Sustainable Succinic Acid

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Key Messages

Commercializing a leading, sustainable technology

- Bio-based succinic acid will drive a portfolio of renewable and more sustainable products
- 5 Keys to Success to overcome commercialization challenges for bio-based chemicals and materials → collaboration DSM-Roquette well positioned
- Demo-plant production and market development progressing very well
- DSM and Roquette will operate under 50:50 JV* for the commercialization of Biosuccinium™

* Subject to regulatory approvals and notifications.
A New Company in the Industrial Biotech Sector…

Addressing the Megatrends

Decreasing oil dependency

Sustainability, renewability

Environmental concern

Green Building blocks for green materials

Sustainable solutions powered by DSM + Roquette
Reverdia™: Powered by DSM + Roquette

Global Leaders Combine Expertise to Produce Bio-based Succinic Acid

Shared Vision on Sustainability and Complimentary Competencies

- Experience large scale biorefineries and logistics
- Starch based chemistry pioneer & Leader in Starch based products
- Worldwide biorefinery operations
- Extensive purifications capabilities
- Strong scale-up experience

- Global biotech leader (chemicals, food, enzymes)
- Developing technologies for next generation feedstocks
- Leader in metabolic engineering
- Broad understanding of materials
- Strong fermentation & scale-up experience
Bio-based Succinic Acid Will Lead to a Portfolio of Products and Applications

- Biopolymers - PBS
- Solvents
- Pharmaceuticals
- Pyrrolidones
- Coatings and resins
- Polyurethanes
- Plasticizers
- Food
- Freezing point depression agents

1,4 BDO/THF
Succinic Acid Market - Today

Global Market

Current 2010 (total ~35 kton)
- Polymers 7%
- Food 9%
- Pharma 12%
- Metal industry 14%
- Agriculture 1%
- Photo 6%
- coating, pigments, dyes, inks 31%
- Miscellaneous 20%

Addressable 2020 (total ~2000 kton)
- Polyurethanes 38%
- 1,4-Butanediol / Pyrrolidones 31%
- Biopolymers / plasticizers 16%
- Coatings / resins 7%
- Solvents 4%
- Miscellaneous / metal ind. / pharma / food 4%

Drivers
- Energy security: reducing dependency on oil
- Climate change: increasing environmental concerns
- Public interests in sustainability: growing sustainable and renewable developments
Quality Will Be of Utmost Importance in Polymer Applications

Bio-based thermoplastics

Novel, bio-based polymer

Poly-butylene Succinate
Favorable Bio-SA Economics Will Enable Bio-1,4 BDO leading to 100% renewable PBS

Bio-based thermoplastics

Novel, bio-based polymer

Biobased Succinic Acid + 1,4 BDO

Biobased Succinic Acid 1,4 BDO Biobased Succinic Acid 1,4 BDO

Poly-butylene Succinate

100% Renewable Solution
5 Keys to Success for Biobased Chemicals

- **STRENGTHS IN STRAIN DEVELOPMENT & FERMENTATION**
  Many groups have already worked many years on Succinic acid

- **INNOVATION IN PRODUCT RECOVERY**
  Importance customer specification

- **FEED STOCK KNOWLEDGE AND GLOBAL REACH**
  Feedstock is major cost component

- **MARKET KNOWLEDGE AND EXPERTISE**
  New markets will need to be developed

- **SCALE-UP EXPERTISE and TECHNOLOGY IMPLEMENTATION**
  Requires a good demo and can be capital intensive

Sustainable Solutions
Powered by DSM + Roquette
Renewable Feedstocks Have Experienced Lower Price Volatility

Crude Oil, Raw Cane Sugar and Corn

Price Index
Indexed at January 1984 = 100

Standard Deviation of Price Index
1984-2009: Indexed at January 1984 = 100
1993-2009: Indexed at January 1993 = 100
Technology Breakthrough for Sustainable Production

Better Technology and Product

- Multiple host organisms, gene pathways and recovery methods were explored and tested
- Using e.g. yeast as the manufacturing organism allows the process to operate at low pH
  - Less salt waste generated in the environment
  - Better economics, not all fermentation processes are the same
  - Yeast-based fermentation provides high quality starting point for DSP with less by-products
- Novel proprietary technology (more than 15 patents filed)
S. cerevisiae Engineering Strategy
Combination Reductive & Oxidative TCA

DCA transporter

Succinic acid

DCA transportar

S. cerevisiae Engineering Strategy
Combination Reductive & Oxidative TCA

Net CO₂ input

DHAP –––> Glycerol

PEP

ATP

Ethanol

Malate synthase

Isocitrate lyase

CO₂

Malate dehydrogenase

Phosphoenolpyruvate carboxykinase

Fumarase

Fumarate reductase

Succinic acid Secretion

DCA transporter

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DCA transporter
Value Proposition to Customers

FAVORABLE LIFE CYCLE ASSESSMENT
Renewable but also a more favorable LCA and carbon footprint than alternatives which is becoming increasingly important to downstream customers.

MORE STABLE PRICING
Integrated biorefinery will achieve the best economics and more stable pricing is expected in both the short and longer-term.

HIGHEST PRODUCT QUALITY/PURITY
Tested and Validated
Essential for applications where color and other criteria are important.

PROPRIETARY TECHNOLOGY
Robust Patent Portfolio
Non-gypsum process
Able to achieve performance and value, opening up new markets faster overtime.
The unique and proprietary low pH process has superior performance.

Potential for further substantial improvements.

This Cradle-to-Gate study was executed by expert firm CE Consult (NL).

The results were independently confirmed by Patel and Roes of the Copernicus Institute of Utrecht University (NL).
So Where are We with Commercialization?

- Product from demo plant available now in ton quantities
- On track to take a decision on large scale manufacturing end of 2010
- Actively working with prospects in many new segments (for qualification /launch purposes)
Bio-based succinic acid will drive a portfolio of renewable and more sustainable products

5 Keys to Success
- The industry, including ourselves, will continue to improve in all areas

Reverdia, aspires to be an industry leader
- Powered by DSM + Roquette
- Enabled by a differentiated technology and product
- Assurance of improved sustainability