Advanced Machinery & Technology Chemnitz GmbH
Catalytic Reactors and Processes
–
Key Enabler in Chemistry and Environmental Conservation
About Amtech

- chemical engineering
- process design
- software & automation
- customer network in chemical industry and R&D

Total staff about 85 people (25 + 60)  
Annual turnover > EURO 6.5M
Chemical processes - environmental challenges

- Chemical industry consumes 10% of total energy production in the world or 30% of total industry consumption
- About 42 EJ/year emitting billions of tons of GHG /CO2
- 90% of all chemical processes use catalysts as promoters to lower activation energy
- Most energy intensive processes are production of ammonia, ethylene, propylene, methanol and aromatics
- Need to reduce energy intensity of chemical processes by new catalysts for GHG abatement
About Amtech

Chemical Engineering

Technology provider for high-throughput screening of catalyst materials and process upscaling

- laboratory and mini-pilot scale parallel reactor rigs for high-throughput experimentation
- mini-pilot plants, customized systems, fully automated reactors for catalyst testing and process development

Customers

- chemical, oil, refining, pharmaceutical industries
- academic research groups
High – Throughput - Method

**Conventional Process Development**

- Discovery
- Development
- Pilot Plant
- Market

**High-Throughput Process Development**

- Discovery
- Development
- Micro Plants
- Market

10 to 15 years
HTE - What exactly?

Programmed tests/experiments in parallel
Discovery of an efficient HC-SCR Denox Catalyst: from HT screening to pilot testing

Aim: catalytic material for NOx reduction by HC-SCR which is active at the lowest temperature and hydro thermally stable at high temperature.

A library of 150 samples was synthesized. Catalysts are supported Ag, Au, Cu on Al$_2$O$_3$, TiO$_2$, ZrO$_2$, CeO$_2$ and further doped with dopants (Ga, Mo, ...). They were tested in a 16-parallel reactor (SWITCH-16) using a Temperature Program Reaction (TPR) protocol with a model feed (100ppm NO / 350ppm C$_3$H$_6$ / 15% O$_2$ /11% H$_2$O).

Catalysts efficiency was investigated under various conditions of C$_3$H$_6$ partial pressure, water content etc. The best formulation shows a light-off temperature of 50°C lower than the reference catalyst and is stable after ageing at 750°C in presence of water for 16hrs.

Figure 1: HT testing of DeNOx catalysts in the SWITCH-16 reactor. Result of secondary (left) and tertiary (right) screening.
Benzonitrile Hydrogenation ($C_7H_5N$)

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Metall-Antimon(V)-Mischoxide mit Pyrochlor-Struktur als neue Alkylierungskatalysatoren

Problemstellung
Selektive Herstellung von Glykolen

\[ ROH + KCl \rightarrow ROCl + KCl \]

Katalysatoren
- Metalloxid(V)-Mischoxide
  \[ \text{Zn(SiO}_2\text{)}_2 \text{Al(SiO}_2\text{)}_2 \text{Mg(SiO}_2\text{)}_2 \]
- Mit Phosphoformat und Lewis-Acidd (S. Abb.)
- Synthese aus SiO\textsubscript{2} + H\textsubscript{2}O und Verwendung der gebildeten Antimon(V)- Oxide mit Metalloxid

Strategie
Lewis-Säuren = anderer Mechanismus = bessere Selektivität

Screening in Labor

- Kontinuierliche Umsetzung zu Monoxi, Dr. und Trägervergasung (60 bar, 120 °C, \( \Delta T = 100^\circ \text{C} \)), ROH: Alkohol + 8:1 (cch), SPH 10-Realizer
- Metalloxid(V)-Mischoxide mit wässrigen Antimon(III)- Oxidation in einem massenbezogenen Monoxiderzeuger

-...und Technikum

Zusammenfassung
- Reproduzierbare Synthese und Verwendung der Metalloxid(V)-Mischoxide im Labor und Technikum auf der Basis von Phosphoformat und Lewis-Acidd
- Auch im Festbett bessere Selektivität als im Homogenverfahren (ROS 5 mit 100 % Alkohol/Lösung verwendet)

Literatur
1. V. N. Seguvin, G. K. Buseck, V. A. Dieto, V. P. Kartes, V. V. Klimes, J. V. Pogorelov, N. M. Samokhina, D. V. Taranova, D. N. 2436871
Parallel fixed-bed and trickle-bed reactor systems

**SPIDER series** … a state-of-the-art reactor system for parallel testing of materials and heterogeneous catalysts

- individual, continuous flow fixed bed reactors
- independent liquid and gas flow control with MFC and LFC for each reactor
- individual temperature and pressure measurements in each reactor
- PLC control and safety system
- data management and seamless online analysis integration
SPIDER series – reactor configurations
Parallel Fixed Bed Reactor System 2x8

standard operating limits

> 2 x 8 fixed bed reactor system
> working pressure up to 60 bars
> working temperature up to 500 °C
> benzene, propylene, naphthalene
> hydrogen, nitrogen
> analysis inside
Customized SPIDER for Fischer -Tropsch synthesis - GTL

- CO/H\(_2\) can be varied automatically at full range
- Individual temperature and pressure control for each reactor channel
- Tempered separator vessels at each reactor channel for collection of wax fractions and liquid products
- Online GC analysis for gaseous products
Customized SPIDER for hydrodesulfurization of Diesel and VGO

- individual gas dosing with MFC to each reactor
- individual dosing of diesel to each reactor channel using LFC
- tempered separator stage for collection of liquid products
- automated sampling of liquid and gaseous products
Customized SPIDER technology for methyl methacrylate application

- MMA polymers and copolymers used in surface coatings and impregnation resins
Parallel batch reactor and CSTR systems

SPR series … fast parallel screening of multiphase reactions under high pressure and elevated temperatures

- $n$ (4, 8, 16, 16+) individual batch reactors
- Automated feeding of gas and liquids
- Individual temperature and pressure control in each reactor
- PLC control and safety system
- Data management and seamless online analysis integration
SPR 16 – Bench Top
SPR 16 Generation2

16 vessels ss 15ml, independent heating, cooling, stirring, liquid and gas dosing, liquid sampling under reaction conditions

- operating temperature up to 250 °C (o-ring seal)
- operating pressure up to 200 bar
- automated collection of up to 144 liquid samples in standard GC vials
- stirring speed up to 2000 rpm
SPR 16 generation2

Glove box for air sensitive homogenous catalysts
Heavy oil processing
Reactor system for test and quality monitoring of automotive or power plant catalysts

- screening of catalyst monoliths under automotive/industrial exhaust gas conditions
- testing and quality monitoring of catalysts / monoliths / honeycombs
- process optimization in automotive/power plant catalyst production
Transient Testing Automotive Catalysts
Automotive Catalyst Testing (quartz glas reactor)
Industrial DeNOx Catalyst Testing (powerplant)
Design and Engineering to optimize materials and processes depending on application

- for special applications and requirements
- development in close collaboration with the customer
Continuous FCC downer

- fluidized reactor length 1.5 m and 2.5 m
- working pressure up to 6 bars
- working temperature up to 750 °C
- oil from 1 – 10 g/h
- catalyst flow 10 – 120 g/h
4-fold reactor system
Catalytic bio-alcohol dehydration with three flow reactors

**Standard operation limits**

- 3 fixed bed reactors, volume 5 l
- Working pressure 50 bar
- Working temperature 200 – 475 °C
- 0.2 kg/h hydrogen
- 0.5 – 15 kg/h ethanol
BIOMASS Gasification

Standard operating limits

- reactor bed volume 1 l
- working pressure up to 20 bars
- working temperature up to 950 °C
- steam super heating 950 °C
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Huanaco Innovation

MP: 13801356079
Add: 608, Gaolizhuang, Fengtai, 100070, Beijing

Mr. Yunxing Hu

yxhu@huanaco.com
Thank you for your attention!