Innovation at “The Chemical Company” – Challenges and New Perspectives

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BASF Future Business/BASF Venture Capital America

PIRE-ECCI/ICMR Summer Conference

University of California at Santa Barbara, CA

BASF
The Chemical Company

Outline of the Talk

- Introduction to BASF
- R&D at BASF
- Innovation Examples
- We Innovate for Growth – Growth Clusters at BASF
- BASF Future Business/BASF Venture Capital

At a glance

BASF – The Chemical Company

- The world's leading chemical company
- Our portfolio ranges from chemicals, plastics, performance products, agricultural products and fine chemicals to crude oil and natural gas

- Sales 2005: €42,745 million
- Income from operations (EBIT) 2005: €5,830 million
- Employees as of December 31, 2005: 80,945

BASF sales by industry

Percentage of sales in 2005

> 15% each	• Chemicals (not an industry with end users) • Energy		
10–15% each	• Automotive • Agriculture		
5–10% each	• Construction		
< 5% each	• Electrical/electronics • Carpets • Cosmetics • Detergents/cleaners	• Furniture • Health • Leather/ shoes	• Packaging • Paper • Textiles

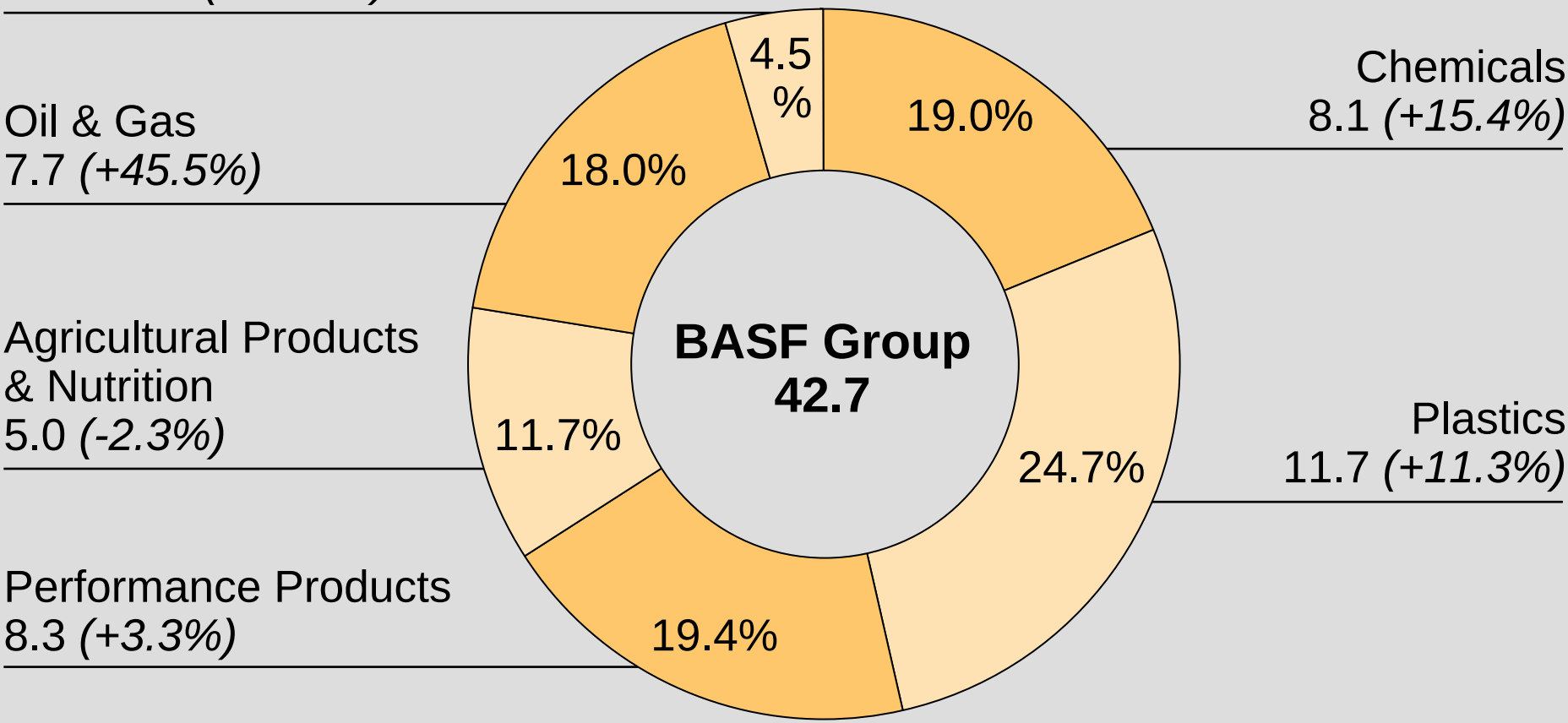
Other industries: approximately 10% in total

BASF's products

Segments	Products (examples)
Chemicals	Inorganic basic chemicals and specialties, electronic chemicals, glues, resins, petrochemical feedstocks, plasticizers, amines, diols, polyalcohols, carboxylic acids, specialty intermediates
Plastics	Styrene, styrene-based polymers and copolymers, caprolactam and nylon, engineering plastics, polyurethane basic materials and polyurethane systems, specialty elastomers
Performance Products	Performance chemicals for coatings, plastics and specialties and for detergents and formulators, textile and leather chemicals, fuel and lubricant additives, automotive OEM and refinish coatings, industrial coatings, acrylic monomers, superabsorbents, adhesive raw materials, construction chemicals, paper chemicals
Agricultural Products & Nutrition	Herbicides, fungicides, insecticides and seed treatments, vitamins, carotenoids, aroma chemicals, pharmaceutical active ingredients and excipients, pharma contract manufacturing, UV absorbers
Oil & Gas	Crude oil and natural gas (exploration, production as well as transmission, storage and trading)

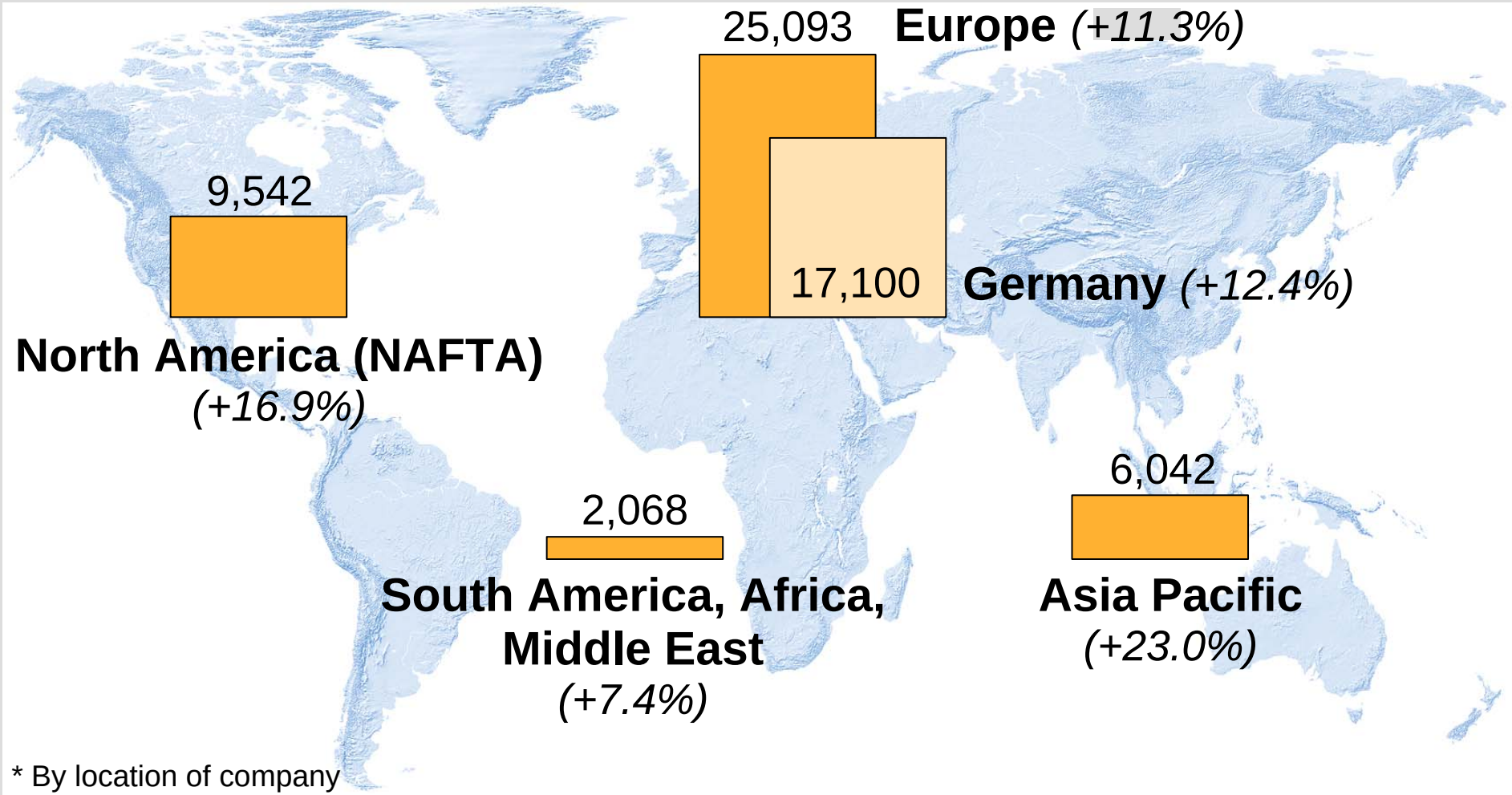
BASF Group:
Sales by segment in 2005

Billion € *(change compared with previous year in percent)*



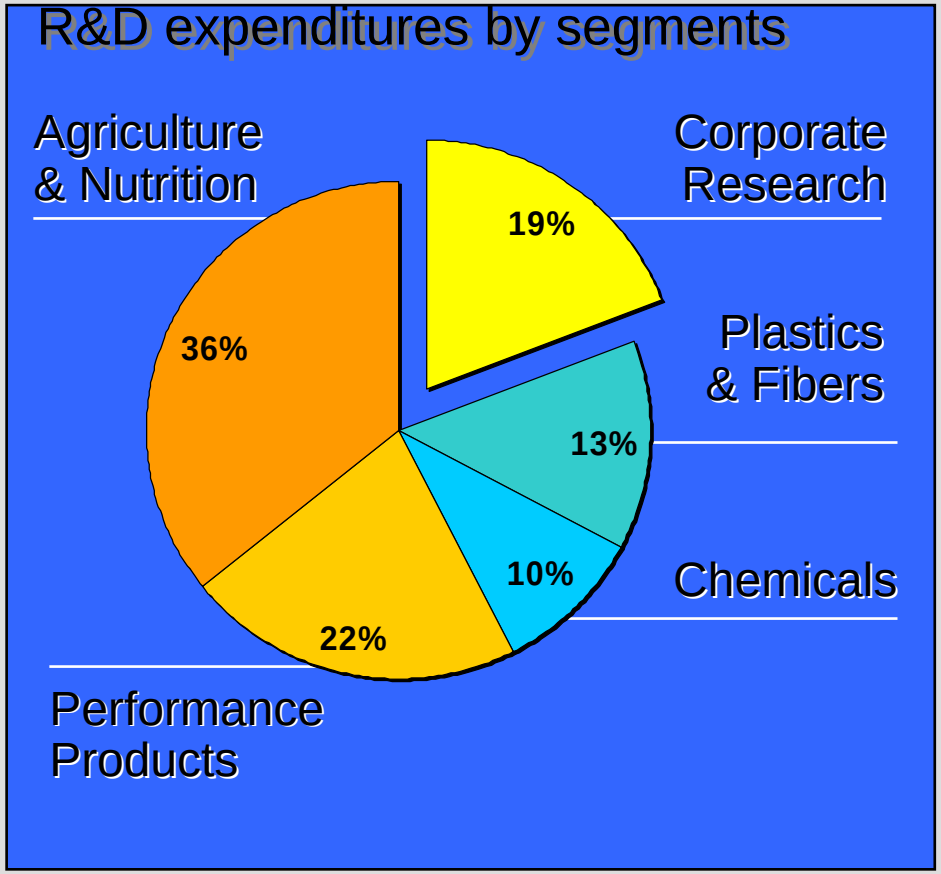
BASF Group:
Sales by region* in 2005

Million € *(change compared with previous year in percent)*



* By location of company

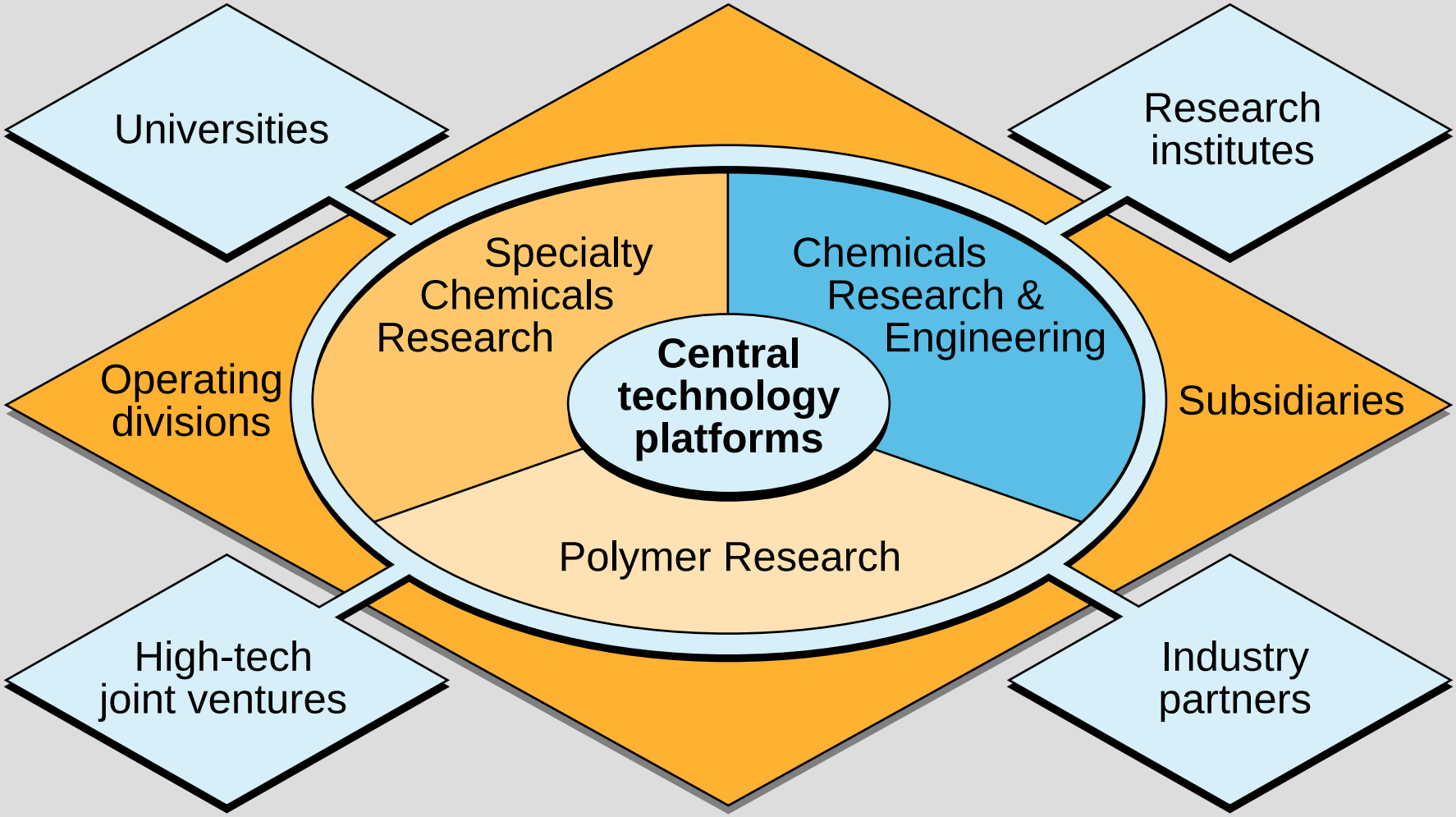
World Class R&D Capabilities



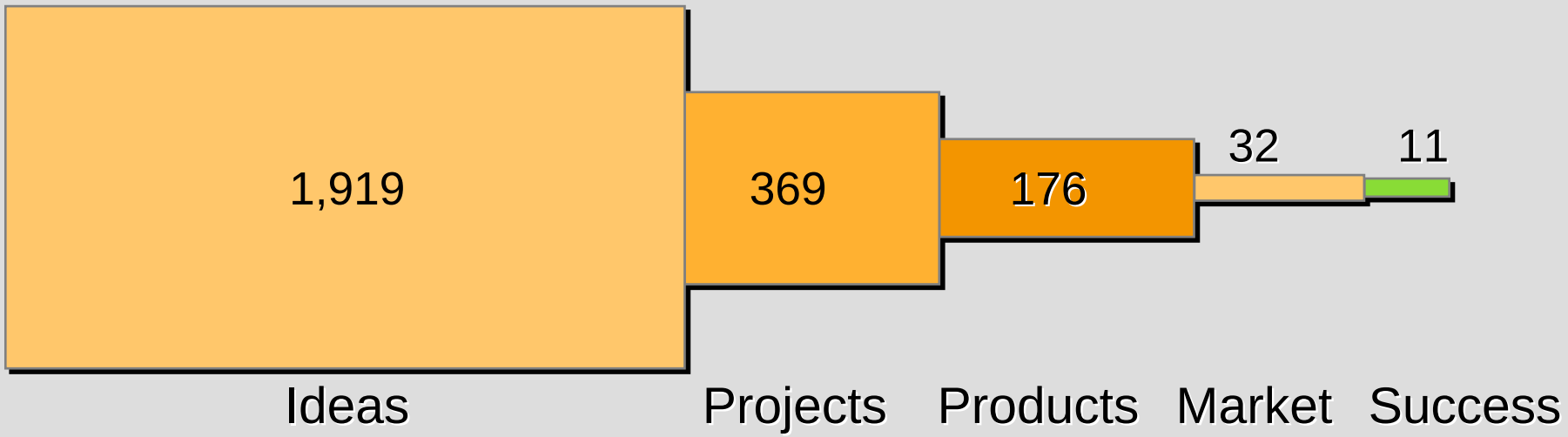
- R&D Expenditure 2004: 1.17 billion Euro
  (incl.. Oil & Gas Exploration)
- > 6,800 R&D personnel worldwide
- Operating divisions finance 80% of our R&D
- 20% Corporate funded Research

➔ Businesses and markets drive our R&D

Research organization



Idea is not equivalent to Market Success

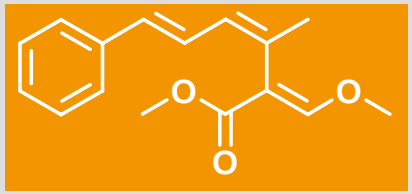


Source: Universität St. Gallen, Prof. Gassmann

Patent Race BASF - Zeneca

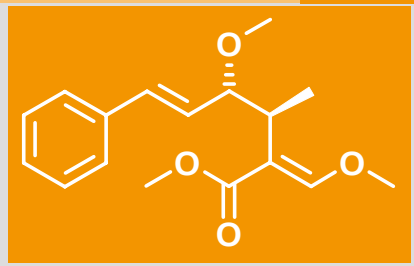
Cooperation with Uni Kaiserslautern (Prof. Anke) and Munich (Prof. Steglich)

BASF The Chemical Company

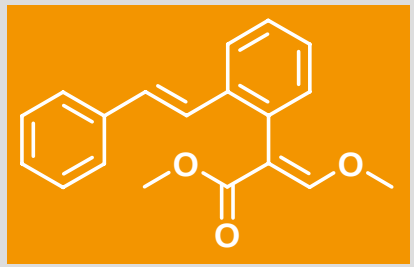


Strobilurin A (Juli 83)

BASF Zeneca

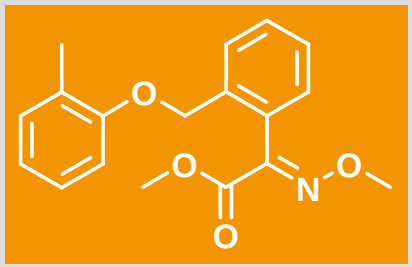


Oudemansin (Juli 82)

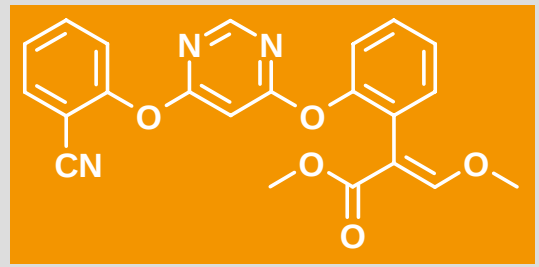


Enol ether stilben

Enol ether patents
30.05.85 19.10.84
Oxime ether patents
16.07.86 18.07.86



Kresoxim-methyl



Azoxystrobin

The Ionic Liquid Story

John Wilkes
Imidazolium salts

400

300

200

100

Number of papers

Prof. Ken Seddon
„Ionic Liquids“

Prof. Peter Wasserscheid

Solvent Innovation

2002

BASIL ™

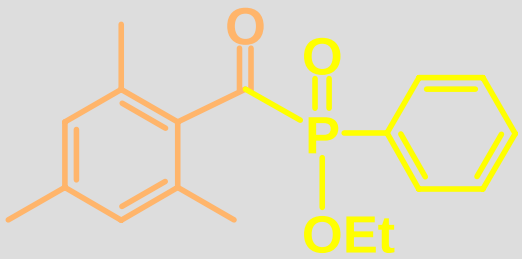
1980

1999

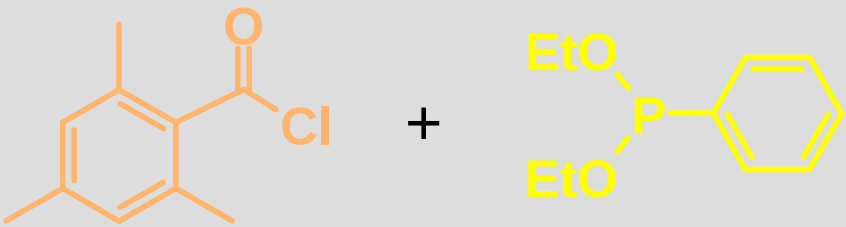
1960s

Time

Lucirin® TPO-L



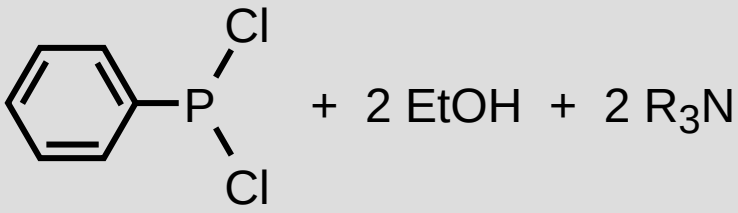
Building blocks



Photoinitiator for UV curing

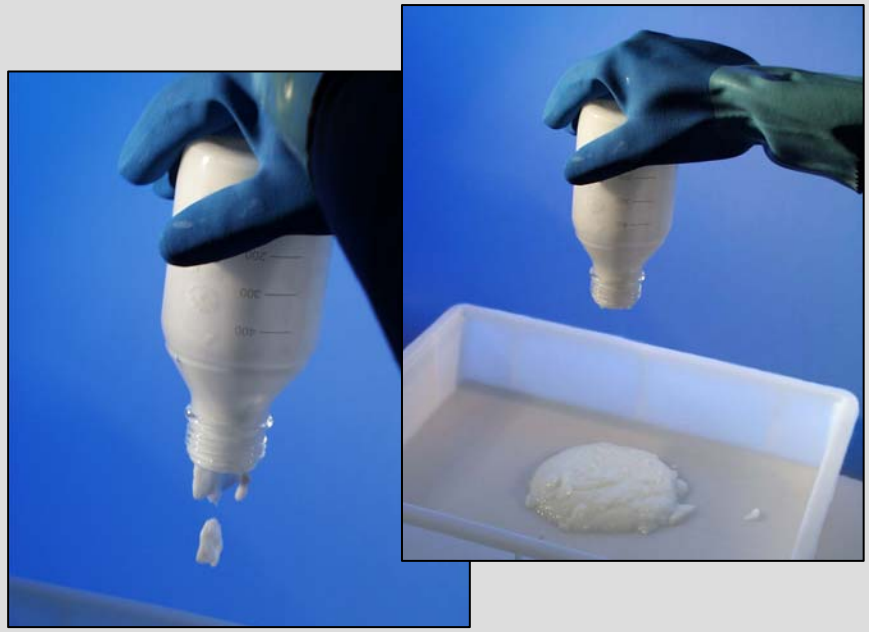
Lucirin® TPO-L

Diethoxyphenylphosphine (DEPP) Synthesis



+ 2 EtOH + 2 R_3N

DCPP tert. amine



2 $R_3N \cdot HCl$ +

Solid salt DEPP

Lucirin® TPO-L

Separation: Solid Liquid

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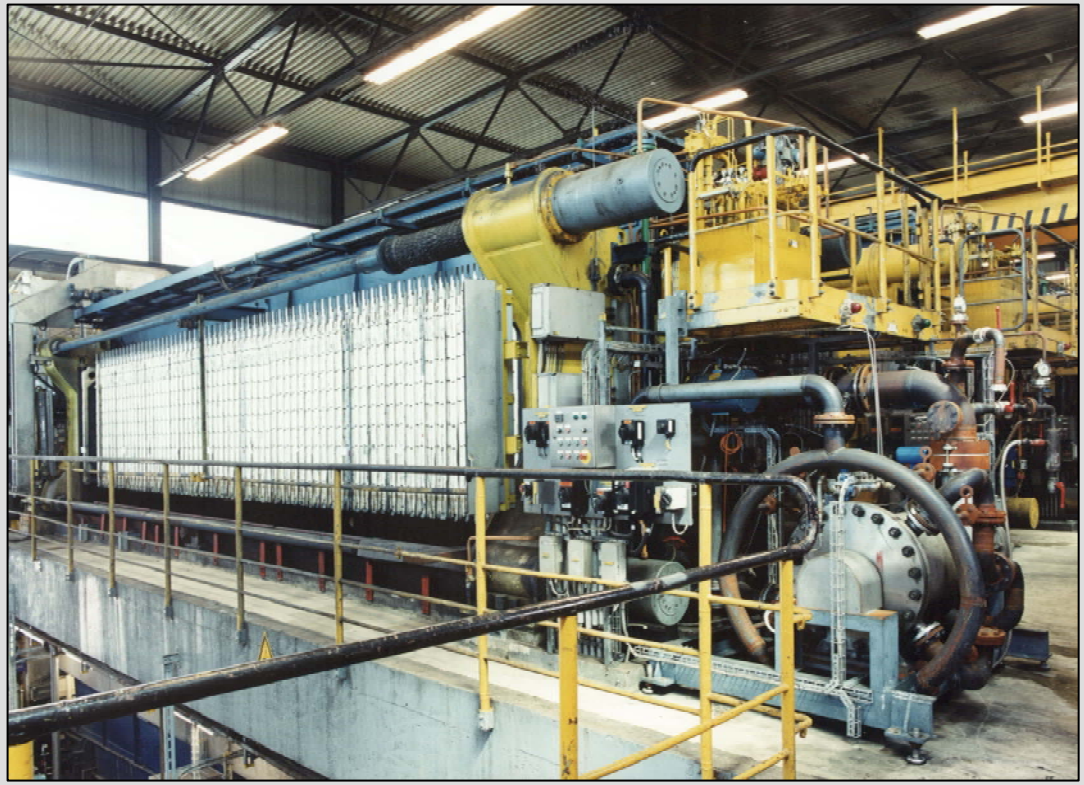
Lab scale



Technical process

Lucirin® TPO-L

Separation: Liquid-Liquid

Lab scale

Technical process

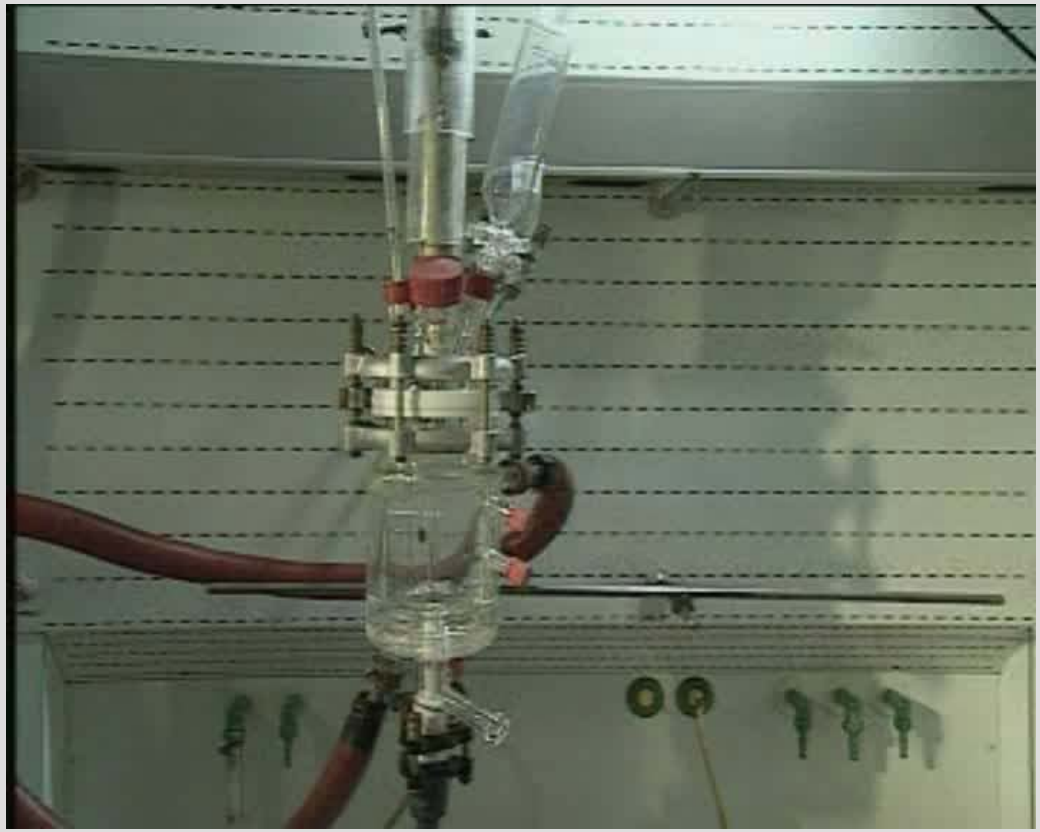
Simple, reliable and cheap !

Can 1-Methylimidazole do the job?

DCPP

DEPP

Liquid salt
(ionic liquid)



Lucirin® T
New Reac

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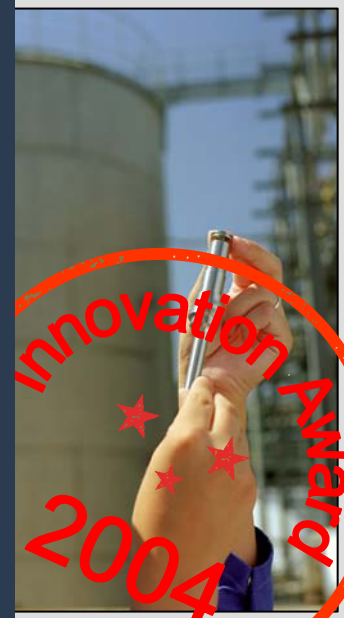
Batch P

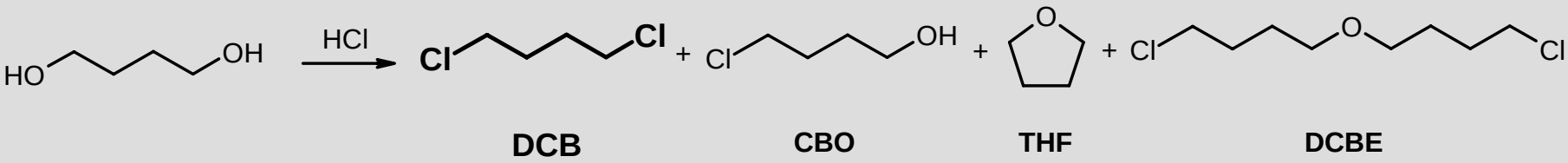
rocess with
actor



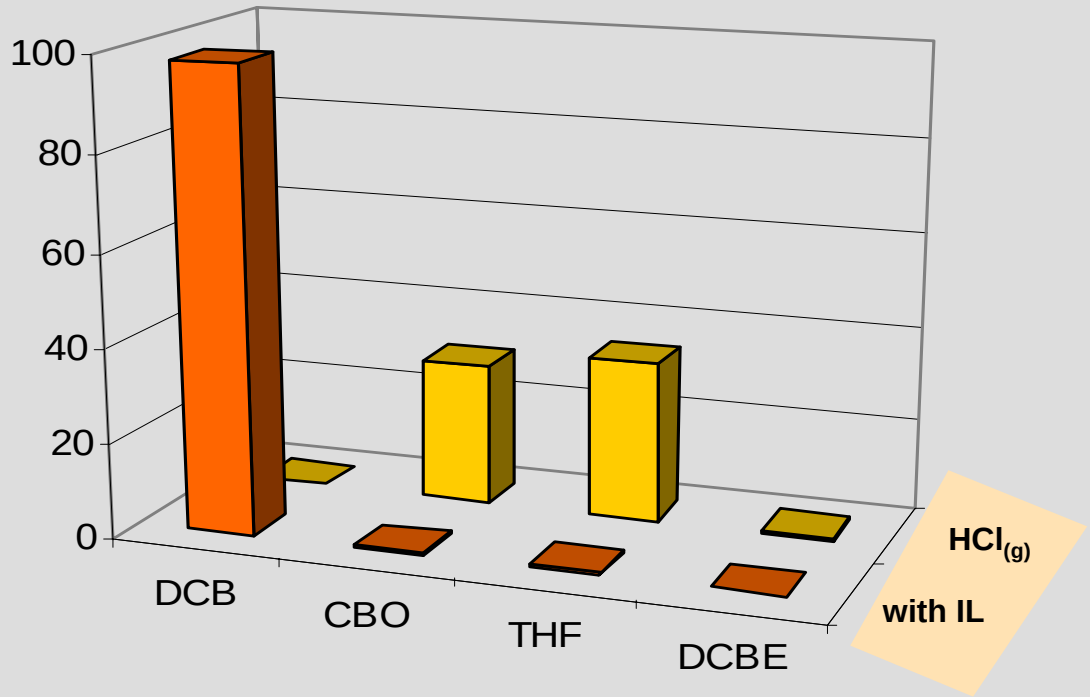
Spac

yield
m^{-3} h^{-1}

Another Example from BASF
Nucleophilic HCl



DCB **CBO** **THF** **DCBE**

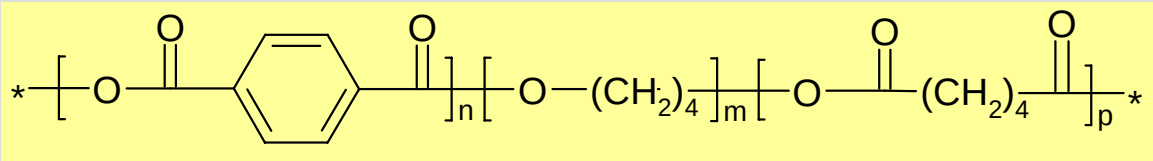


Nucleophilic HCl as alternative to phosgene

DE 10341308 (BASF)

Ecoflex - new biodegradable polyester

- Statistical polyester synthesized from BASF monomers:
  1,4-butane diol, adipic acid and teraphthalic acid.
- Good thermoplastic properties.
- M.p.: 110 °C; Tg = -33 °C.
- Forms semi-transparent films for packaging..
- Low water solubility



Composting initial

Composting after two weeks

Composting after four weeks

Polymers from CO_2 in Air

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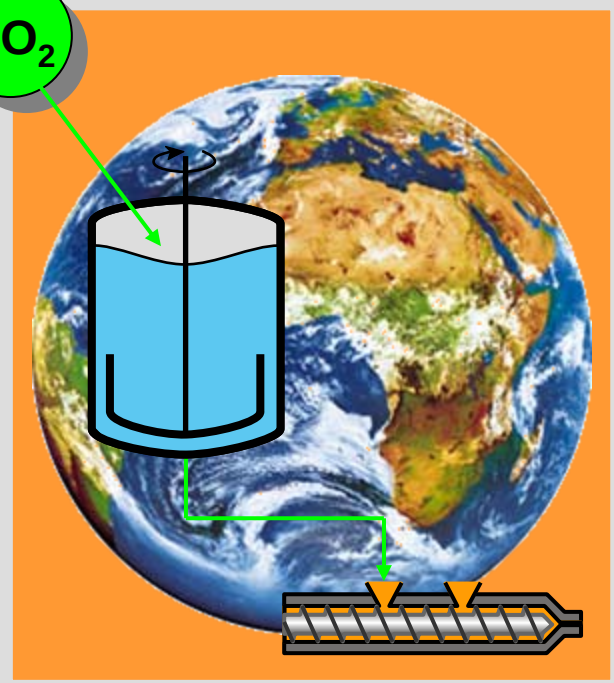
CO_2-circle

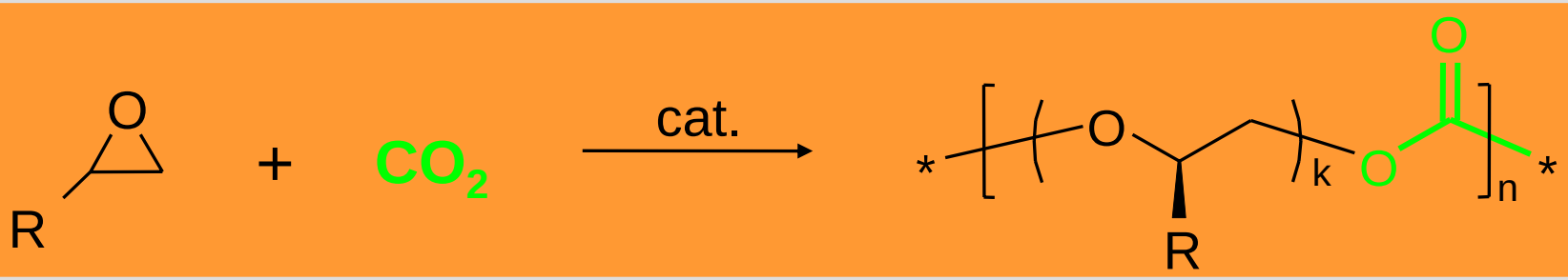
Gas-barrier-properties

Material properties tunable

Biodegradability

Transparency





Epoxide **Carbon dioxide** **Aliphatic Polycarbonates**

Structural changes in the chemical industry

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External driving forces

- Globalisation of customer industries
- Increasing cost pressure, especially on commodities
- New technological challenges, particularly in the area of biotechnology, genetic engineering and nanotechnology
- Appearance of small high-tech companies
- Strong pressure to increase shareholder value
- Environmental pressure to increase sustainability of the industry

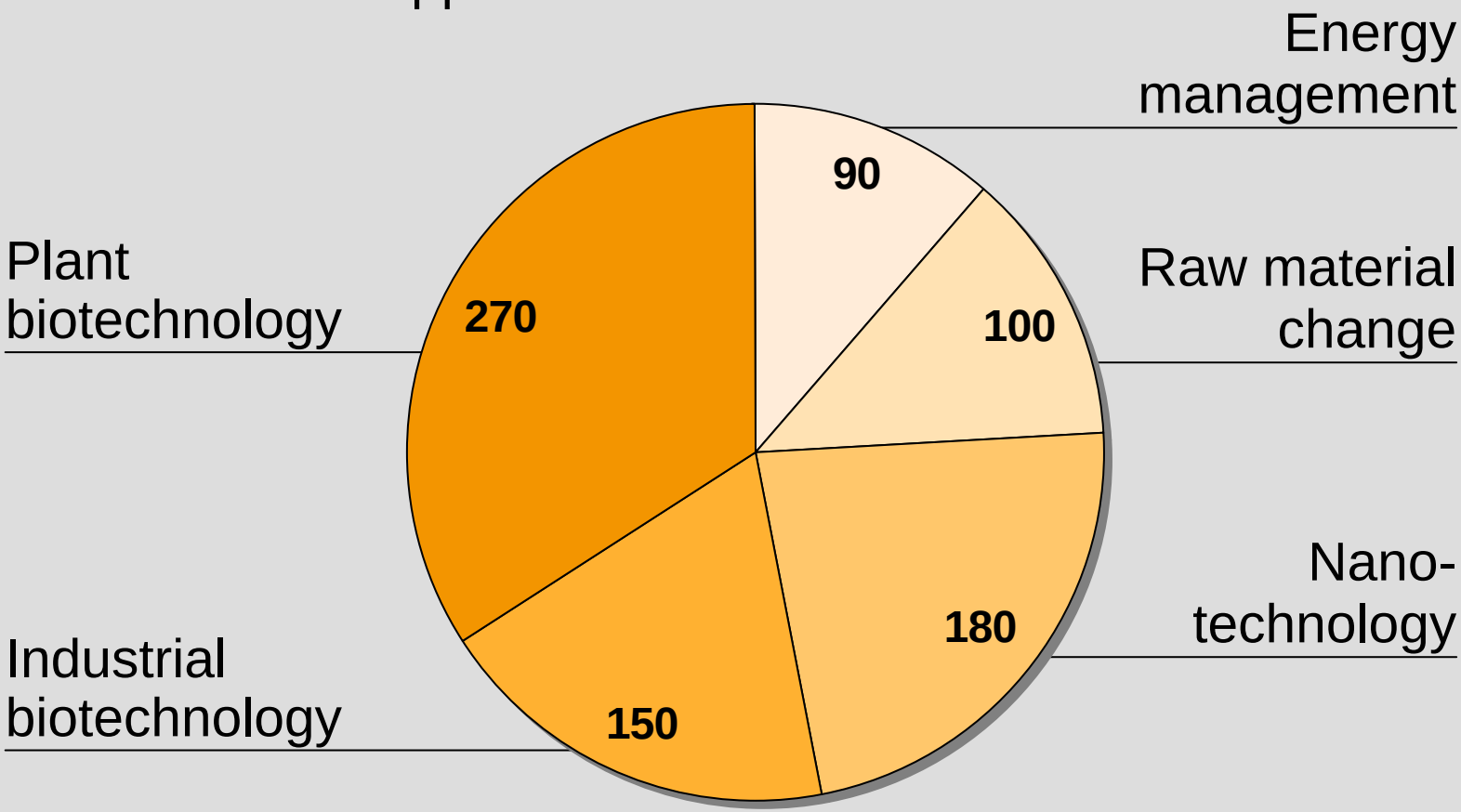
Internal processes of adaptation

- Development of transnational chemical companies
- Focus on core competences
- Continuing consolidation
- Marked increase in the number of joint ventures in sub-segments of the portfolio

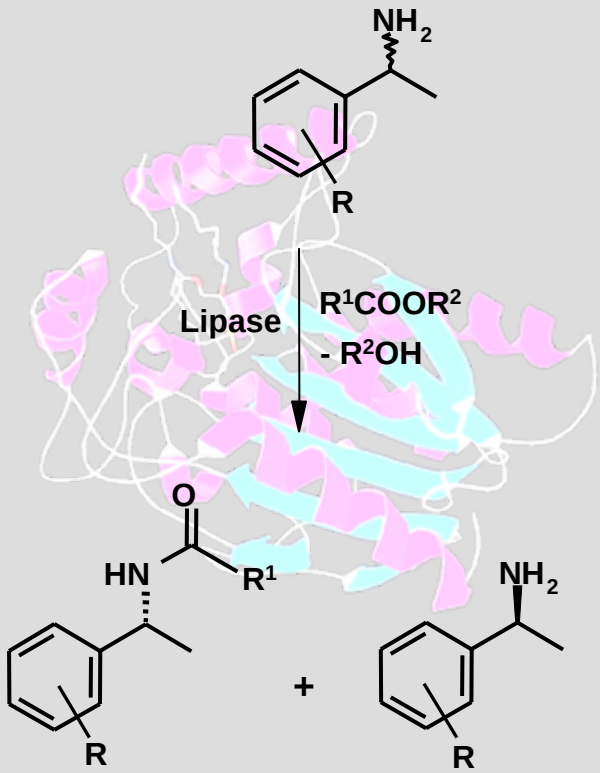
„We innovate for growth!“

Stimulate growth from inside

Cross-platform developments in growth clusters:
2006 – 2008 of approx. €800 million



Biocatalysis: Use of Enzymes



ChiPro® - Plant, Ludwigshafen

Products via Biocatalysis: Chiral Amines

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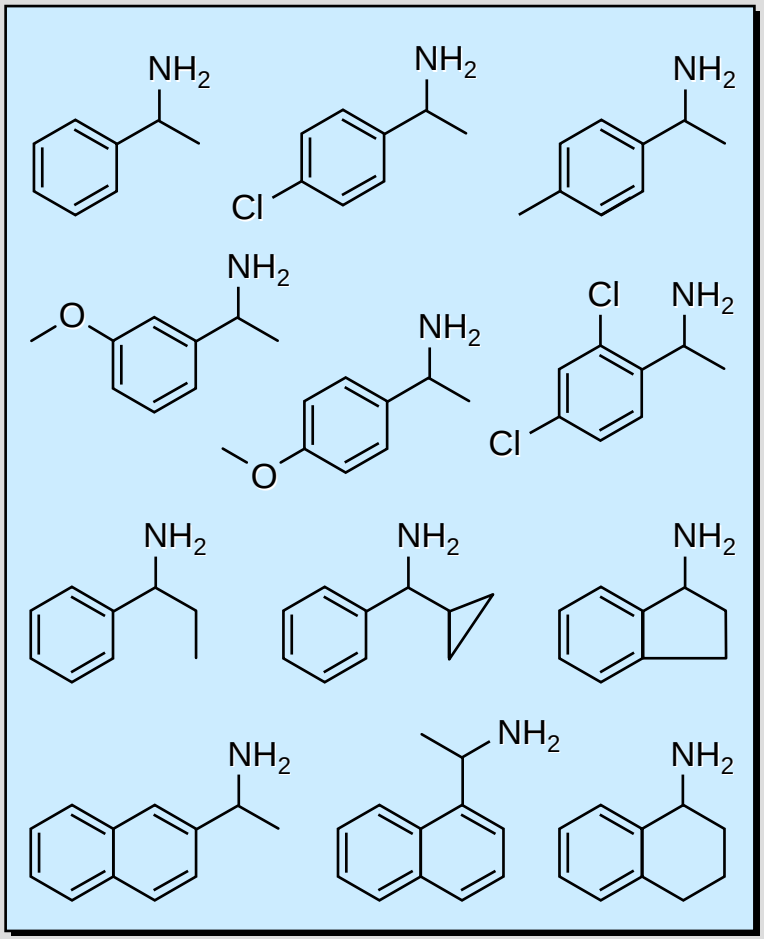
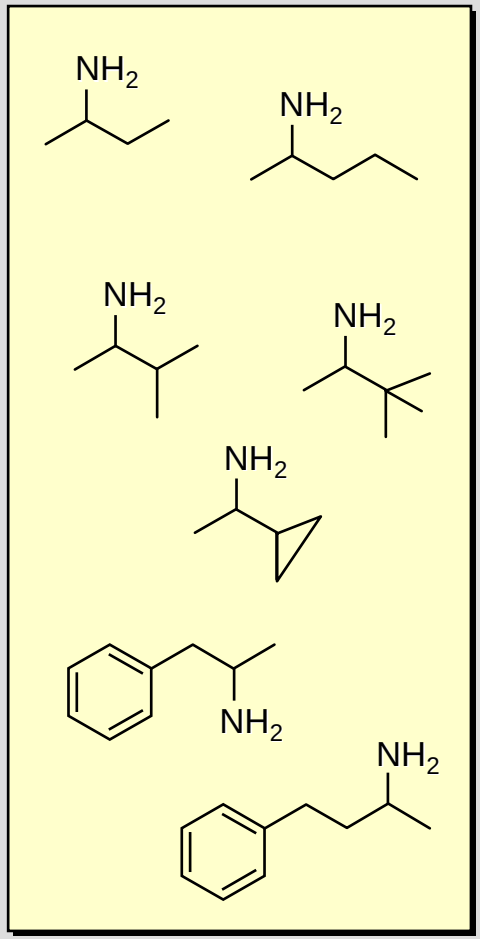
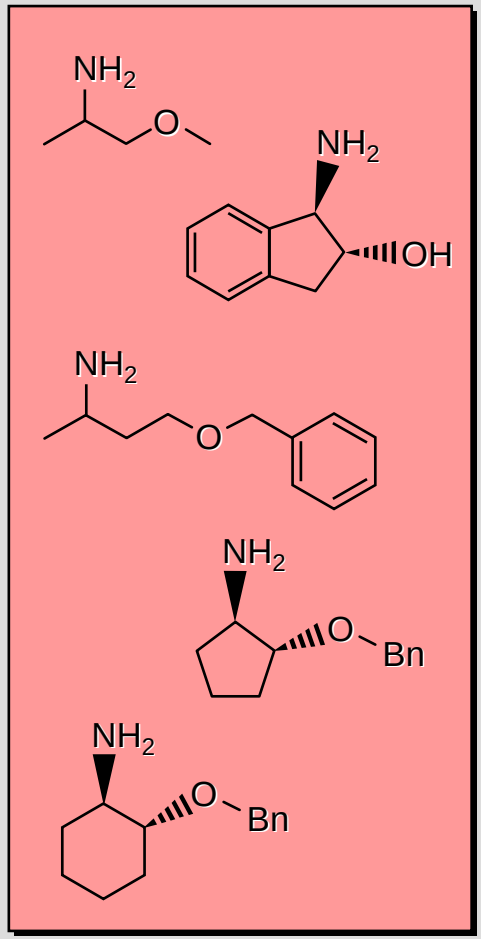
Aryl-Alkyl-Amines



Alkyl-Amines

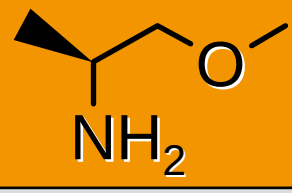


Aminoalcohols

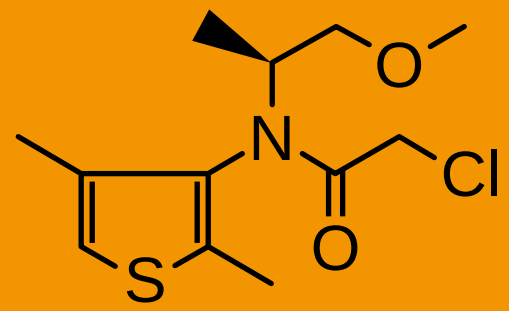


Optically active amines

S-MOIPA



Outlook®



Vitamin B2

Cooperation with Uni Salamanca (Prof. Revuelta)

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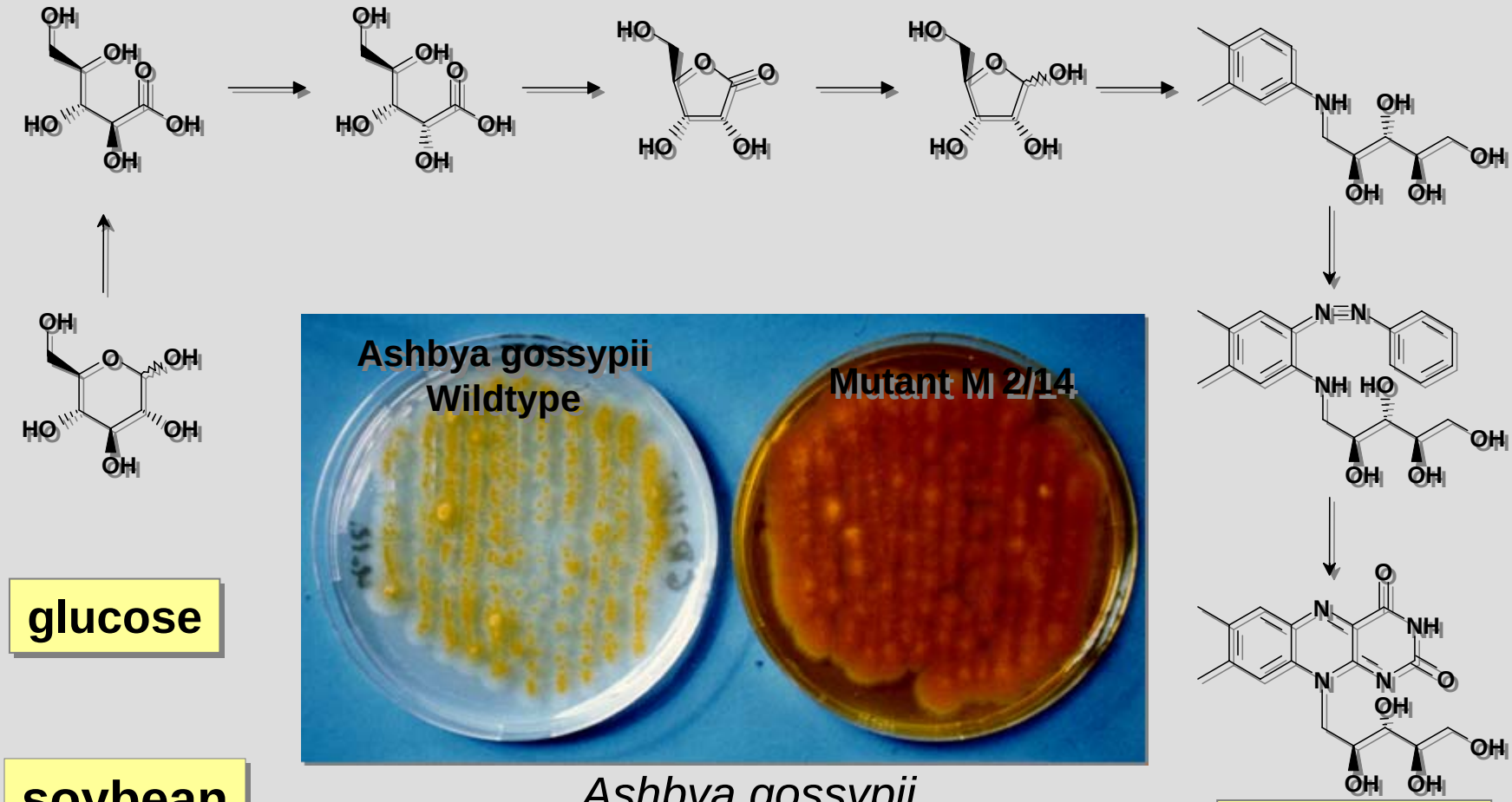

Energy storage

Metal organic frameworks for gas/hydrogen storage

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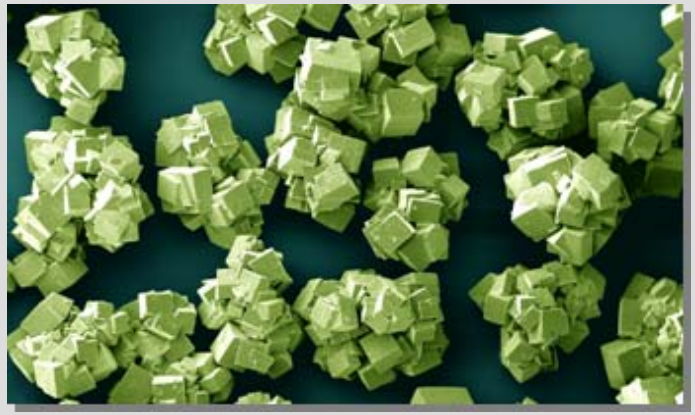
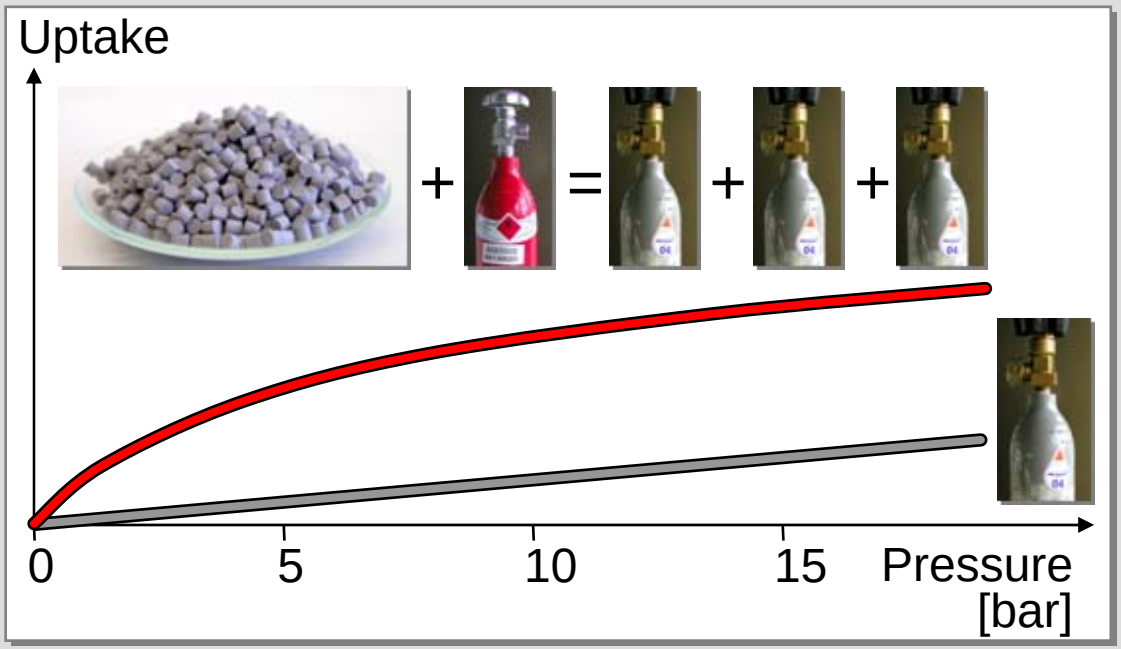
Target

- Storage density of liquid hydrogen
- Setting and removal within seconds
- Use for mobile and portable fuel cells

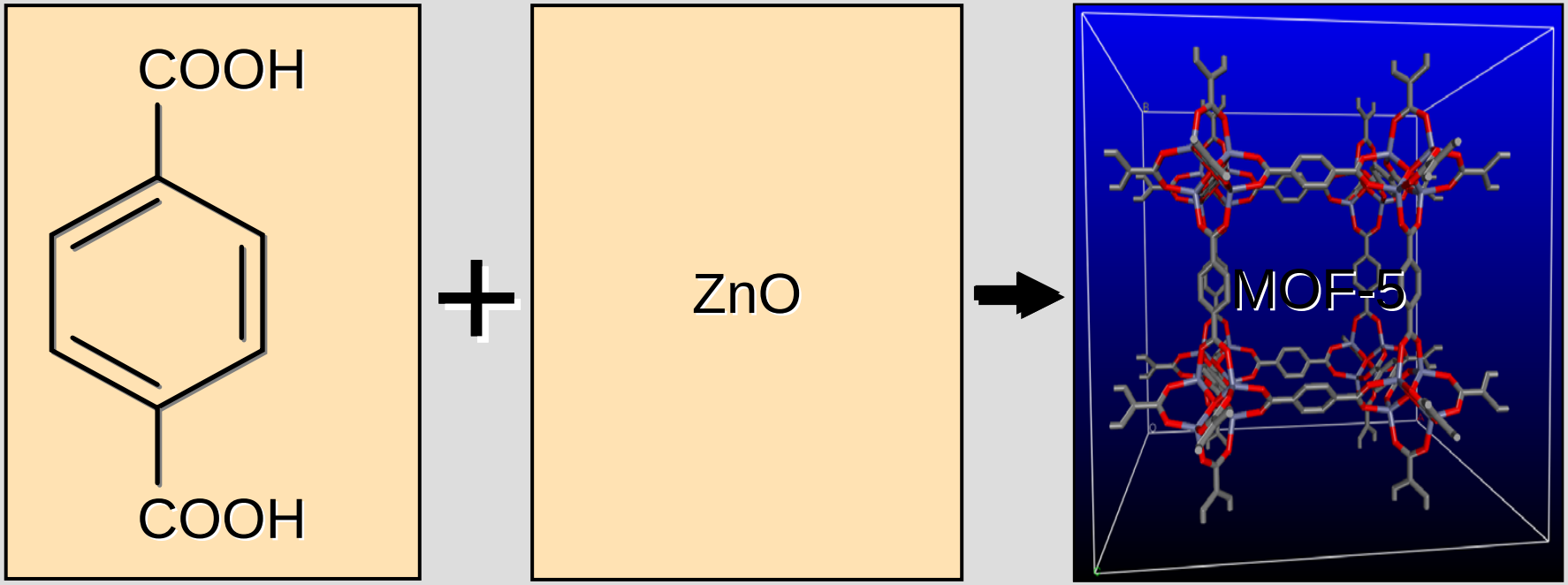




Approach

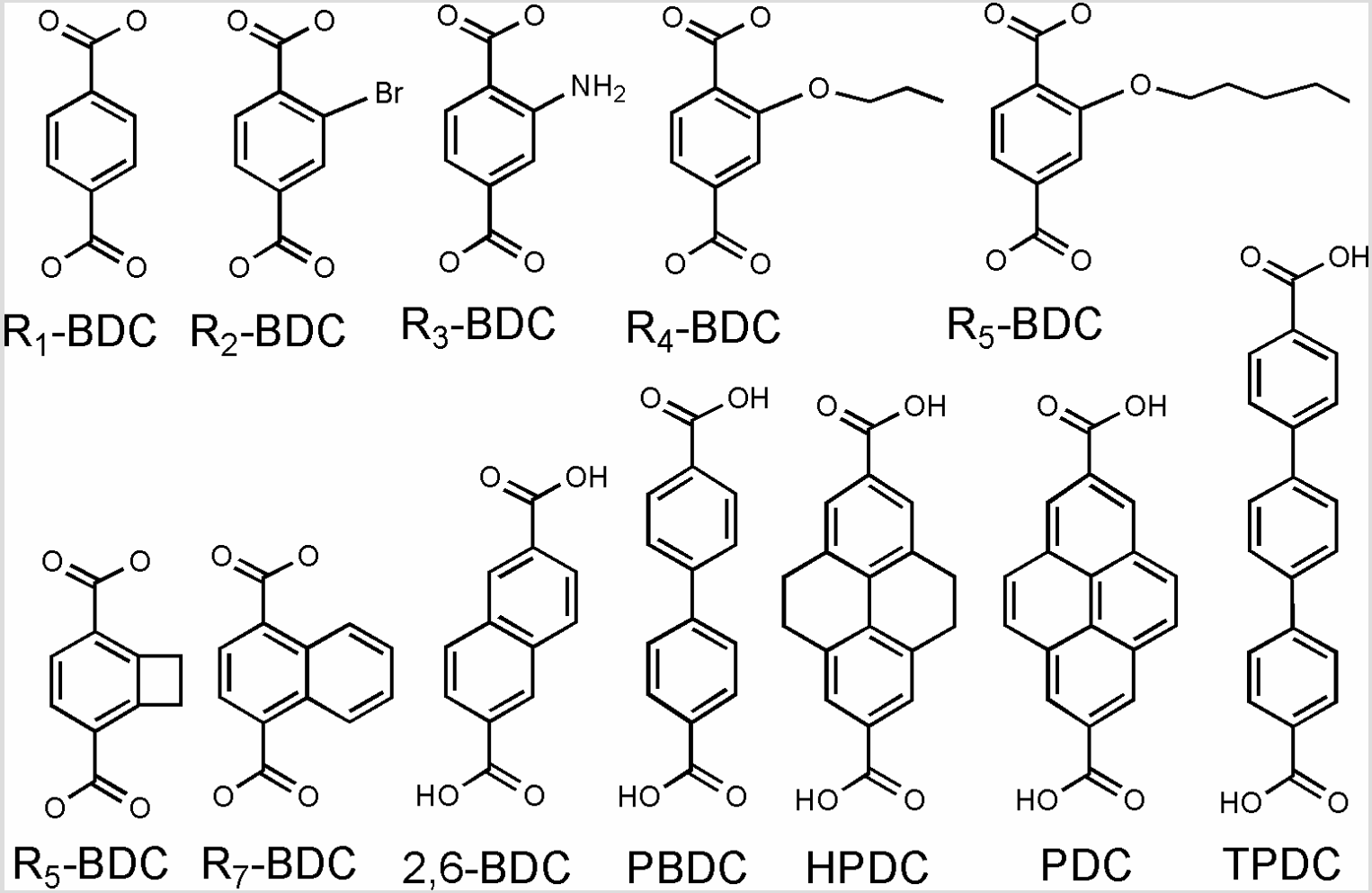
- Modelling of high surface structures
- Synthesis, scale-up and shaping of MOF
- Cooperation with Prof. Yaghi, University of California at LA

MOF-Nanocubes



MOF =
Metal Organic
Framework

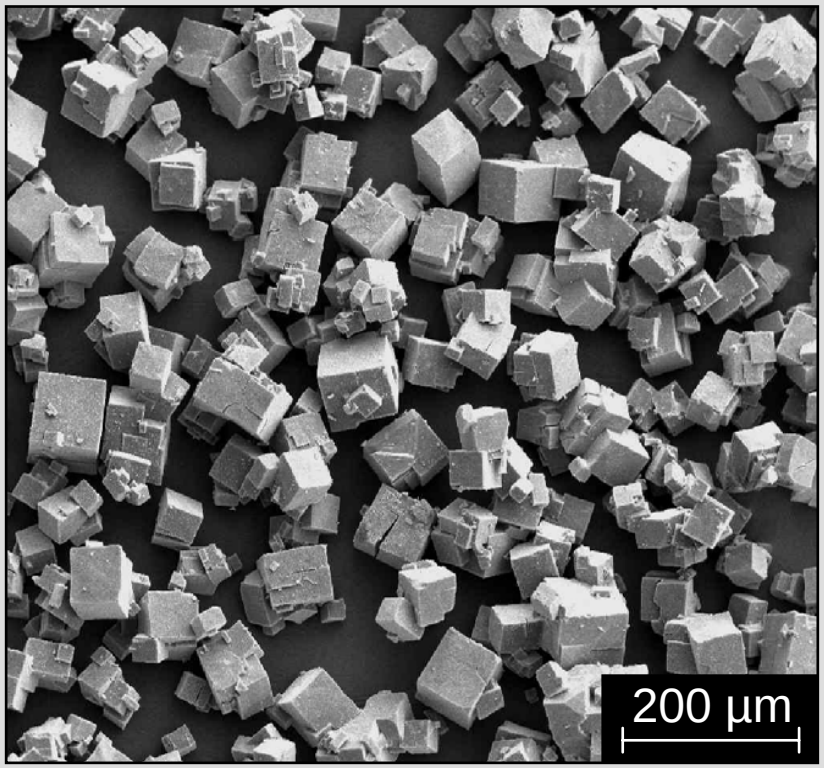
Linkers Possibilities

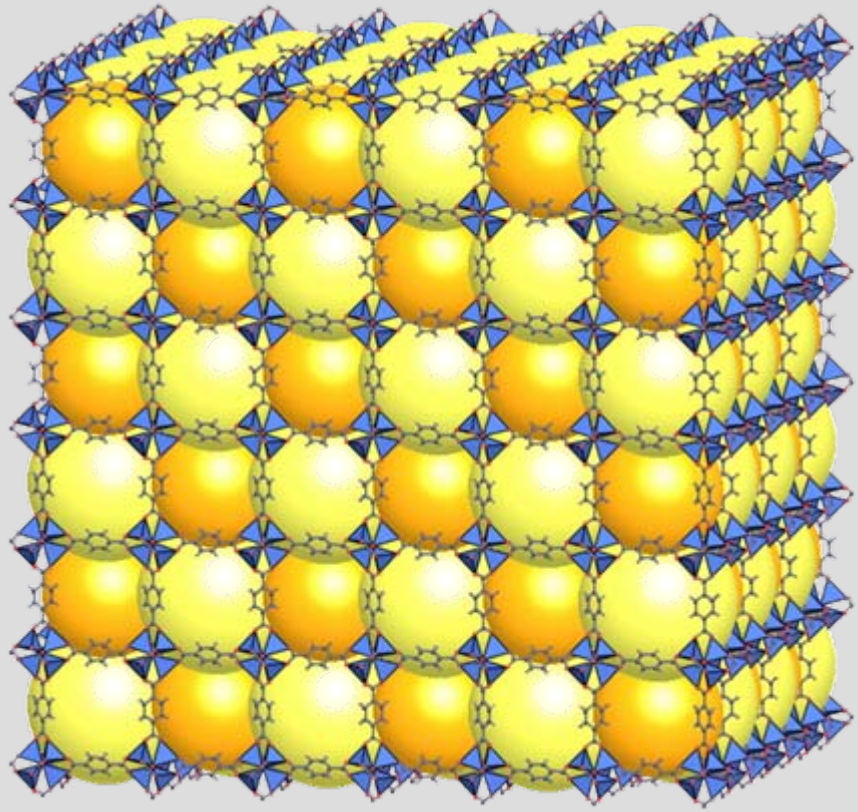


MOF-Nanocubes

BASOCUBE™

3 000 m^2/g

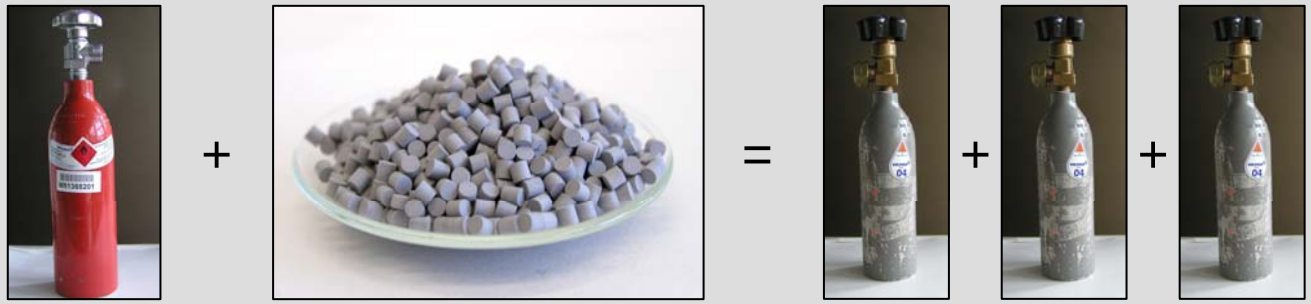




Simple chemicals into novel nano-networks

MOF-Nanocubes

Gas-Storage in MOF



7.5 wt % Hydrogen uptake at 77K

(30 % more Hydrogen in a tank filled with MOF)

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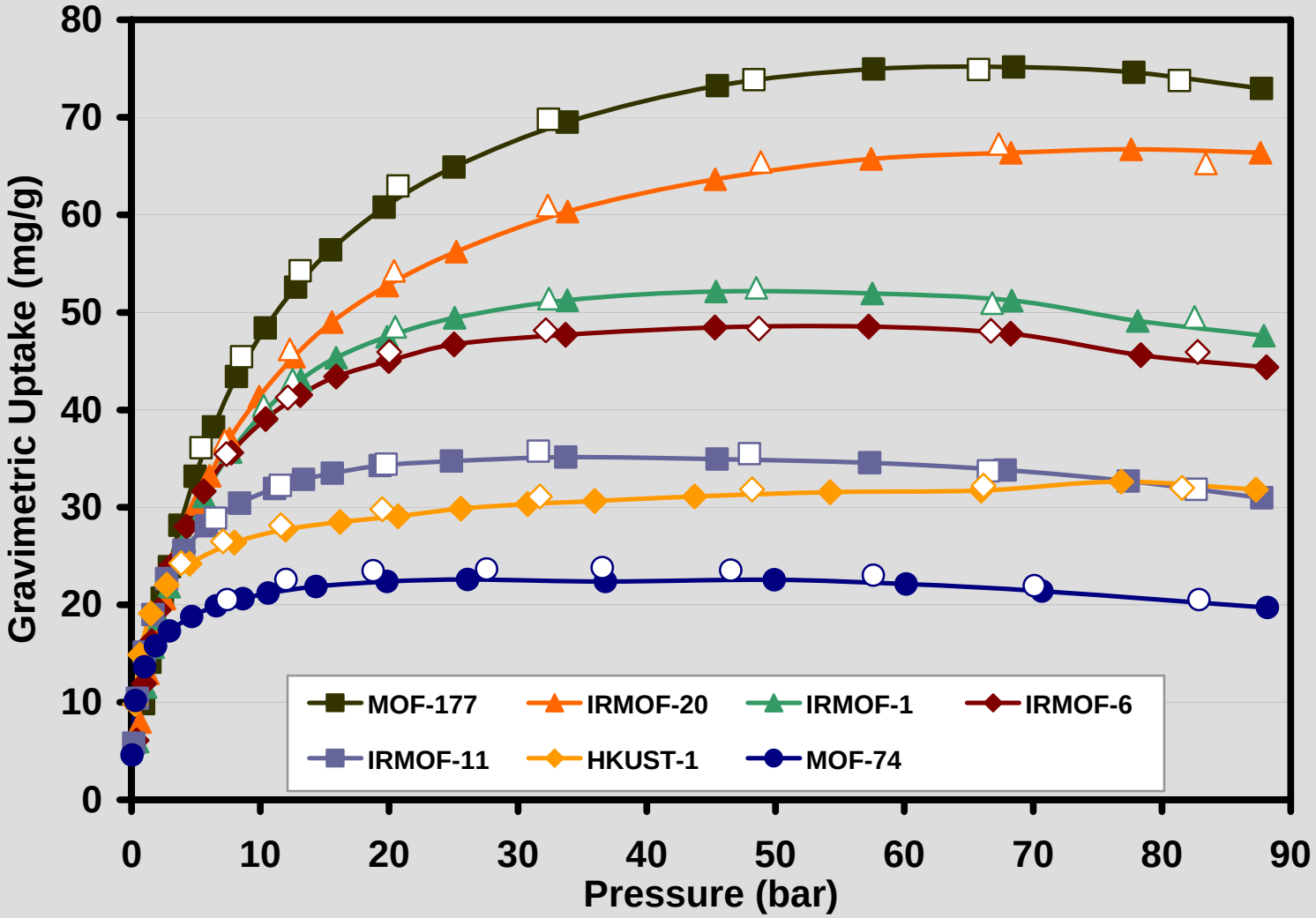
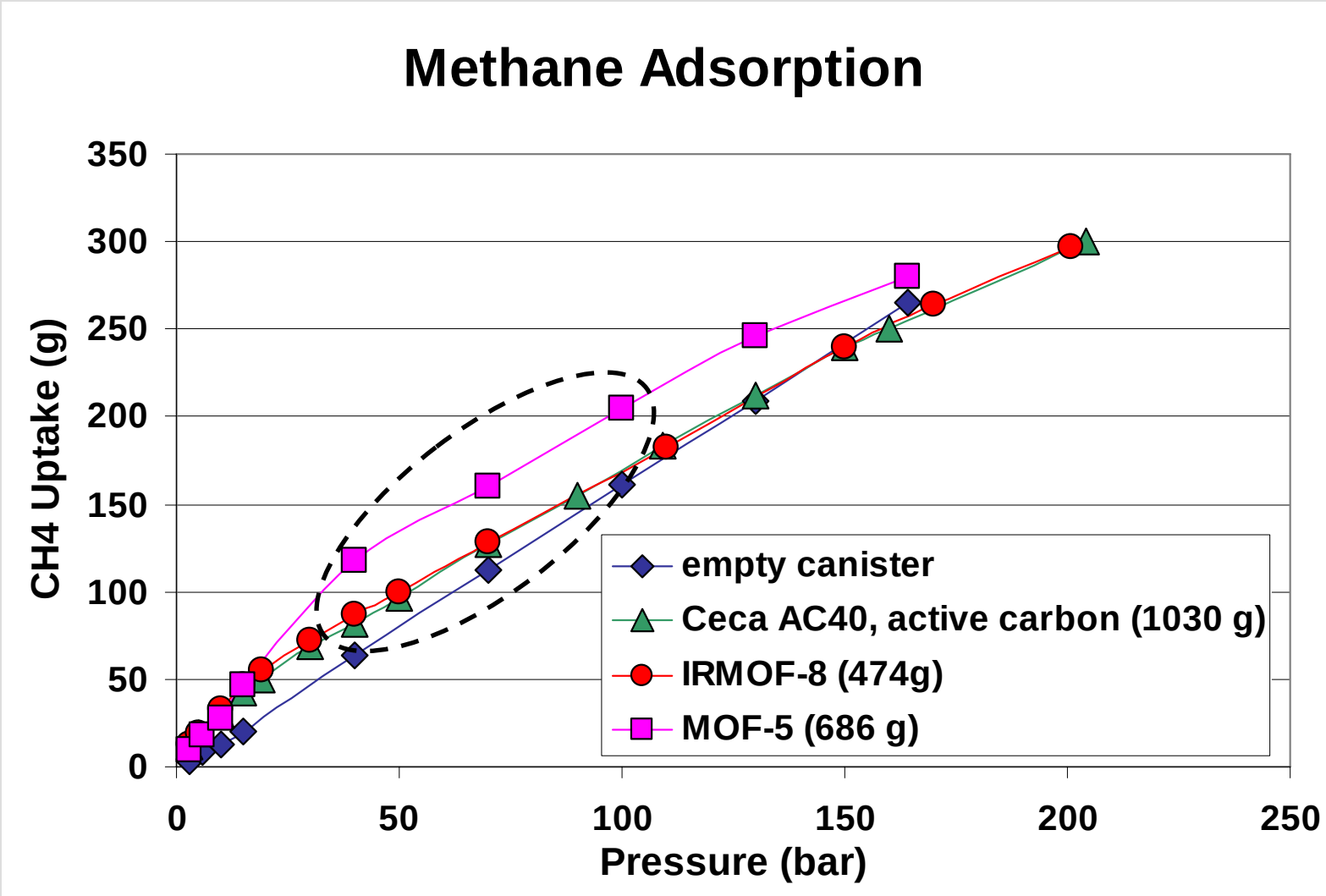
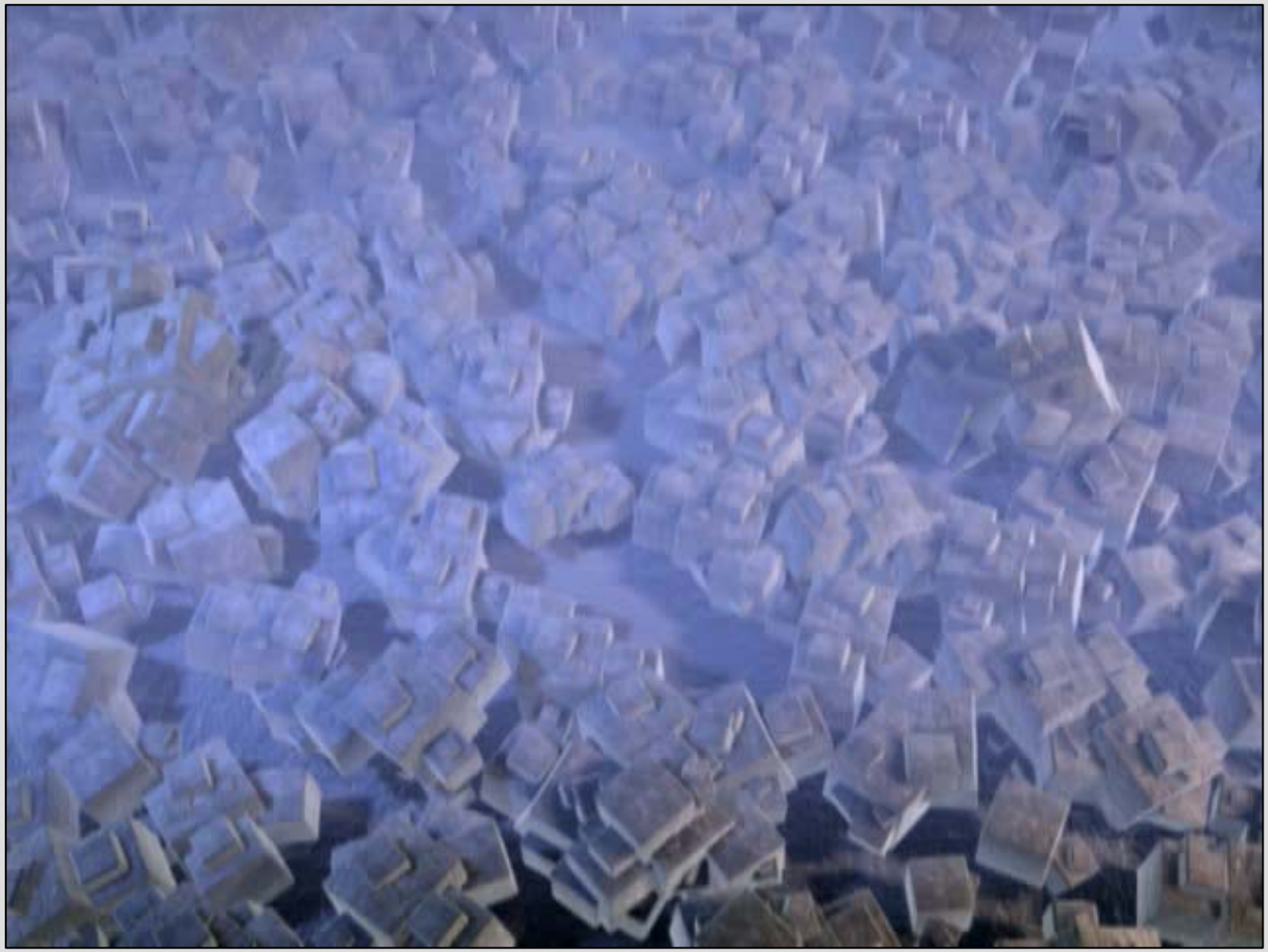


Gas Storage – Methane (295 K; prototype)



MOF-Nanocubes

BASOCUBE™



MOF-Nanocubes

BASOCUBE™

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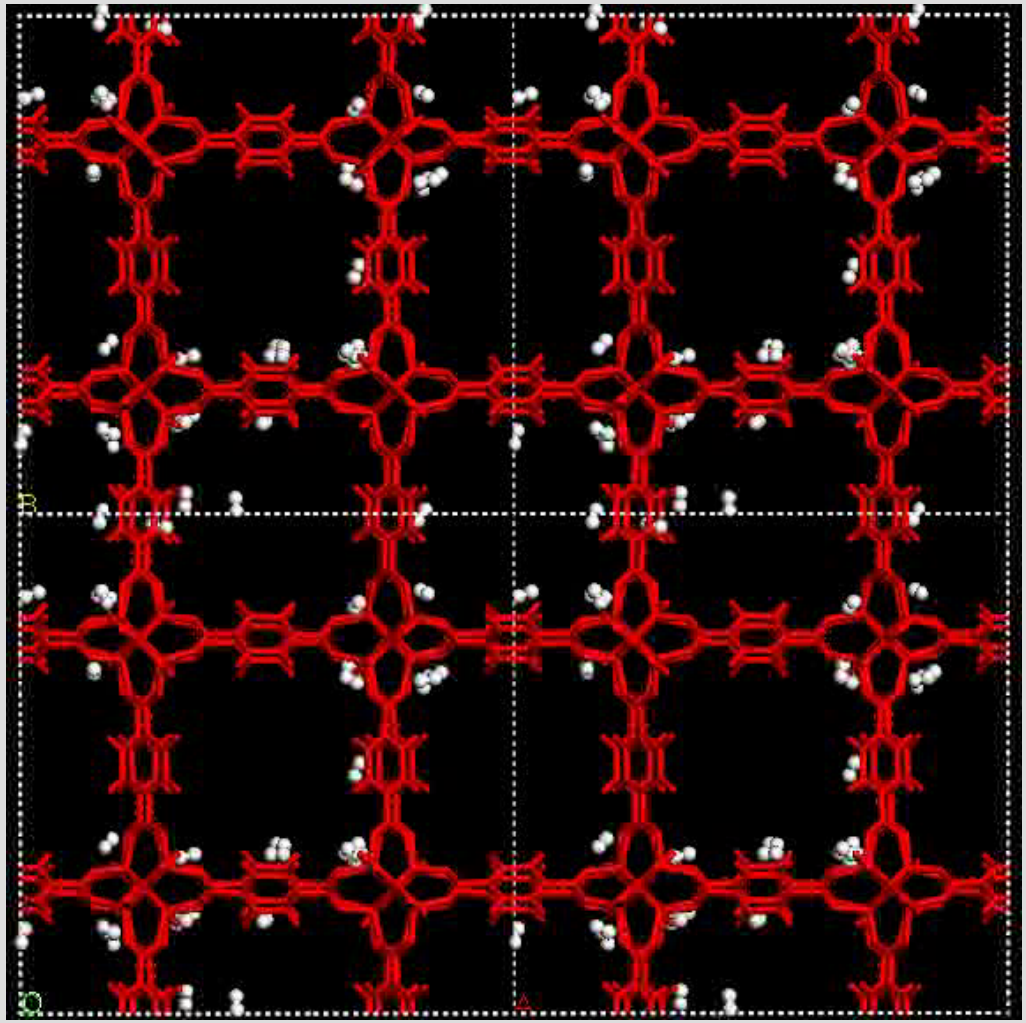


MOF-Nanocubes

Applications

gas storage

catalysis

MOF = Metal-Organic Framework

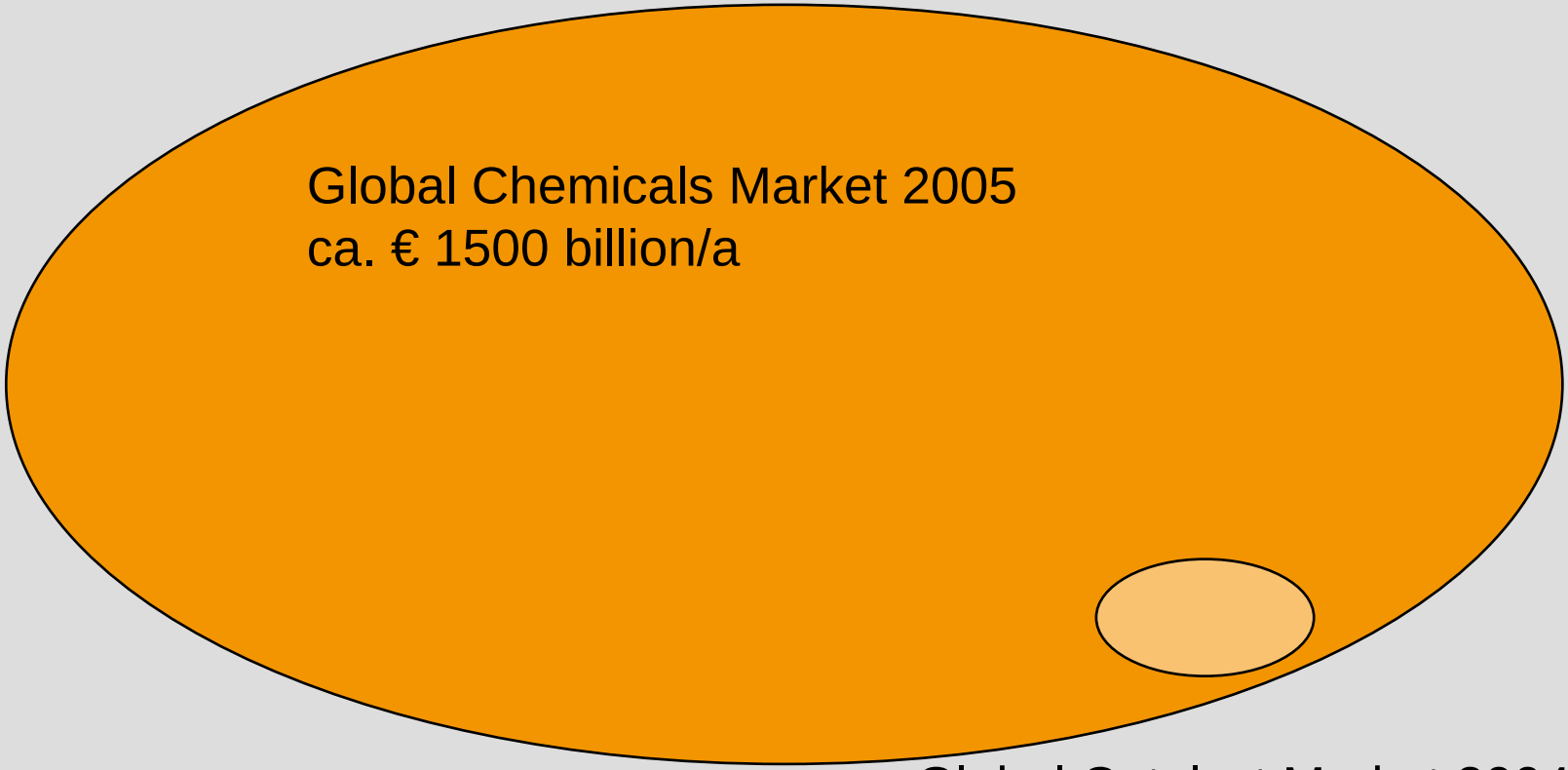
gas purification

odor control

gas separation

Catalysis:
Multiplicator and Innovation Engine for Chemicals

About 90% of all chemicals are produced using catalysis!!!!



Catalysis -
a Key Technology Platform for Business and Society

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Energy

Oil
Gas
Petrochemicals
Polymers

Auto Emissions
Fuel Cells
Hydrogen
Economy
Syn Gas

Oven linings

Process Catalysis

Consumer Catalysis

Water/Air treatment

Solvent free paints & adhesives

Fine and Speciality Chemicals

Cosmeceuticals

Sustainable material substitution

Biocatalysis

Pharmaceuticals

Catalysis Research at BASF

History

Ammonia-Laboratory was founded by Bosch and Mittasch

- **1903 Research on ammonia began: $N_2 + 3\ H_2 \rightleftharpoons 2\ NH_3$**
- **1913 First production of ammonia by the Haber-Bosch-Process**
- **1931 Nobel Prize: Bosch / Bergius**

Carl Bosch

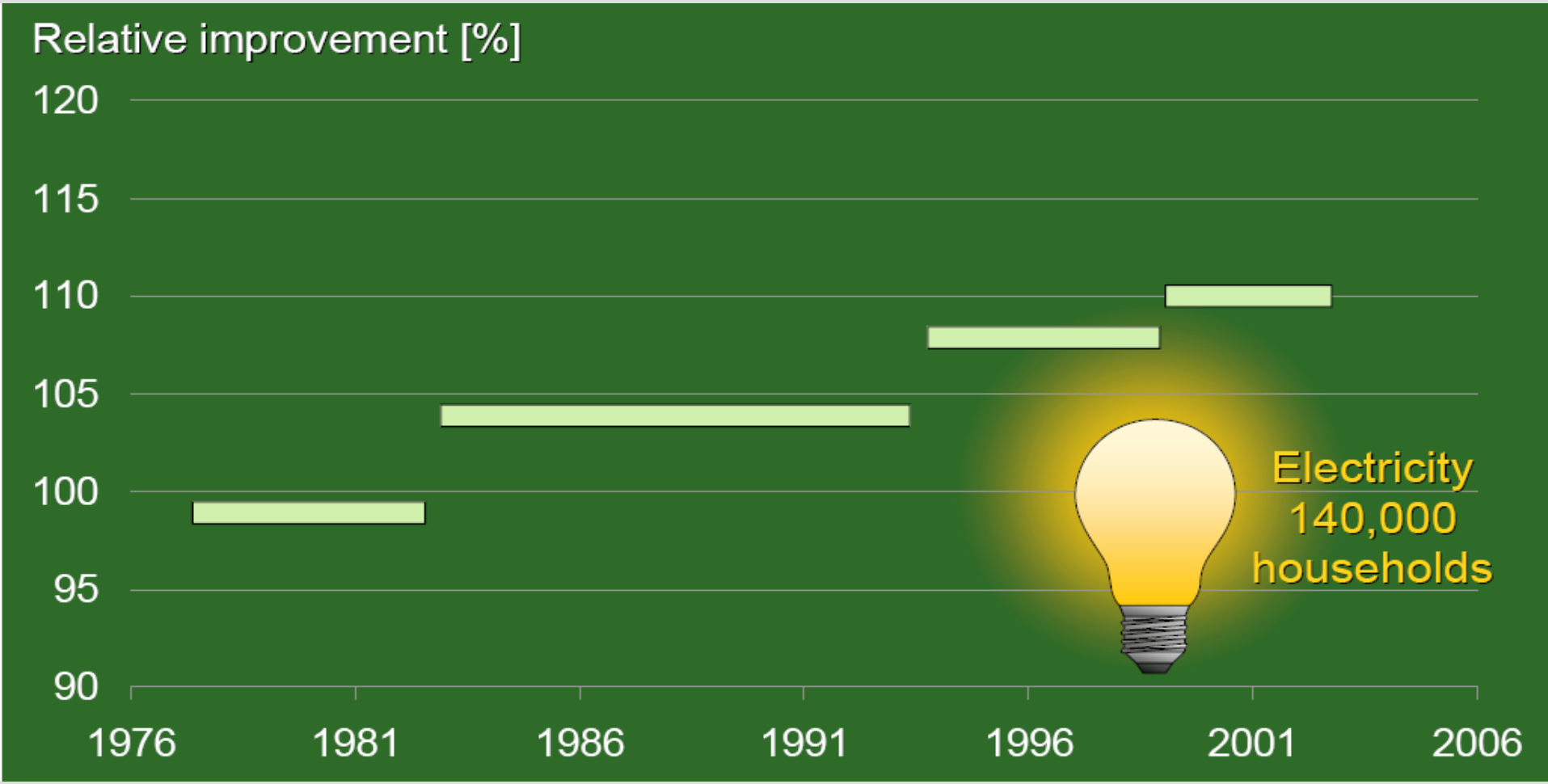
Historic Reactor

Plant Antwerp

500 million tons of artificial fertilizer per year employing 1% of the world's energy. It sustains about 40% of our planetary population

Example: Acrylic Acid

Increase in yield through improvement of catalytic system



Propylene Oxide Technologies

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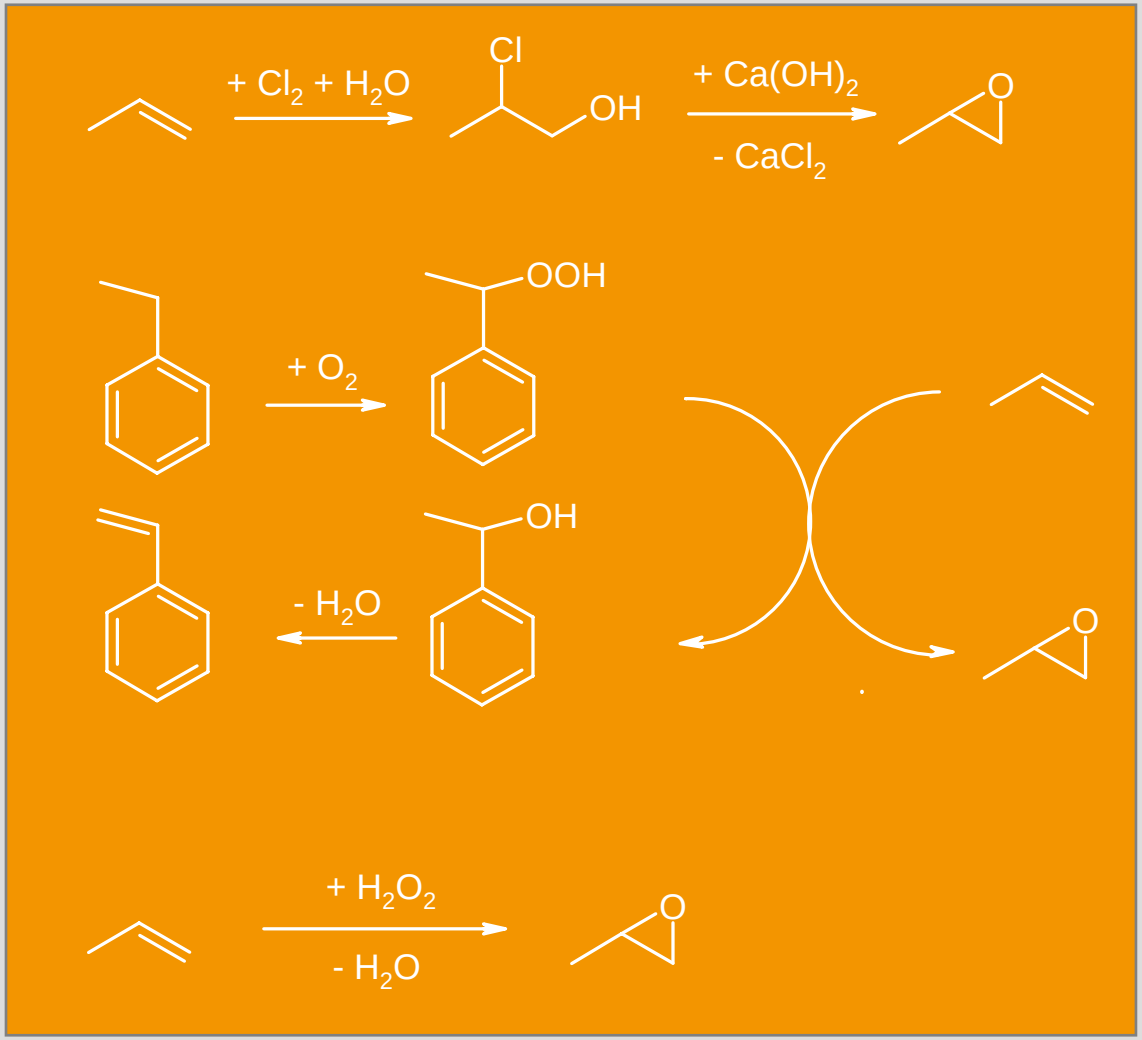
Chlorohydrin
1930



1.5 t salt/t PO

SMPO
1975

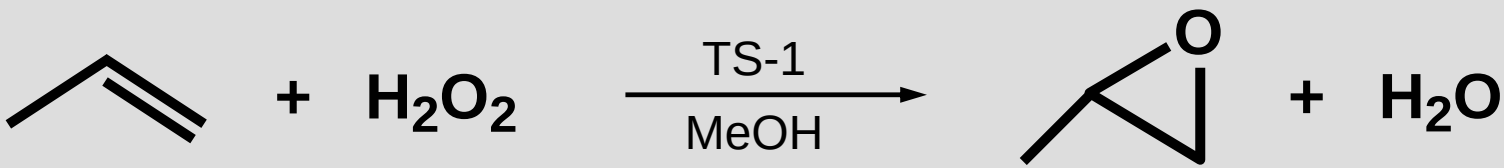
2.2 t SM/t PO

BASF-HPPO
JDA with DOW
2008

water only

Propylene Oxide – HPPO Process

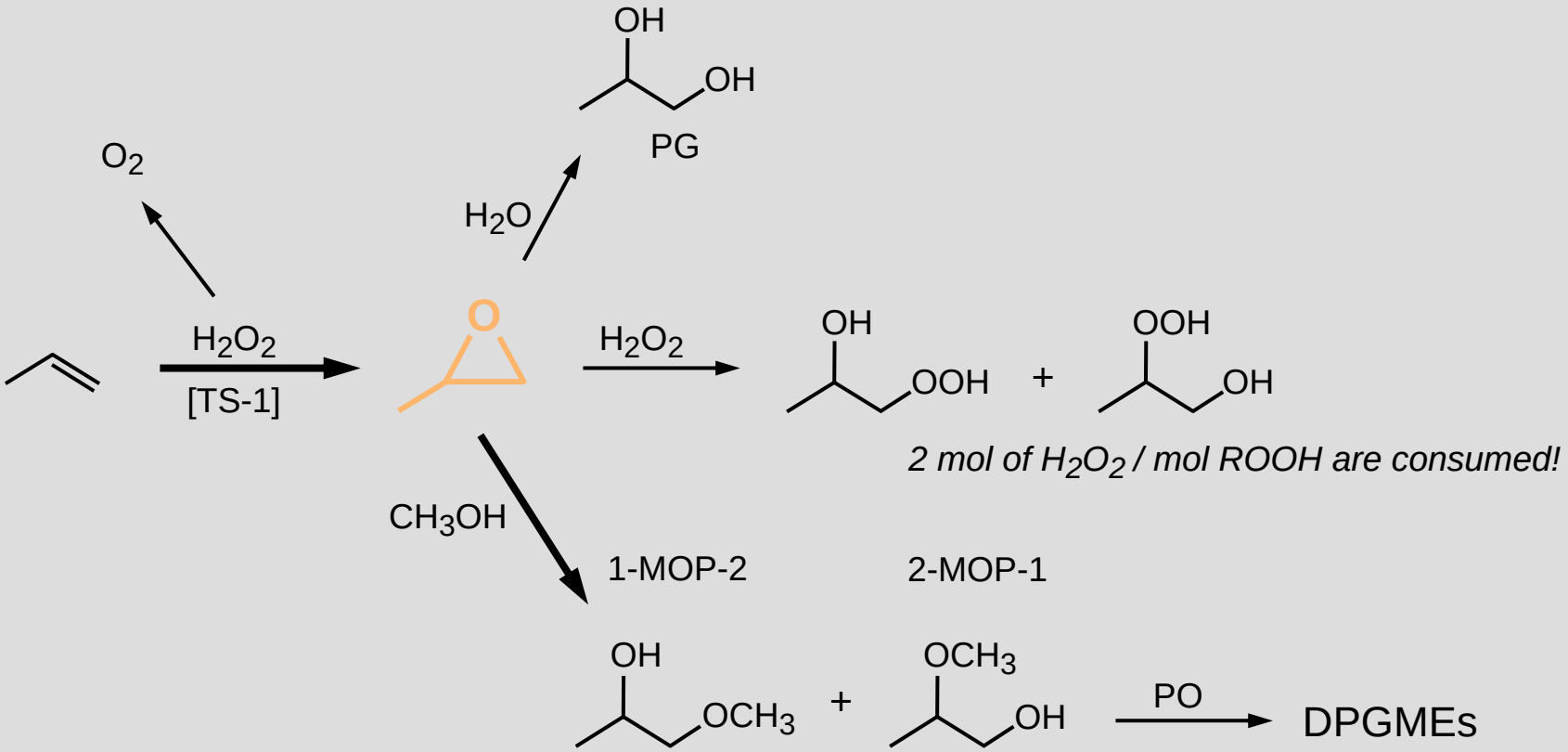
Process Description



- Co-product free epoxidation of propylene with crude H_2O_2
- Heterogenous liquid phase epoxidation with methanol as solvent
- Fixed bed technology using a proprietary TS-1 catalyst

Propylene Oxide – HPPO Process

Chemistry of the Process

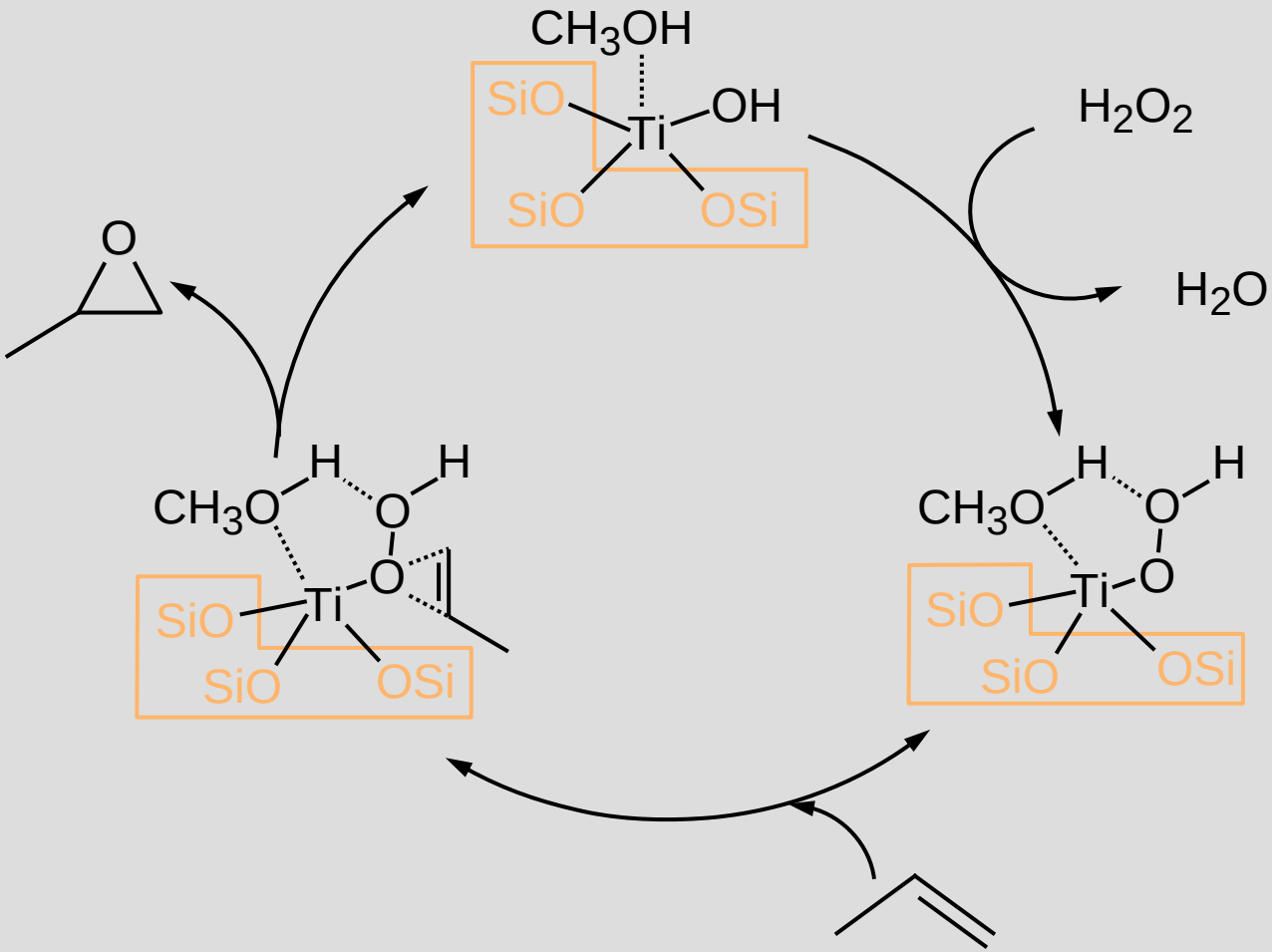


Side products: formed by addition of nucleophiles to PO

Parallel reaction : O_2 formed by the decomposition of H_2O_2

Propylene Oxide – HPPO Process

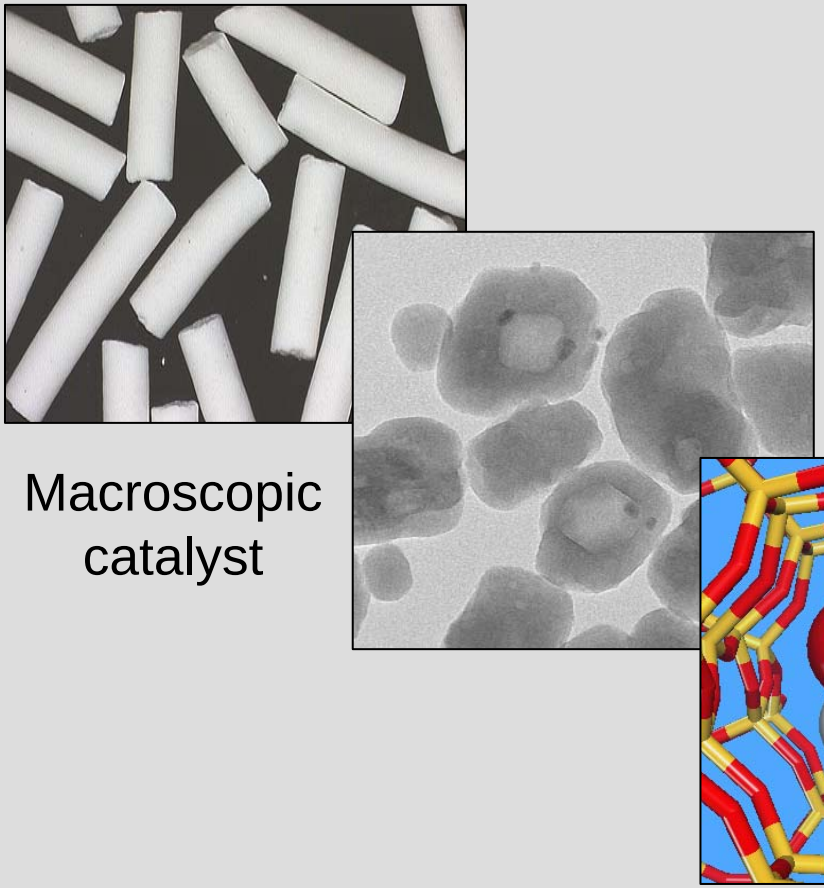
Catalytic Cycle



Propylene Oxide – HPPO Process

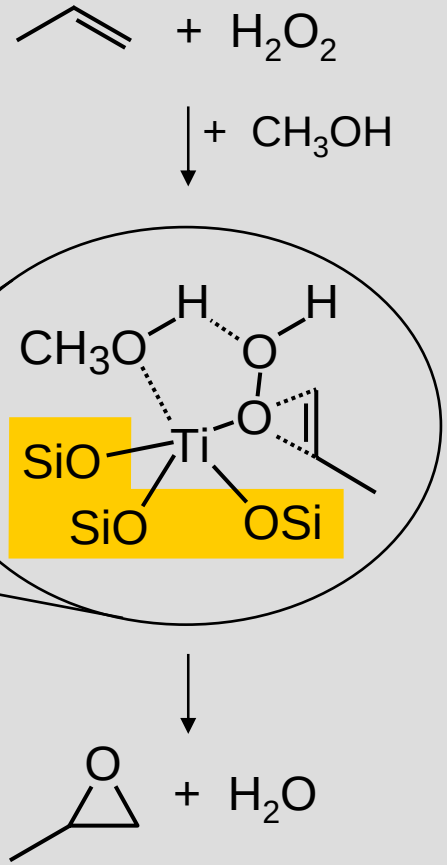
BASF Catalyst – Proprietary Ti-zeolite System

BASF
The Chemical Company

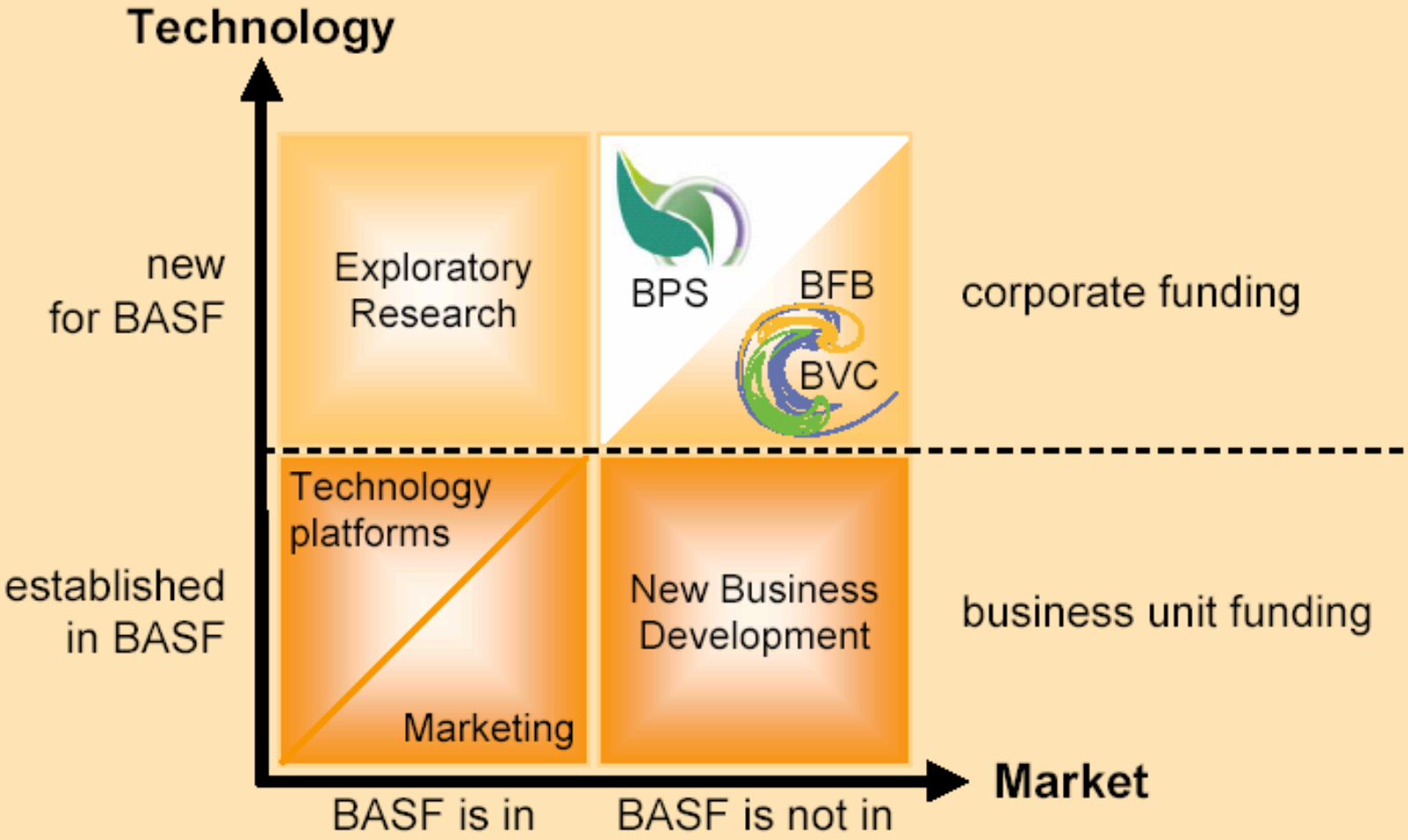


Macroscopic catalyst

Microscopic catalytic site



Innovation Process – Roles & Responsabilities



Opportunity fields and projects

Energy Management

New materials and technologies to transform, save, or store energy

Challenge: Enhanced materials, system integration

Projects (among others): Fuel cells, Thermoelectric Materials, Lighting

Quality of Life

New materials and technologies to enhance quality of life

Challenge: Business model to target consumers

Projects (among others): Individualize Nutrition and Body Care

Communication, Information, and Entertainment

Organic semiconductors in displays, chips, or photovoltaics

Challenge: Participation in next level of value chain

Projects (among others): Printed Electronics, Electrophoretic Displays

Mission and Strategy

- **Identification and development of new business segments for BASF group**
  - Outside of the existing global and regional business units
  - Based on chemistry and/or related technologies
  - Markets with above-average growth rates
- **Building a sustainable competitive position in these segments**
  - Selecting the appropriate business model
  - Developing proprietary technology and system solutions
  - Establishing partnerships
- **Investing in new technology-based companies and funds**
  - Return on investment adequate to the high risk
  - Window on technology

Current BASF Venture Capital-Portfolio