White Biotechnology in the Context of the BOKU Network of Bioconversion of Renewables

Diethard Mattanovich

Department of Biotechnology
University of Natural Resources and
Life Sciences Vienna

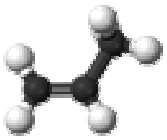
Production of Materials by Chemical Industry

- Today, 400 Mio T of materials are produced by petrochemistry each year (world market 2300 Mrd. €/year)
- Compared with ca. 5 – 8 Mio T materials produced by industrial biotechnology (world market 50 Mrd. €/year)
- This market share is estimated to rise to 20% of total chemical market by 2020

Product Classes of Chemical Industry

- Products from petrochemistry

Polymers
Industrial chemicals
Solvents
Elastomers
Paint
Pharmaceuticals
Agrochemicals
Oleochemicals

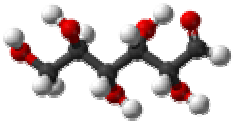


Common feature of petro- and biochemicals:

Carbon as backbone

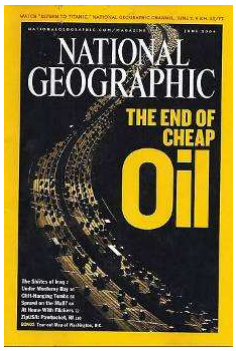
- Products from industrial biotechnology

Alcohols
Amino acids
Organic acids
Vitamins

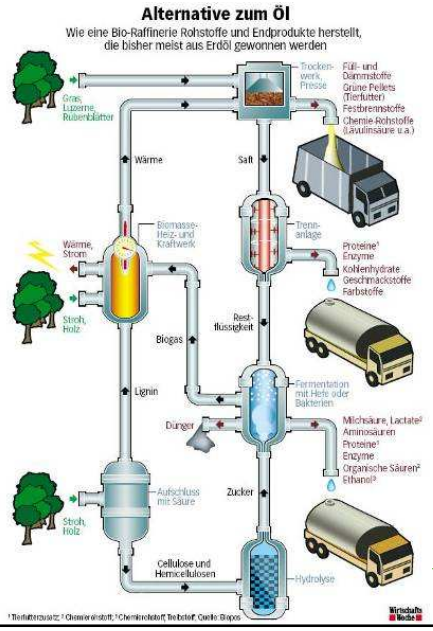


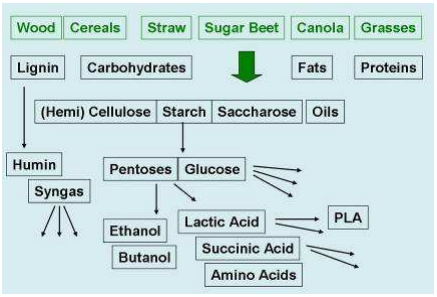
Worldwide Discussion about the Future of Chemical Production

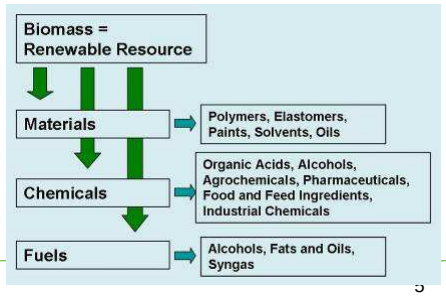
- Petrochemistry is not long-term sustainable
- In a range of 50 years, we need novel production technologies established



Alternatives: Biorefinery + Bioconversion

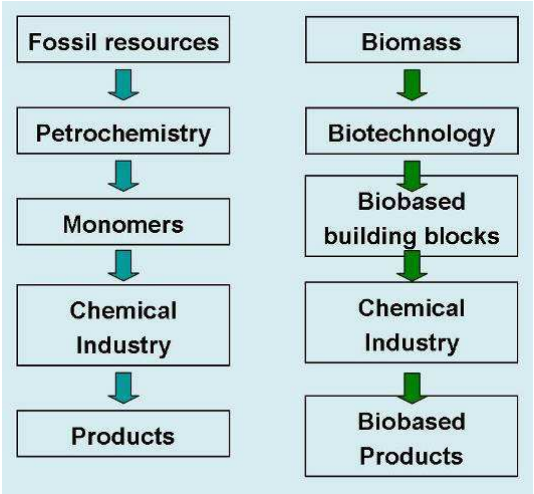




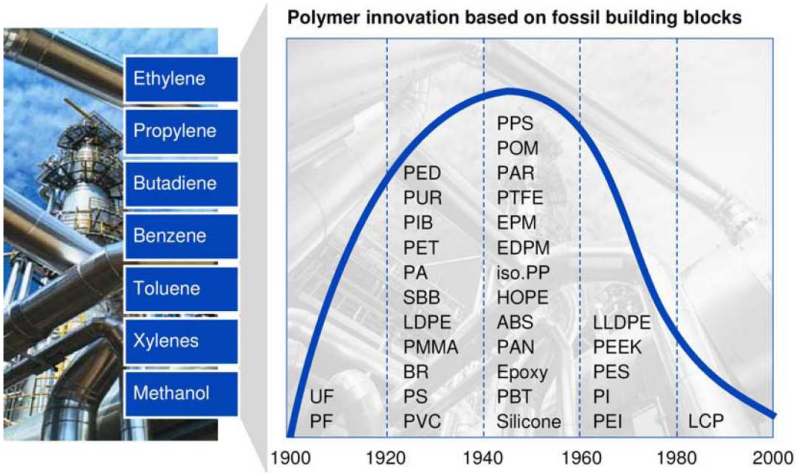


5

Similar Flow Charts Facilitate Transition



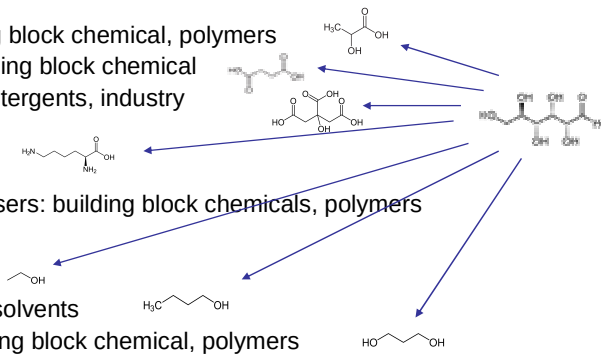
Long Term Perspective of Development



Development of polymers based on building blocks (source: McKinsey & Company: Industrial Biotechnology, 2003)

Products from White Biotechnology

- **Organic acids**
  - lactic acid: building block chemical, polymers
  - succinic acid: building block chemical
  - citric acid: food, detergents, industry
- **Amino acids**
  - Lysin: food, feed
  - Amino acid precursers: building block chemicals, polymers
- **Alcohols**
  - Ethanol: biofuels
  - Butanol: biofuels, solvents
  - Propanediol: building block chemical, polymers



Produced from sugar

Metabolic engineering = essential technology to direct the process from substrate to product

Competition with Food Production ?

- The choice of substrate will be an essential topic for successful developments!

- Potential competition between food/feed and production
- However, only a fraction of biomass is used for food and feed

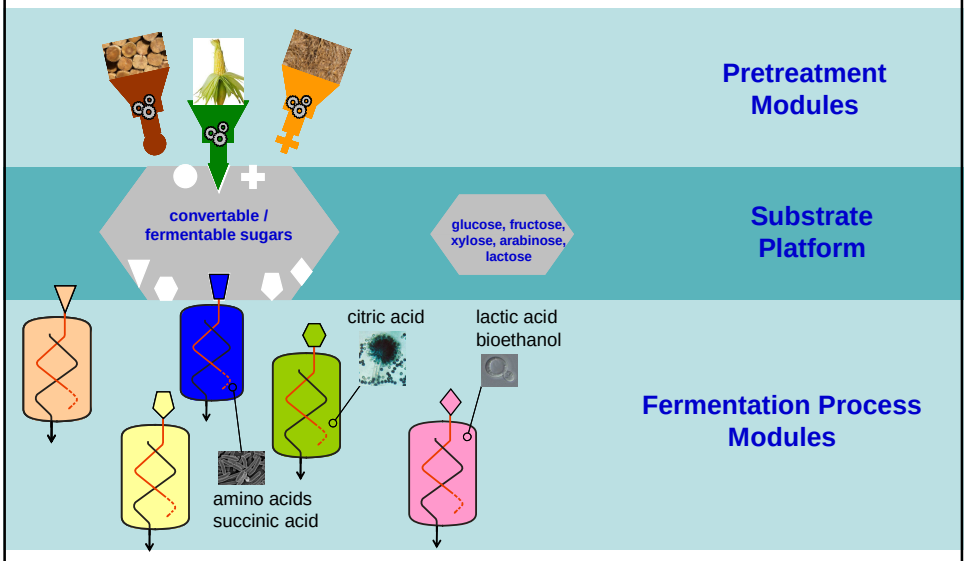
2nd Generation: Use of Non-Food Substrates

- Therefore: use cellulose and hemicellulose as substrates:
- Consist of sugars → can be used by biotechnology
- Technological challenges!

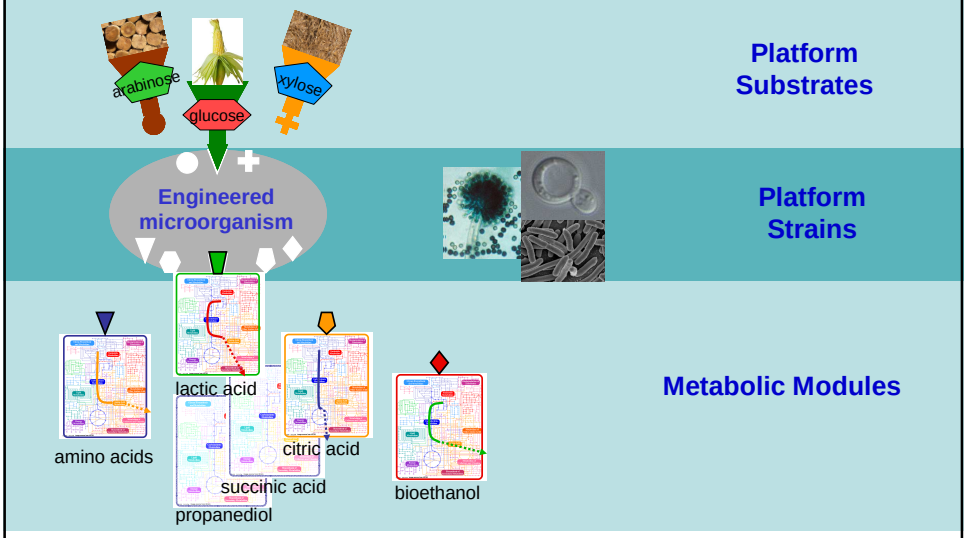
New Challenges with (Hemi) Cellulose Substrates

- Difficult to hydrolyse
- Impurities: phenols, acetate, etc. toxic to the bioprocess
  - Purification
  - Resistance by cell engineering
- Uncommon sugars: Xylose, Arabinose
  - Platform strains for their utilisation
  - Metabolic engineering

Modular Biorefinery Concept



Platform Strains and Processes



Example: Lactic Acid

biomass

biorefinery

sugar

fermentation

lactic acid

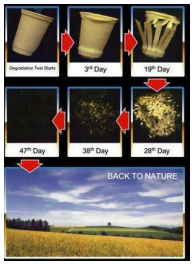
destillation

lactide

polymerisation

Polylactic acid (PLA)

- Made from renewable recources
- Biologically degradable



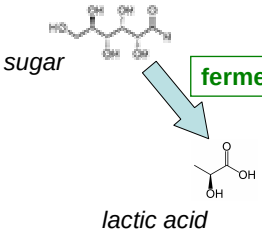
Lactic Acid Production

Major cost factors

- **Raw materials**
- **Purification**

Traditionally lactic acid is produced with lactic acid bacteria

→ Production at high pH > 5



- Addition of base during process → cost
- Addition of acid for purification → cost
- Disposal of gypsum (by-product) → cost

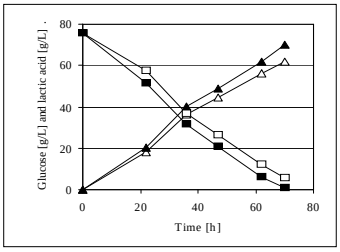
Our approach (in cooperation with Danilo Porro, Univ. Milano-Bicocca): Production of lactic acid with acid tolerant yeast

Further Improvement of Lactic Acid Production

Combined approach of:

- Detailed cell biological analysis
- Mutagenesis and high throughput cell sorting
- Metabolic engineering

⇒ **About 20 % increase of lactic acid**



Valli et al, 2006, Appl. Env. Microbiol, 72: 5492-5499
Rossi et al. 2010, Micr. Cell Fact. 9: 15
Valli et al. 2005 US patent US 7,473,540 (granted 2009)
Porro et al. 2009, Intl. patent application WO2009144013

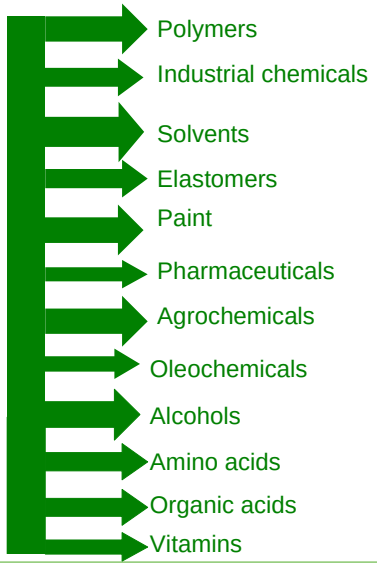
General Features of a Platform Strain

- Wide substrate spectrum:
  - Glucose, fructose, xylose, arabinose, lactose
- Robust to external stress:
  - Acidity, high concentrations of substrate and product, substrate impurities
- High yield and productivity
  - No by-products, high fluxes

⇒ **Metabolic Engineering & Systems Biology**

Outlook

Sustainable technologies producing all materials from renewable resources



BOKU Network for Bioconversion of Renewables

- Bundle expertise at BOKU
- Initiate cooperations with industry, academic partners, agriculture and forestry, public administration
- Join our initiatives
- See the posters outside!
- More information: www.boku.ac.at/bioconversion.html