reFlex™ 100
High Solvating Bio-Derived Plasticizer

as an
“Accelerator”
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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

- Working in collaboration with Archer Daniels Midland and the Battelle Institute to develop and commercialize a pipeline of plasticizer technologies based upon renewable feedstocks.

- Seeking to validate the commercial and technical viability of these solutions.

- The initial commercial offering reFlex™ 100 offers the potential to replace other high solvating plasticizers as a co-plasticizer or “accelerator” across a range of applications.

- reFlex 100 has been produced on a large, commercial scale, and is available for sampling or sale.
reFlex™ 100 as an “Accelerator”
Companies who historically used fast gelling, high solvating phthalate plasticizers have been compelled to switch to alternate systems, most of which are not as fast or efficient.

reFlex™ 100 shows significant promise as an “accelerator” for both phthalate and non-phthalate plasticizers to restore lost productivity.

reFlex™ 100 offers significant benefits as a co-plasticizer with the capability to:

- Dramatically improve the rate of gelation and fusion, thereby recovering lost manufacturing efficiencies,
- Reduce paste viscosity without sacrificing viscosity stability,
- Improve heat stability allowing for the elimination of ESO and the potential reduction of metal stabilizers.
**reFlex™ 100 as an “Accelerator”**

**Test Formulations**

<table>
<thead>
<tr>
<th>Material</th>
<th>DINP</th>
<th>10%</th>
<th>25%</th>
<th>50%</th>
<th>DIDP</th>
<th>10%</th>
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<tr>
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<td>82</td>
<td>79</td>
<td>75</td>
<td>83</td>
<td>82</td>
<td>80</td>
<td>75</td>
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</tbody>
</table>

**reFlex 100**

- Provides the functionality of ESO, imparting excellent thermal stability.
- Does not slow air release whereas many other high solvating plasticizers can.
- Offers greater efficiency. Less plasticizer is required to achieve equal hardness.
reFlex™ 100 as an “Accelerator”

Paste Viscosity

✓ reFlex 100 can be used at various levels to reduce paste viscosity without significantly impacting viscosity stability.
reFlex™ 100 as an “Accelerator”

Gel Rates

As the level of reFlex 100 is increased, the gel temperature is continuously decreased by as much as ~15°C at a 50% substitution.
reFlex™ 100 as an “Accelerator”
Mechanical Properties

reFlex 100
✓ Promotes early development of mechanical properties...

...but ultimate tensile strength is lower due to the reduced durometer of the blends.
reFlex™ 100 as an “Accelerator”

Heat Stability

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

<table>
<thead>
<tr>
<th></th>
<th>5 Minutes</th>
<th>60 Minutes</th>
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<td>50% reFlex 100</td>
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As the level of reFlex 100 is increased, heat stability progressively improves.
reFlex™ 100 as a Non-Phthalate “Accelerator”

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- Again, ESO is not required as reFlex 100 imparts excellent heat stability.
- Excellent air release is maintained at all levels of reFlex 100.
**reFlex™ 100** as a Non-Phthalate “Accelerator”

**Paste Viscosity**

- While DINCH has lower paste viscosity than typical phthalates, **reFlex 100** is still effective in reducing paste viscosity further.

- Viscosity stability is not adversely affected until levels of 50% are approached.
**reFlex™ 100** as a Non-Phthalate “Accelerator”

*Gel Rates*

- 100% DINCH
- 10% reFlex 100
- 25% reFlex 100
- 50% reFlex 100

✓ Adding more **reFlex 100** progressively reduces the gel temperature and increases the gel rate as evidenced by the slope of the plot increasing.
**reFlex™ 100 as a Non-Phthalate “Accelerator”**

**Mechanical Properties**

- **reFlex 100**
  - Promotes early development of mechanical properties...

...but ultimate tensile strength is lower due to the reduced durometer of the blends.
**reFlex™ 100 as a Non-Phthalate “Accelerator”**

**Heat Stability**

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✔️ As the level of **reFlex 100** is increased, heat stability progressively improves as before.
reFlex™ 100 as an “Accelerator”

Summary

- As companies have been compelled to replace high solvating phthalate plasticizers, productivity has often been sacrificed.
- **reFlex 100** allows lost productivity to be restored through:
  - Fast gelation and fusion
  - Increased efficiency
- With the added benefits of:
  - Reduced paste viscosity
  - Improved heat stability
  - The incorporation of rapidly renewable content
- Without impacting:
  - Air release and viscosity stability
- These benefits can be achieved in both traditional phthalate as well as non-phthalate systems.
Purpose: To promote the increased purchase and use of biobased products with the following benefits:

经济 - Promote economic development, create new jobs, provide new markets for farm commodities

环境 - 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:

产品标签 - USDA certifies and awards labels to qualifying products to increase consumer recognition of biobased products

联邦采购偏好 - 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
Discussion

Questions?
Thank You!

Please contact

stephen.horton@polyone.com

with any questions

Steve Horton

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