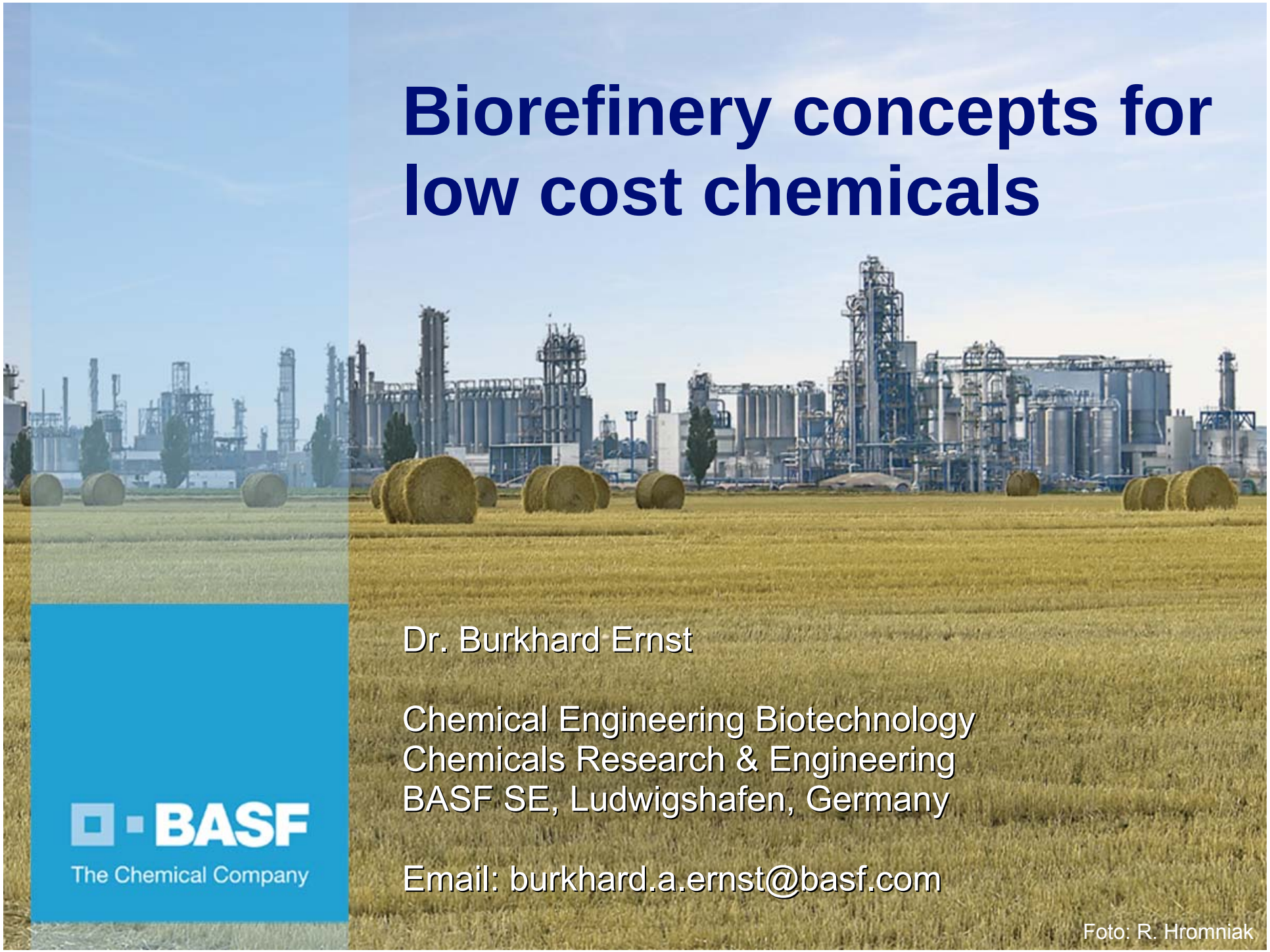
Biorefinery concepts for low cost chemicals



Dr. Burkhard Ernst

Chemical Engineering Biotechnology
Chemicals Research & Engineering
BASF SE, Ludwigshafen, Germany

Email: burkhard.a.ernst@basf.com

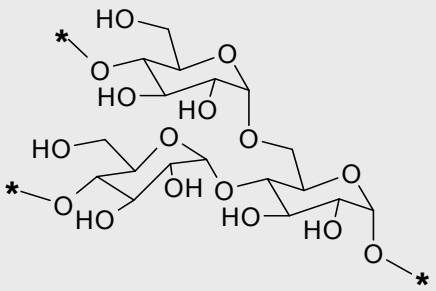
BASF
The Chemical Company

Foto: R. Hromniak

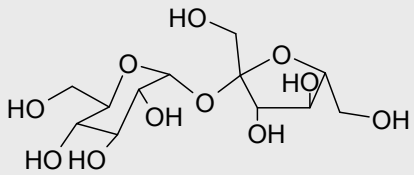
BASF – The Chemical Company

- Offers intelligent system solutions and high-value products for almost all industries
- Sales: 62.3 billion € (2008)
- Employees: 96,924 (12/2008)
- „Verbund“ sites in Ludwigshafen (Germany), Antwerp (Belgium), Geismar (USA), Freeport (USA), Kuantan (Malaysia), Nanjing (China)

Biomass
Mixture of highly functionalised chemicals

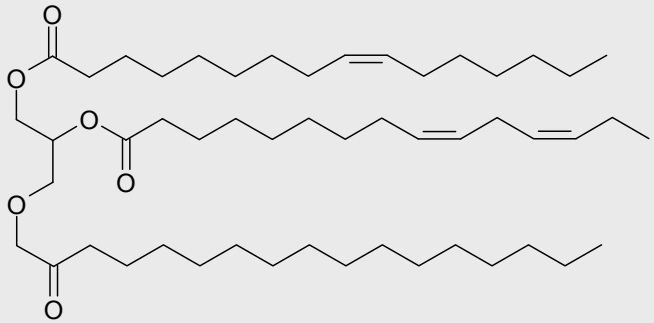


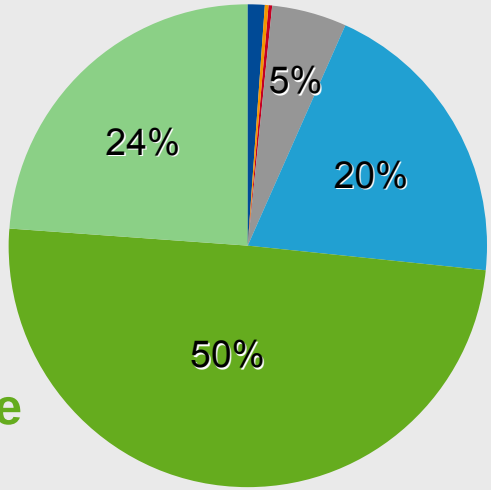
Starch
1%



Sucrose
0,1%

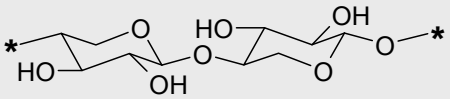
Plant oils
0,1%



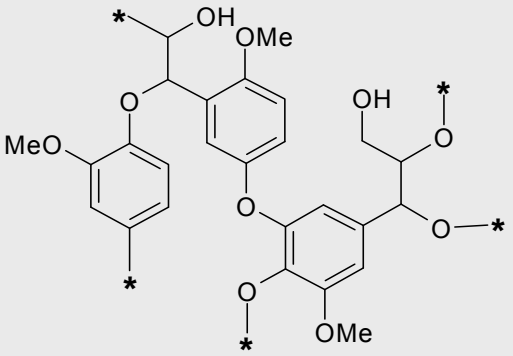


Others
(Proteins, terpenes, ...)

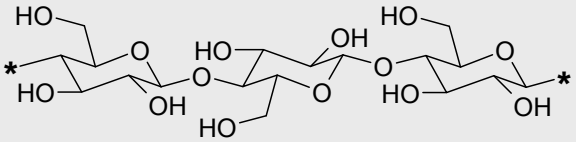
Hemicellulose (Xylanes)



Lignin

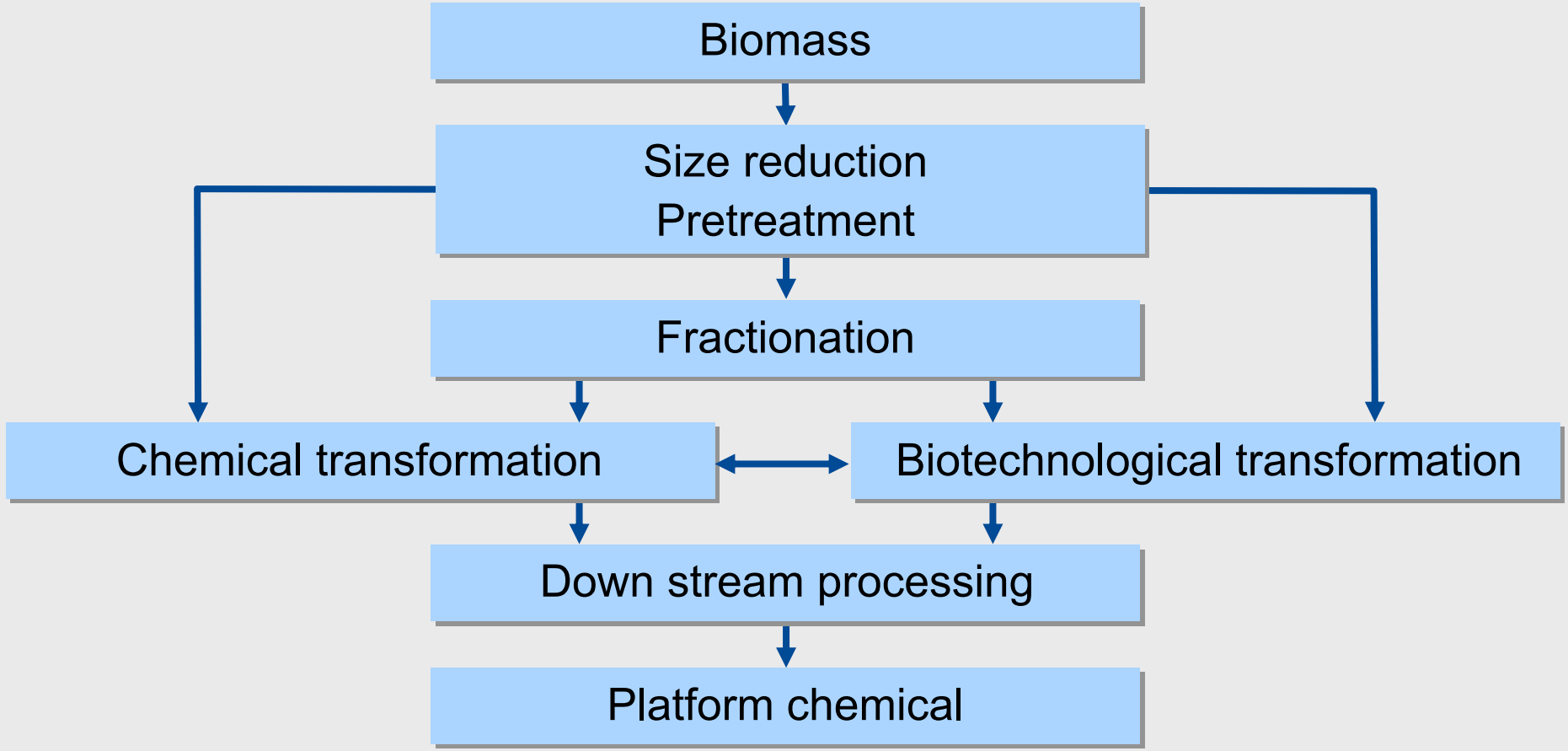


Cellulose



Total: 180 bn t/a

General biorefinery concept

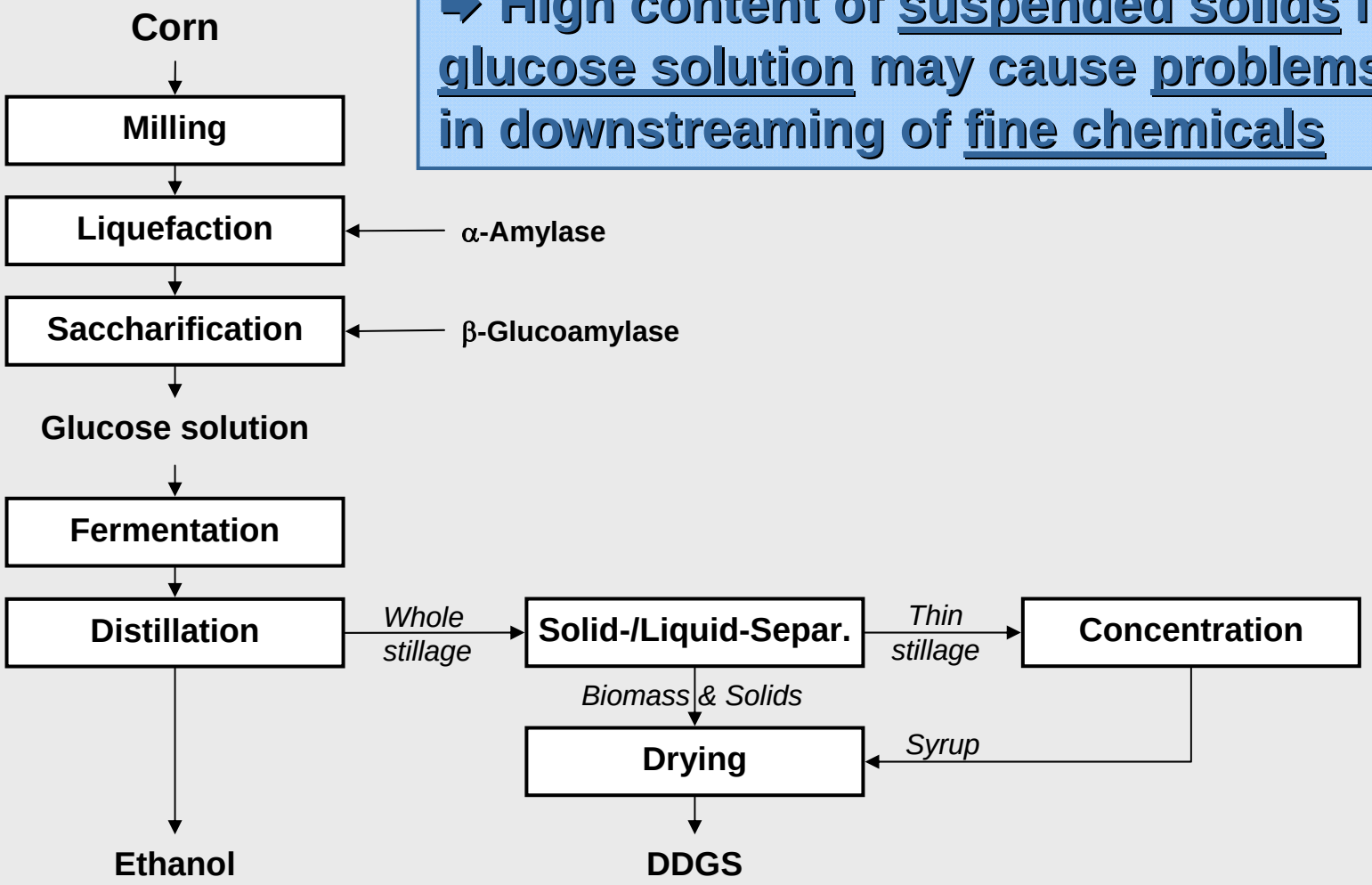


➡ **Efficient refinery and conversion technologies are essential**

Process idea for a corn-based biorefinery

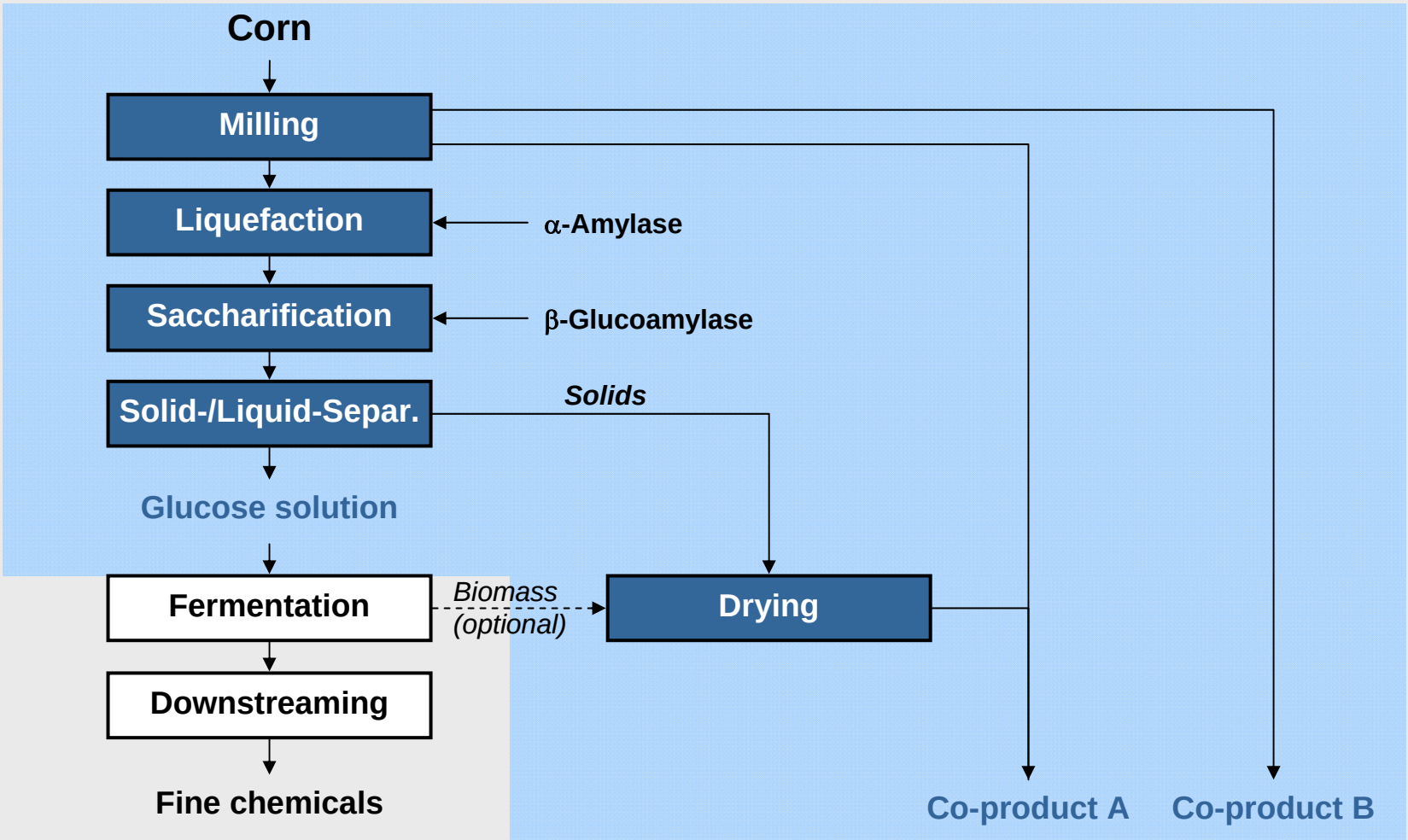
Basic flow scheme of bioethanol production

➡ High content of suspended solids in glucose solution may cause problems in downstreaming of fine chemicals



BASF corn-based biorefinery

Adaption for fine chemical fermentation processes



BASF corn-based biorefinery
Comparison of existing technologies & BASF process

Process	Sugar mill	Wet-milling	Dry-milling (BioEtOH)	BASF process
Raw material	Sugar cane	Corn	Corn	**Corn**
Fermentation sugar purity	> 98 %	> 99% (food-grade)	~ 70%	**> 90%**
Autonomy of sugar production	Low	Low	High	**High**
Raw material costs	World market	World market	World market	**World market**
Investment costs	Low	High[1]	Low	**Medium**
Production costs	Low	Low[1]	Low	**Low**

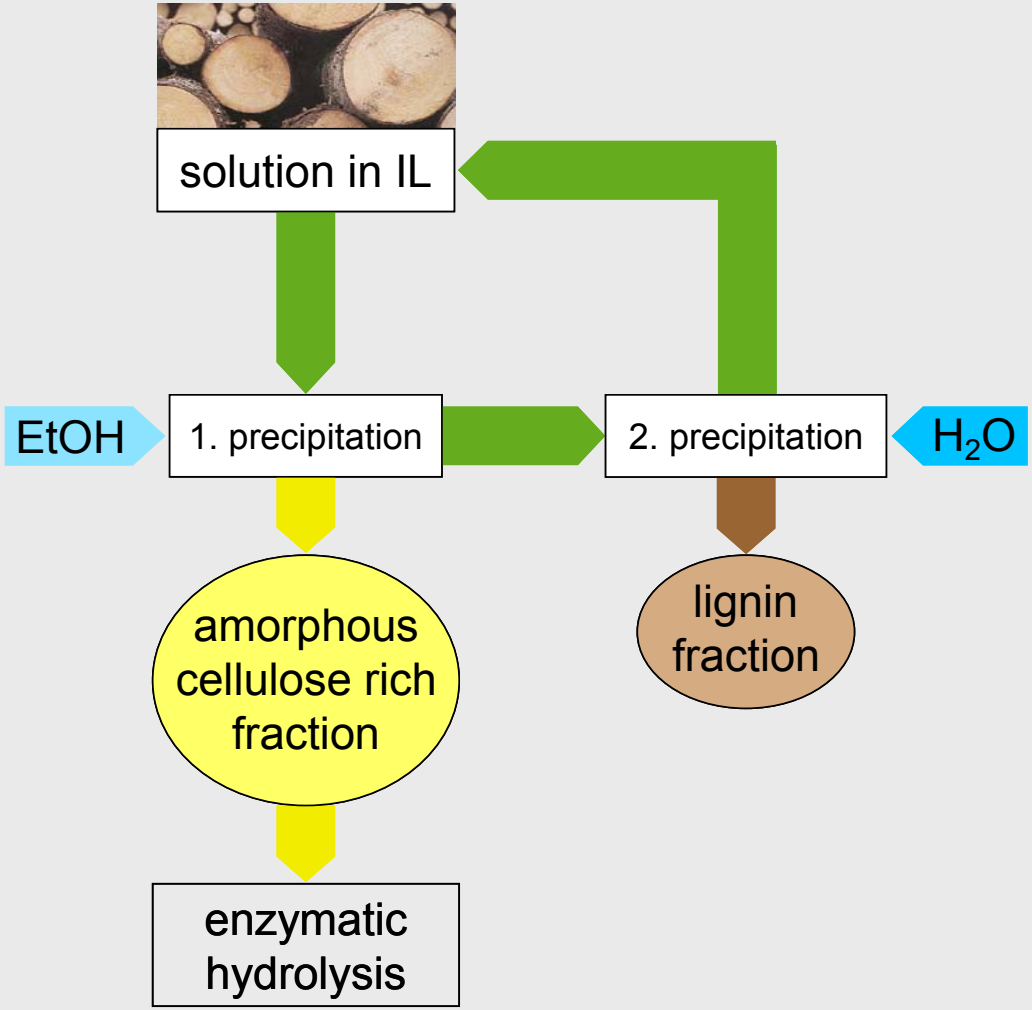
[1] World-scale plants (>1.5 Mio tons/a crushing capacity)

Biomass pretreatemt with ionic liquids
Ionic liquids (IL)

- Liquid below 100 °C
- Non flammable
- Immiscible with many organic solvents
- BASF know-how & production
- Various emerging applications
- Dissolution of (ligno-)cellulose
- Exclusive license from the University of Alabama (patents of Prof. Rogers)

Biomass pretreatemt with ionic liquids

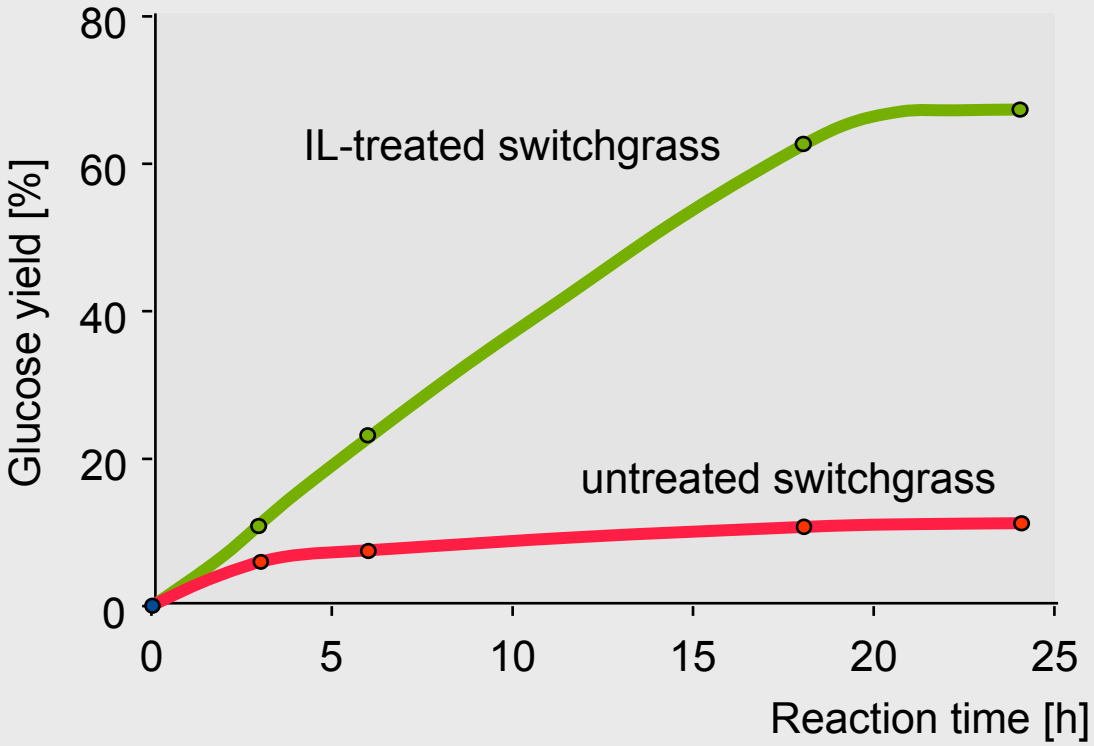
Biorefinery with ILs

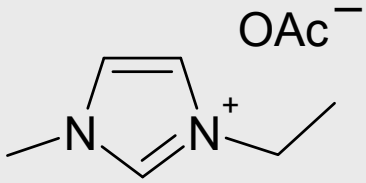


- Screening of >50 ILs
- Screening of parameters:
  - Temperature
  - Precipitating agent
  - Water content of the IL
  - Precipitation protocol
- Series of experiments in closed process cycles
- Two patents filed:
  WO 2008090155
  WO 2008090156

Biomass pretreatemt with ionic liquids

Digestion of IL-treated/untreated switchgrass by cellulases

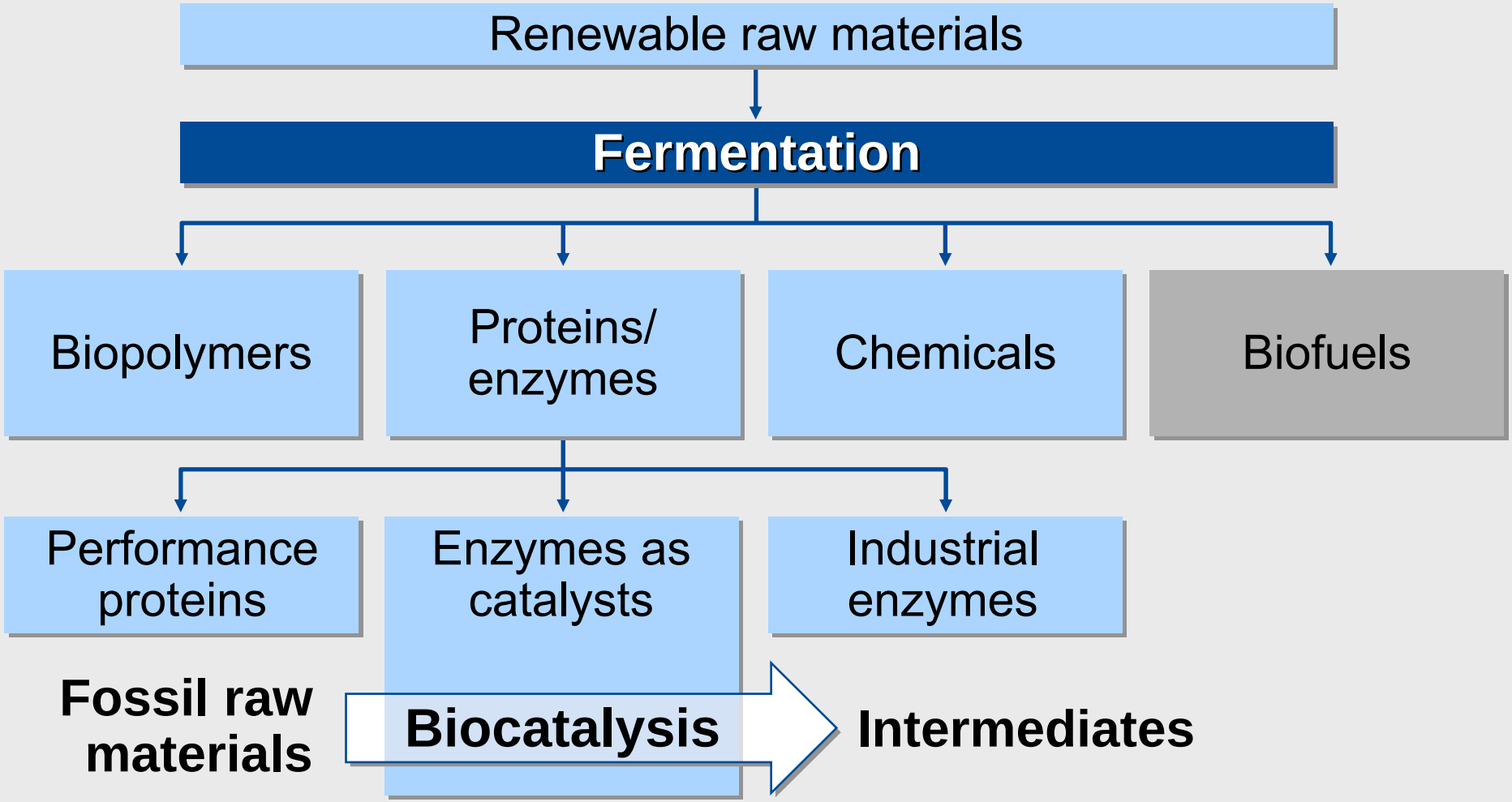




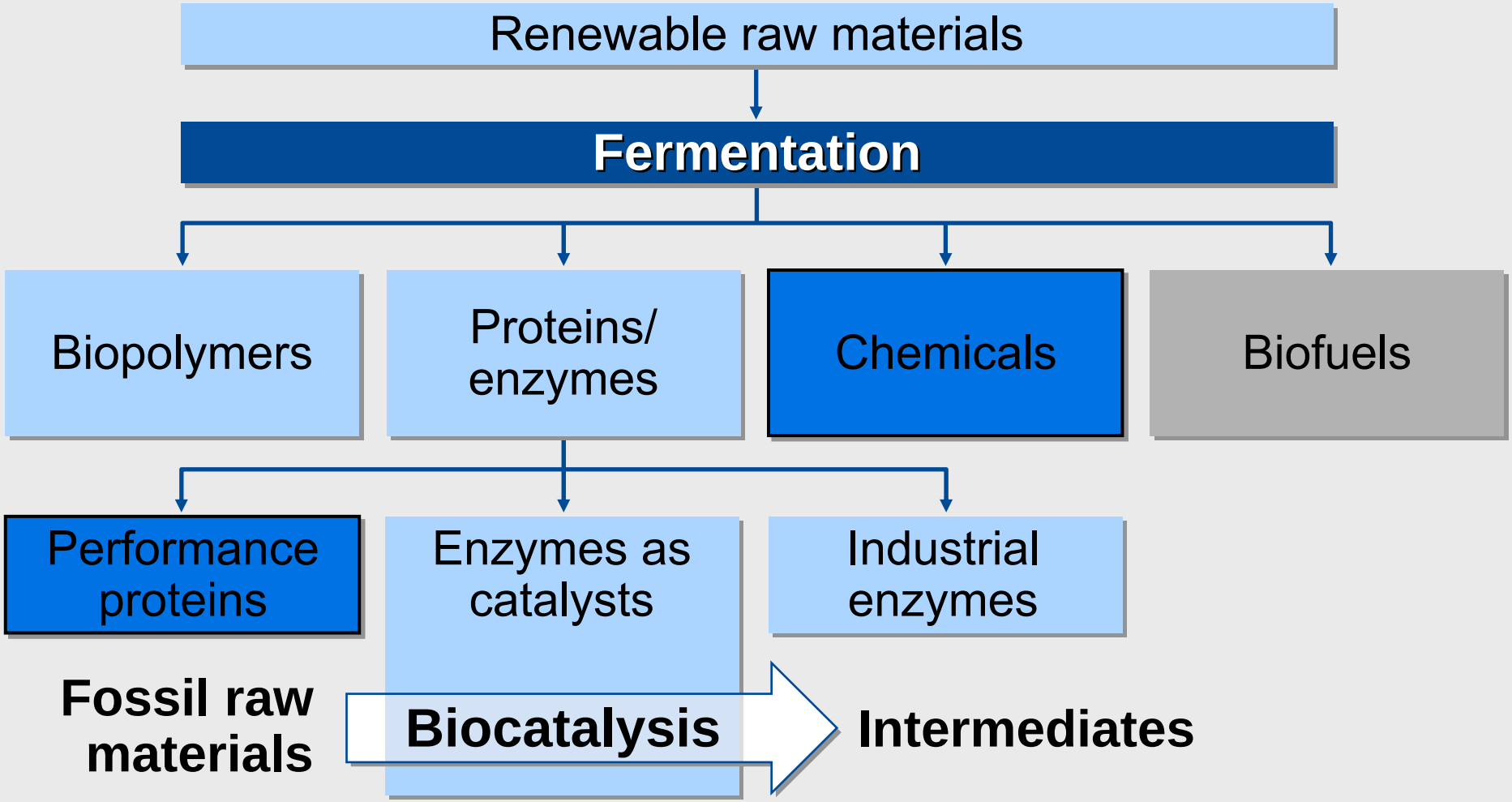
EMIM OAc

- Disintegration of the lignocellulose structure (hydrolysis rate x7)
- Challenges:
  - >99% IL-recycling
  - high investment costs
  - energy costs

Fermentation products

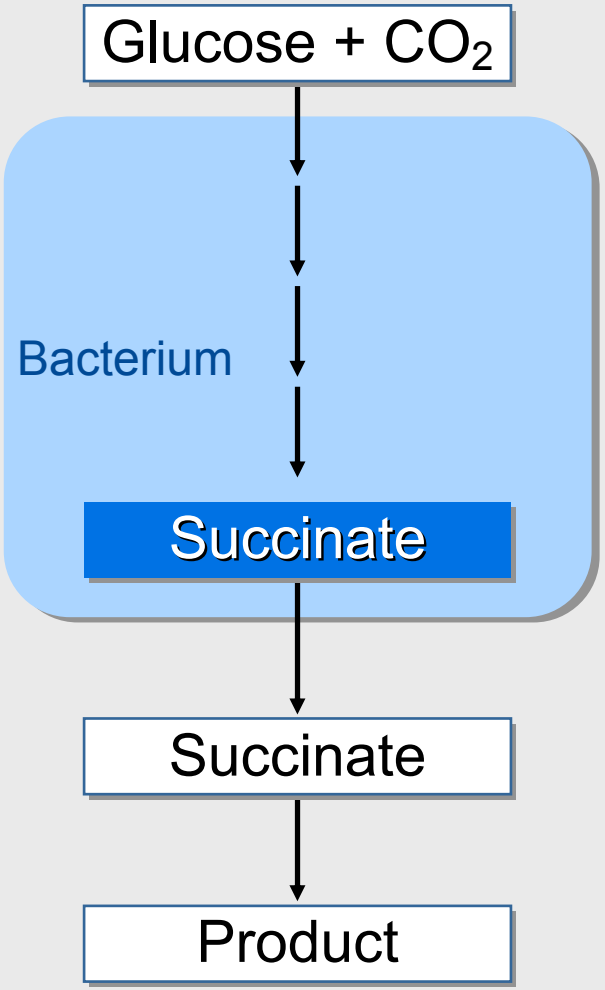


Fermentation products



Chemicals via fermentation

Succinate as an intermediate and monomer: Production

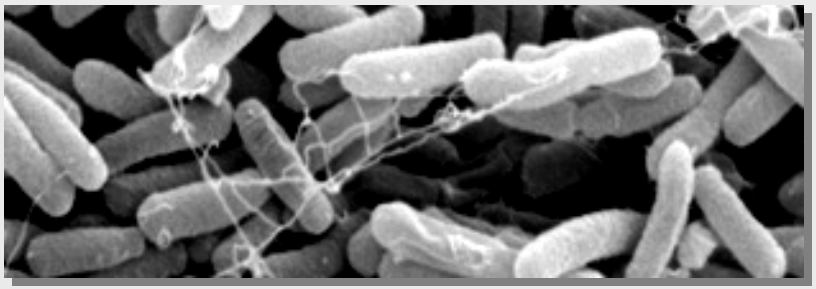


Chances:

- Succinate as monomer and intermediate
- Potential for 100% yield
- CO_2 fixation

Challenges:

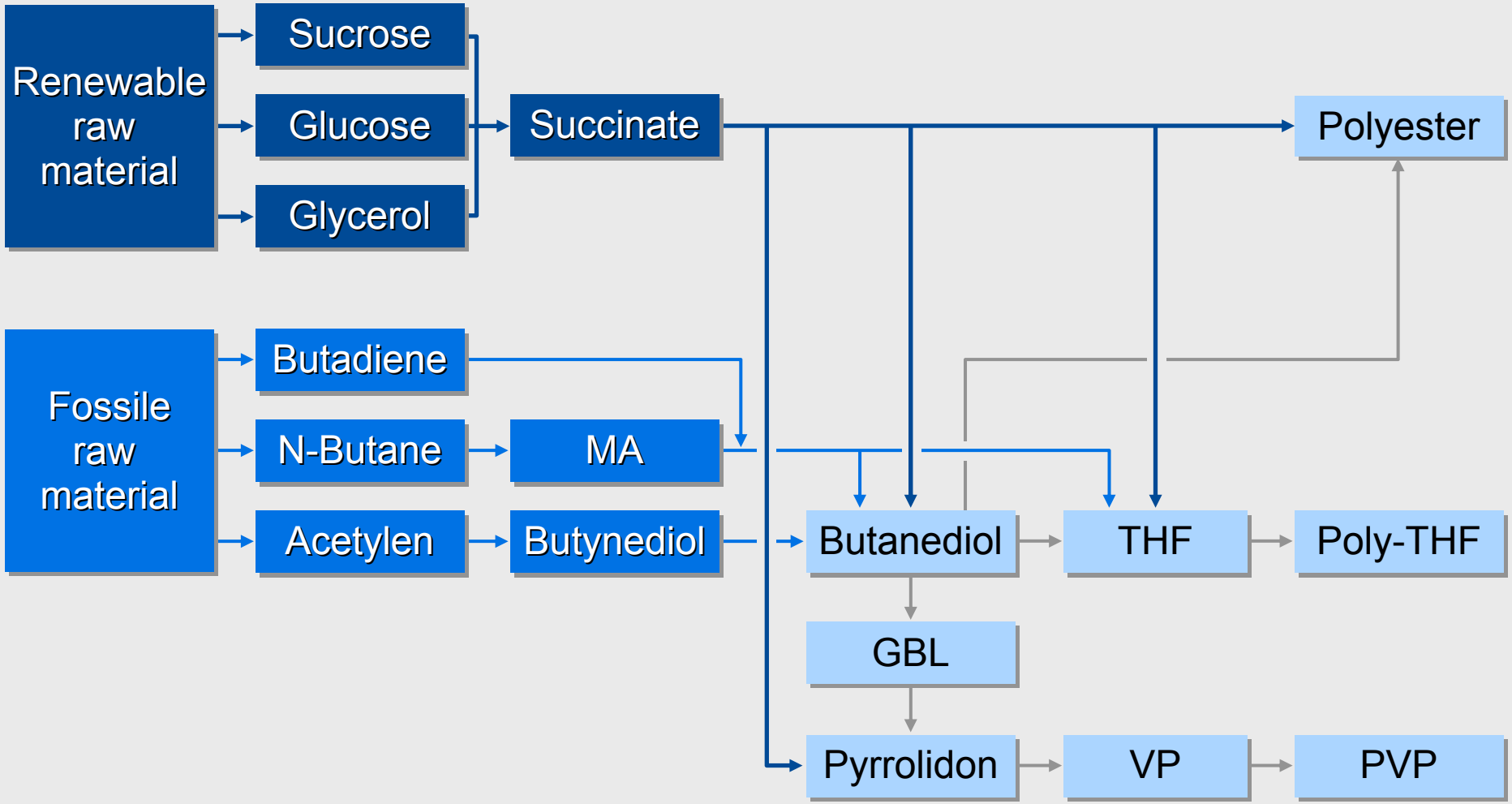
- Improve microbial strain & fermentation
- Develop *"In broth chemistry"*



Succinate producing bacterium

Chemicals via fermentation

Succinate as an intermediate and monomer: Value chains



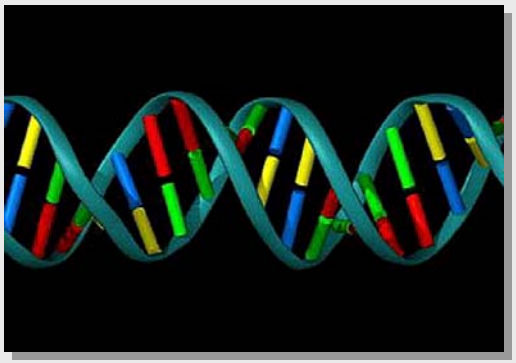
Performance Proteins

Hydrophobin – The surface modifier

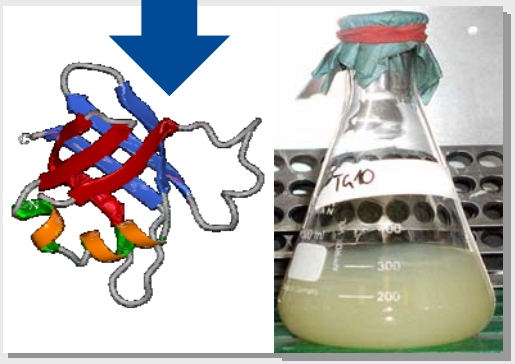
BASF
The Chemical Company

Identification of protein

Isolation of genes



Transfer into micro-organisms (GMO)



Low scale protein production

Evaluation of performance

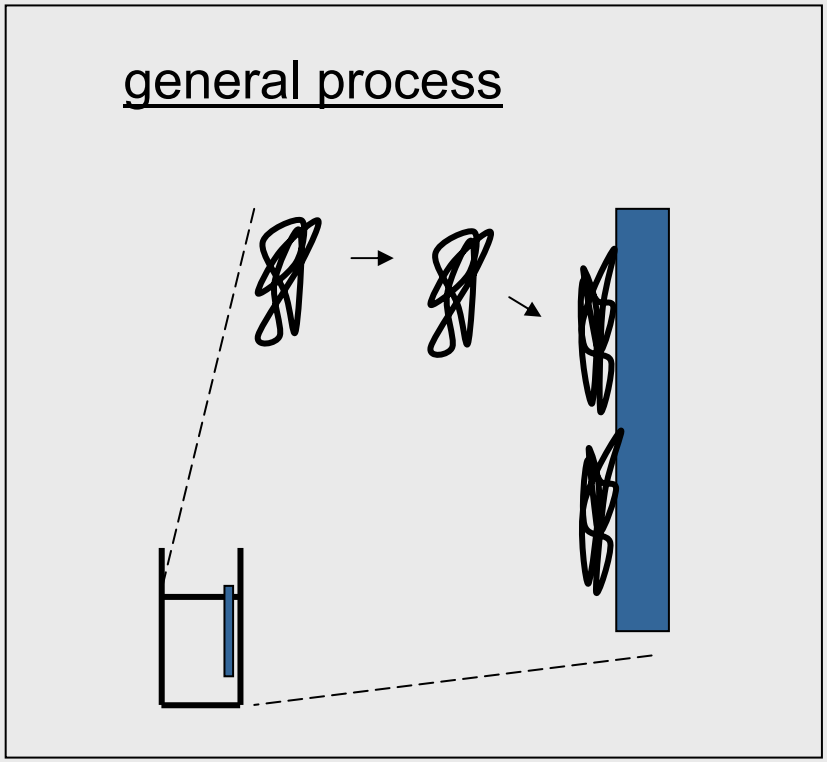
Upscaling of protein production

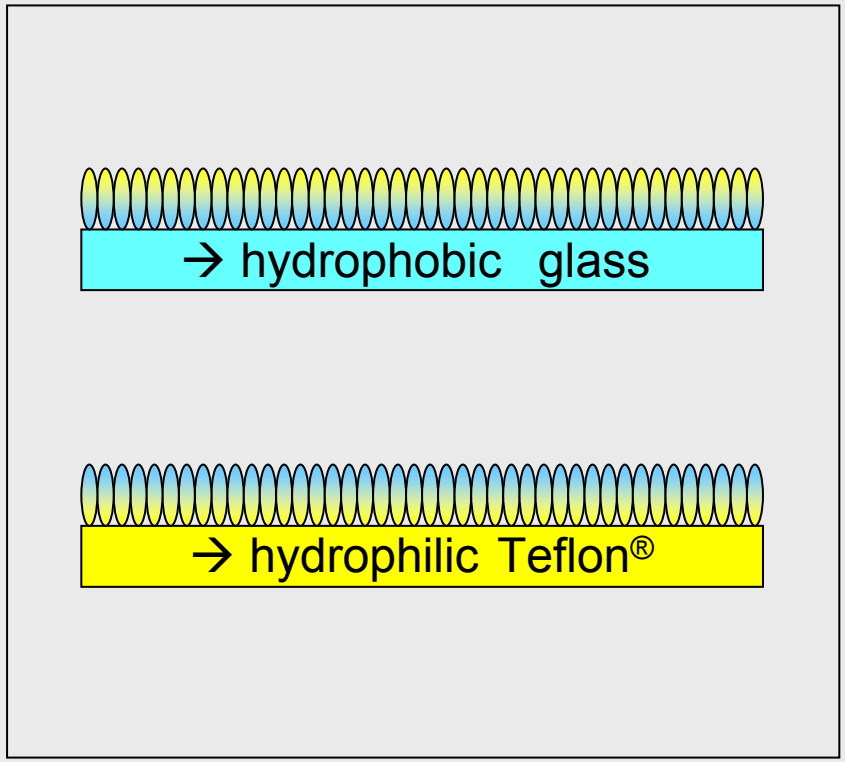
Hydrophobin
Adhesion to liquid-solid interfaces

BASF
The Chemical Company

Surface modification

- ➔ Adhesion to all surfaces (Teflon®, Carbon, PP, PE, PET, Al, wood, SiO_2)
- ➔ Inversion of surface property

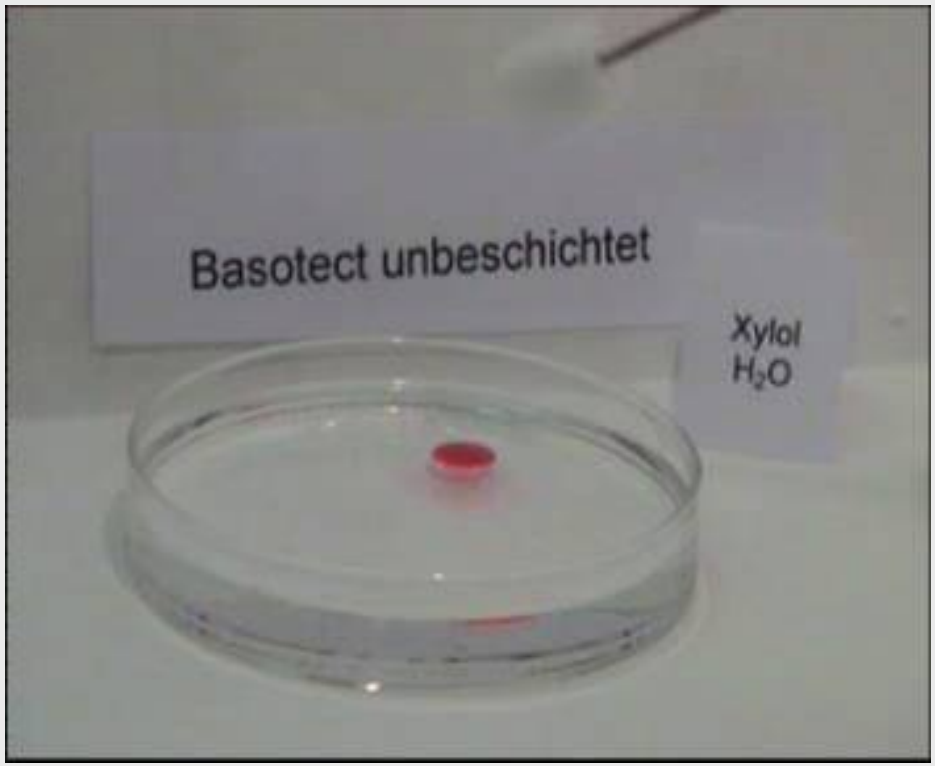


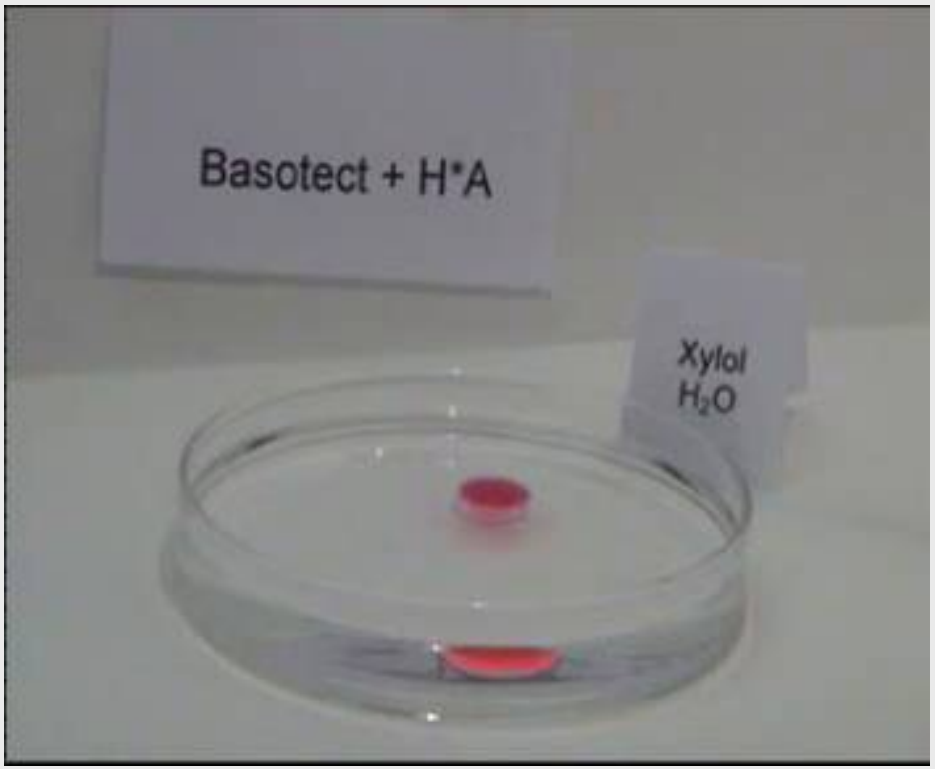


Hydrophobin & Basotect®

Soaking of alkanes

➔Potential application in oil spill damage






BASF
The Chemical Company
Email: burkhard.a.ernst@basf.com
Potato Leaf Amflora