sunliquid® process

Cellulosic Sugars and Ethanol from Agricultural Residues
A world leader in specialty chemicals

Clariant focuses on creating value by investing in future profitable and sustainable growth.

KEY FACTS

Sales 2011 (CHF m) 7370
EBITDA 2011 (CHF m) before exceptionals 975
End 2011 employees 22149
Production Sites in countries 44
More than Group companies world-wide 100
Business Units 11
Clariant’s Products and Services are delivered through 11 business units

<table>
<thead>
<tr>
<th>Additives</th>
<th>Masterbatches</th>
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</thead>
<tbody>
<tr>
<td>▪ Additives for plastics, coatings, adhesives, incl. flame retardants, waxes etc.</td>
<td>▪ Color and additives concentrates/technical composites for plastics</td>
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<table>
<thead>
<tr>
<th>Catalysis &amp; Energy</th>
<th>Oil &amp; Mining Services</th>
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<tbody>
<tr>
<td>▪ Catalysts for chemical, refining and autos</td>
<td>▪ Chemical solutions serving refining and mining industries</td>
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<tr>
<td>▪ Lithium Battery materials</td>
<td></td>
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</tbody>
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<thead>
<tr>
<th>Emulsions, Detergents &amp; Intermediates</th>
<th>Paper specialties</th>
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<tbody>
<tr>
<td>▪ Chemicals for detergents and household cleaners, Emulsions for coatings etc.</td>
<td>▪ Optical brighteners, colorants and chemicals for paper and packaging</td>
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<tr>
<th>Functional Materials</th>
<th>Pigments</th>
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<tbody>
<tr>
<td>▪ Adsorbents, solutions for protective packaging and water treatment</td>
<td>▪ Organic pigments, pigment preparations, and specialty dyes for coatings etc.</td>
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<thead>
<tr>
<th>Industrial &amp; consumer specialties</th>
<th>Textile Chemicals</th>
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</thead>
<tbody>
<tr>
<td>▪ Application solutions for consumer care and industrial markets</td>
<td>▪ Chemicals for pre-treatment dyeing printing and finishing textiles</td>
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<tr>
<th>Leather Services</th>
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<tbody>
<tr>
<td>▪ Chemicals and services for the Leather industry</td>
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</table>
Acquisition of Süd-Chemie by Clariant – What’s New?

- 2 new business units resulting from Süd-Chemie with strong R&D programs
  - Catalysts & Energy (including Battery Materials)
  - Functional Materials
- Clariant has established its new Innovation Chain in 2010
  - Group Technology Services with central R&D and New Business Development amongst others
- Biotechnology from Süd-Chemie is now integrated into Group Technology Services
  - Project Center Renewables was merged with the new Biotech Center forming the Biotech & Renewables Center
The Engine for Innovation – Facts & Figures Research & Development

2.4% Of sales product innovation 67% and process innovation 33%

5 R&D Centers for Chemical Technologies

1 R&D Center for Biotechnology

1,100 People in Research & Development

65 Technical Application Centers around the world

3 R&D Centers for Process Technologies

3 R&D Centers for Catalysis

9,500 Patents

>140 Scientific collaborations
Global innovation network

CENTRAL FUNCTIONS
- 1 R&D Center Biotechnology
- 5 R&D Centers Chemistry
- 3 R&D Centers Process Technologies
- 3 R&D Centers Catalysis

BUSINESS UNIT FUNCTIONS
- 65 Technical Centers
  (Application Development)
Dedicated biotech R&D sites with a green strategy

Key facts:

- Two sites: Munich & Straubing (Germany)
- Started in 2006, 67 Employees in 2012
- Lab and office space: 3.300 m²
- Demonstration plant: 2.500 m²

Green strategy

- Process and enzyme development under one roof
- Renewable feedstock as the basis for sustainable developments in biofuels and green chemicals
- Biotechnology as part of a strong technology platform for sustainable production of renewables
Biotech Center has a wide range of competences

- Renewable Feedstocks
- Enzymes & Microorganisms
- Biotechnology & Genetic Engineering

Business Development

Large-Scale Production

Bioprocess Engineering
Biotechnology R&D located in Munich, Germany
Developing industrial processes for biobased products

Microbiology
- Isolation and optimization of biocatalysts

Screening
- Detection and selection of biocatalysts

Pilot plant
- Process development
- Up-scaling

Industrial process
- Synergies between technology platforms
- New products
sunliquid® process

Detailed Technology Overview
The way to competitive cellulosic ethanol

- Integrated on-site enzyme production
- C6 & C5 fermentation
- Feedstock & process specific enzymes
- Energy saving ethanol separation
Challenges for cellulosic ethanol production

- High process yields
- Low operating costs
- Low investment costs
- Sustainable process
Challenges for cellulosic ethanol production

- High process yields
- All sugars to ethanol
- Feedstock specific reaction conditions
- Feedstock optimized enzymes

- Low operating costs

- Low investment costs

- Sustainable process
World leading enzyme and strain optimization technology
Fully automated ultra high throughput screening

- Evaluation of up to 100,000 samples per day
- Unique setup, highly specialized for optimization of enzymes and microorganisms
- Large spectrum of assay formats possible
- Optimized feedstock specific enzymes already developed for various feedstock including corn stover, sugarcane bagasse and wheat straw
- Proprietary fermentation C5/C6 platform to convert all sugars to ethanol simultaneously
Challenges for cellulosic ethanol production

sunliquid® process solutions

- All sugars to ethanol
- Feedstock specific reaction conditions
- Feedstock optimized enzymes
- Process integrated, on-site enzyme production
- No external energy required

High process yields

Low operating costs
On-site process integrated enzyme production
Enzyme cost USD/gal

Advantages of on-site integrated enzyme production

- **Low substrate cost**
  Enzymes are produced on lignocellulosic substrate.

- **No additional utilities needed**
  Enzyme production is process and plant integrated

- **No formulation and logistics**
  Enzymes are produced directly where they are needed

- **Feedstock and process specific**
  No “one-size-fits-all” solution

- **Independent from enzyme suppliers**
  An their pricing strategy
Low energy consumption in downstream processing

- New ethanol separation process with very low energy consumption
- Based on Clariant technology
- Patented process and material

With the innovative separation process up to 50% of energy can be saved in down-stream processing
Challenges for cellulosic ethanol production

**sunliquid® process solutions**

- High process yields
  - All sugars to ethanol
  - Feedstock specific reaction conditions
  - Feedstock optimized enzymes

- Low operating costs
  - Integrated enzyme production
  - No external energy required

- Low investment costs
  - Proven (bio)chemical process technology
  - All scalable to production scale
Challenges for cellulosic ethanol production

sunliquid® process solutions

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  - All scalable to production scale

- Sustainable process
  - No Food-or-Feed issue
  - Ethanol is nearly Carbon neutral
  - Process is energy self sufficient
sunliquid® process

Commercialization Status
Pilot plant operational for nearly 4 years
Demonstration plant is in operation

Feedstock: ~ 4.500 t/a wheat straw, corn stover, bagasse

Output: 1.000 t/a (330,000 gal/year)

Location: Straubing, Germany

Official Inauguration: July 20th 2012
Images from inside the demonstration plant

Lignocellulosic biomass

Pre-treatment

Hydrolysis

Fermentation
Inauguration of the Straubing plant highlights the strategic importance for Clariant

"The inauguration of the new plant marks an important milestone in the production of a climate-friendly biofuel that can also be used as a raw material for the chemical industry."

Hariolf Kottmann, CEO, Clariant
sunliquid® - An ideal platform for the production of sustainable solutions at large scale
Biorenewable Chemicals Platform -> C₂-Platform

Scientific Design Inc.: Global Process Licensing Leader

Ethylene Oxide/Ethylene Glycol Technology
Awarded ~ 80% of non-captive licenses since 1980 (30 awards since 1990)
Licenses other EO derivative technologies

Alcohol Dehydration Technology
Awarded 2 ethanol-to-ethylene and 6 ethanol to EO/EG licenses since 2006
Expanding technology to butanols

Diagram showing the production of various chemicals from C₂H₄ and O₂ using Ag catalyst.
Timeline for industrial commercialization by 2013

- **Platform technology** able to provide cellulosic sugars, ethanol, and C2 chemicals
- **Pilot plant** has been operational for nearly 4 years
- **Demonstration plant** is on-stream and operating
- **Technology validation** at demonstration plant level
- Identification of **potential commercialization partners**
- **Technology package ready** for industrial-scale by 2013
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