reFlex™ 100
High Solvating Bio-Derived Plasticizer

Compared with
Butyl Benzyl Phthalate

Introduction to PolyOne
PolyOne at a Glance

Global Reach & Breadth

- More than 35,000 solutions
- 40 manufacturing facilities and warehousing facilities in 20 countries
- More than 10,000 customers in 35 countries
- Operations in North America, South America, Europe and Asia
- Joint ventures in North America and South America
- Corporate headquarters in northeast Ohio, U.S.A.
- Annual revenues of $2.9 billion
PolyOne’s Bioplasticizer Initiative
PolyOne’s Bioplasticizer Project

- PolyOne and Archer Daniels Midland have agreed to develop and commercialize a portfolio of sustainable plasticizers based upon renewable feedstocks.
- PolyOne has licensed bio-plasticizer technology from Battelle to support this initiative.
- PolyOne and ADM have a pipeline of technologies in development and are working to engage validation users to establish the commercial and technical viability of these solutions.
- The initial commercial offering is reFlex 100, a high solvating plasticizer that has excellent potential to replace, in whole or in part, butyl benzyl phthalate (BBP) or other high solvating plasticizers across a range of applications.
- This initial product has been produced on a large, commercial scale, and is available for sampling or sale.
reFlex™ 100

VS

Butyl Benzyl Phthalate
Butyl benzyl phthalate, or BBP, is a high solvating plasticizer used across a range of vinyl applications including flooring and foams.

BBP, along with several other phthalates have come under increasing scrutiny from a range of stakeholders.

reFlex 100 bioplasticizer has many performance similarities which may allow its substitution for BBP and other high solvating plasticizers such as DIHP and benzoates.

reFlex 100 plasticizer is a bio-derived, non-phthalate alternative, produced from rapidly renewable feedstocks and certified under the USDA BioPreferred® Program to be 94% biobased.
### reFlex™ 100 vs BBP

#### Test Formulations

<table>
<thead>
<tr>
<th>Material</th>
<th>BBP</th>
<th>reFlex™ 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geon 121 AR (vinyl resin)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Butyl Benzyl Phthalate (BBP)</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>reFlex™ 100</td>
<td>0</td>
<td>70</td>
</tr>
<tr>
<td>Epoxidized Soybean Oil (ESO)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Ba/Zn Stabilizer</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

- Both systems have 70 parts of plasticizer.
- reFlex 100 imparts exceptional heat stability and is substituted for the ESO
## reFlex™ 100 vs BBP

*Misc Properties*

<table>
<thead>
<tr>
<th>Property</th>
<th>BBP</th>
<th>reFlex 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Release</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td>Hardness, Shore A</td>
<td>79</td>
<td>70</td>
</tr>
<tr>
<td>Yellowness, D1925 YI</td>
<td>19.4</td>
<td>18.0</td>
</tr>
</tbody>
</table>

### reFlex 100

- Exhibits much improved air release.
- Has significantly greater efficiency.
- Shows reduced yellowness due to its low initial color and improved heat stability.
reFlex™ 100 vs BBP

Gel Rate

- reFlex™ 100 exhibits gelation at even lower temperatures than BBP.

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Gel Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBP</td>
<td>~59° C</td>
</tr>
<tr>
<td>reFlex 100</td>
<td>~53° C</td>
</tr>
</tbody>
</table>
**reFlex™ 100 vs BBP**

**Paste Viscosity**

**20rpm Brookfield (RV) Viscosities**

**2rpm Brookfield (RV) Viscosities**

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**reFlex 100**

- Provides lower initial paste viscosity.
- However, as the low gelation temperature would imply, viscosity stability is reduced.
reFlex™ 100 vs BBP
Mechanical Properties

reFlex 100
✓ Fuses rapidly, but at equal loading, exhibits lower tensile...

...and higher elongation due to its lower durometer, which results from its greater efficiency.
### reFlex™ 100 vs BBP

#### Heat Stability

<table>
<thead>
<tr>
<th></th>
<th>5 Minutes</th>
<th>60 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reFlex 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Metrastat Oven, 375°F; from 5 to 60 minutes

**reFlex 100**
- Contributes greatly to heat stability.
- May allow for the reduction/elimination of metal stabilizers
# reFlex™ 100 vs BBP

## Summary

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Resulting From</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Allows the incorporation of rapidly renewable content</td>
<td>Certified to 94% renewable content</td>
</tr>
<tr>
<td>✓ Customers may be able to certify their products to USDA BioPreferred® standard and potentially qualify for the Federal Procurement Preference program</td>
<td></td>
</tr>
<tr>
<td>✓ Increased productivity due to reduced evacuation time</td>
<td>Improved air release</td>
</tr>
<tr>
<td>✓ Improved quality due to reduced defect rates</td>
<td></td>
</tr>
<tr>
<td>✓ Reduced usage level</td>
<td>Greater efficiency</td>
</tr>
<tr>
<td>✓ Fast processing</td>
<td>Fast gelation and fusion</td>
</tr>
<tr>
<td>✓ Lower gelation &amp; fusion temperatures possible</td>
<td></td>
</tr>
<tr>
<td>✓ Easier material handling</td>
<td>Lower paste viscosity / viscosity stability</td>
</tr>
<tr>
<td>✓ Consistent processing</td>
<td></td>
</tr>
<tr>
<td>✓ Reduced levels of heat stabilizers</td>
<td>Imparts excellent thermal stability</td>
</tr>
<tr>
<td>✓ More robust performance</td>
<td></td>
</tr>
<tr>
<td>✓ Can blend with non-phthalates and retain non-phthalate status</td>
<td>Non-Phthalate</td>
</tr>
</tbody>
</table>
USDA BioPreferred® Program

**Purpose:** To promote the increased purchase and use of biobased products with the following benefits:

- **Economic** - Promote economic development, create new jobs, provide new markets for farm commodities
- **Environmental** - Reduce petroleum consumption, increase the use of renewable resources, better manage the carbon cycle, and contribute to reducing adverse environmental and health impacts

**Program:** Driving two major initiatives:

- **Product Labeling**
  - USDA certifies and awards labels to qualifying products to increase consumer recognition of biobased products

- **Federal Procurement Preference**
  - USDA designates categories of biobased products that are afforded preference by Federal agencies when making purchasing decisions
reFlex™ 100: USDA BioPreferred® Status

- reFlex 100 was tested to USDA BioPreferred standards and has been certified to be 94% biobased
The Changing Plasticizer Landscape

**reFlex™ 100** adds another tool to your toolbox

- **Renewable?**
  - 94% renewable

- **Phthalate?**
  - Recover lost productivity

- **Non-Phthalate?**
  - Improve fusion of DINCH, DOTP

**reFlex™ 100** is 94% renewable.
Thank You!

Please contact stephen.horton@polyone.com with any questions

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