Biocatalysis – We create chemistry …. cheaper

Kai Baldenius
BASF SE, Ludwigshafen

Fine Chemicals & Biocatalysis Research

BASF
The Chemical Company

BASF – The Chemical Company
We create chemistry for a sustainable future

- Our chemistry is used in almost all industries
- We combine economic success, social responsibility and environmental protection
- Sales 2013: €73,973 million
- EBIT 2013: €7,273 million
- Employees (as of December 31, 2013): 112,206
- 6 Verbund sites and 376 other production sites

Innovation
Meeting challenges, developing new business areas

Research for the future: with our innovative products and processes, we provide sustainable solutions for global needs.

- Expenditures for R&D circa €1.84 billion, world leader in chemical industry
- Around 10,650 employees worldwide involved in research and development
- Around 3,000 projects
- Around 1,300 new patents registered in 2013
- Targets 2020: circa €30 billion sales and circa €7 billion EBITDA from innovations

Demographic challenges set the stage for the future of the chemical industry

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Nine billion people in 2050 **but** only one earth

Chemistry & Biology as enabler

Chemistry-based innovations growth and technology fields

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Global needs

Resources, Environment & Climate

Food & Nutrition

Quality of Life

Key customer industries

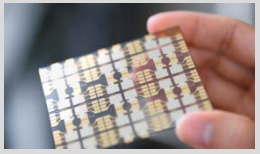

Transportation


Agriculture


Construction


Energy & Resources


Consumer Goods


Electronics


Health & Nutrition

Growth fields

- Batteries for Mobility
- Enzymes
- E-Power Management
- Functional Crop Care
- Heat Management for Construction
- Lightweight Composites
- Organic Electronics
- Plant Biotechnology
- Water Solutions
- Wind Energy
- ...

Technology fields

Materials, Systems & Nanotechnology

Raw Material Change

White Biotechnology

Growth field Enzymes

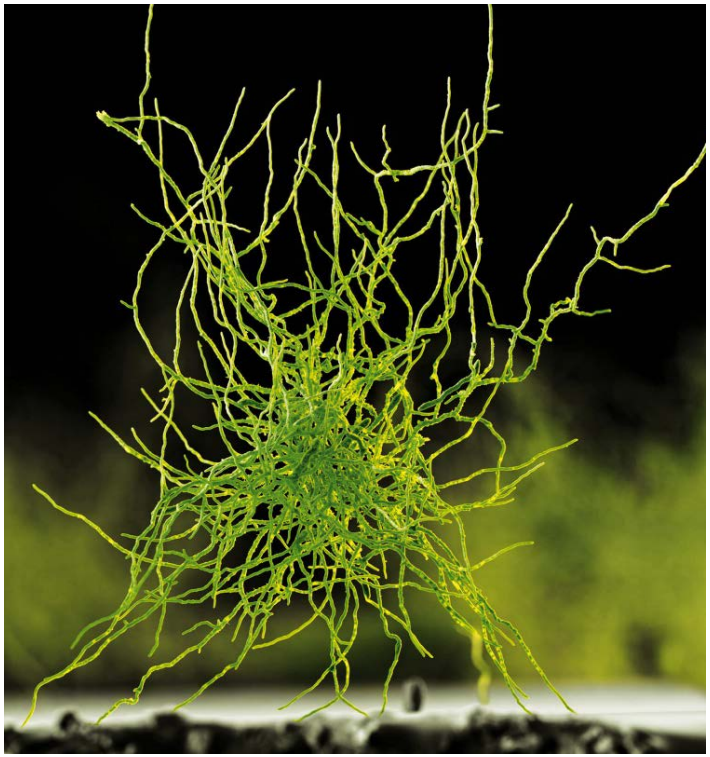
Enzymes from BASF enable innovative product and system solutions for various customer industries.

Existing activities

- Enzymes for animal nutrition (phytase, glucanase, xylanase)
- Establishing an enzyme platform through several acquisitions

Targets

- Position BASF as an integrated enzyme supplier in strategically important markets (animal nutrition, detergents and cleaning agents, food and baking industry)
- Access new markets, e.g. in water treatment and oilfield chemicals



Technology field
White Biotechnology

We use nature’s synthetic power to develop innovative and resource-conserving solutions for our customers.

Examples of existing activities

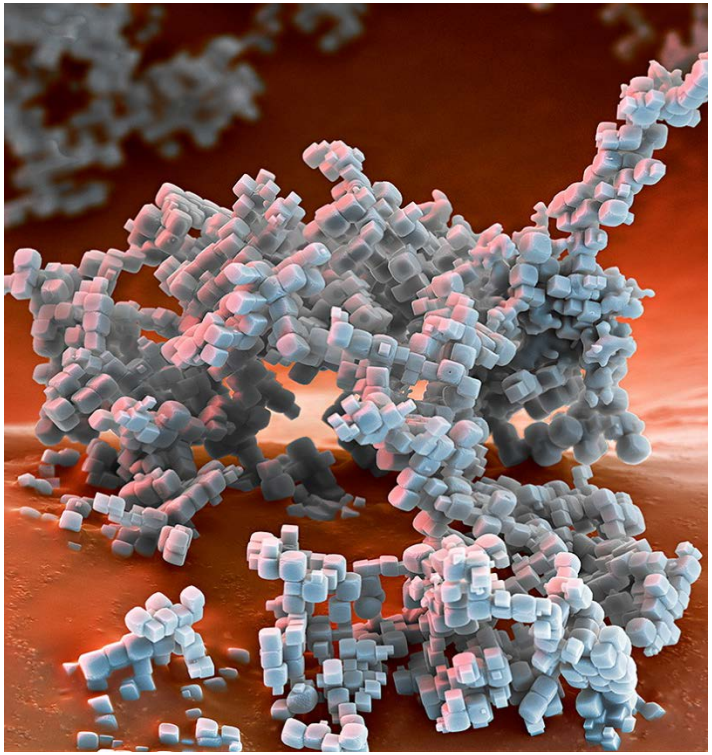
- Food and animal nutrition: Vitamin B_2, thermostable enzymes (phytase, xylanase, glucanase)
- Enhanced oil recovery: biopolymer Schizophyllan
- Bulk chemicals: biobased succinic acid

Technology field
Raw Material Change

We work on sustainable processes for using alternative raw materials such as natural gas, biomass and CO_2.

Research focus

- Increased use of natural gas, biomass and CO_2 as basis for raw materials
- Integration of competencies: synthesis, catalysis, process development and unit operations, high-throughput methods



The “Chemis-tree”

Major basic products and intermediates
about 200

Raw materials

Crude oil Natural gas Coal Ores
Rock salt Phosphate Sulfur Water Air

ChiPros made by BASF - with a little help of:
Lipases, Esterases, Nitrilases, Dehydrogenases

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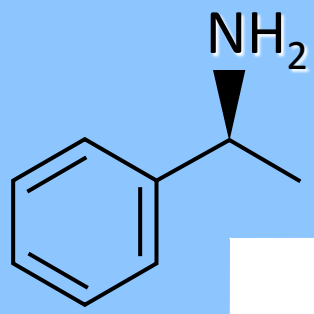
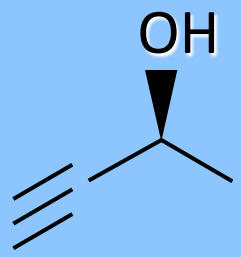
Amines

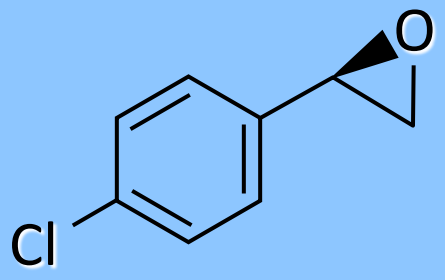


Alcohols

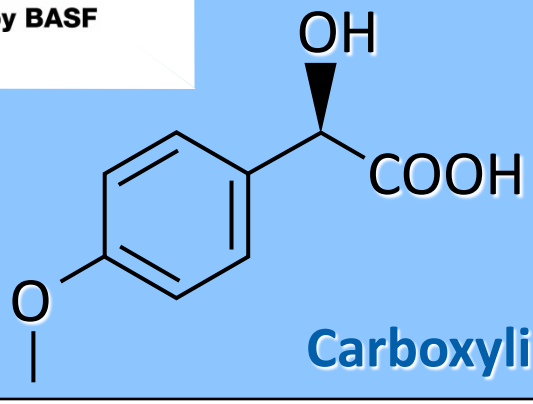


ChiPros
Chiral Products by BASF

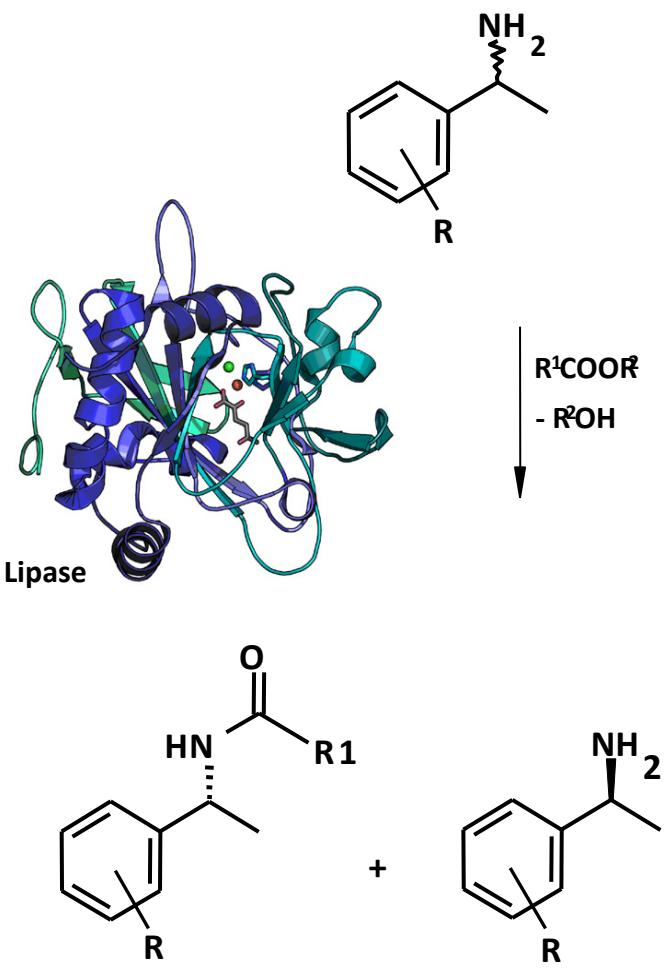
Epoxides



Carboxylic acids

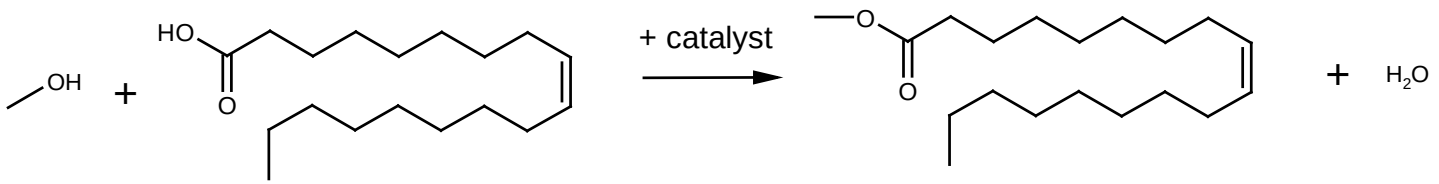


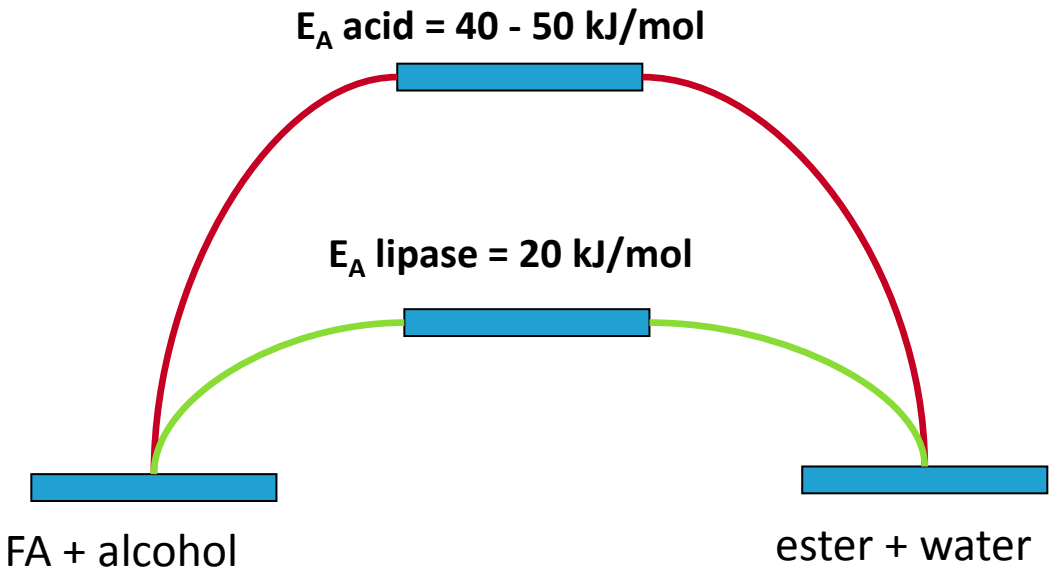
ChiPros® Amines
BASF Process



ChiPros® - Plant, Ludwigshafen

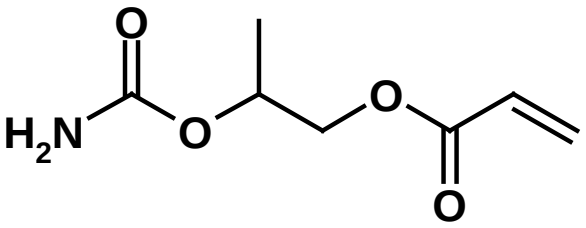
Lipase – a superior catalyst



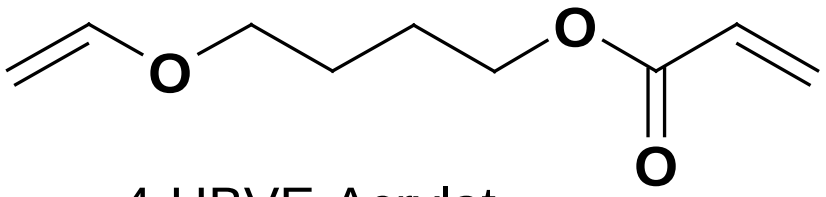


Energies 2008, 1, 79; Fuel 2007, 86, 2383.; Biotechnol. Bioeng. 2008;99: 855

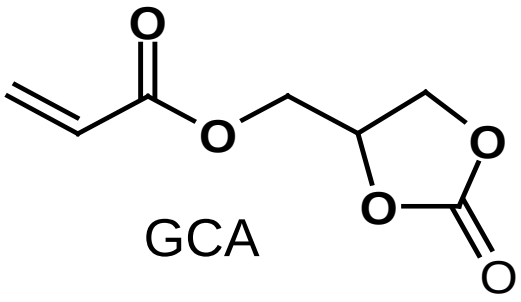
New acrylates
Enzyme catalysis as the enabler



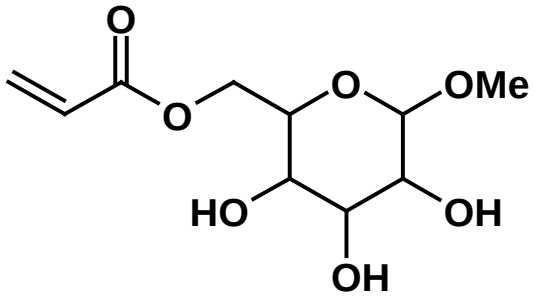
HPCA

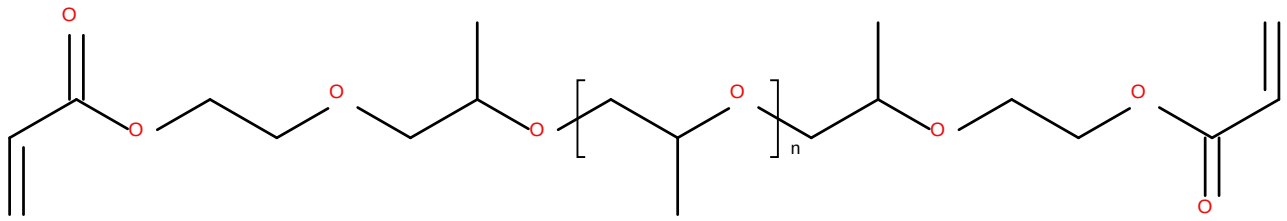


4-HBVE-Acrylat

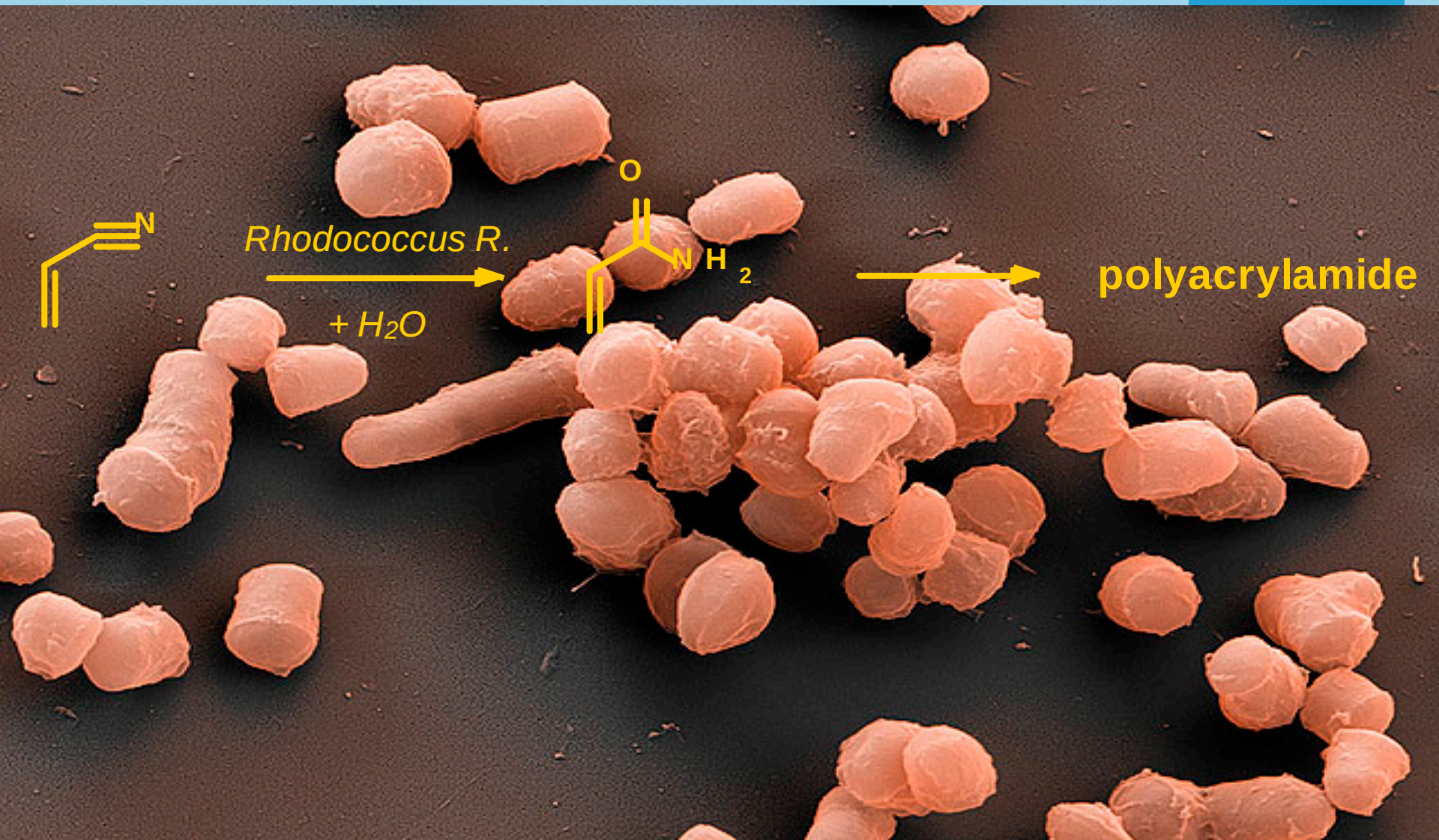


GCA



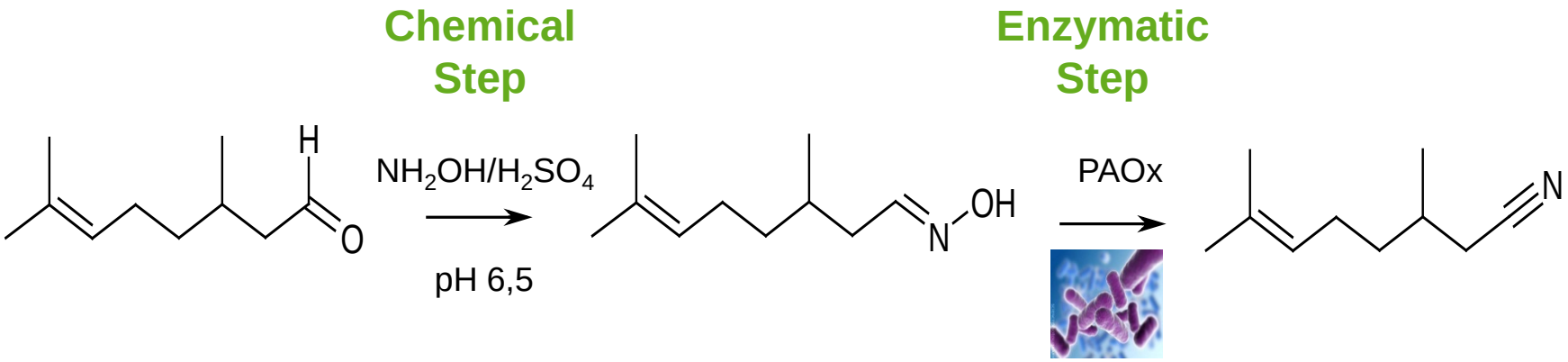


Acrylamide



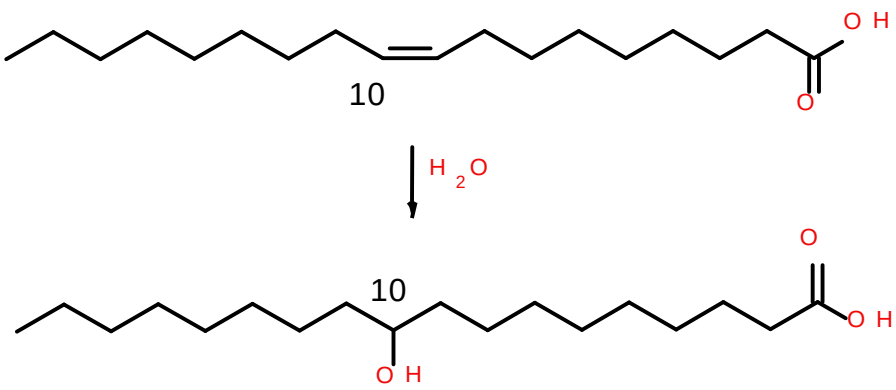
Aldoxime dehydratases
efficient enzymes for industrial purpose

- Enzymatic route to Citronellylnitrile
  - Safer and shorter process
  - No need for acetic anhydride activation
  - No need for a solvent



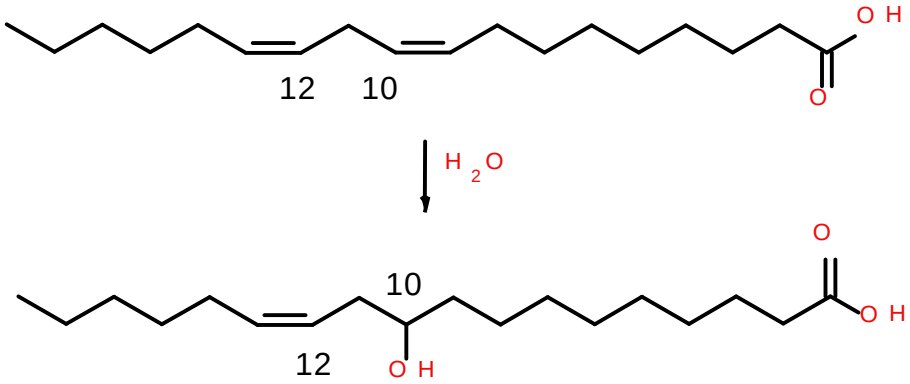
Oleate hydratase

A oleic acid



10-hydroxystearic acid

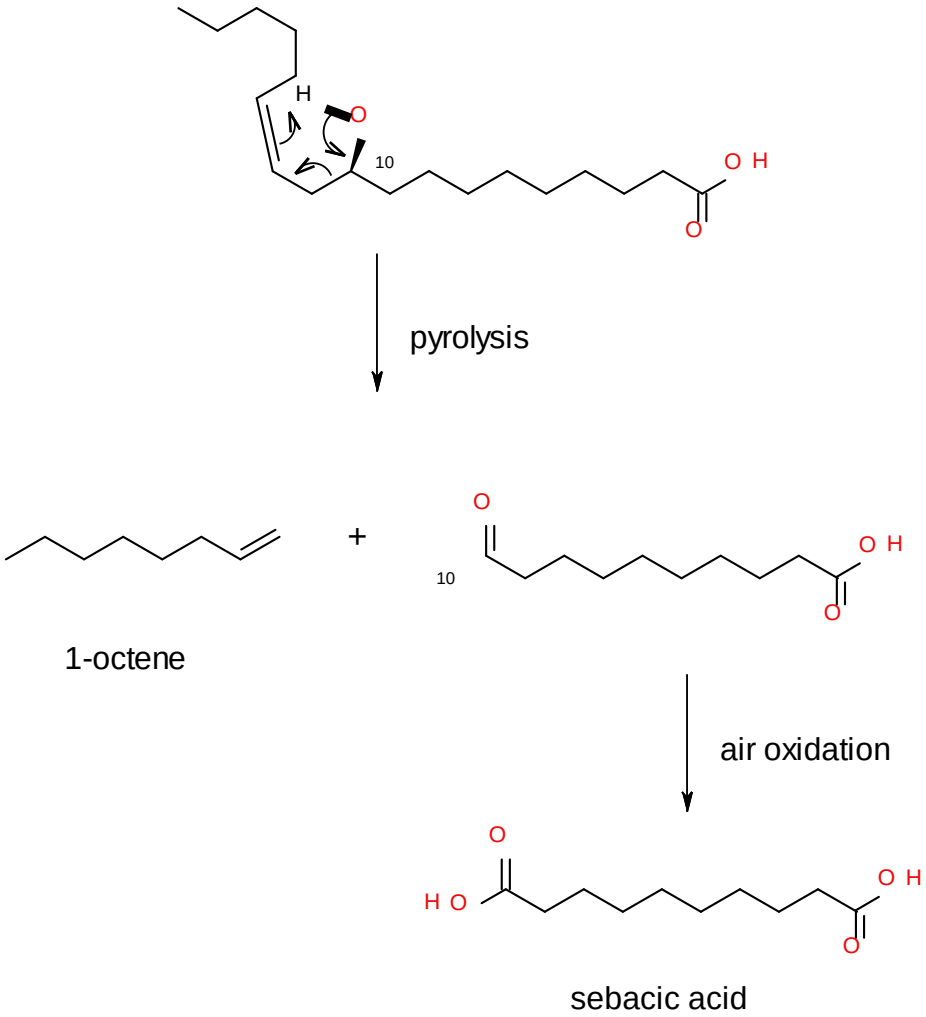
B linoleic acid



10-hydroxy-12-octadecenoic acid (10-HOA)

Oleate hydratase of
Elizabethkingia meningoseptica

Oleate hydratase – the key to a more sustainable synthesis of sebacic acid



New route to sebacic acid discovered

- more sustainable raw material source (sunflower oil vs. castor oil)
- lower raw material costs
- Patent protected by BASF

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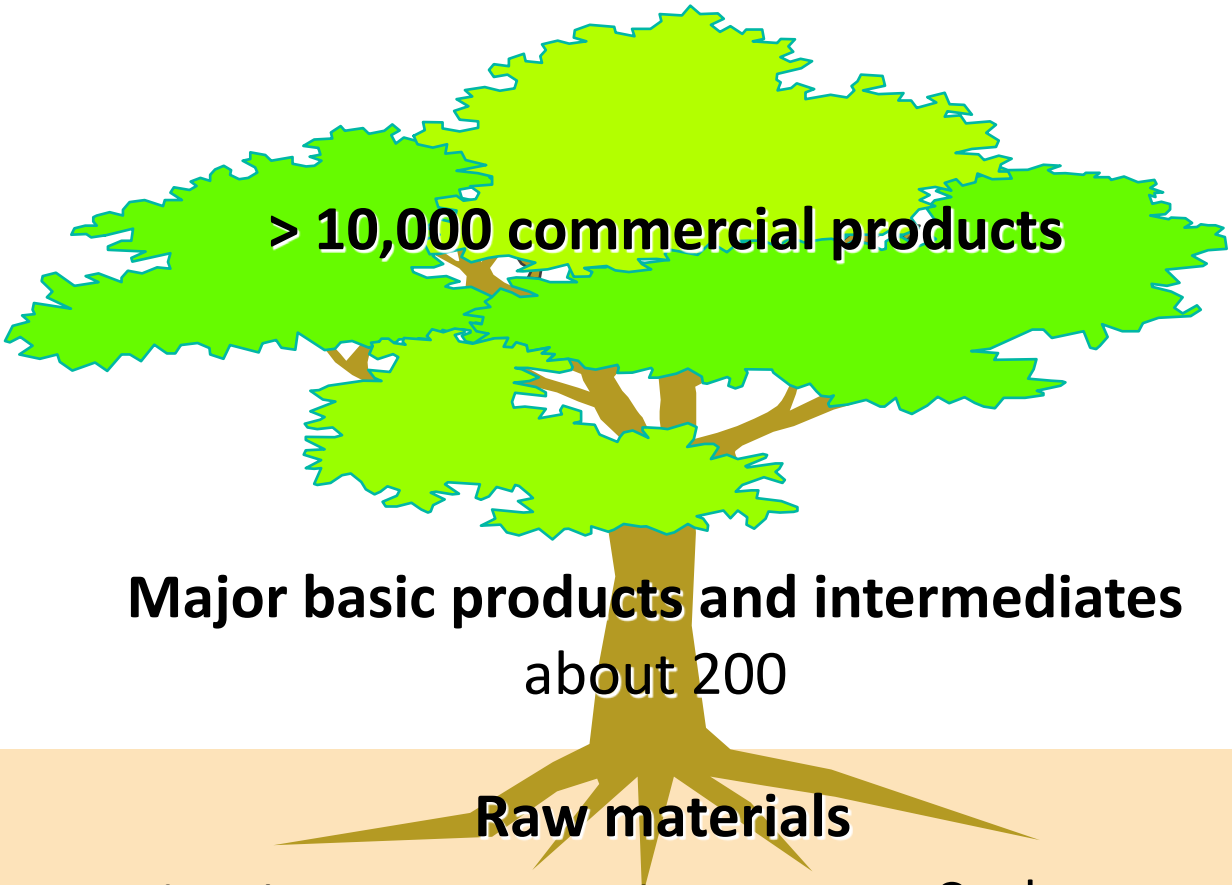
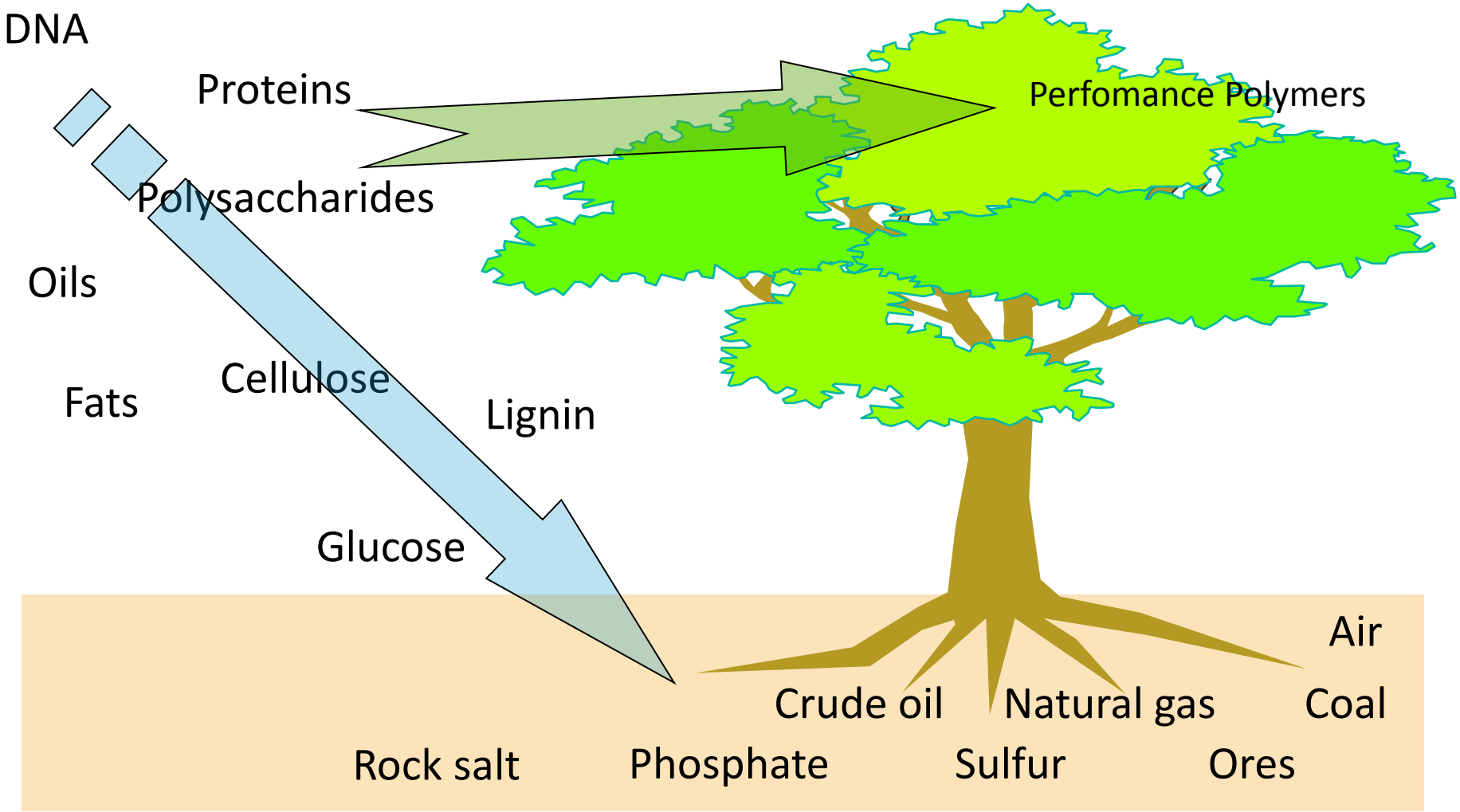
The “Chemis-tree”



Value creation from renewables



Xyloglucan & Guar Gum Structures

Selective <u>modification</u> for better thickening

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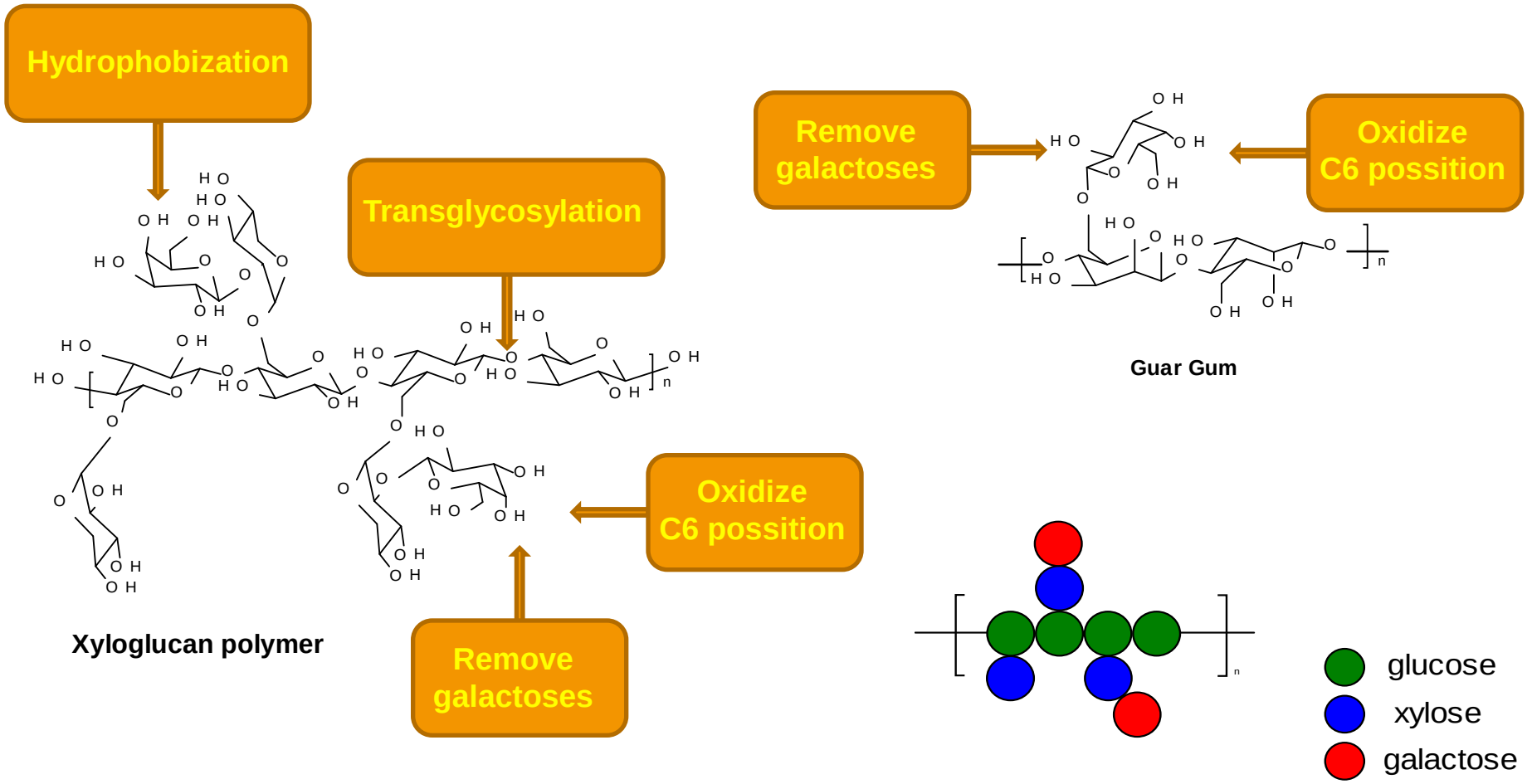
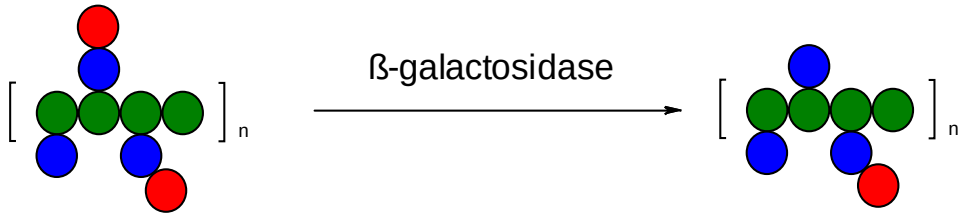


Enzymatically modified Xyloglucan
de-galactosidation leads to gelating polymer



Xyloglucan polymer **50% XG-degal.**

glucose
xylose
galactose