Biosuccinium
Made in Italy, Enabling Sustainable Materials Globally

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Ramspc
October 2nd, 2014
Biosuccinium™ - biobased succinic acid made in Italy

How can Biosuccinium™ enable more sustainable materials and products

An opportunity for you?
Global Megatrends Drive the Need for Sustainability

**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
Examples: Sustainable / Bio-based Products

- DANONE: Launches sustainable Ingeo Activia yogurt cup in the German market

- Coca-Cola: 30% plant-based, 100% recyclable bottle

- Suntory: Globio® for Suntory Natural Mineral Water bottles

- Puma: Degradable shoe

- Timberland: Developed Green Index™

- Nike: Green Speed soccer shoe
Governments and NGO’s: Defining, Promoting and Requiring Sustainable Products or Services

US Department of Agriculture BioPreferred Program

US Department of Agriculture voluntary labeling program for bio-based products

LMI identified bio-based products as a lead market

World Wide Fund for Nature endorses bio-based products

Italy bans non-biodegradable plastic bags in shops
Biosuccinium provides a new non-fossil resource that allows customers to choose a bio-based material with an improved environmental footprint to develop superior sustainable products like polyurethanes for footwear and new polymers for packaging.
Biosuccinium™ Production Integrated in Roquette’s Biorefinery in Cassano Spinola, Italy

Optimum Synergy, Shipping Product Globally

Facts and Figures

- Employees: ~460
- Surface: 40 hectares
- Corn grinding capacity: 2,200 t/d
- Activity: 620 kt corn/year

Benefits to Customers

- Existing fully integrated biorefinery
- Ships product globally today
- Largest plant in Europe producing high quality Bio-based succinic acid using only a fraction of its available feedstocks
Reverdia 10 kta Facility in Cassano, Italy
In operation since December 2012
Product Packaging and Distribution
100% biobased (ASTM D6866)

Improved carbon footprint

Act today to build a sustainable supply chain for the future

Renewable Raw Materials Impact Total Value Chain

Improving Sustainability Characteristics of Materials

Biomass Feedstocks

Materials

OEM/Part maker

Brand Owner
Large CO₂ reduction potential with Biosuccinium™

Technology, feedstock and location dependent

The Biosuccinium™ Cradle-to-Gate study was executed by Dr. M. K. Patel, Dr. A. L. Roes and B. Cok , MSc. at the Copernicus Institute of Sustainable Development at Utrecht University, the Netherlands (For full study visit: http://onlinelibrary.wiley.com/doi/10.1002/bbb.1427/abstract)
Biosuccinium™ Qualified in Multiple Applications

**Polyurethanes**
- Running Shoes
- Automotive Textiles
- Wheels
- Wood & Furniture coatings
- Construction

**Resins**
- Coatings Resins
- Composite Resins

**Polybutylene Succinate (PBS)**
- Plastic Utensils
- Disposable Cups
- Food Packaging
- Agricultural Films
- Non-wovens Fibers

**1,4 BDO/THF**
- Elastic Fibers
- Engineering Plastics

**Pyrrolidones**
- Solvents
- Cables

**Miscellaneous**
- Pharmaceuticals
- Food Flavor
- Metal Plating
- Lubricants

**Plasticizers**
- Polymer Modification
Example of Biosuccinium Use: Biobased TPU for footwear

Technical Feasibility in collaboration with Brand Owners and TPU manufacturers

<table>
<thead>
<tr>
<th>Footwear requirements</th>
<th>Partly Biobased TPU’s Offered</th>
<th>Requirement met</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hardness 75 – 95 Shore A</td>
<td>77</td>
<td>86</td>
</tr>
<tr>
<td>Renewable content %</td>
<td>?</td>
<td>60</td>
</tr>
<tr>
<td>Density [g/cm³]</td>
<td>1,2</td>
<td>1,18</td>
</tr>
<tr>
<td>Tensile strength [MPa]</td>
<td>min 32</td>
<td>36,6</td>
</tr>
<tr>
<td>Elongation at break [%]</td>
<td>min 400-600</td>
<td>800</td>
</tr>
<tr>
<td>Tear strength [N/mm]</td>
<td>min 40</td>
<td>57,9</td>
</tr>
<tr>
<td>Abrasion loss [mm³]</td>
<td>max 50</td>
<td>65</td>
</tr>
<tr>
<td>Hydrolysis 80 – 100 % after 7 days 95%RH, 70 C</td>
<td>85%(1)</td>
<td>87%(1)</td>
</tr>
</tbody>
</table>

1: 2 weeks
2: 80 C

Disclaimer: Data is based on information from TPU producers and is shown here for illustrative purposes only. All data needs to be confirmed by the actual TPU producers.

Differentiated performance identified: improved chemical resistance
Example of Biosuccinium Use: Paint – Alkyd Resin

Biobased Alkyds Commercialized

- Resin:
  - biobased from 66% to 96%
  - several renewables used
- Coating with dimethyl succinate solvent:
  - reduction drying time ~40%.
  - hardness developed faster
Example of Biosuccinium Use:
Paint – UV curable acrylate

Biobased monomers with fossil-based acrylic acid

- Oligomeric polyester:
  - Biobased carbon content: 44%
  - Biosuccinium content: 12%
  - Excellent appearance and hardness
  - Excellent chemical resistance

- Reactive diluent:
  - Biobased carbon content: 63%
  - Biosuccinium content: 25%
  - Excellent appearance / good hardness
  - Excellent chemical resistance
Example of Biosuccinium Use: Biosuccinium Esters for Plasticizers

- **Improved sustainability characteristics**
  - Phthalate-free plasticizers
  - Partly renewable because Biosuccinium is 100% biobased
  - Opportunity for improved environmental footprint
    - Biosuccinium carbon footprint is 90% lower than that of adipic acid!

- **DEHSu**
  - Indications are that performance is quite similar to DOA (di-octyl adipate)
    - Good plasticizing efficiency, fast fusing properties, very good low-temperature flexibility behaviour
  - Uses might be in flooring, food wrap film, coatings and low-temperature applications

- **DPHSu**
  - Performance expected close to DOA (di-octyl adipate)
  - Properties to be evaluated

- **DTDSu**
  - Performance to be evaluated
    - Relatively high molecular weight
Example of Biosuccininium Use:
PBS – a New Thermoplastic Polymer

- PBS is an aliphatic, biodegradable polyester
  - Flexible, high elongation
  - Good temperature resistance
  - Easy processing

- Ideal blend partner
  - bring flexibility / impact resistance to PLA based compounds

Table 1: Indicative performance comparison of a selection of biopolymers and fossil-based polymers

<table>
<thead>
<tr>
<th>Property</th>
<th>Units</th>
<th>PBS</th>
<th>a-PLA</th>
<th>c-PLA</th>
<th>PBAT</th>
<th>PE-LD</th>
<th>PE-HD</th>
<th>PP</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology semicrystalline - amorphous</td>
<td>-</td>
<td>SC</td>
<td>A</td>
<td>SC</td>
<td>A</td>
<td>SC</td>
<td>SC</td>
<td>SC</td>
<td>A</td>
</tr>
<tr>
<td>Melting temperature</td>
<td>°C</td>
<td>115</td>
<td>~58</td>
<td>&gt;150</td>
<td>~115</td>
<td>110</td>
<td>130</td>
<td>165</td>
<td>-</td>
</tr>
<tr>
<td>Heat Deflection Temp-B</td>
<td>°C</td>
<td>85</td>
<td>55</td>
<td>&lt;100</td>
<td>40</td>
<td>50</td>
<td>75</td>
<td>105</td>
<td>90</td>
</tr>
<tr>
<td>Tensile modulus</td>
<td>MPa</td>
<td>550</td>
<td>3500</td>
<td>3500</td>
<td>80</td>
<td>200</td>
<td>1000</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>Tensile elongation at break</td>
<td>%</td>
<td>300</td>
<td>3</td>
<td>2</td>
<td>600</td>
<td>400</td>
<td>150</td>
<td>150</td>
<td>1,6</td>
</tr>
<tr>
<td>Processability</td>
<td></td>
<td>fast</td>
<td>fast</td>
<td>slow</td>
<td>fast</td>
<td>fast</td>
<td>fast</td>
<td>fast</td>
<td>fast</td>
</tr>
</tbody>
</table>
Reverdia and Helm AG partner for Biosuccinium™ distribution and market development in Europe.

- Building on Helm’s strong position as a marketing enterprise and distributor.
- Making Biosuccinium™ available for a broad range of markets and applications.
Online reference database for uses of succinic acid

The Succinic Acid Reference Finder

Please use the selectors below to find references on succi application.

The Succinic Acid Reference Finder assists you in finding relevant publications pertaining to the properties and potential applications of succinic acid in various fields.

Quick and Easy online ordering of Biosuccinium™ samples

Request a Sample

www.reverdia.com
Biosuccininium™: we are ready!

- Validated sustainable low pH process
- Availability of high quality product from demo plant to bridge to 2012
- Commercial manufacturing as of 2012 in Cassano Spinola
- Reach/TSCA compliant
- Logistics in place
- Customer support team
- Global NBD team (EU, China, Japan, USA)
- Committed organization
Visit us in the B2B area at the Ramspec

For more information

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Thank You