A New Generation of Cost-Effective Bio-Based Succinate Plasticizers
BioAmber: A Renewable Chemicals Company

- Succinic Acid “Bio-SA™”
- 1,4-Butanediol “Bio-BDO™”
- Adipic Acid “Bio-AA™”

____________________________ TECHNOLOGY and SUSTAINABILITY ______________________________

- A renewable chemical company that produces chemicals by fermentation of plant-based sources.
- BioAmber has principle offices in Montreal and Minneapolis, MN.
- Shareholders include VCs such as Sofinnova Partners, Naxos, and strategic investors such as Mitsui&Co, Ltd and Lanxess
- Leverages open innovation and partnerships to accelerate development

* Trademark registered in Europe and Japan, pending in China, South Korea and Canada

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We Convert Sugars into **Renewable Chemicals**

**Petrochemical Process**

- Oil & Gas
- Butane / Benzene
- Maleic Anhydride
- 1,4-Butanediol

- Succinic Acid
- Gammabutyrolactone
- Tetrahydrofuran

**Sugars + CO₂**

- Fermentation
- Succinic Acid
- Conversion

- 1,4-Butanediol
- Tetrahydrofuran
- γ-butyrolactone

Simpler... Cheaper... Cleaner

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BioAmber’s technology is carbon neutral: will emit 100% less greenhouse gas than conventional technologies to produce petrochemical adipic acid.
BioAmber’s Bio-SA™ Plant (Sarnia, Ontario) Energy Savings

Energy Savings 60.9%

Riffel Consulting
*Field-to-Gate Energy and Greenhouse Gas Emissions Associated with Succinic Acid Produced At BioAmber’s Facility In Sarnia Ontario, March 2013
BioAmber’s Bio-SA™ Eco-Calculator

Calculate your way to green!
Introducing our Eco-Calculator

See the impact of substituting petro-chemicals with Bio-SA™

Quantity of Succinic Acid: [Blank]
Unit of Measure: Metric tonnes
Baseline: Petro-AA

Calculate Eco-Benefits

www.bio-amber.com
BioAmber Succinic Acid: A Platform Chemical

Bio-Based Succinic Acid: Large Addressable Markets
The Renewable Plasticizer Supply Chain

- **Biobased Succinic Acid**
- **Esterification & Formulation**
- **PVC Applications**

*Biobased Succinic Acid - Renewable dicarboxylic acid building block*

*Family of bio-based succinate plasticizers*

*Performance evaluations with SolVin PVC resin*
Succinate Esters

Plasticizer Performance Data
Dissolution Temperature (Acc. DIN 53 408)

- DOP
- BEHS
- DINP
- DOA
- DEHS
- DINS
- ODS
The succinates are efficient plasticizers providing a high hardness reduction.
### Low Temperature Properties and Volatility

<table>
<thead>
<tr>
<th>Plasticizer 60 phr</th>
<th>Shore A Hardness After 1 week</th>
<th>Cold Flex</th>
<th>Volatility vs DOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODS</td>
<td>74</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>DINS</td>
<td>76</td>
<td>+</td>
<td>o</td>
</tr>
<tr>
<td>DEHS</td>
<td>73</td>
<td>+</td>
<td>o/-</td>
</tr>
<tr>
<td>BEHS</td>
<td>70</td>
<td>o</td>
<td>o/-</td>
</tr>
<tr>
<td>DOA</td>
<td>71</td>
<td>+</td>
<td>o</td>
</tr>
<tr>
<td>DINP</td>
<td>76</td>
<td>-</td>
<td>++</td>
</tr>
</tbody>
</table>

Excellent low temperature performance, similar to other dibasic acids
Volatility dependent on molecular weight
The succinates allow the production of low viscous, storage stable pastes. BEHS provides the option of a higher production speed.
Compact and Foam

Layer Evaluations

SolVIn®
The Partner in Vinlys
Compact Layer Evaluations

General Considerations:

- Transparent formulations (flooring-type, wear layers) were used for the evaluations (table below). Pastes were prepared in a speed mixer and de-aerated before assessment;

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Phr</th>
</tr>
</thead>
<tbody>
<tr>
<td>SolVin 382NG*</td>
<td>100.0</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>50</td>
</tr>
<tr>
<td>Ca/Zn thermal stabilizer</td>
<td>2.5</td>
</tr>
</tbody>
</table>

* K 82, microsuspension, low viscosity resin;

- Plasticizers were assessed regarding rheology, air entrapment/air release, gelation, thermal stability, weight loss, water pick-up, color, transparency and gloss.
Paste Rheology

Rheology Evaluations on Transparent Formulations Eta 1.4 - RS1

Viscosity (Pa.s)

DEHP  DNP  DIDP  DNS  DIDS  ODS  DEHS

To To+ 24h
Air Release Evaluations

- Pastes were assessed regarding air release/air entrapment according to internal methods.

- Air release is expressed in terms of the maximum height of plastisol column and the time to collapse this column (break of surface tension).

- As a rule, succinates are outstanding.

<table>
<thead>
<tr>
<th>Plasticiser</th>
<th>Column Height (mL)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEHP</td>
<td>96</td>
<td>71</td>
</tr>
<tr>
<td>DINP</td>
<td>96</td>
<td>71</td>
</tr>
<tr>
<td>DIDP</td>
<td>61</td>
<td>54</td>
</tr>
<tr>
<td>DINS</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>DIDS</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>ODS</td>
<td>98</td>
<td>61</td>
</tr>
<tr>
<td>DEHS</td>
<td>46</td>
<td>17</td>
</tr>
</tbody>
</table>
For air entrapment evaluations, after the de-aeration during 5 minutes, pastes are gelled in Werner Mathis oven for 2 min at 200°C (thickness: 0.3mm).

These pastes are then re-stirred during 1 and 5 minutes. The re-stirred pastes are again gelled in the same conditions as before. Photos were taken in the three conditions (the bubbles are the black spots) and grades attributed afterwards.

0 = good       5 = poor
Air Release Evaluations

DEHP

DINS

after air removal  after 1 min of re-stirring  after 5 min of air re-stirring

09077A/A3
DEHP - RE 898
Sans rémélange - 0' remélange

09077A/A3
DEHP - RE 898
1' rémélange

09077A/A3
DEHP - RE 898
5' rémélange

10007 B/A1
DEX 9 SU - Sans débullage
2010-02-12/03

10007 B/A1
Dex 9 SU - 1' débullage
2010-02-12/03

10007 B/A1
Dex 9 SU - 5' débullage
2010-02-12/03
Thermal stability of pastes was assessed regarding DHC (dehydrochlorination) and Metrastat.

- As a rule, succinates performed better than GP phthalates. ESBO is outstanding.

<table>
<thead>
<tr>
<th>Plasticizer</th>
<th>DHC* (min)</th>
<th>Metrastat** (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEHP</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>DINP</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>DIDP</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>DIDP</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>ESBO</td>
<td>233**</td>
<td>19</td>
</tr>
<tr>
<td>DINS</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>DIDS</td>
<td>39</td>
<td>29</td>
</tr>
<tr>
<td>ODS</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>DEHS</td>
<td>28</td>
<td>19</td>
</tr>
</tbody>
</table>

* Time to reach a conductivity of 50 μS/cm
** We stopped after 233 min
*** Time to reach 60% of the original reflectance
Weight Loss for Transparent Formulations
100°C - Films 0.7 mm thick

- DEHP
- DINP
- DIDP
- DINS
- DIDS
- ODS
- DEHS

Weight Loss (%)
- After 4 days
- After 7 days
Foam Layer Evaluations

General Considerations:

- Foam formulations (flooring-type, decor layers) were used for the evaluations (table below). Pastes were prepared in a speed mixer and de-aerated before assessment;

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Phr</th>
</tr>
</thead>
<tbody>
<tr>
<td>SolVin 367NK*</td>
<td>100.0</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>62.0</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>40.0</td>
</tr>
<tr>
<td>MB (50%) Porofor ADC+DINP</td>
<td>6.0</td>
</tr>
<tr>
<td>Rapid K/Zn kicker</td>
<td>2.0</td>
</tr>
</tbody>
</table>

* K 67, microsuspension, medium viscosity resin;

- Pastes were evaluated regarding rheology. Foams were assessed regarding density, cell quality, expansion rate and Yellow Index.
Rheology Evaluations on Foamy Formulations Eta 1.4 - RS1

- DEHP
- DINP
- DIDP
- DIN
- DID
- ODS
- DEHS

Viscosity (Pa.s)

- Eta 1.4 - To
- Eta 1.4 - To+ 24h
Foam Density

Foam Density at 200°C (2 minutes, 0.35 mm thickness)

Density (g/cm³)

- DEHP
- DINP
- DIDP
- DINS
- DIDS
- ODS
- DEHS

The graph shows the foam density for different compounds at 200°C. The densities range from 0.00 to 0.30 g/cm³. The compounds DEHP and ODS have the highest density, while DEHS has the lowest. The graph highlights the density values for each compound.
Expansion Rates at 200°C (2 minutes, 0.35 mm thickness)
Cell Quality

Cell Quality at 200°C (2 minutes, 0.35 mm thickness)

0 = good
5 = poor
Succinic Acid Ester Plasticizers

- Unique combination of properties - sustainability, performance and economics
- Family of plasticizers offering excellent cold flex, range of processing speeds, high efficiency
- Improved paste aging, excellent air-release and thermal stability in flooring formulations
- Sampling succinate plasticizers today
Thank You!

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