Novel Applications for Industrial Enzymes

JULY 2015
Clariant: a leading, global specialty chemical company

6116
Sales 2014 (CHF m)
from continuing operations

235
Net result 2014 (CHF m)
from continuing operations

4
Business Areas

>200
Production sites

867
EBITDA 2014 (CHF m)
before exceptionals

14.2%
EBITDA margin 2014
before exceptionals

110
in
60
companies
countries

17 003
Employees 2014
The right portfolio with leading market positions in four business areas

- Care Chemicals
- Catalysis & Energy
- Natural Resources
- Plastics & Coatings

Group Technology & Innovation

- Catalysts
- Process Technology
- Chemistry & Materials
- Bio-technology

Integrated Research Platforms
Two Clariant Biotechnology sites

**Munich**
- 100+ employees
- Main Research & Development Center
- Lab and office space: 6,000+ m²
- Pilot plant

**Straubing**
- 20+ employees
- Demo plant & Large scale pilot
- Area: 2,500+ m²

New Biotech R&D Center in Munich (opening Q3/2015)
Group Biotechnology provides key expertise in industrial biotech

- **Biotechnology**
  - Isolation and optimization of enzymes and strains

- **Screening**
  - High throughput screening for selection of better enzymes and strains

- **Pilot plant**
  - Bioprocess development
  - Up-scaling

- **Industrial process**
  - Synergies between technology platforms
  - New products
Core competencies developed from sunliquid®

- Strong expertise in enzyme development from sunliquid® cellulosic ethanol process development
- Derived extensive library of bioprocessing enzymes
- Strains adapted to produce optimized enzyme mixture, minimizing downstreaming requirements and maximizing protein recovery
sunliquid® - a competitive path to cellulosic ethanol

Key features and advantages

- Integrated enzyme production
- Fermentation of C6 and C5 sugars into ethanol
- Feedstock and process specific enzymes
- Energy saving ethanol separation technology
Industrial enzyme solutions

DIVERSITY
- 12,000+ strains, 2,000 enzymes
- Fungal, plant, bacterial origin
- Bioinformatics capabilities

EXPRESSION SYSTEMS
- Filamentous fungi
- Bacteria
- Yeasts

OPTIMIZATION
- Miniaturized assays
- Optimization of enzymes, strains, enzyme mixtures

APPLICATION TESTS
- Small scale, up to 1 m³
- Samples for application tests
- Rapid process implementation
Liquibeet™: enzyme-enhancing yield from sugar beet
Shared Processes

Sugar beet

Washing

Slicing

Juice extraction

Purification

Evaporation

Crystallization

Carbohydrate source

White sugar

Standard fermentation

Divergent Processes

Sugar beet

Beet crushing

Crushing on solids

Fermentation

Sugar mash

Standard fermentation

Liquibeet™

Sugar beet

Sugar Syrup (+10%)

Crushing & Enzymatic Treatment

Complicated
Enzymatic effects on mass balance

**Liquebeet®**
- Complete liquefaction of sugar beet in 4-6 hours
- ~10% increase in fermentable C6 sugars
- Release of up to 3% C5 sugars

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**Standard technology**
- Sucrose 74%
- Cellul. 5%
- Hemi. 4%
- Pectin 4%
- Other sol. 9%
- Other insol. 4%

**Liquebeet technology**
- Glucose 42%
- Fructose 37%
- Galact. 2%
- Arab. 3%
- GalUA 3%
- Other sol. 9%
- Other insol. 4%
Liquebeet® offers superior liquefaction to other commercial enzymes

![Graph showing liquefaction performance of different enzymes]

- **High liquefaction**
- **Medium liquefaction**
- **Low liquefaction**

Commercial cellulase and commercial pectinase require several hours for high liquefaction, while Liquebeet® enzyme achieves high liquefaction much faster.
Enzymatic processing of various feedstocks

**Pectinase-Cellulase mixture** for sugar beet / pulp liquefaction (Liquebeet®)

**Cellulase-Hemicellulase mixture** for hydrolysis of orange/citrus peel

**Cellulase enzyme** for fiber processing, e.g. cotton wastes

**Hemicellulase enzyme cocktail** for improving biomass hydrolysis

Enzyme activity graphs and images showing the effectiveness of the enzymes.
Transfer of concept to other industrial processes—Clariant’s enzyme technology

Opportunities for the fermentation-based chemical industry. Deloitte white paper, 2014
Conclusions

• Clariant’s integrated research platforms allow it to develop novel enzyme technologies for new & existing applications

• Liquebeet is a novel enzyme technology for enhancing sugar yield within the beet industry

• Clariant’s developmental capabilities have allowed it to develop numerous other enzymes used in various bioprocessing applications

Interested in Clariant’s enzyme technologies?

Contact: timothy.wallace@clariant.com