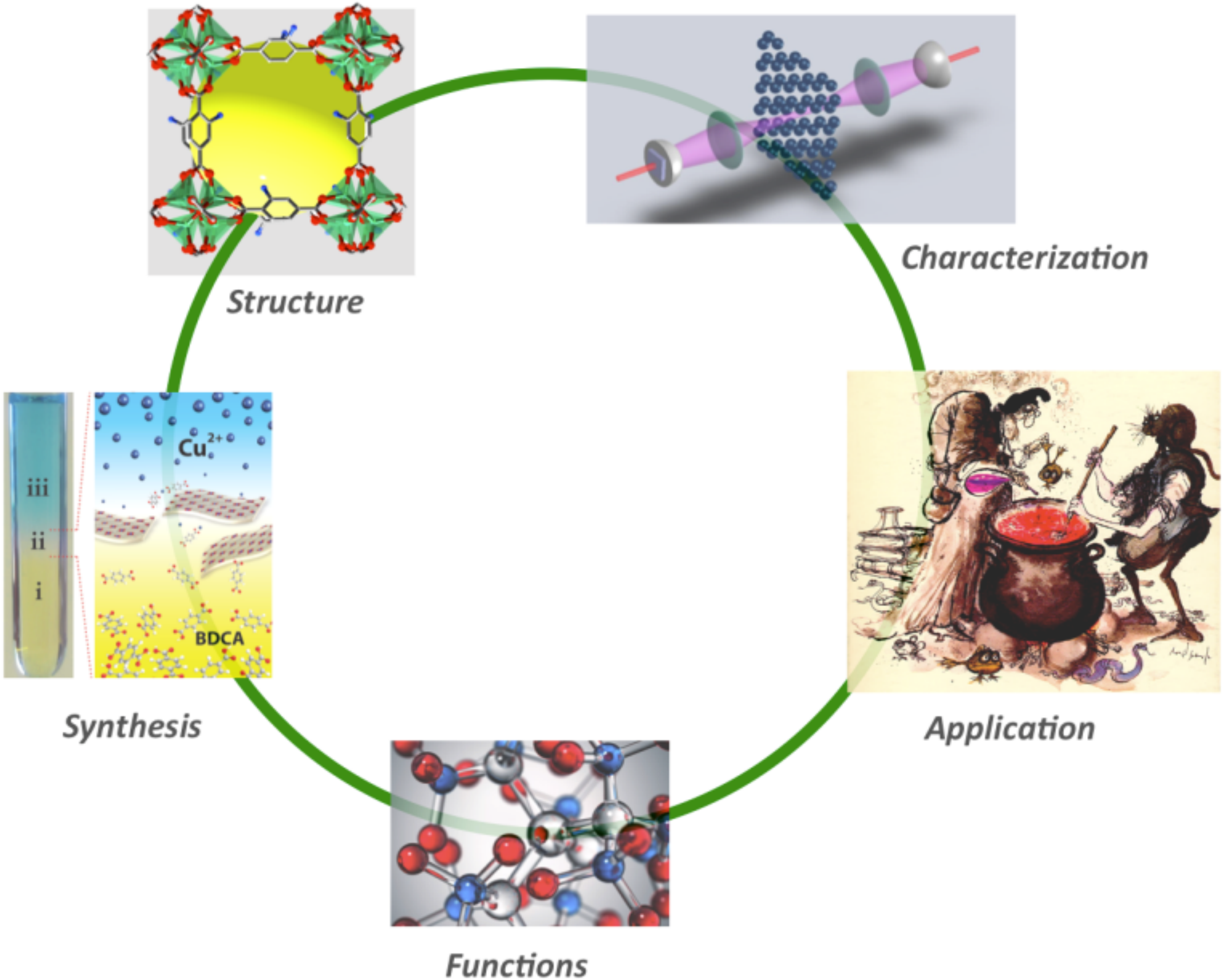


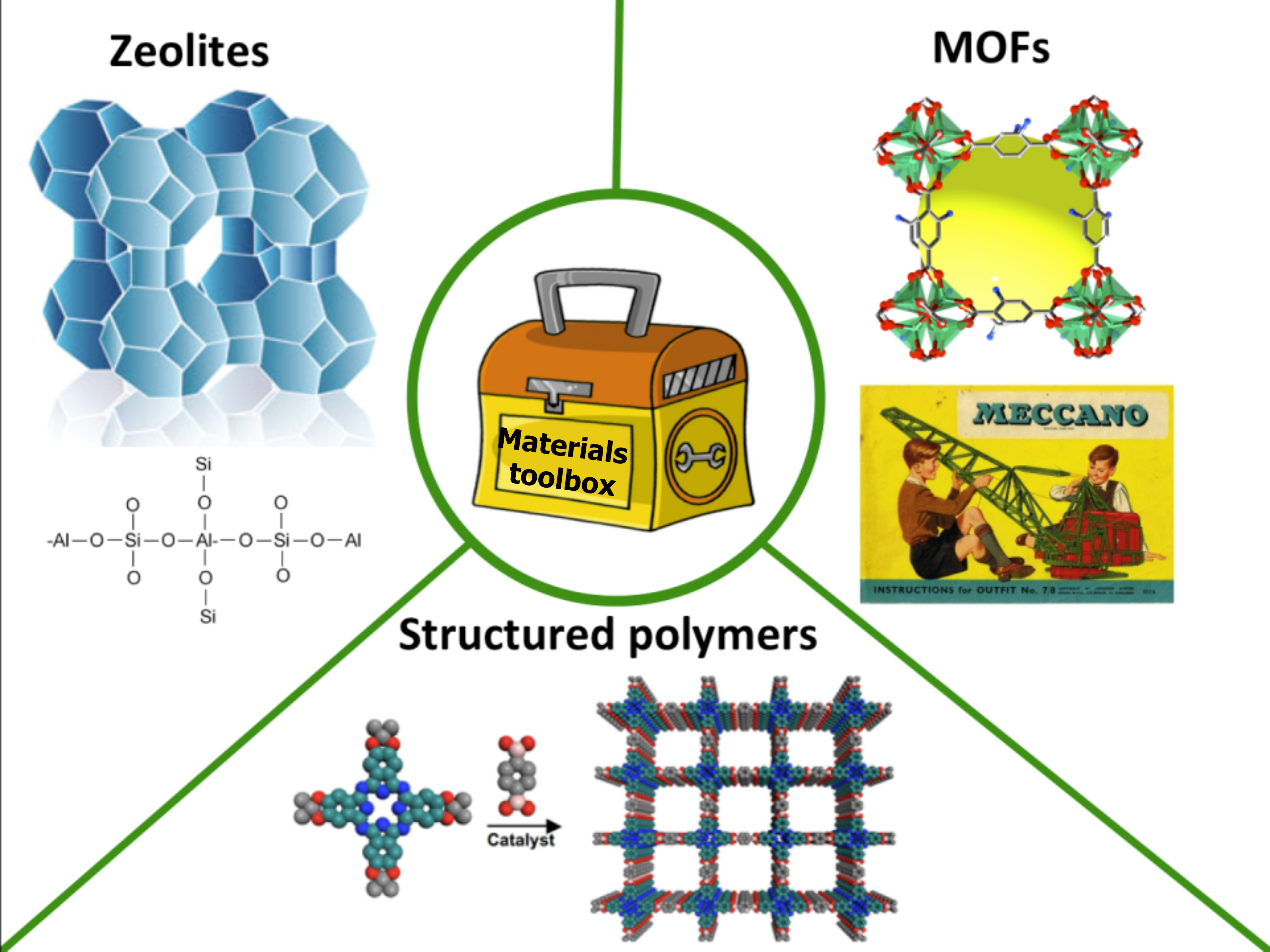
Michiel Makkee

www. tudelft.nl/cheme/catalysis-engineering www.tudelt.nl/cheme/vanderveengroup

Catalysis
Engineering

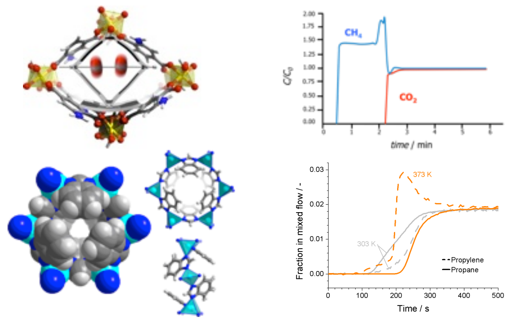
Our philosophy

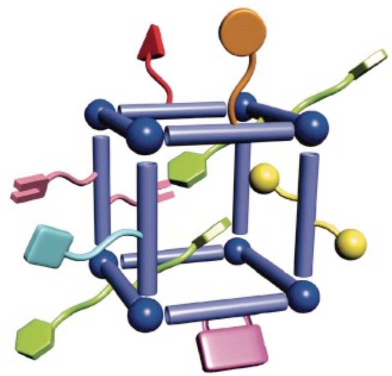



Zeolites
MOFs
Materials toolbox
-Al—O—Si—O—Al-—O—Si—O—Al
MECCANO
INSTRUCTIONS for OUTFIT No. 7/8
Structured polymers
Catalyst

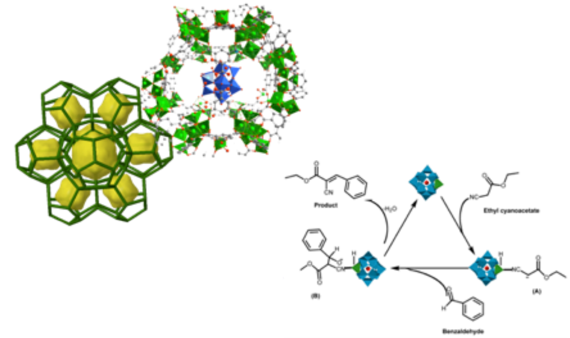
Advanced Functional Materials

MOF separation

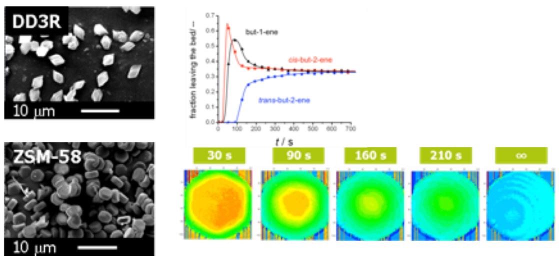




MOF catalysis



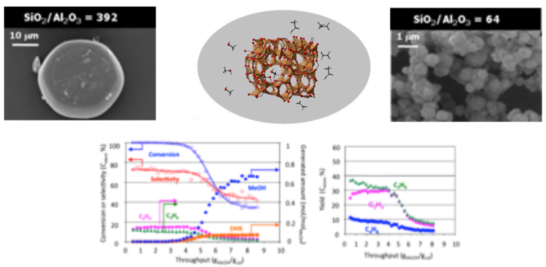
Zeolite diffusion



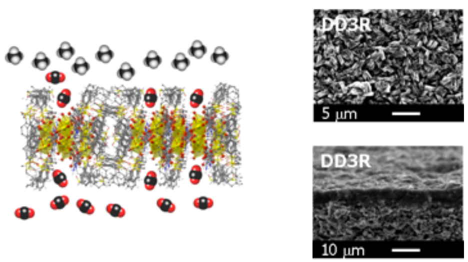
Catalysis

Engineering

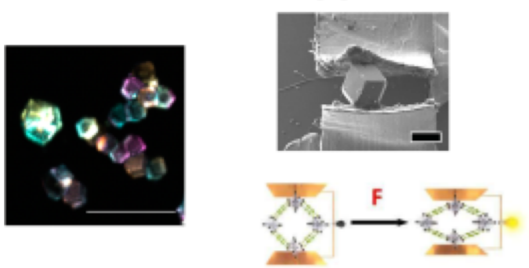
Zeolite catalysis



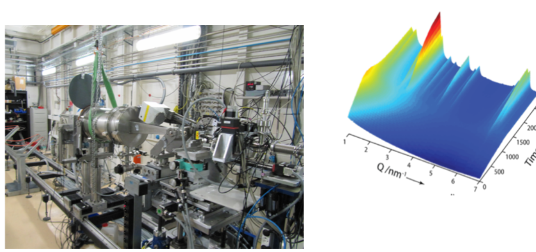
Membranes



MOF electronic applications



Advanced spectroscopy



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Shell

SEVENTH FRAMEWORK PROGRAMME

Catalysis Controlled by Chemical Design

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Catalysis Engineering

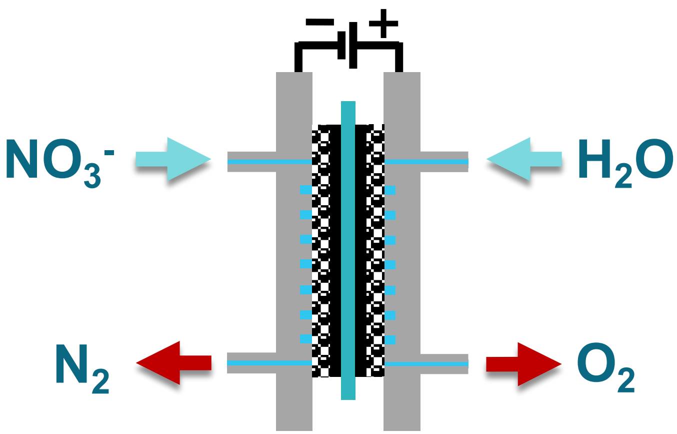
Theme 1: Heterogeneous catalysis for sustainable generation of energy and chemicals

Electrochemical NO_3^- reduction in a PEM Electrolyzer

NO_3^- → NO_2^- ✗ → N_2 ✓ → NH_4^+ ✗

Cathode: $2\,NO_3^- + 12\,H^+ + 10\,e^- \rightarrow 2N_2 + 6\,H_2O$ $E^\circ = +1.25$ V

Anode: $2H_2O \rightarrow 4H^+ + O_2 + 4e^-$ $E^\circ = +1.23$ V

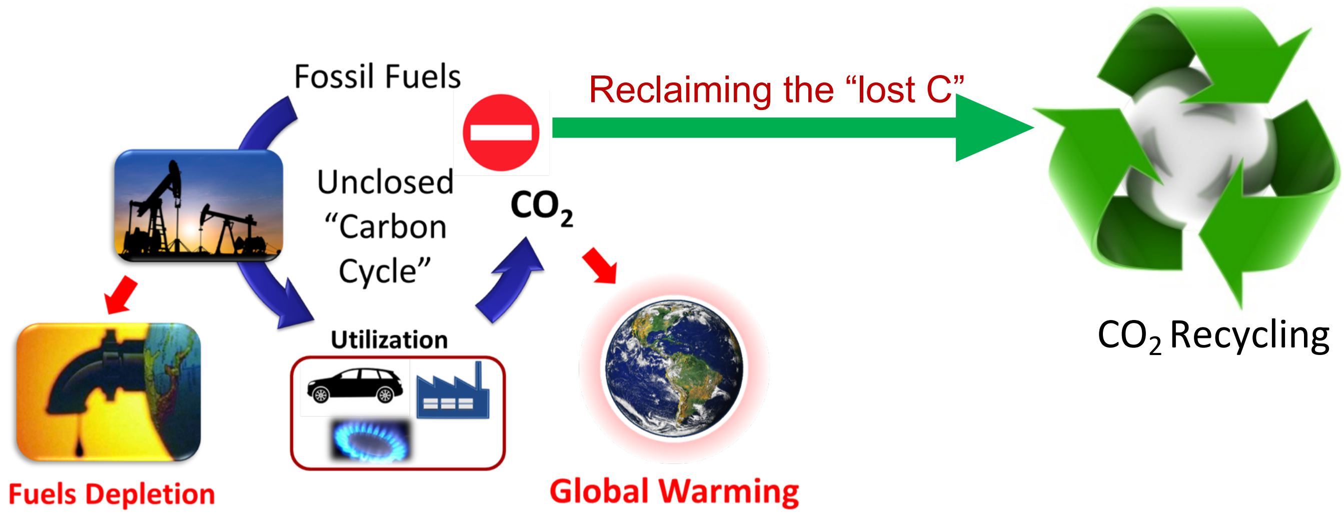


You will learn:

- To synthesize heterogeneous electrocatalysts
- To perform catalyst characterization
- To assemble and operate a PEM electrolyzer cell
- To optimize reaction parameters in order to obtain the best activity and selectivity towards NO_3^- reduction

For more information contact Sorin Bunea (s.bunea@tudelft.nl)

Development of catalytic CO_2 conversion processes



Target projects

- Development of innovative characterization methods/tools for *in situ/operando* studies
- High pressure catalytic CO_2 hydrogenation to industrially important chemicals & fuels
- Process optimization and catalytic activity evaluation using high pressure micro-reactors
- New catalytic material development using novel synthesis methods

Keywords :- heterogenous catalysis, micro reactors, online gas chromatography, high pressure, inorganic material synthesis, space and time resolved approaches, process optimization, spectroscopy

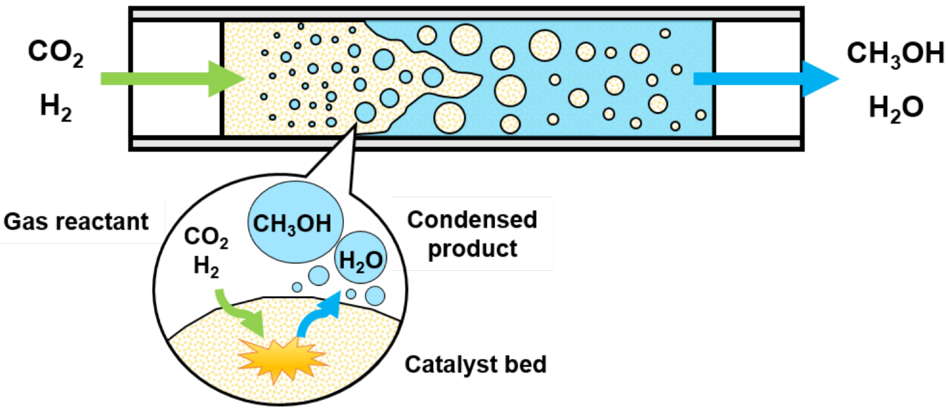
Found interesting?

Contact Dr. Atul Bansode (A.B.Bansode@tudelft.nl) for more information

High-pressure CO_2 hydrogenation to methanol
(up to 400 bar)

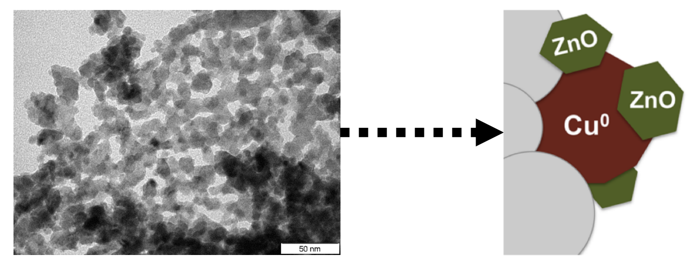
Why using high pressure?

We use high pressure to increase productivity and overcome one-phase chemical equilibrium by *in situ* phase condensation and separation of products.



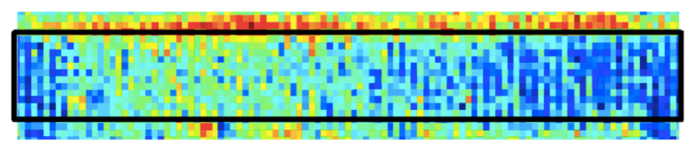
How do we make reaction faster?

Commercially, $Cu/ZnO/Al_2O_3$ catalysts are used. We developed a preparation technique for such catalysts with high Cu dispersion and intimate contact between Cu and ZnO.



What do we eventually want to see?

We want to see the catalyst bed under working conditions. With an IR camera, we observed temperature gradients originated from multi-step reaction pathway. The reaction mechanisms could be further investigated by IR spectroscopy.



$CO_2 \longrightarrow CO \longrightarrow CH_3OH$

endothermic reaction | exothermic reaction

TU Delft

Need more information? Please contact N.Phongprueksathat@tudelft.nl

Heterogeneous catalysis - In situ/Operando analysis

Investigate the catalyst in real operation conditions

Space and time resolution of the information

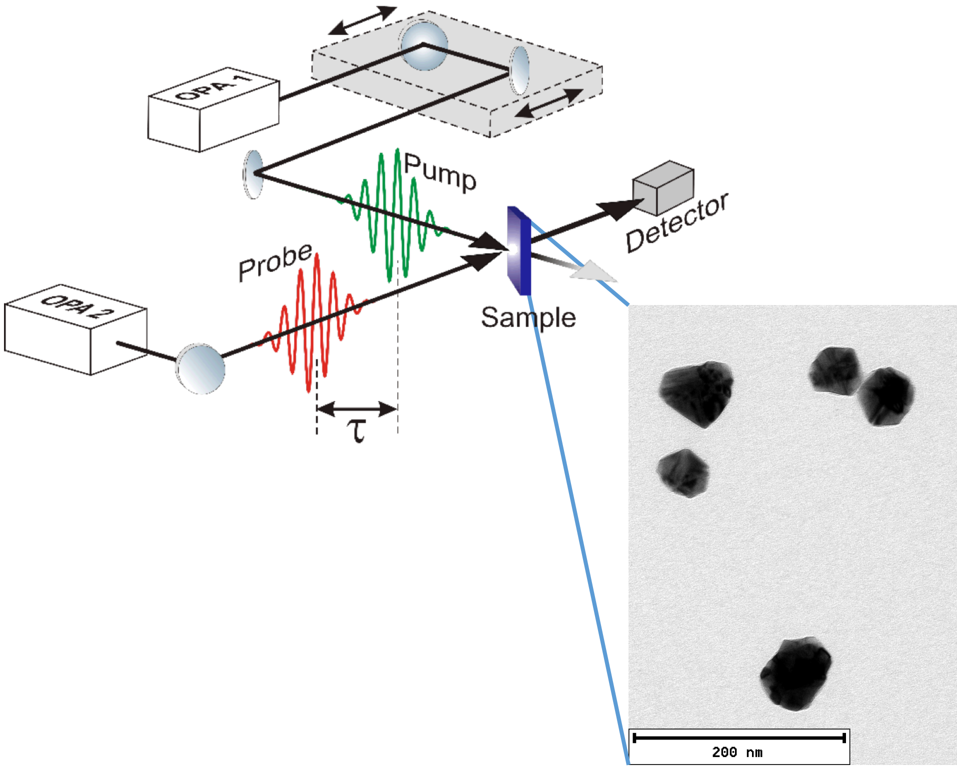
TOPIC
<u>Methane activation to valuable chemical/fuels</u>
- Partial Oxidation
- Dry Reforming

GOALS
Fundamental steps of the reactions
Catalyst properties controlling activity/selectivity

TOOLS
IR spectroscopy, Mass Spectrometry, Gas Chromatography, etc.
Data processing and automation (Matlab)

For more information contact: d.pinto@tudelft.nl

Ultrafast spectroscopy for reaction dynamics

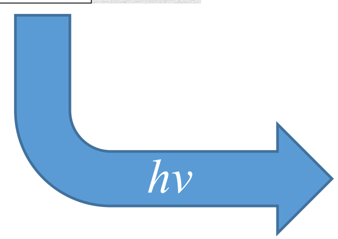


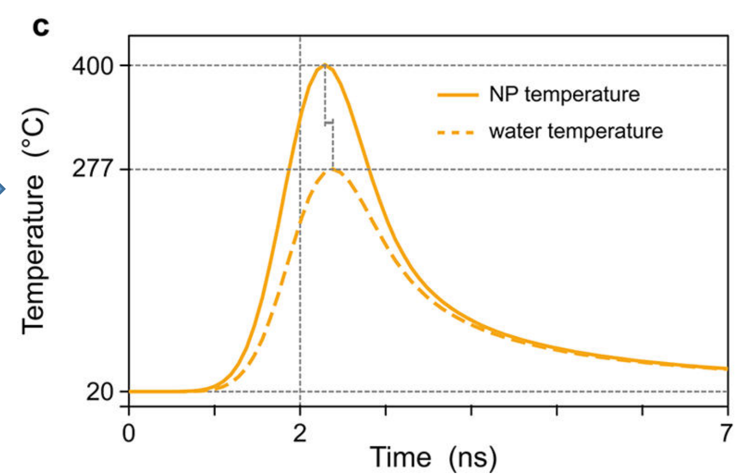
Plasmonic nanoparticles

Femtosecond light pulse →
Nanosecond heating →
Study reaction dynamics

Research areas

Nanoparticle synthesis
Time-resolved spectroscopy
Reaction dynamics

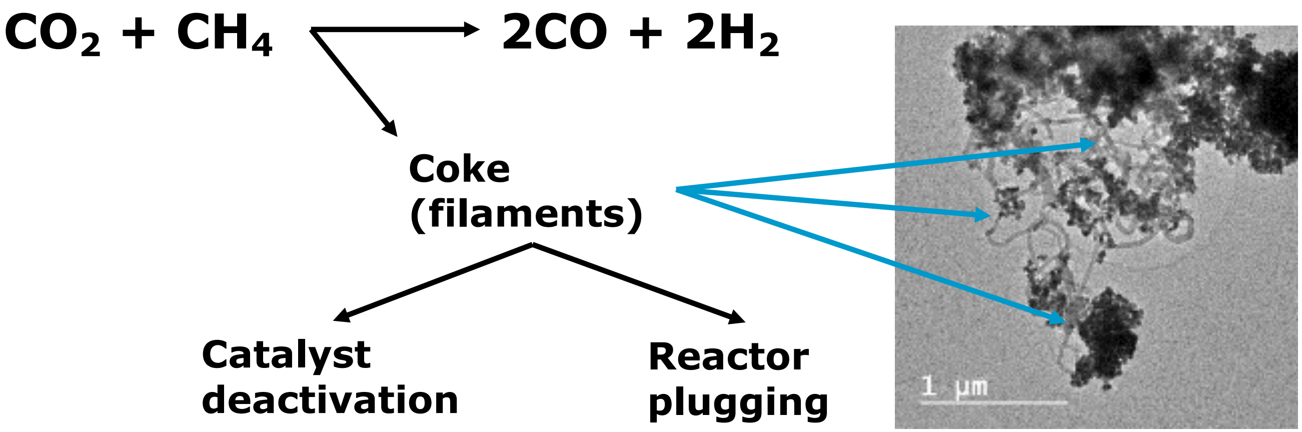




Contact

Han Mertens
j.c.j.mertens@tudelft.nl

Deactivation of methane dry reforming catalysts



Projects:

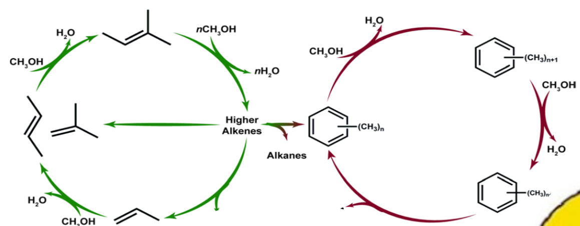
- Studying the impact of different catalytic promotors
- Optimizing the pre-treatment and reaction procedures

Typical activities: Catalyst synthesis and testing, temperature programmed analyses, electron microscopy, spectroscopic techniques

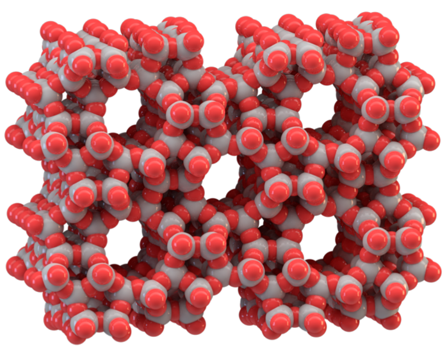
For more information, please contact Robert Franz: r.p.m.franz@tudelft.nl

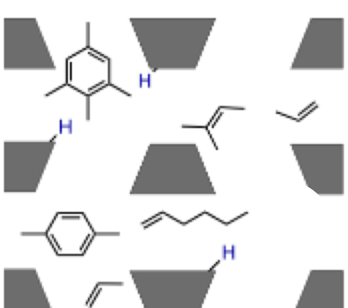
Investigation of Non-commodity Zeolite Frameworks for MTH reaction

$nCH_3OH \rightarrow C_2H_4, C_3H_6, C_4H_8, C_6H_6, \ldots + H_2O$



Targets:
- ❖ Highly selective to favoured products
- ❖ Stable – no deactivation





Main activities:
- Test MTH catalytic process by varying working conditions
- Figure out the structure-performance correlation
- obtain mechanistic insights of the coking process

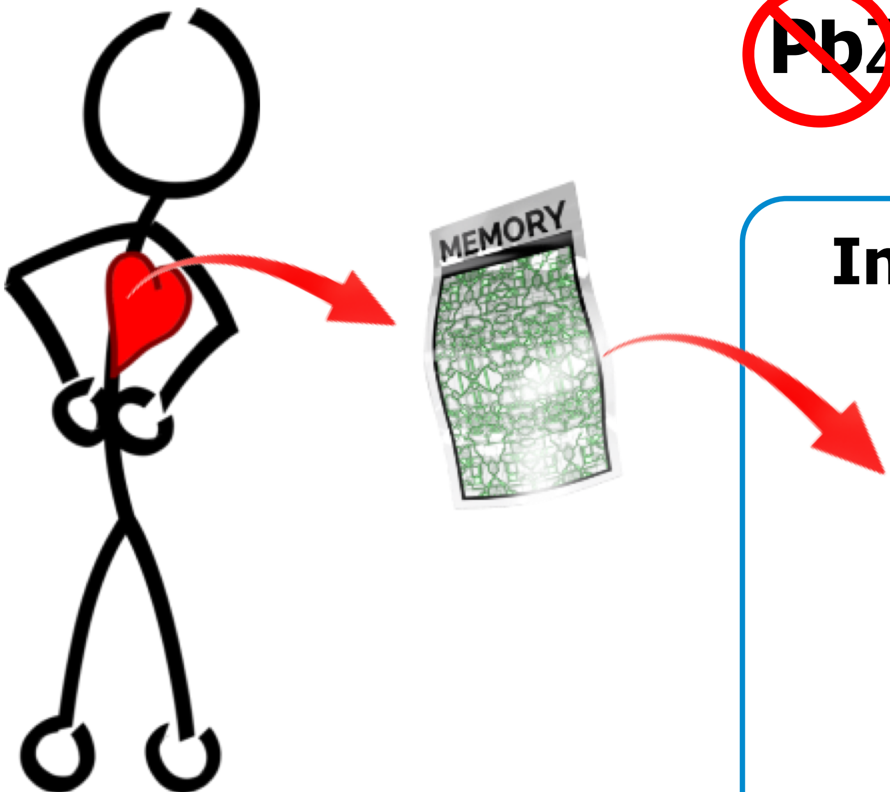
For more info: Chuncheng Liu
C.Liu-6@tudelft.nl

Catalysis
Engineering

Theme 2:
Nanoporous materials for emerging applications

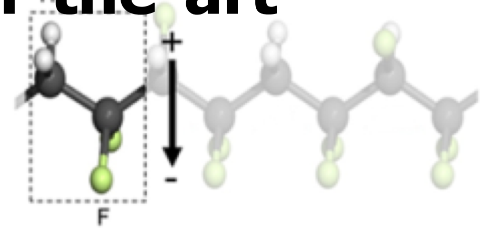
MOFs: The first tuneable ferroelectrics

Challenge



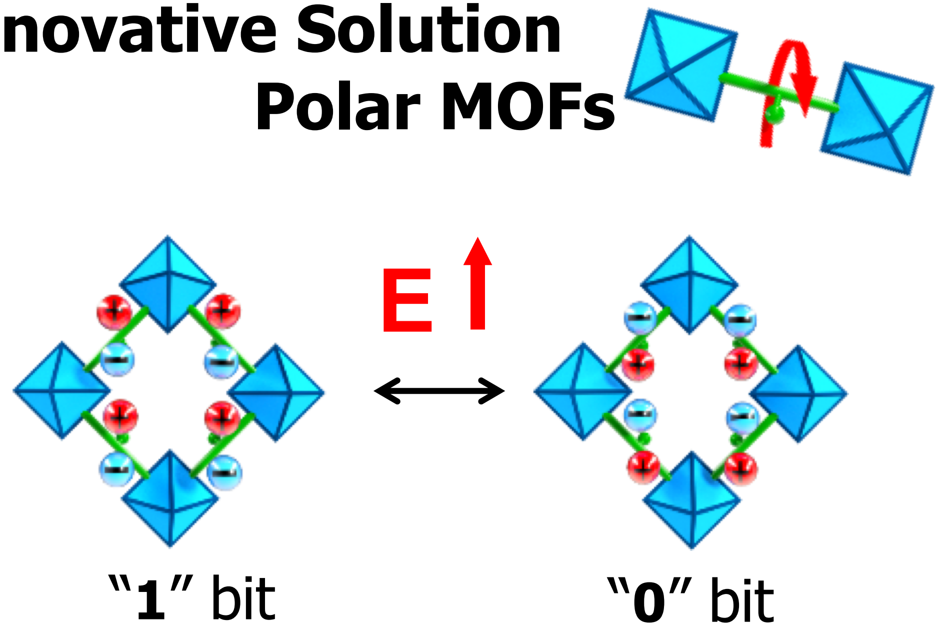
State-of-the-art

~~Pb~~$ZrTiO_3$



Innovative Solution

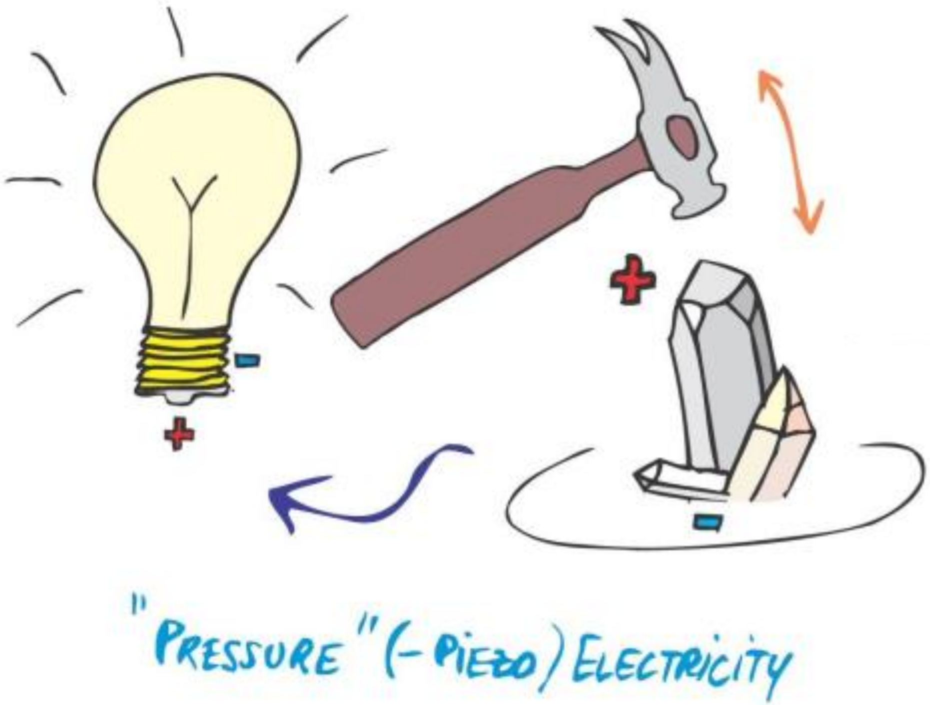
Polar MOFs



You will learn: MOF synthesis,
diverse characterization techniques,
strategies for control and design of MOFs

For more information contact Adrian Gonzalez (A.M.GonzalezNelson@tudelft.nl)

Piezoelectric Metal-Organic Frameworks for mechanical energy harvesting



What we want to know

- Which properties of MOFs affect their piezoelectric response? In which way?
- Is it possible to rationally tune a MOF for energy harvesting?

What you'll learn

- A broad variety of synthesis techniques
- Characterization of materials' structure and piezoelectric properties

Contact:
Davide Rega
d.rega@tudelft.nl

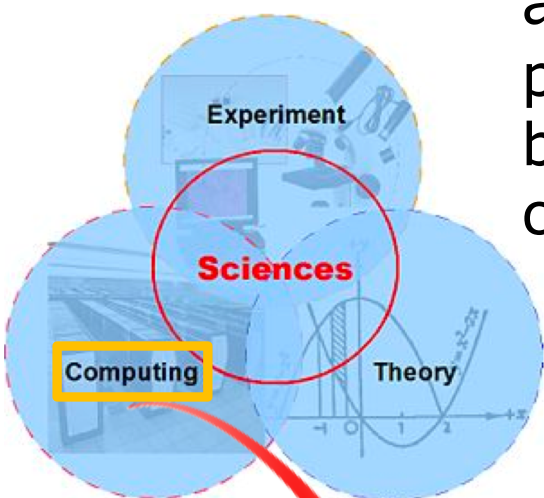
MOFs: Flexible Piezoelectric Materials

Will Learn:

a) to use CRYSTAL17 software to obtain piezoelectric properties

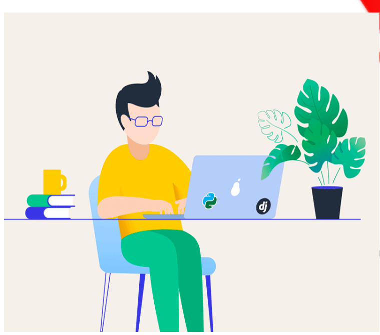
b) Using Command line

c) Basics of Quantum Chemistry

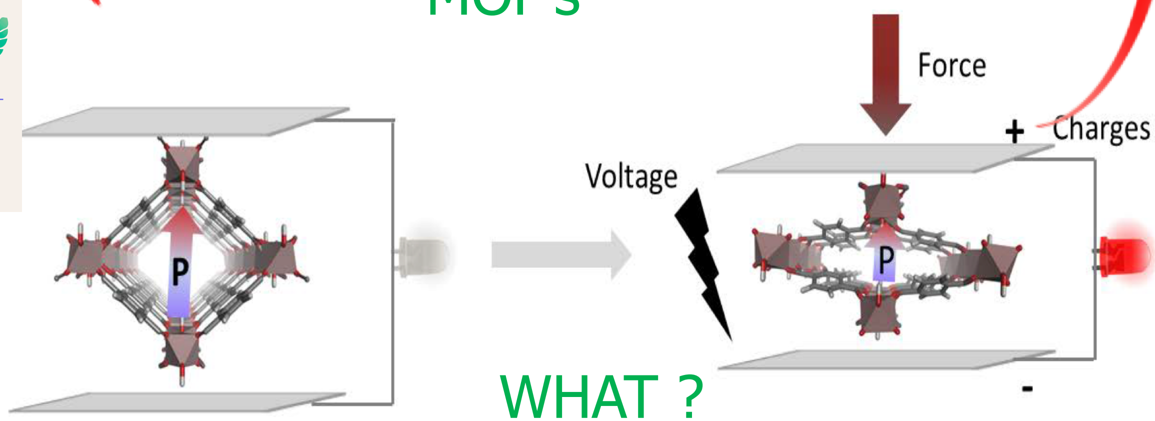


HOW ?

CRYSTAL17



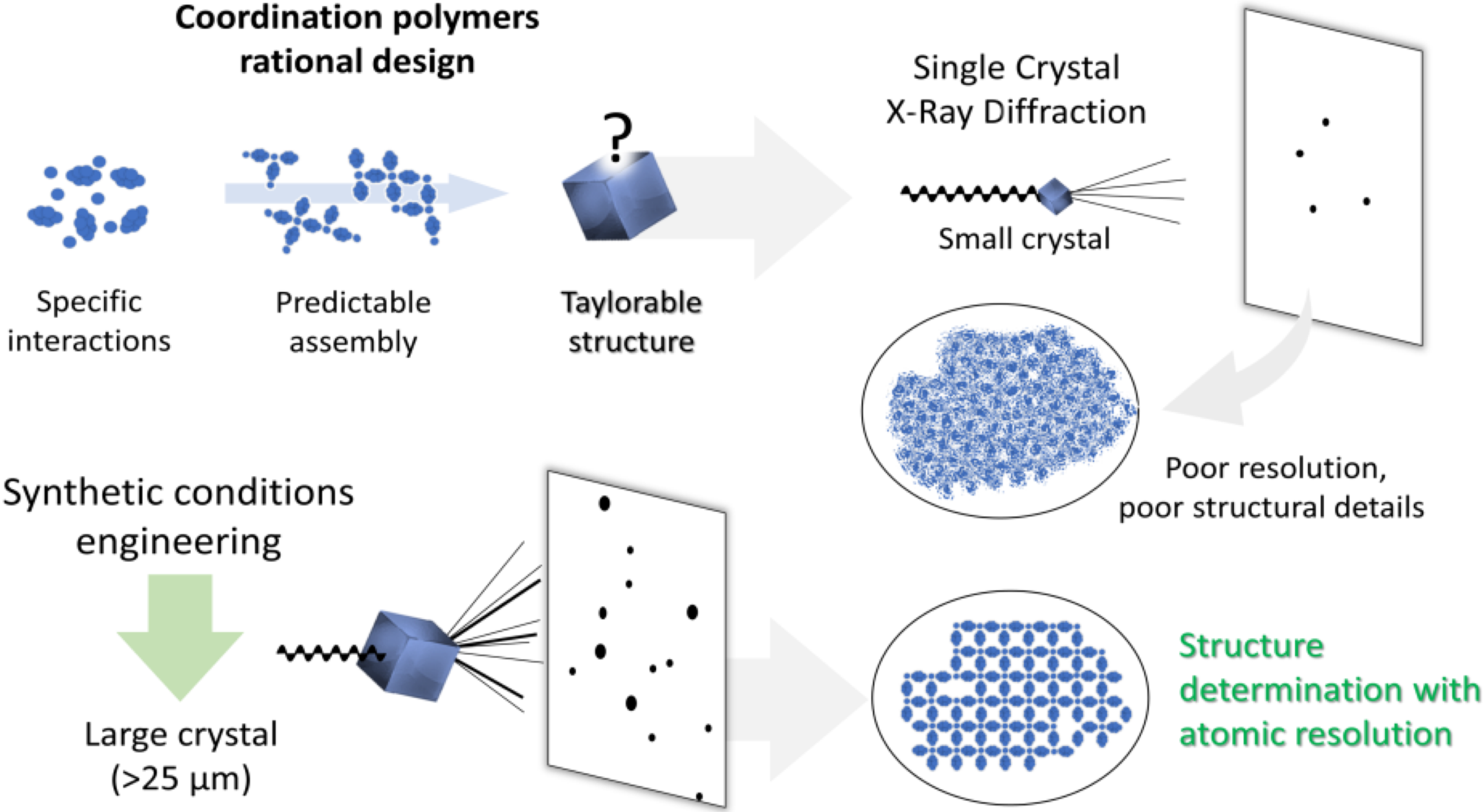
Computing Piezoelectric properties of a series of MOF's



WHAT ?

For more information contact Srinidhi Mula (S.Mula@tudelft.nl)

Growing bigger crystals for a deeper knowledge



For more information contact Stefano Canossa (s.canossa@tudelft.nl)

Catalysis Engineering

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

Catalysis Engineering

For the slides and more information go to:

tudelft.nl/cheme/catalysis-engineering

Choose the “Education” tab