Allessa VELVETOL®
A Family of Sustainable High Performance Polyols

Royal Society of Chemistry Symposium 2019
June 26, 2019, Basel

David Hess
Sales & Marketing Manager
### ICIG - Market Oriented Platforms

<table>
<thead>
<tr>
<th>Platform</th>
<th>Sales (€ million)</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Chemicals</td>
<td>~613</td>
<td>~1,785</td>
</tr>
<tr>
<td>Pharma</td>
<td>~363</td>
<td>~1,367</td>
</tr>
<tr>
<td>Chlorovinyls(1)</td>
<td>~1,209</td>
<td>~1,209</td>
</tr>
<tr>
<td>Enterprises</td>
<td>~118</td>
<td>~945</td>
</tr>
</tbody>
</table>

**ICIG BUSINESS SERVICES:** IT, Accounting, Finance, Human Resources, Legal

- Corporate headquarters in Luxembourg and Frankfurt
- Back-office, ICIG Business Services, located in Wuppertal and Frankfurt, 100 employees
Allessa at a glance

- HQ and Production based in Frankfurt, Germany
- Production of fine chemicals and functional polymers
- ISO9001, 14001, 50001 certified
- Sales 2018: between 120 and 130 M€
- 70 / 30 split between custom manufacturing and line products
- About ~450 employees

Founded in the 19th century as Cassella AG
Allessa - Production Range

Line & Performance Products

Polymers & Specialties (Phenothiazine)

Performance Products

Pharma Intermediates

Coatings, Pigments & Dyes

Agro

Cosmetics & Pharma

Polymers & Specialties

Custom Manufacturing & Tolling
VELVETOL® - Landscape of Polyols

Bio-Based Polyol

PO3G
(VELVETOL®)
Polypropanediol
CAS# 31714-45-1

Polyester polyols

Polyether polyols

VELVETOL®

Petro-Based Polyols

PEG
Polyethylene glycol
CAS# 25322-68-3

PPG
Polypropylene glycol
CAS# 25322-69-4

PTMEG
Poly-(tetramethylene ether)-glycol
CAS# 25190-06-1

Vegetable Oil based Polyols
e.g. Soy bean oil, Castor oil…

1 Polyurethane / 2 co-polyetheramide / 3 co-polyetherester
VELVETOL® - The Bio-Based Manufacturing Process

Renewably sourced feedstocks are harvested, dried and then wet-milled to create a range of carbohydrate rich feedstocks such as glucose.

Glucose is converted into 1,3-propanediol using a patented microorganism under exact temperatures and conditions.

1,3-propanediol is used as a building block to produce a broad range of high performance Polyetherpolyols via Polycondensation.
Bio-based materials represent a minimal fraction of land usage globally ~ 810,000 ha

### Global Land Use: 2018 and 2023

- **Pasture**: 67% / 3.3 b ha
- **Food & Feed**: 25% / 1.24 b ha
- **Biofuels**: 1% / 53 mm ha*
- **Material Use**: 2% / 106 mm ha*
- **Biomaterials**: 0.016% / 0.81 mm ha* (2018)
  - 0.020% / 1.02 mm ha* (2023)

The land needed to produce biomaterials is a tiny fraction of the available land.

**Notes:**
- ha = hectares
- * In relation to global agricultural area
- ** Land use for biomaterials is part of the 2% material use

The critical challenges in food supply are not in capacity as the world produces enough food to feed everyone. The root causes of food insecurity, vary weak infrastructure to economic instability.
Feedstock: Critical Challenges in Food Supply

Poverty and Income Inequality

Lack of Proper Distribution and Logistics

Military Conflicts

Inefficient Agriculture Practices

Climate, Pest and Disease Effects

According to the UN, “there is sufficient capacity in the world to produce enough food to feed everyone adequately; [but]...793 million people still suffer from chronic hunger.”

VELVETOL® - External Growth Drivers

Global trends

- Climate change
- Population growth
- Increasing urbanization
- Growing middle class

Needs

- Global trends
- Growing middle class

- Climate change
  - Efficient production concepts
  - Reduction of emissions

- Population growth
  - Long-lasting goods
  - Recycling concepts

- Increasing urbanization
  - New housings
  - New furnitures

- Growing middle class
  - High quality goods
  - Higher standard of living
  - Sustainability as USP for brands

Outlook

- PUs
  - 2017: 16.9 Mt
  - 2022E: 21.3 Mt
  - ~5% growth

- CASE®
  - 2017: 3.3 Mt
  - 2022E: 3.9 Mt
  - ~4% growth

Solutions

- ~40% less greenhouse gas emissions
- ~40% less fossil energy
- PUs made from renewable resources
- Recyclable TPs
- Solvent-free coatings and adhesives
- PUs without plasticizers

Notes:
Mt = Mio. tons
1 Polyurethane / 2 Coatings, Adhesives, Sealants, Elastomers

Source: Securing profitable growth in more challenging times, Roadshow presentation Covestro; February 2019
VELVETOL® - Drivers for the introduction of sustainable goods

Differentiation

New Features & Performance
Brand Value & Reputation
Cost savings
Legislation

Externality
VELVETOL® - Environmental Benefits

Non-Renewable Energy

Green House Gas Emission

Source: DuPont™ Cerenol® - A New Family of Sustainable and Environmentally Friendly Materials, 2008, Washington DC

1 Industrial Average: 39% Reppe, 26% GEMINOX, 21% Davy, 14% Mitsubishi
VELVETOL® - Key PU Applications

Footwear
- TPU elastomers
- TPU waterproof breathable films
- Hot melt adhesives
- WPUD adhesives/coatings

Performance Textiles
- TPU waterproof breathable films
- PU synthetic leather (e.g. accessories)
- TPU membranes (e.g. softshell jacket)
- PU fibers

Furniture and Automotive
- TPU elastomers
- Hot melt adhesives
- PU synthetic leather
- PUD coatings
VELVETOL® - Performance at the Molecular Level

The odd even effect varies the packing of the hard block segments, and results in unique mechanical properties of the final product.

## Physical Properties: VELVETOL® vs. other Polyols

<table>
<thead>
<tr>
<th>Property</th>
<th>VELVETOL®</th>
<th>PTMEG</th>
<th>PPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material source</td>
<td>Renewable</td>
<td>Non-renewable</td>
<td>Non-renewable</td>
</tr>
<tr>
<td>OH-Type</td>
<td>Primary</td>
<td>Primary</td>
<td>Secondary</td>
</tr>
<tr>
<td>Reactivity</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Physical state</td>
<td>Liquid/Solid</td>
<td>Semi-crystalline</td>
<td>Solid</td>
</tr>
<tr>
<td>Crystallinity</td>
<td>Semi-crystalline</td>
<td>Semi-crystalline</td>
<td>Amorphous</td>
</tr>
<tr>
<td>Polydispersion</td>
<td>Broad</td>
<td>Narrow</td>
<td>Narrow</td>
</tr>
<tr>
<td>Tm</td>
<td>Low</td>
<td>High</td>
<td>No melt</td>
</tr>
<tr>
<td>Tg</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Low</td>
<td>High</td>
<td>Very low</td>
</tr>
<tr>
<td>Oxidative stability</td>
<td>Superior</td>
<td>Superior</td>
<td>Inferior</td>
</tr>
</tbody>
</table>

Easier operation at conveying, handling and mixing processes thanks to its superior properties versus PTMEG

Source: DuPont™ Cerenol® - A New Family of Sustainable and Environmentally Friendly Materials, 2008, Washington DC
## Physical Properties: VELVETOL® vs. other Polyols

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tg, °C</td>
<td>-77</td>
<td>-85</td>
<td>-72</td>
</tr>
<tr>
<td>Tm, °C</td>
<td>17</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>Viscosity @60°C, cP</td>
<td>340</td>
<td>575</td>
<td>130</td>
</tr>
<tr>
<td>Tc, °C</td>
<td>-37.5</td>
<td>5.7</td>
<td>30.8</td>
</tr>
<tr>
<td>Crystallization half time @-5°C, min</td>
<td>16.4</td>
<td>0.85</td>
<td>ND</td>
</tr>
<tr>
<td>MWD</td>
<td>1.7 - 18</td>
<td>1.7 - 1.9</td>
<td>&lt; 1.2</td>
</tr>
</tbody>
</table>

Easier operation at conveying, handling and mixing processes thanks to its superior properties versus PTMEG

Source: DuPont™ Cerenol® - A New Family of Sustainable and Environmentally Friendly Materials, 2008, Washington DC
VELVETOL® has comparable thermo-oxidative stability vs. PTMEG in spite the higher ether links.

Source: DuPont™ Cerenol® - A New Family of Sustainable and Environmentally Friendly Materials, 2008, Washington DC
VELVETOL®: PU Synthetic Leather

- Velvetol® can be used in PU skin coatings
- Based on bio-content needs we can explore use in the top coat or form layer

Source: Susterra® Propanediol Synthetic Leather, Laurie Kronenberg, March 2016
VELVETOL®: Waterborne PUDs

Physical properties of waterborne PU leather samples

<table>
<thead>
<tr>
<th>Polyol</th>
<th>VELVETOL®</th>
<th>PTMEG</th>
<th>AA-PDO</th>
<th>Sb-PDO</th>
<th>AA-BDO</th>
<th>AA-HDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Content, %</td>
<td>38.9</td>
<td>39.7</td>
<td>40.6</td>
<td>40.7</td>
<td>40.6</td>
<td>40.1</td>
</tr>
<tr>
<td>pH</td>
<td>7.36</td>
<td>7.11</td>
<td>7.23</td>
<td>7.34</td>
<td>7.15</td>
<td>7.44</td>
</tr>
<tr>
<td>Viscosity, mPa·s</td>
<td>18.0</td>
<td>46.5</td>
<td>34.3</td>
<td>76.3</td>
<td>29.3</td>
<td>41.3</td>
</tr>
<tr>
<td>Particle Size, nm</td>
<td>76.8</td>
<td>72.3</td>
<td>74.8</td>
<td>68.2</td>
<td>65.6</td>
<td>73.9</td>
</tr>
<tr>
<td>PDI</td>
<td>0.081</td>
<td>0.081</td>
<td>0.099</td>
<td>0.095</td>
<td>0.073</td>
<td>0.046</td>
</tr>
</tbody>
</table>

The viscosity of the VELVETOL® sample is the lowest among all of the waterborne PUD samples due to its high particle size!

Source: Bio-based waterborne polyurethane dispersion evaluation for synthetic leather applications, M. Shen, April 2017
VELVETOL®: Waterborne PUDs

DSC curves of waterborne WPU films

\[ T_g \approx \text{Tg}^{\text{PTMEG}} \quad \text{Flexibility and cold resistance performance should be improved.} \]

Source: Bio-based waterborne polyurethane dispersion evaluation for synthetic leather applications, M. Shen, April 2017
### Physical test results of waterborne PU leather samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Polyol</th>
<th>VELVETOL®</th>
<th>PTMEG</th>
<th>AA-PDO</th>
<th>Sb-PDO</th>
<th>AA-BDO</th>
<th>AA-HDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20°C</td>
<td></td>
<td></td>
<td>Pass</td>
<td>Pass</td>
<td>Slight damage</td>
<td>Pass</td>
<td>Crack</td>
</tr>
<tr>
<td>Taber abrasion</td>
<td>10000</td>
<td></td>
<td>7500</td>
<td>850</td>
<td>2100</td>
<td>700</td>
<td>1700</td>
</tr>
</tbody>
</table>

The synthetic leather sample based on VELVETOL® has the best combined abrasion resistance and low temperature flexibility.

Source: Bio-based waterborne polyurethane dispersion evaluation for synthetic leather applications, M. Shen, April 2017
VELVETOL®: Waterborne PUDs

Taber abrasion testing (H22 1kg/cycle) on various skin coat samples
Each sample was run until 1500 cycles

PUDs comprising PO3G had the best combined abrasion resistance and low temperature flexibility!

- BDO/AA: 0% bio-content
- PDO/AA: ~22% bio-content
- PDO/Sb: ~70% bio-content
- PO3G: ~70% bio-content
**VELVETOL®: Performance Coatings**

The addition of VELVETOL® in combination with an ethylene oxide oligomer improves chip performance in comparison to the use of only ethylene oxide oligomer in Primer C.

**Gravelometer Test Results**

<table>
<thead>
<tr>
<th>Blue Metallic Base Coat</th>
<th>3 pints stones room temp.</th>
<th>1 pints stones frozen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer A (VELVETOL®)</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Primer B (VELVETOL®)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Primer C</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Red Base Coat</th>
<th>3 pints stones room temp.</th>
<th>1 pints stones frozen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer A (VELVETOL®)</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Primer B (VELVETOL®)</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Primer C</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
VELVETOL®: Performance Coatings

Gravelometer Test

- PO3G
- EO

- Improvement in flexibility
- Hardness retention
- Improvement in chip resistance

Scratch Test

- PO3G
- PPG

- Improved adhesion
- Improved drying time

Source: DuPont™ Cerenol® - A New Family of Sustainable and Environmentally Friendly Materials, 2008, Washington DC
VELVETOL®: Summary

- High durability (abrasion resistance)
- Highly flexible molecules vs. PTMEG
- Improved hardness retention & chip resistance
- Improved adhesion…

Features & Performance

- ~40% less greenhouse gas emission
- ~40% less use of non-renewable energy
- 100% bio-based feedstock
- 100% recyclable high performance TPUs…

Brand Value & Reputation

- Reduced drying / demolding time
- Improved processability (mixing, pumping etc.) and less wear (low mp, low viscosity)
- Reduction of cycle times (low mp and viscosity)…

Cost Reduction
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