Case study –
a new starch-based biorefinery

Linde Engineering

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Agenda

— The Linde Group
— Linde-KCA-Dresden GmbH – competence center BIOTECHNOLOGY
— Starch – a major feedstock for biorefineries
— Case study „Zeitz“ – a first generation biorefinery
  — Project overview
  — Project structure/organisation
  — Technology & products
  — Integration in local infrastructure
  — Picture from the site
— Conclusion
Synergistic cooperation of divisions — Integration of biotechnology & chemistry

Biotechnology Plants (B)
- Biotechnology
  - process technology
  - basic know-how
- design & construction of large-scale biotech plants
- process technology fine chemistry

Chemical and Gas Plants (C)
- Chemistry
  - process technology
  - basic know-how
- design & construction of large-scale chemical plants

"key to success" for BIOREFINERY projects
Selected reference BIOPHARMA – Large-scale cell culture plant for production of MABs

Client
F. Hoffmann-La Roche AG

Location
Basle/Switzerland

Type of plant
New cell culture plant for production of monoclonal antibodies (MAB)

Investment
400 mio CHF

Product
Anticancer drug Avastin

Scope of work
Project coordination, Conceptual design, Basic engineering, Detail engineering, Support in procurement, Engineering support during installation and commissioning

Commissioning
2007
Selected reference INDUSTRIAL BIOTECH – Plant for the Production of Pectin

Client
CITRICO Deutschland GmbH
(today: CARGILL-Group)

Location
Malchin/Germany

Type of plant
Turnkey plant for the production of Pectin

Scope of work
Assistance in Basic engineering,
Project and Quality management,
Detail engineering, Procurement,
Installation, Preparation of
commissioning

Commissioning
2001
Selected reference REFINERY – Linear alpha olefin plant

Client & development partner
United Petrochemical Company

Location
United Olefins Complex in Al-Jubail/Saudi Arabia

Process
Sabic Linde “α-Sablin” Process

Capacity
150 000 t/a α-Olefine

Process steps
Feedstock and catalyst handling, reaction and catalyst removal, primary separation, product separation

Scope of work
Turnkey lump sum: Detail engineering, procurement, construction, precommissioning, commissioning support

Start-up
2006
Starch – a major feedstock for biorefineries
Biorefinery – starch as a central component & Linde-KCA starch-based project approaches

STARCH is the most abundant storage carbohydrate on earth

scale of annual production: ≈ 1.8 bn t

direct consumption as food & feed

industrial starch platform: ≈ 60 mio t*

processed food & food ingredients & feed

paper & corrugating

chemicals & pharmaceuticals

Industrial starch platform – Market analysis

Product groups

Europe (% share)

- Native & modified starch: 47.05%
- Ethanol: 46.23%
- Isoglucose/HFCS: 2.28%
- Other syrup based starches: 4.44%

USA (% share)

- Native & modified starch: 32.04%
- Ethanol: 15.29%
- Isoglucose/HFCS: 8.55%
- Other syrup based starches: 44.12%

Consumption by end use markets

Europe (% share)

- Corrugating and paper making: 29.13%
- Confectionary and drinks: 27.46%
- Processed food: 25.11%
- Pharmaceuticals and chemicals: 13.08%
- Feed: 1.69%
- Others: 3.53%

Industrial starch platform – FUTURE

STARCH as renewable raw material for chemical production
Case study „Zeitz“ – a first generation biorefinery

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Project „Zeitz“ – Facts & figures

Type of plant:
— Plant for production of modified wheat starch and gluten
— Capacity: 120,000 t/a wheat (10,000 t gluten, 60,000 t modified starch, 30,000 t feed)

Investor/client:
— FRP CS GmbH (Food Retail & Production CS GmbH)

Investment:
— > 50 Mio EUR
— supported by the European Regional Development Fund (ERDF)

Location:
Project „Zeitz“ – Fast-track schedule

**Contract signing**
December 12, 2007

**Groundbreaking ceremony**
on February 1st, 2008

**Start-up**
planned for August 2009
Contractor

ASK (All Starch Consortium), consisting of
- Linde-KCA-Dresden GmbH (technology/EPC, consortium lead)
- Kaefer Construction GmbH, Bremerhaven (building & mill/EPC)
Project „Zeitz“ – Process technology

- Wheat grain storage
  - Mill
  - Storage flour & bran
  - Gluten separation
  - Starch raffination
  - B-starch fraction & pentosans
  - Liquid fraction

- Gluten (28% DS) to:
  - Gluten dewatering, gluten drying
  - Packaging, storage

- Gluten (90% DS) to:
  - Modification
  - A-starch dewatering

- A-starch (38% DS) to:
  - Biogas plant external
  - Drying modified A-starch
  - Packaging, storage

- Modified A-starch (58% DS) to:
  - Packaging, storage

- Modified A-starch (88% DS) to:
  - Packaging, storage
Key-equipment – starch raffination

TRICANTER® Technology
Flottweg GmbH & Co. KGaA
— efficient separation of wheat flour into 3 distinct phases
— continuous process

wheat starch granules

A-starch

pentosans

gluten/B-starch

heavy phase discharge under pressure

solids discharge

light phase discharge by gravity

feed inlet
Key-equipment – Airstream drying for A-starch & gluten

Flash Dryer/Ring Dryer

— highly specialised vendors, e.g. Anhydro & GEA Barr Rosin
— basic principle:
  — pneumatic system
  — material to be dried is dispersed and conveyed in a hot air stream
  — with selective internal recirculation of semi-dried solids in Ring Dryers

Source: GEA Barr Rosin / examples taken from similar plant
Starch modification – textbook overview of different types

Starch

- Cross linked Starch
  - Diether
  - Diester
- Derivatized/Substituted Starch
  - Starch Ethers
    - Sebaccate
    - Diphosphate
  - Starch Esters
    - Acylated (succinic, acetylated)
    - Nitrated, Sulfated, Phosphated
    - Carbamated
- Degraded Starch
  - Oxidation
    - Periodate Dialdehyde
    - Hypochlorit, Hydroperoxide: Carboxyl
    - Persulfate
  - Thermal/Acid Degradation
    - Dextrin
    - Maltodextrin
  - Enzymatic Degradation
    - Maltose
    - Glucose
    - Cyclodextrin

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→ Design for flexibility essential

Project „Zeitz“ – 3D model

- mill
- raw material silos with future extension
- starch raffination & modification
- flour silo
- gluten dryer
- administration/canteen
- A-starch dewatering & drying
- packaging
- products storage
- storage
Project „Zeitz“– Integration into established infrastructure
Project „Zeitz“ – Picture from the site
Conclusion & outlook

— **Future trend** - from „1G reality“ such as „Zeitz“ to 2G biorefineries
  → from established mature technology with easy-to-process food raw materials and well-known products
  → to emerging technologies under development with difficult-to-process LCB raw materials and either well-known or new products

— **Linde-KCA’s path forward**
  → biorefinery R&D projects
    — BMBF program „BioEnergie 2021“ (focus on „new concepts“)
    — BMU project „Grüne Bioraffinerie“ (focus „process technology“)
  → cooperation for stepwise implementation of the vision „Biorefinery Leuna“
  → for 2G Biofuel/cellulosic ethanol & butanol plants, development on-going
Thank you for your interest!

Questions?
Cooperations?

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