Biosuccinium™, enabling sustainable polymer solutions

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Reverdia: Powered by DSM + Roquette

Complimentary Competencies Create a Single Force for Market Success

- Ranked among top global manufacturers of renewable raw materials (starch) for food ingredients & bio-based products
- Biorefinery experts
- €2.5 billion Euros turnover
- 6600 people in more than 100 countries worldwide
- Member of UN Global Compact

- Life Science and Material Science company
- Biotechnology leader
- 22,000 employees in 200 locations across all continents
- Annual net sales of around €9 billion
- Top ranking Dow Jones Sustainability Index
Reverdia is dedicated to be the global leader in the market for sustainable succinic acid, focusing on market development by establishing partnerships with direct and indirect customers, building on customer needs and Reverdia strengths.
Global Megatrends

Drive the Need for Products Made from Green Materials

Sustainability
Renewability

• Long-term maintenance of planet’s well being
• Drives the growth of jobs & the economy

Decreasing Oil Dependency

• Scarcity
• Price volatility
• Energy security

Environmental Concern

• Consumer demand for sustainability
• Governmental regulation on climate change
Commercialization Strategy

TECHNOLOGY
World Class Sustainable

BUSINESS MODEL
Manufacture and Sales

MARKET DEVELOPMENT
Customer Partnerships
Emerging Value Chain for Sustainable Materials

Biosuccinium™, a bio-based alternative for fossil-based raw materials

**Current Technology: Industry based on fossil-based raw materials**

- Oil
- Fossil based
  - Succinic acid
  - Adipic acid
  + others
- Fossil based materials
- End-user products

**New Technology: Biosuccinium replaces fossil based raw materials**

- Biomass
- Biosuccinium
  + other raw materials
- (Partly) Bio-based Materials
- End-user products
Large CO₂ reduction potential using Biosuccinimum™

Biosuccinimum™, a bio-based alternative for fossil-based raw materials

- In polymer-related applications, Biosuccinimum™ typically replaces:
  - fossil based succinic acid
    - reduced carbon footprint
    - Increased biocontent
  - fossil based adipic acid
    - strongly reduced carbon footprint
    - Increased biocontent

- Calculated Cradle-to-Gate for Biosuccinimum and Adipic Acid

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<thead>
<tr>
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<th>Biosuccinimum™ Current Process</th>
<th>Biosuccinimum™ Potential Process</th>
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<tbody>
<tr>
<td>Fossil-based Succinic Acid</td>
<td>2,3</td>
<td>0,9</td>
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<td>Fossil-based Adipic Acid</td>
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- Biosuccinimum™ and Adipic Acid
# Biosuccinium™
## Portfolio of Products and Applications

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<td>– Interior</td>
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<td>– Apparel</td>
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- TPU = thermoplastic polyurethane; PU = polyurethanes; PBS = polybutylene succinate: new biopolymer; Spandex / Elastane = elastic fibers
Application of Biosuccinium™ in biodegradable polyesters

PBS-(X) – A family of Biosuccinium™ based co-polyesters

- PBS-X actually represents a family of copolymers, based on combinations of
  - succinic acid,
  - adipic acid, and
  - terephthalic acid

- By varying the type and content of co-monomer a range of properties can be obtained
High level comparison (copolymer ratio 50/50)

PBS-(X) – A family of Biosuccinum™ based co-polyesters

% biobased

- PBS: 50%
- PBSA: 22%
- PBST: 20%
- PBAT: 0%
- PBT: 0%

Biodegradable

- PBS: yes
- PBSA: yes
- PBST: yes
- PBAT: no
- PBT: no

Melt temperature

- PBS: 115°C
- PBSA: 50°C
- PBST: 138°C
- PBAT: 113°C
- PBT: 225°C

E-modulus

- PBS: 650 MPa
- PBSA: 330 MPa
- PBST: 350 MPa
- PBAT: 50 MPa
- PBT: 2000 MPa
Influence of copolymer composition on biodegradability

Source: Poly(butylene-succinate) and its copolymers: Research, development and industrialization
Jun Xu and Bao-Hua Guo, Tsinghua University, Beijing, China
Institute of Polymer Science & Engineering, Department of Chemical Engineering,
Conclusions

- Biosuccinium™ based family of (co)polyesters are a versatile addition to the biopolymer toolbox
  - Properties can be tuned within a relatively wide range
  - Already today a significant biobased content, with significant future potential to increase (ie bio-BDO)

- Although known for a long time in scientific, the materials (and some of it’s suppliers) are relatively new to the commercial industrial scene

- Reverdia has relationships to these suppliers, and can establish connections where desired
World’s 1st commercial bio-succinic acid plant
Cassano, Italy; start-up Q4-2012

Thank you for your attention

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