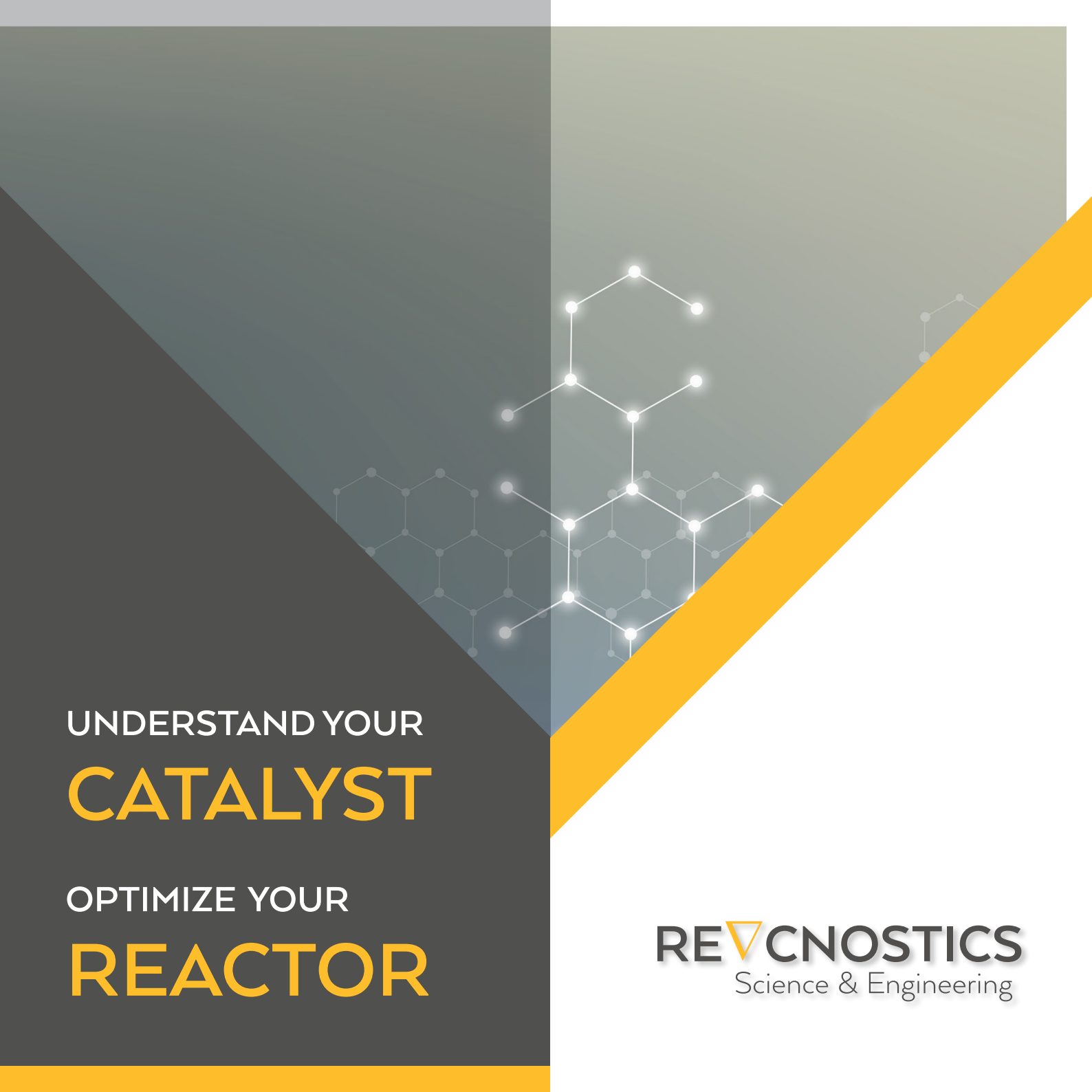




UNDERSTAND YOUR
CATALYST

OPTIMIZE YOUR
REACTOR

RE**CNOSTICS**
Science & Engineering

REACtor diagNOSTICS

REACNOSTICS

Catalysis and Reaction Engineering are key technologies for our modern society. Catalytic reactors produce transportation fuels, base chemicals for polymers, fertilizers, and pharmaceuticals, they are used for energy conversion and they clean emissions from mobile and stationary sources.

Academic and industrial researchers around the globe optimize existing and search for new catalytic processes to meet current and future challenges.

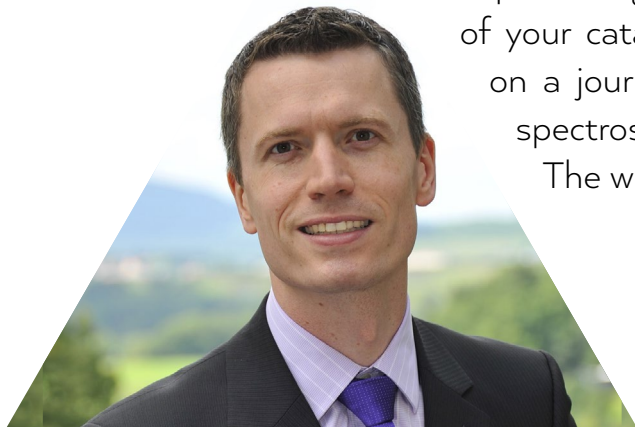
This business is competitive and sometimes frustrating. Promising catalysts often do not perform well outside the lab and improvements to established catalytic processes are incremental. One reason for this is that catalysts are dynamic.



Like a chameleon changes color and pattern to adapt to its habitat, catalysts change their structure and reactivity as function of local temperature and concentration conditions in the reactor. While a chameleon still behaves like a chameleon, a catalyst in a technical reactor might behave totally different than in a well defined laboratory testing unit.

For this reason catalysts synthesized in the lab or designed on a computer often perform poorly in a real world reactor and optimization of catalytic processes is difficult.

We cannot stop your catalyst chameleon from changing but we can provide you with technology to resolve concentration and temperature gradients in catalytic reactors and follow the changes of your catalyst using spectroscopy. We invite you joining us on a journey to the world of profile measurements, reactor spectroscopy, modeling and knowledge based optimization. The world of REACNOSTICS.



A handwritten signature in black ink, appearing to read 'M. Schmidt'.

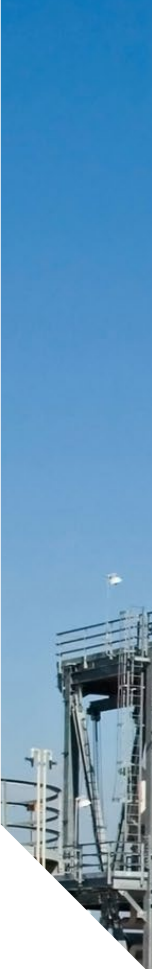
Michael Schmidt

- CEO -

Making Catalytic Reactors Transparent

Catalytic reactors are at the heart of countless industrial production processes and technical solutions.

In most applications, the processes inside the catalytic reactor remain hidden. Reactors are normally non-transparent, operate at high temperature and pressure conditions and contain toxic, flammable or even explosive chemicals.

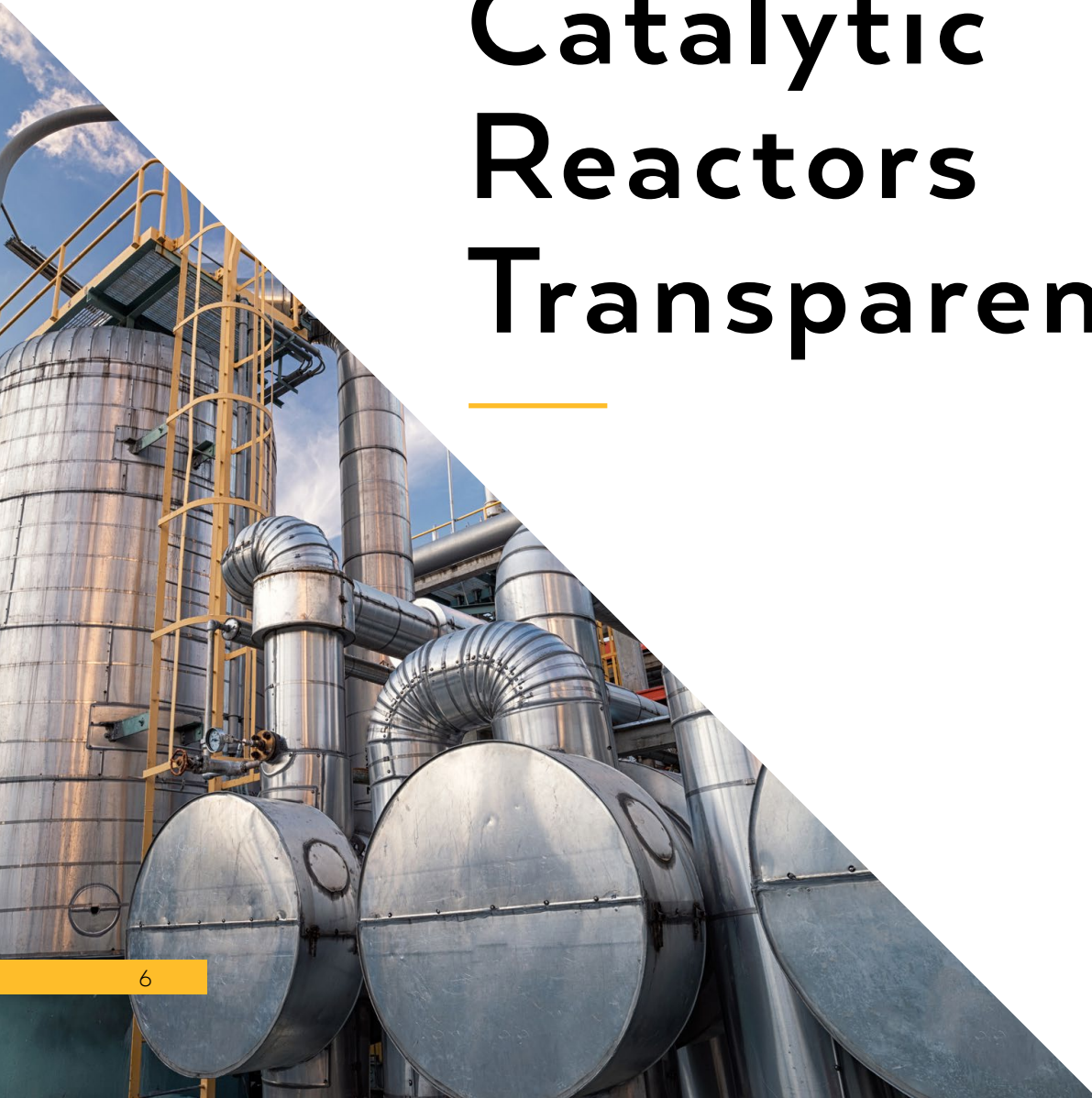




Figuratively speaking, the reactor is a „black box“. Measurements are restricted to inlet and outlet flows, mathematical models are often too simplified and reactor optimization is based on trial and error.



Making Catalytic Reactors Transparent



Conventional Approach

Reactants

Black box

Reactants

Products

Waste

REACNOSTICS Approach

Reactants

Optimized
Reactions + Transport

Optimized
Gradients + Dynamics

Reactants

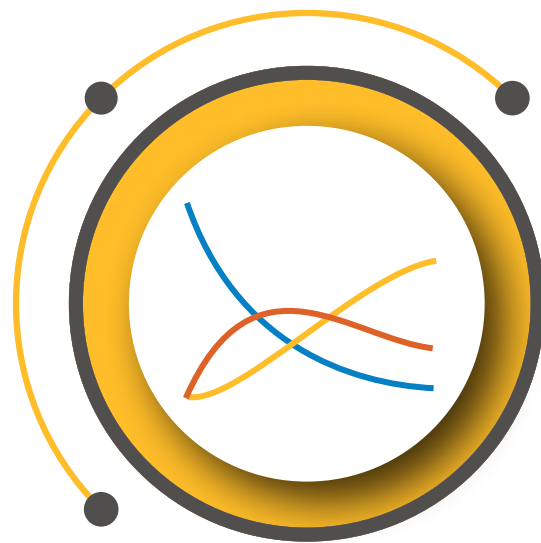
Products

Waste



We help our customers to operate their catalytic reactors in an optimal manner, minimizing cost, environmental footprint and maximizing profit.

Measure



Services

REACNOSTICS provides reactor hardware, measurement services and modeling capabilities to help customers optimize their catalytic reactors based on knowledge. We strive to make the reactor „transparent“

by measuring and/or modeling the concentration, temperature and flow field inside the reactor and characterize the local state of the catalyst by spatially resolved spectroscopy.

Model



Optimize

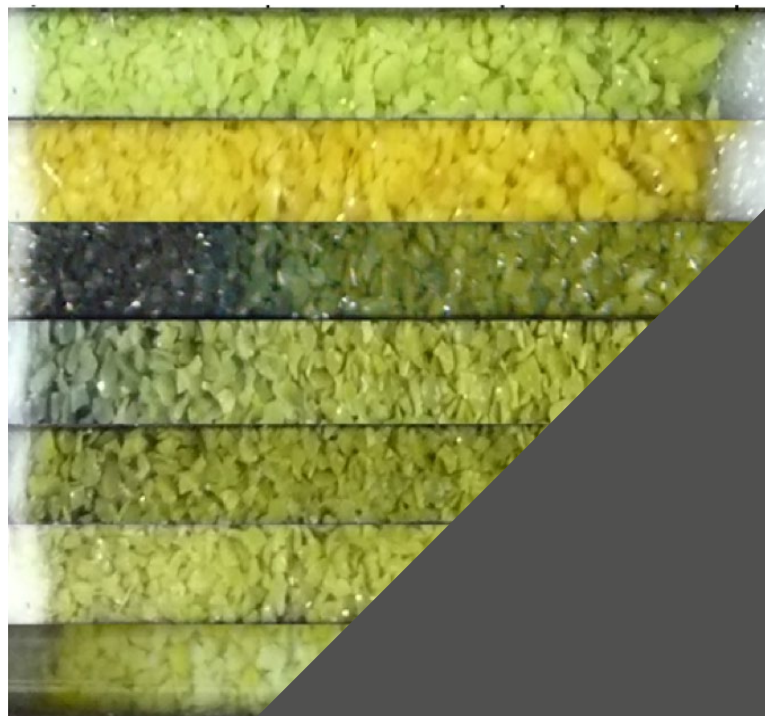


Catalyst Dynamics



Heterogeneous catalysts are dynamic systems. Their chemical composition, surface structure, bulk structure, their type and number of active sites and defects as well as their electronic properties change in response to local temperature, pressure and concentration conditions.

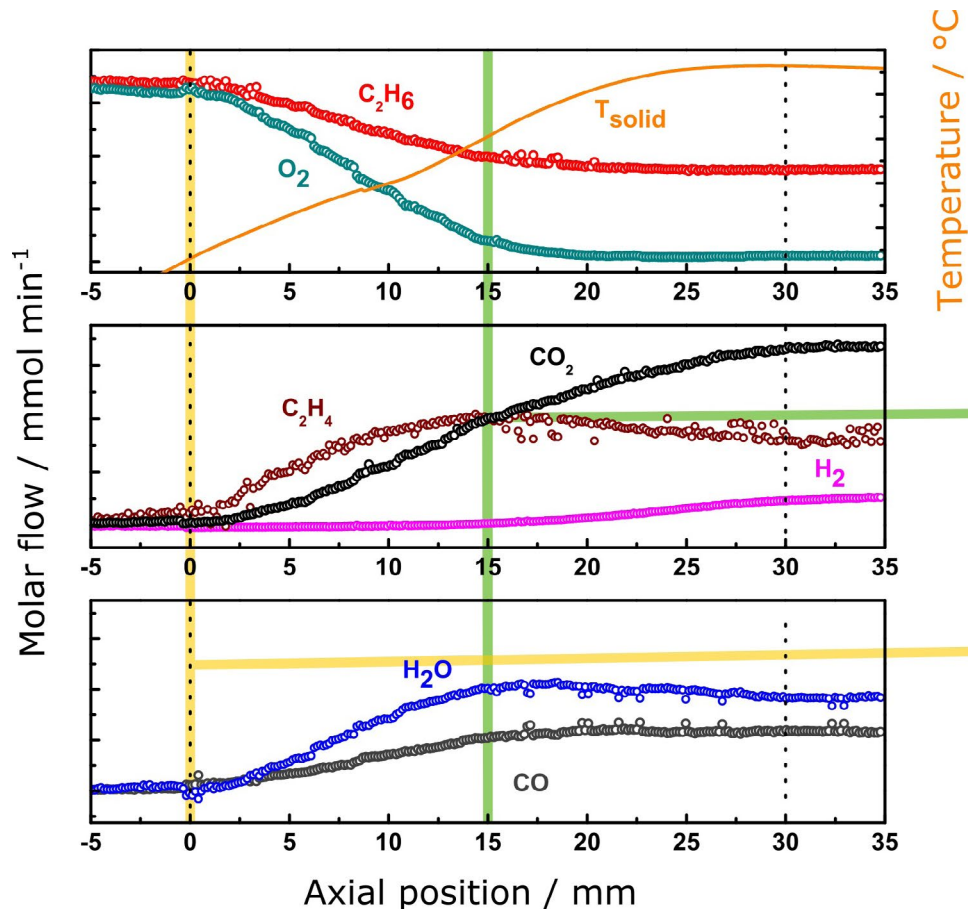
Spatial gradients in these variables occur in almost all catalytic reactors. Color gradients of catalysts after operation in the reactor are an obvious manifestation of catalyst dynamics.



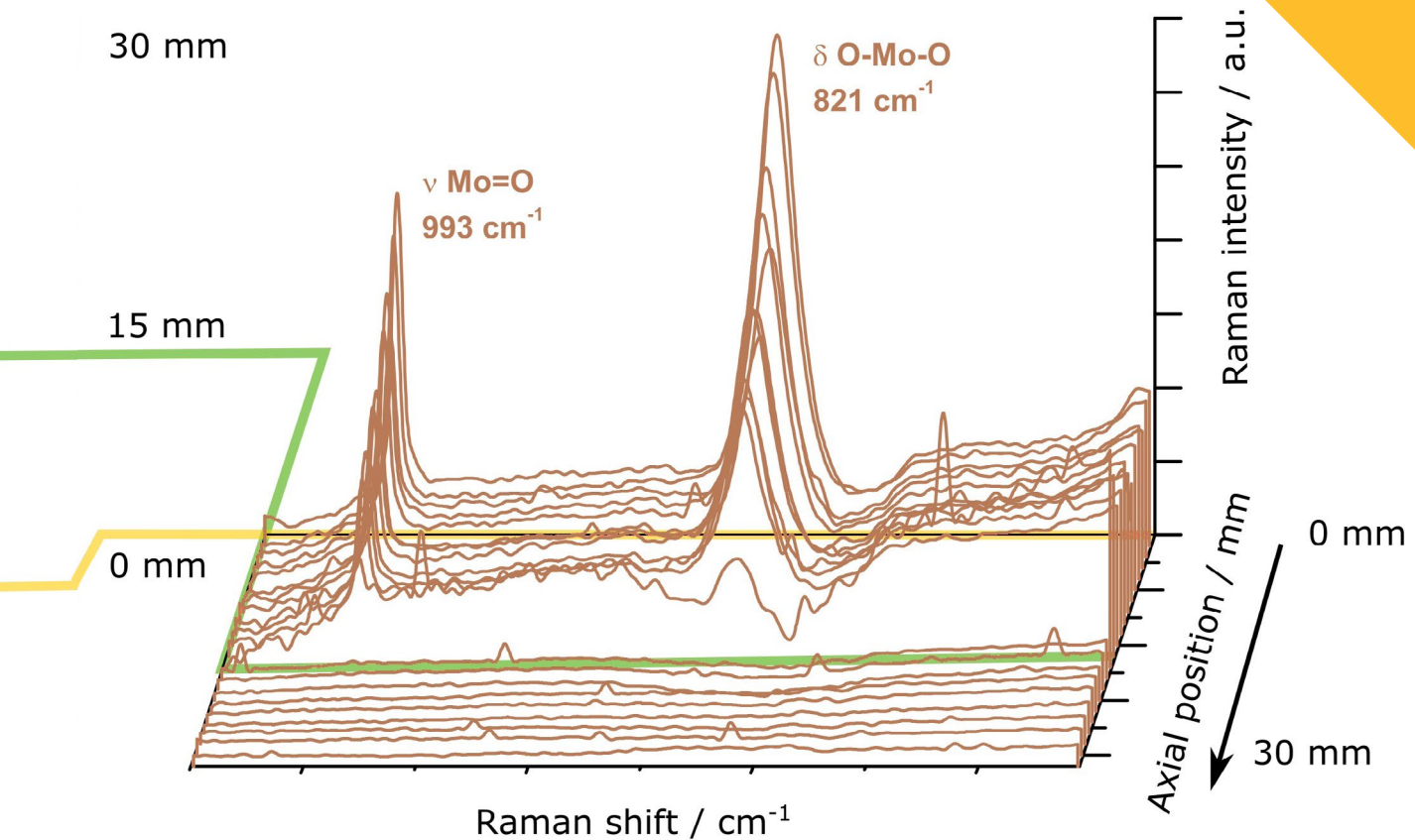
To optimize catalytic reactors, catalyst dynamics must be understood.

Reacnostics provides technology to measure and simulate flow-, temperature- and concentration fields in catalytic reactors and study catalyst dynamics by spatially resolved spectroscopy.

Approach - Profile Measurements



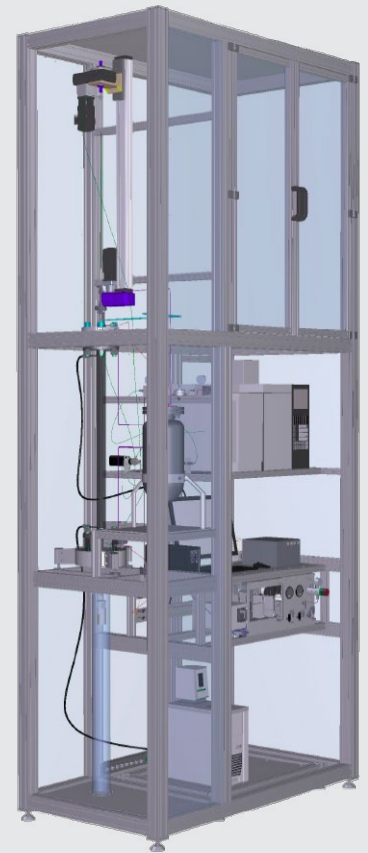
Reactor diagnostics
by high-resolution
concentration-,
temperature- and Raman
spectroscopic profiles.



Products

Pilot Scale
Profile
Reactors

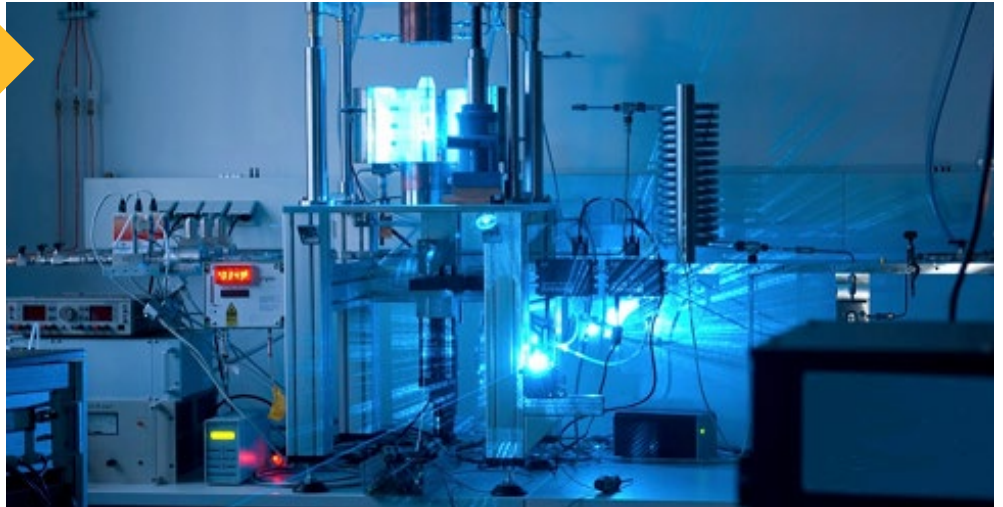
Liquid Phase
Profile
Reactors





Compact
Profile
Reactors

Bench Scale
Profile
Reactors





Features

- » Compact catalytic fixed bed reactor with optical access
- » Fits under Raman microscope
- » 60 mm isothermal zone for catalyst bed
- » 4 mm bed diameter
- » $T_{\max} = 500\text{ }^{\circ}\text{C}$

- » $P_{\max} = 5\text{ bar}$
- » No condensation of products by heated pathways
- » Trigger for external analytical devices (MS, GC, Raman)
- » Control unit
- » Software

Optional:

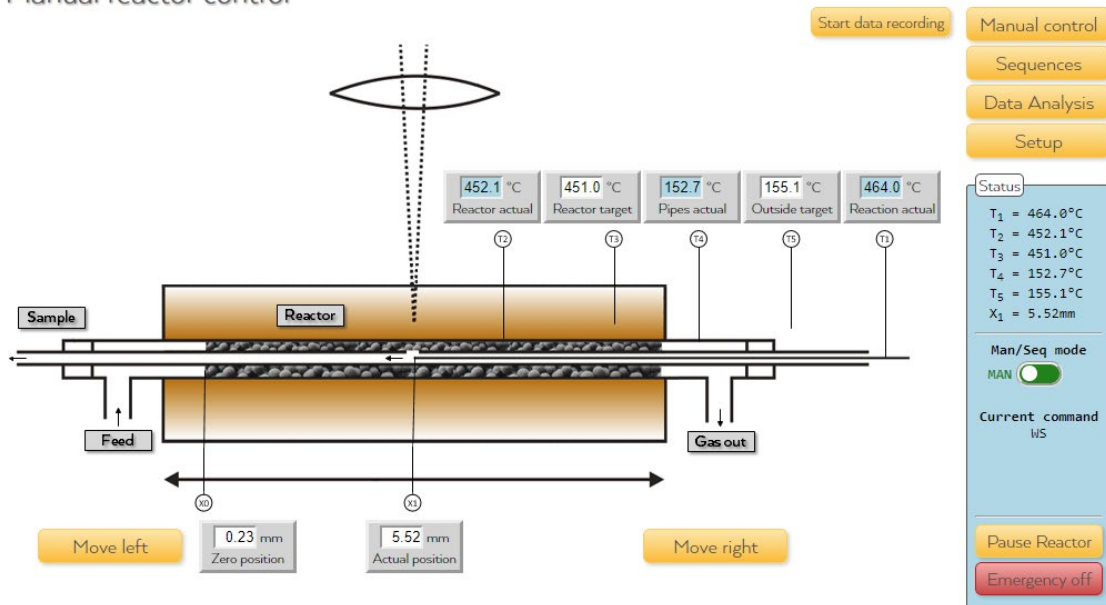
- » Gas feed supply
- » Analytics
- » Fiber optics and coupler for Raman spectroscopy
- » Pyrometer with collection fiber

Compact Profile Reactors

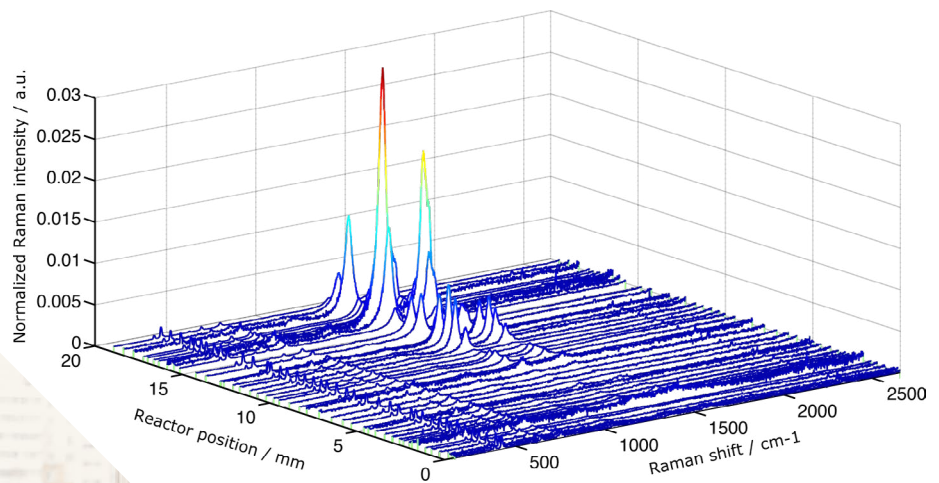
COMPACT PROFILE REACTOR

Manual reactor control

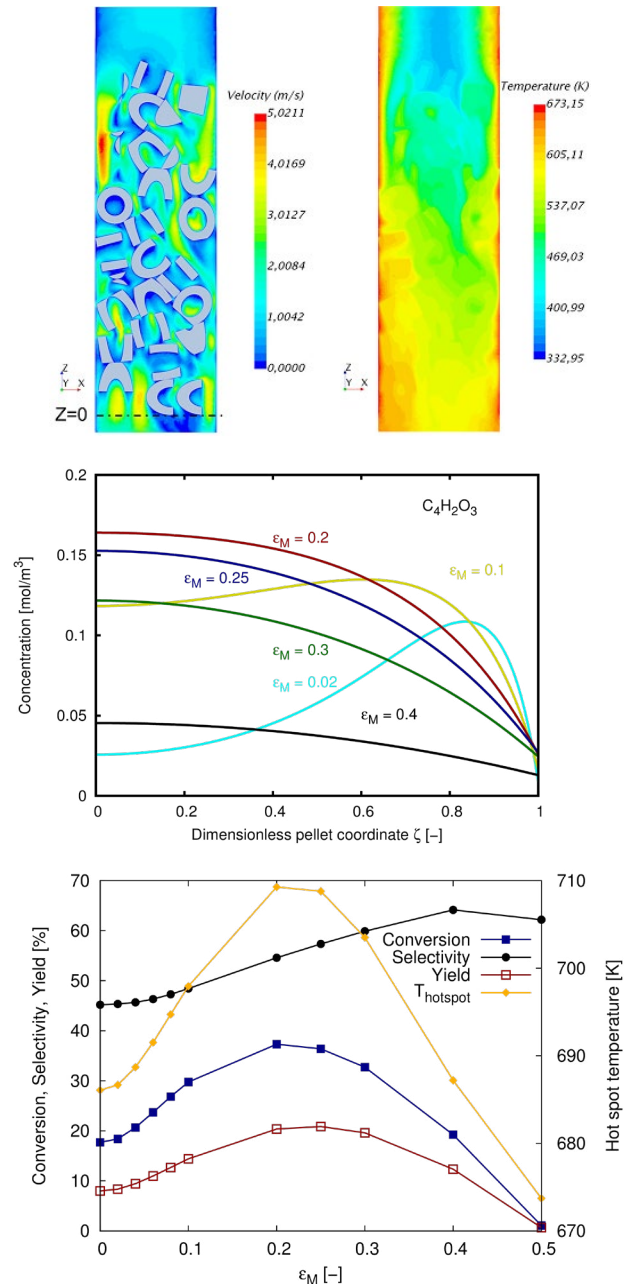
REVCNOSTICS
Science & Engineering



Services & Consulting



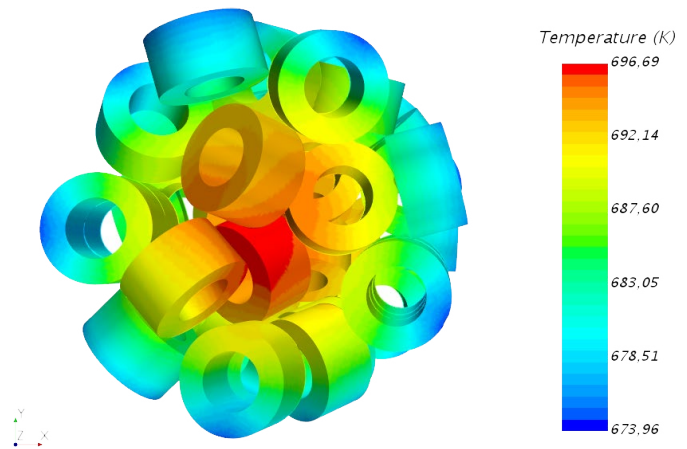
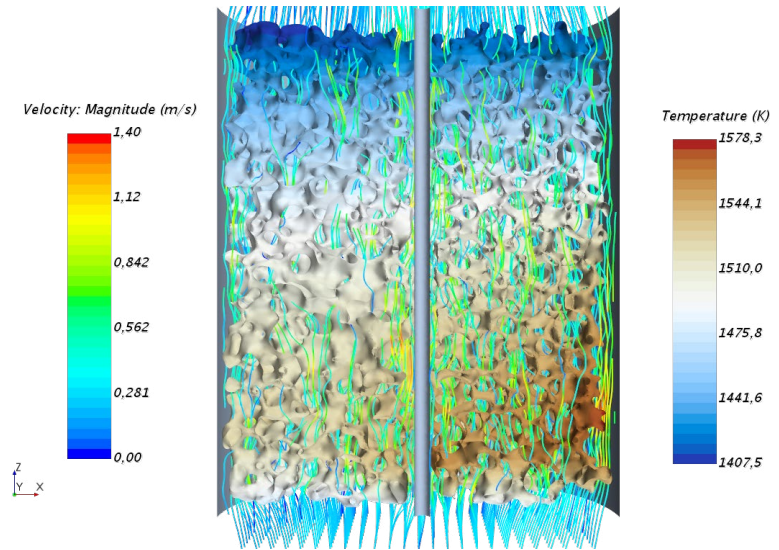
- » Measurement of temperature and concentration profiles
- » Spatially resolved spectroscopy in reactors
- » Data analysis
- » Kinetic studies, measurement of intrinsic catalyst kinetics
- » Investigation and optimization of transport processes
- » Reactor modeling
- » Reactor design
- » Reactor, catalyst and process consulting



Applications

- » Heat transport studies
- » Catalytic partial oxidation of methane on rhodium and platinum
- » Dry reforming of methane on nickel
- » Oxidative dehydrogenation of ethane to ethylene on molybdenum oxide
- » Gas phase methane oxidation
- » Catalytic methane combustion on a platinum gauze
- » Carbon monoxide oxidation on a platinum foam catalyst
- » Catalytic oxidation of n-butane to maleic anhydride on vanadyl pyrophosphate
- » Ammonia oxidation on platinum gauze catalysts (Ostwald process)
- » Ethylene epoxidation to ethylene oxide on silver
- » Propylene epoxidation to propylene oxide on titanium silicalite (HPPO Process)

For details see
[www.reacnostics.com/
applications](http://www.reacnostics.com/applications)



Customer Benefits

Industry

- » Understand reactor and catalyst behavior
- » Optimize reactor design and reaction conditions
- » Increase conversion, selectivity and yield
- » Extend catalyst lifetime
- » Minimize waste and reactor downtime

Academia

- » Spatially resolved investigation of new catalyst materials
- » Flexible profile reactors for various reaction conditions (gas-solid, liquid-solid, gas-liquid-solid)
- » Establishing structure-activity correlations by spatially resolved operando-spectroscopy



REACNOSTICS

- » understand your **CATALYST**
- » optimize your **REACTOR**

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Science & Engineering

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