ALLESSA

Member of WeylChem Group of Companies

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

Fine Chemicals

WEYLCHEM

SALES ~ €613 million

EMPLOYEES ~ 1,785

Pharma

CORDENPHARMA

SALES ~ €363 million

EMPLOYEES ~ 1,367

Chlorovinyls[(1)]

VYNOVA

SALES ~ €1,209 million

EMPLOYEES ~ 1,209

Enterprises

CarboTech Your Adsorption Company

CORDENBIOCHEM

ENKA THE ART OF VISCOSE

RÜTGERS Organics

impra we care for wood

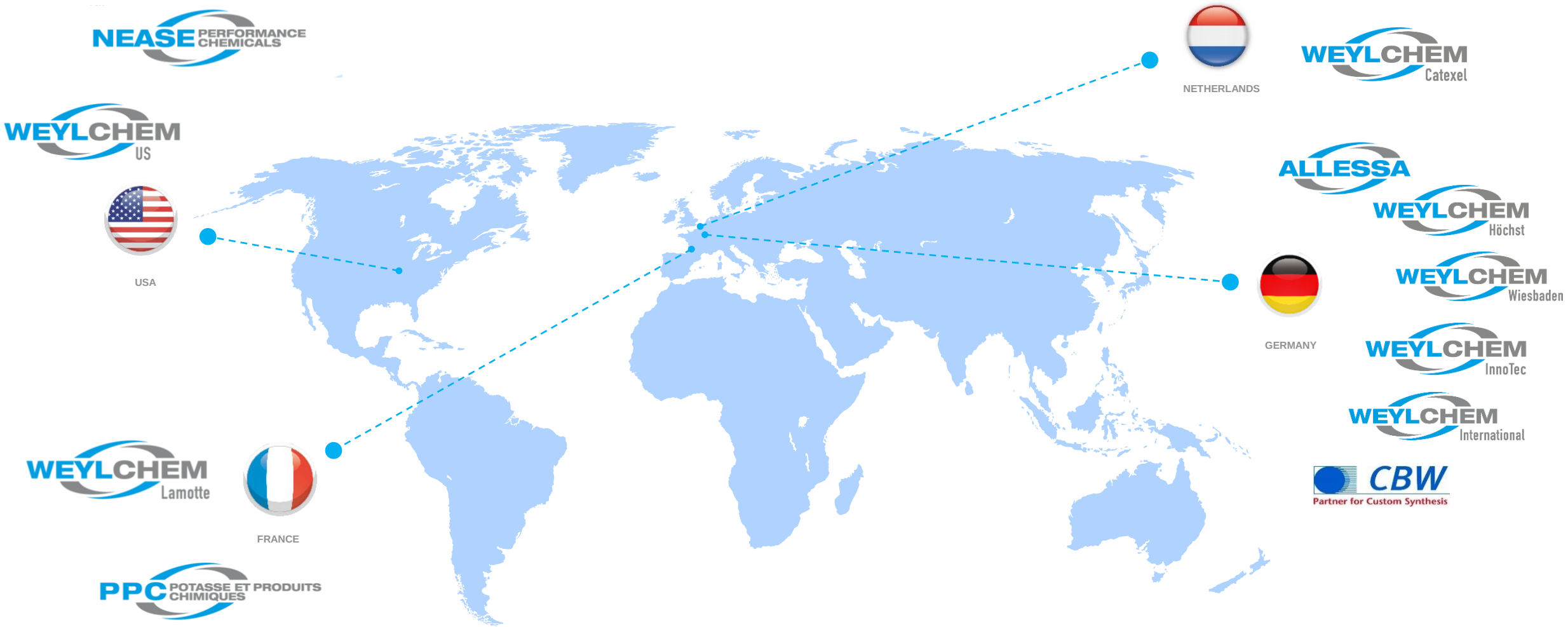
SALES ~ €118 million

EMPLOYEES ~ 945

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

WeylChem - Companies and Locations



Allessa - Overview

Founded in the 19th century as Cassella AG

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

Allessa - Production Range

Line & Performance Products

Polymers & Specialties (Phenothiazine)

Performance Products

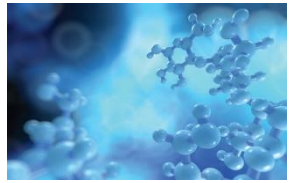
Pharma Intermediates

Coatings, Pigments & Dyes

Agro

Cosmetics & Pharma

Polymers & Specialties



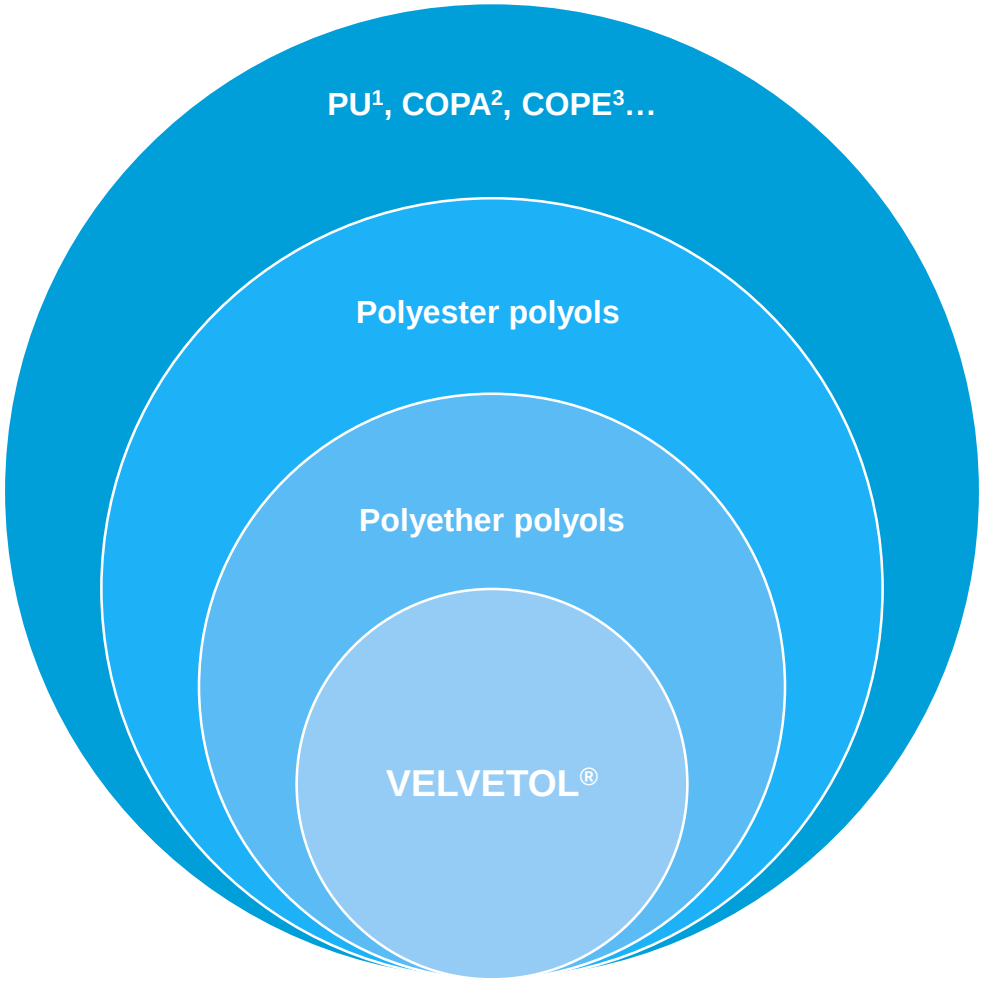
Custom Manufacturing & Tolling

VELVETOL® - Landscape of Polyols

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

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

Bio-Based Polyol



1 Poylurethane / 2 co-polyetheramide / 3 co-polyetherester

Petro-Based Polyols

PEG
Polyethylene glycol
CAS# 25322-68-3

PPG
Polypropylene glycol
CAS# 25322-69-4

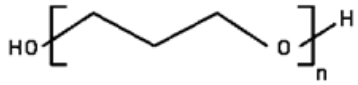
PTMEG
Poly-(tetramethylene ether)-glycol
CAS# 25190-06-1

VELVETOL® - The Bio-Based Manufacturing Process

Enzymes

Microorganisms

Polymerization



MW: 500 – 2700 g/mol

CAS# 31714-45-1

Glucose → Bio-PDO → VELVETOL®

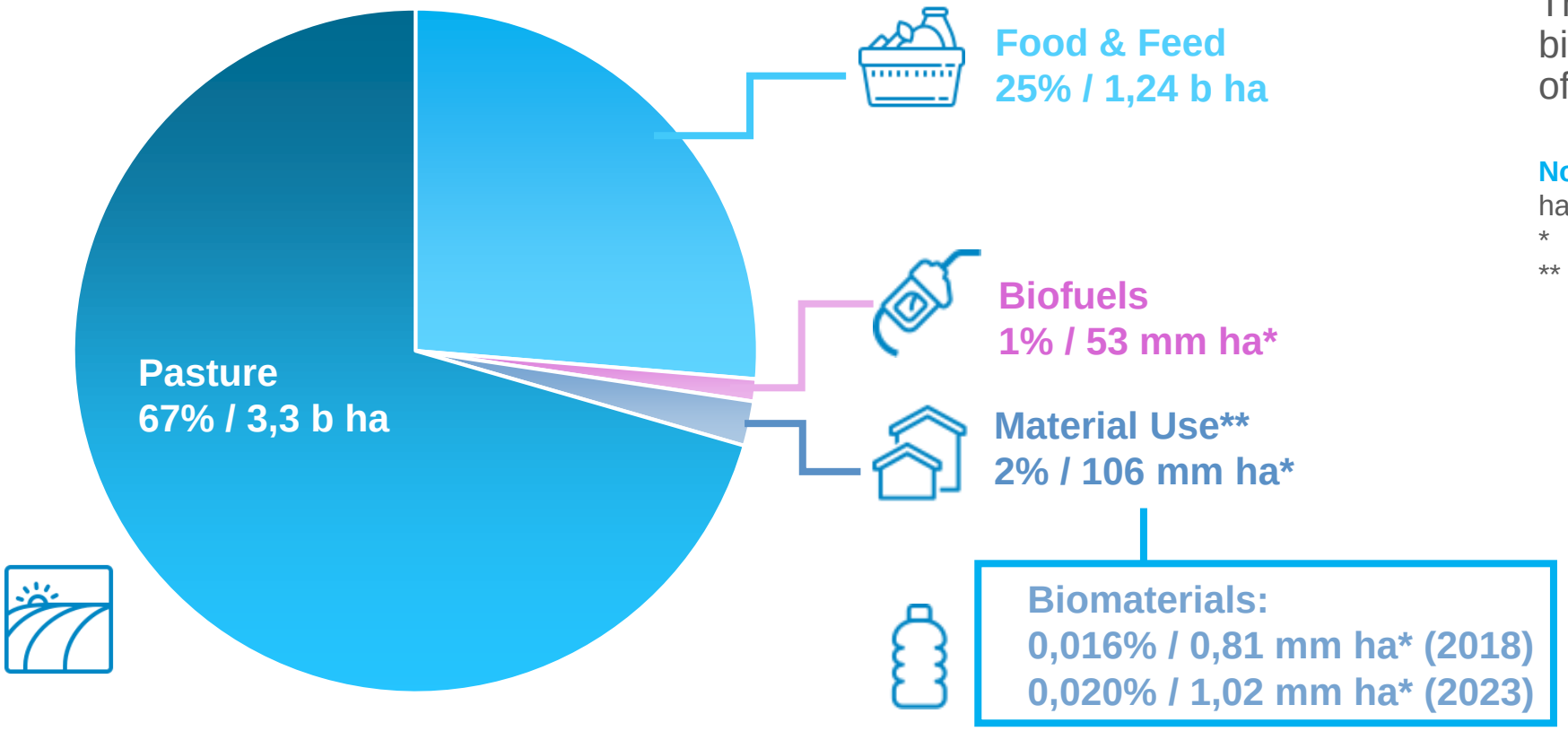
Renewably sourced feedstocks are harvested, dried and then wet-milled to create a range of carbohydrate rich feedstocks such as glucose.

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.

Feedstock: U.S. Industrial Field Corn Processing

Global Land Use: 2018 and 2023



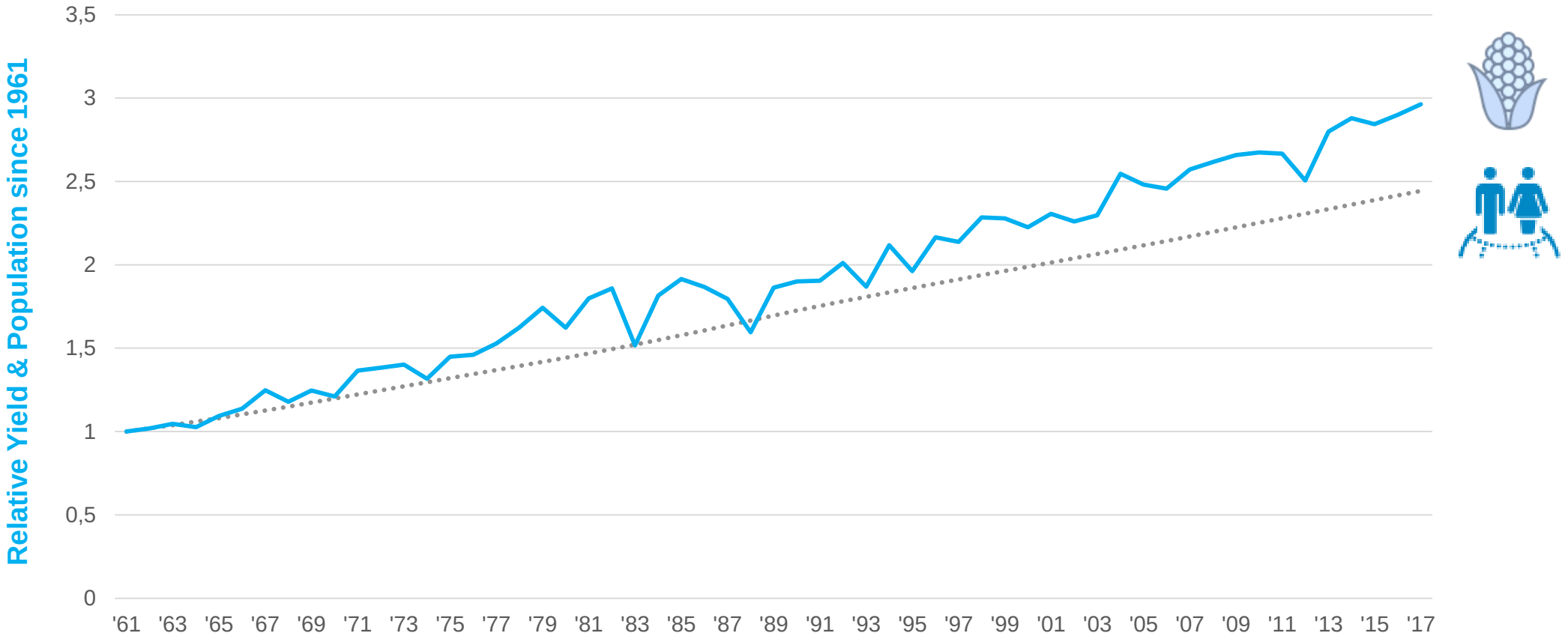
The land needed to produce biomaterials is a tiny fraction of the available land.

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

Bio-based materials represent a minimal fraction of land usage globally ~ 810,000 ha

Source: European Bioplastics (2018), FAO Stats (2014), nova-Institute (2018), and Institute for Bioplastics and Biocomposites (2018)

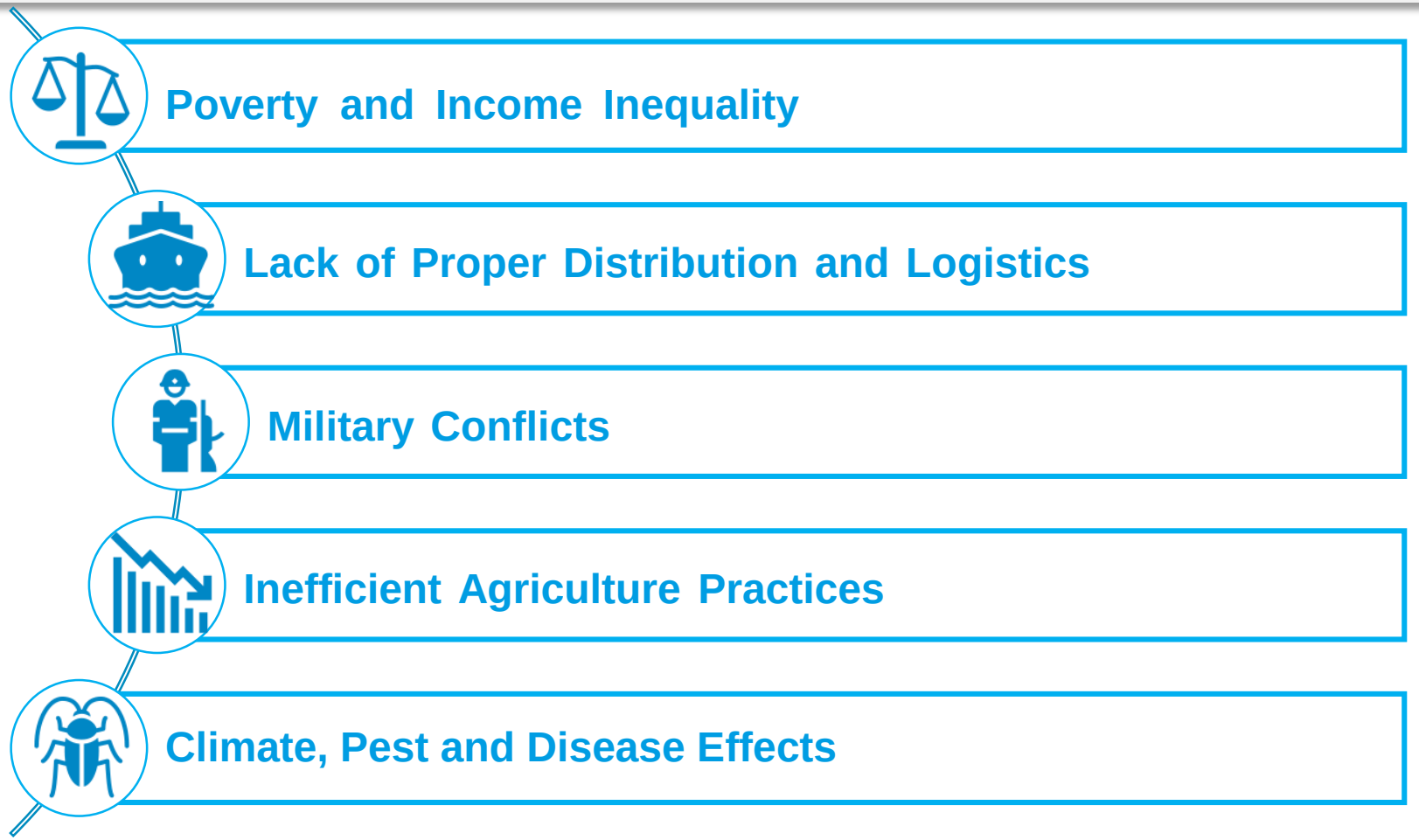
Feedstock: Relative Corn Grain Yield vs Population Growth Since: 1961-2018



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.

Source: ProExporter Network
Faostat data for 1961-2017

Feedstock: Critical Challenges in Food Supply



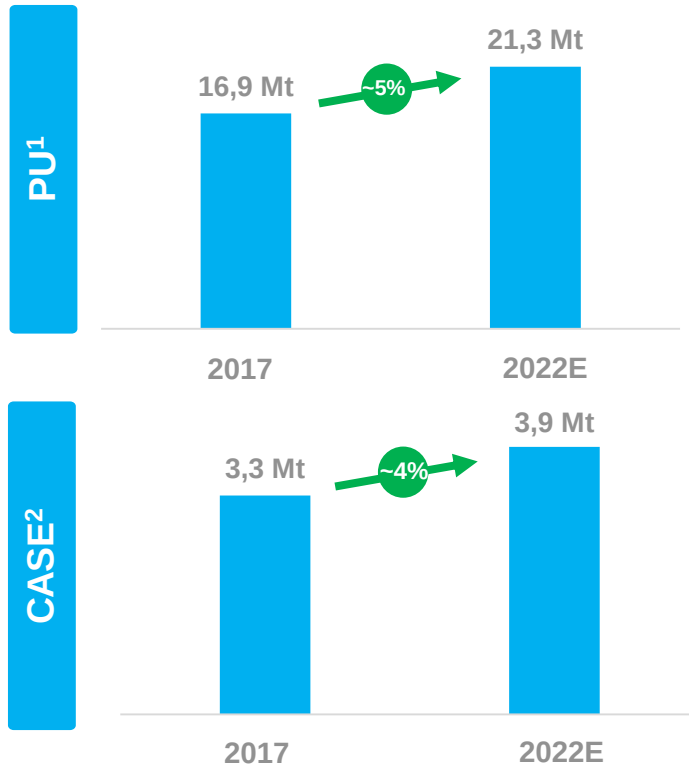
According to the UN, "there is sufficient capacity in the world to produce enough food to feed everyone adequately; [but]…793 million people still suffer from chronic hunger."

Source: www.fao.org/about/en;
FAO (2017) The future of food and agriculture: trends and Challenge;
FAO (2016), Peace and Food Security: Investing in resilience to sustain rural livelihoods amid conflict;
www.fao.org/food-loss-and-food-waste/en; FAO Hunger Map 2015

VELVETOL® - External Growth Drivers

Global trends	Needs
Climate change	• Efficient production concepts • Redution 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 • Sustainablity as USP for brands

Outlook



Solutions

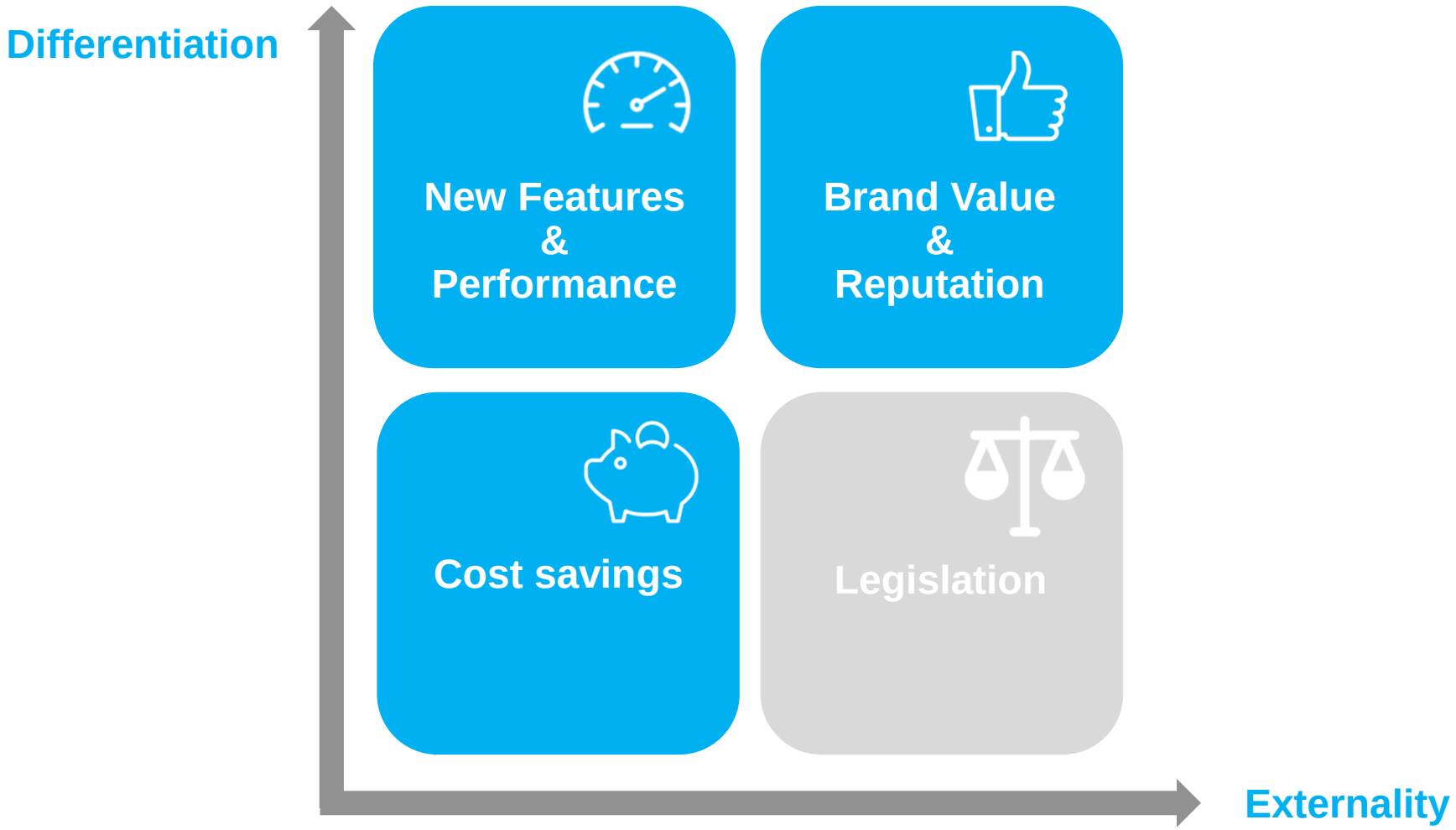
- ~40% less greenhouse gas emissions
- ~40% less fossil energy
- PUs made from renewable resources
- Recyclable TPUs
- Solvent-free coatings and adhesives
- PUs without plasticizers

Notes:
Mt = Mio. tons

1 Poylurethane / 2 Coatings, Adhesives, Sealants, Elastomers

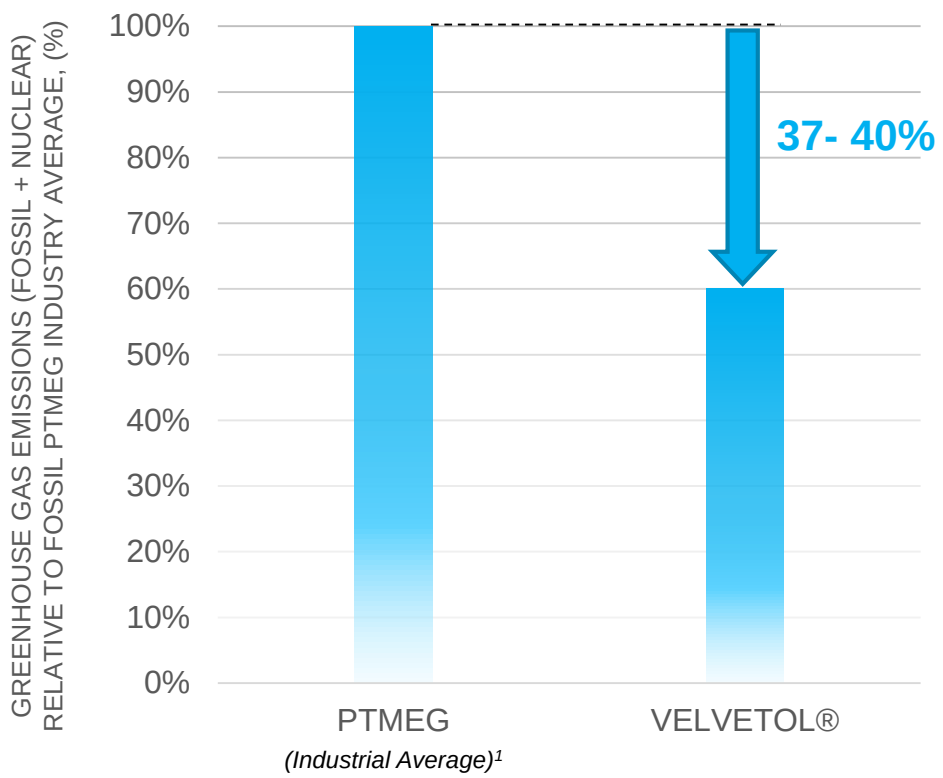
Source: Securing profitable growth in more challenging times, Roadshow presentation Covestro; February 2019

VELVETOL® - Drivers for the introduction of sustainable goods

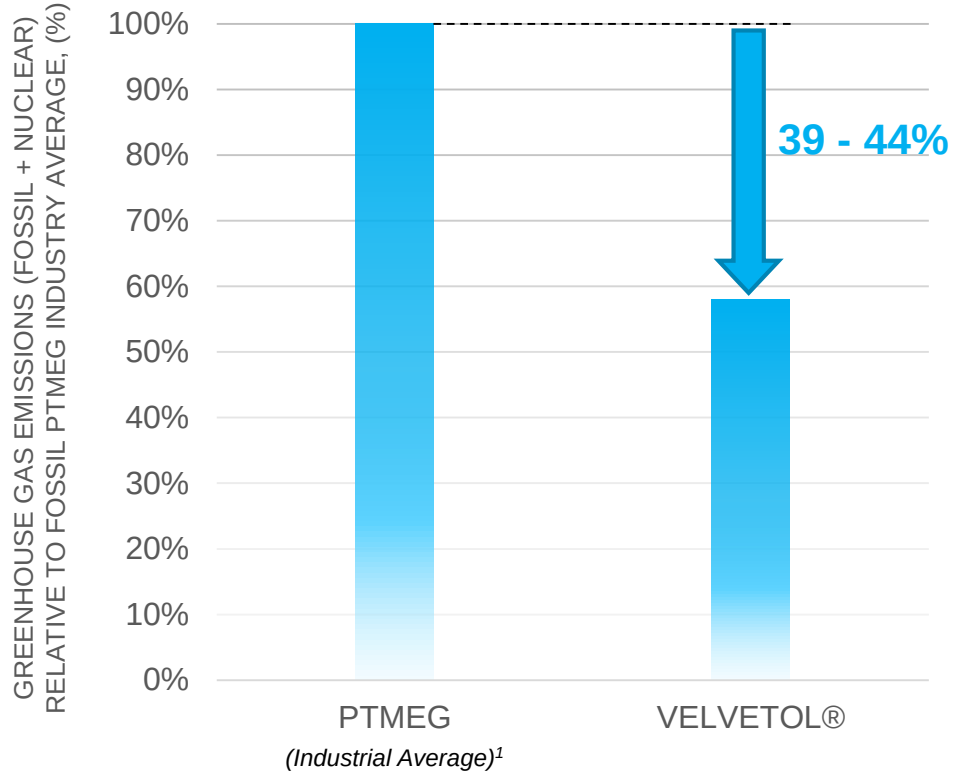


VELVETOL® - Environmental Benefits

Non-Renewable Energy



Green House Gas Emission



[1]*Industrial Average: 39% Reppe, 26% GEMINOX, 21% Davy, 14% Mitsubishi*

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

VELVETOL® - Key PU Applications

Footwear

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

Furniture and Automotive

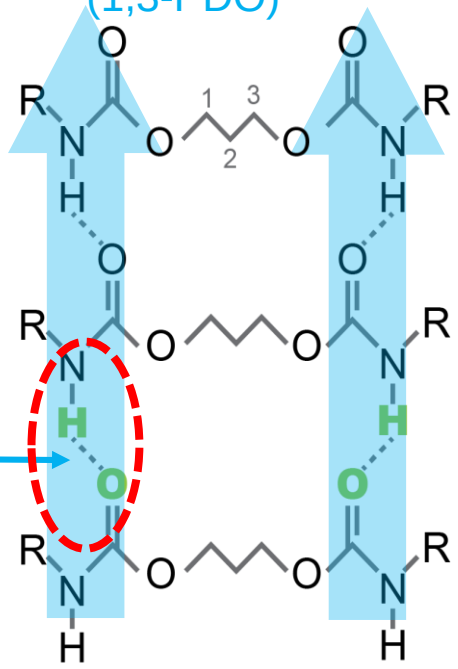
- TPU elastomers
- Hot melt adhesives
- PU synthetic leather
- PUD coatings

Performance Textiles

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

VELVETOL® - Performance at the Molecular Level

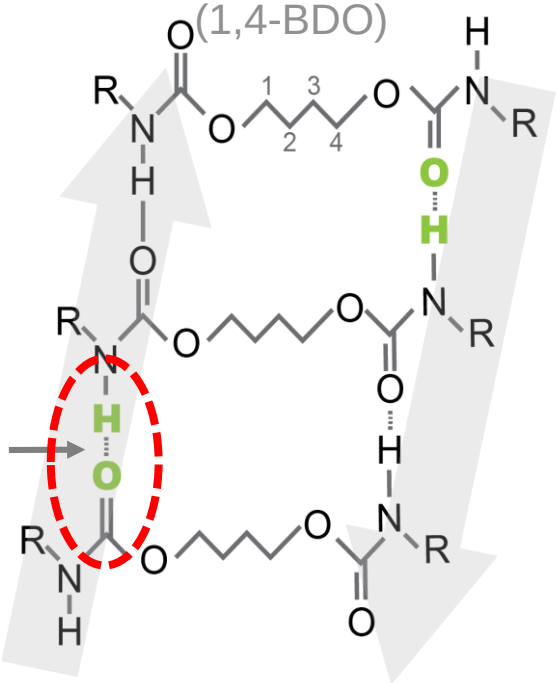
Propanediol
(1,3-PDO)



Long
hydrogen
bond

More
Flexibility

1,4-Butanediol
(1,4-BDO)



Short
hydrogen
bond

Less
Flexibility

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

Source: L. Born, H. Hespe, J. Crone, K.H. Wolf, Colloid and Polymer Science, 1982, 260(9), 819-828., J. Blackwell, M.R. Najarajan, T.B. Hoitink Polymer, 1981, 22, 1534-1539.O. Bayer, Agnew. Chem., A59, 257 (1947)

Physical Properties: VELVETOL® vs. other Polyols

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

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

ALLESSA

Physical Properties: VELVETOL® vs. other Polyols

Polyol	VELVETOL® H2000	PTMEG 2000	PEG 2000
Tg, °C	-77	-85	-72
Tm, °C	17	27	54
Viscosity @60°C, cP	340	575	130
Tc, °C	-37,5	5.7	30.8
Crystallization half time @-5°C, min	16.4	0.85	ND
MWD	1.7 - 18	1.7 - 1.9	< 1.2

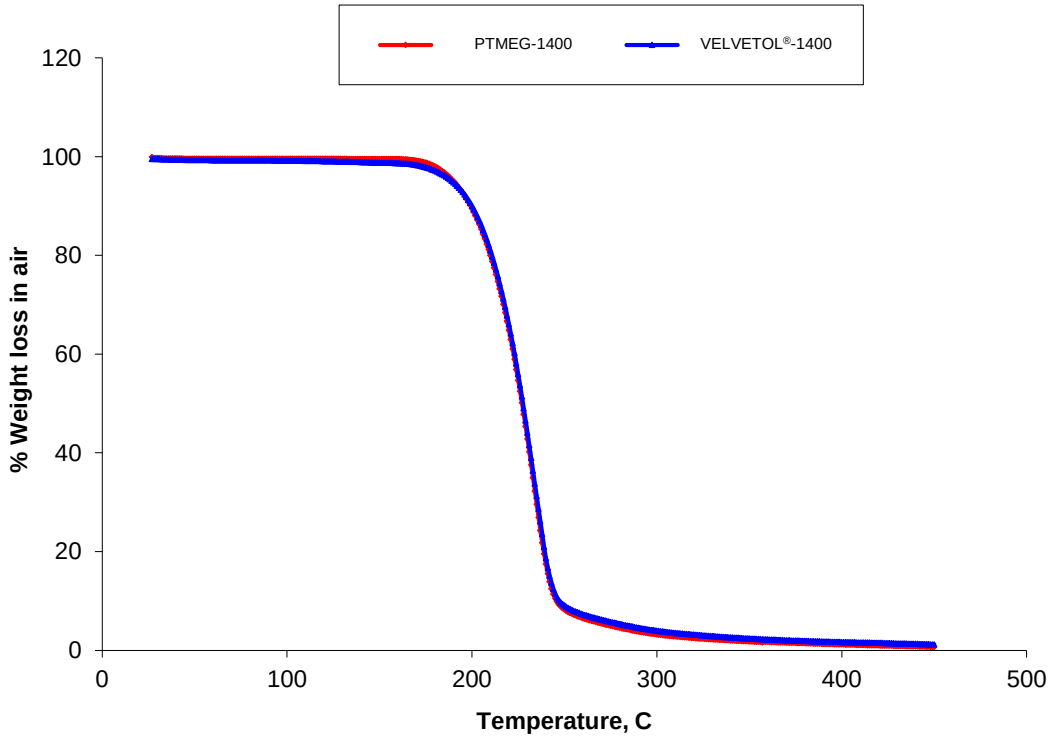
Easier operation at conveying, handling and mixing processes thanks to its superior properties versus PTMEG

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

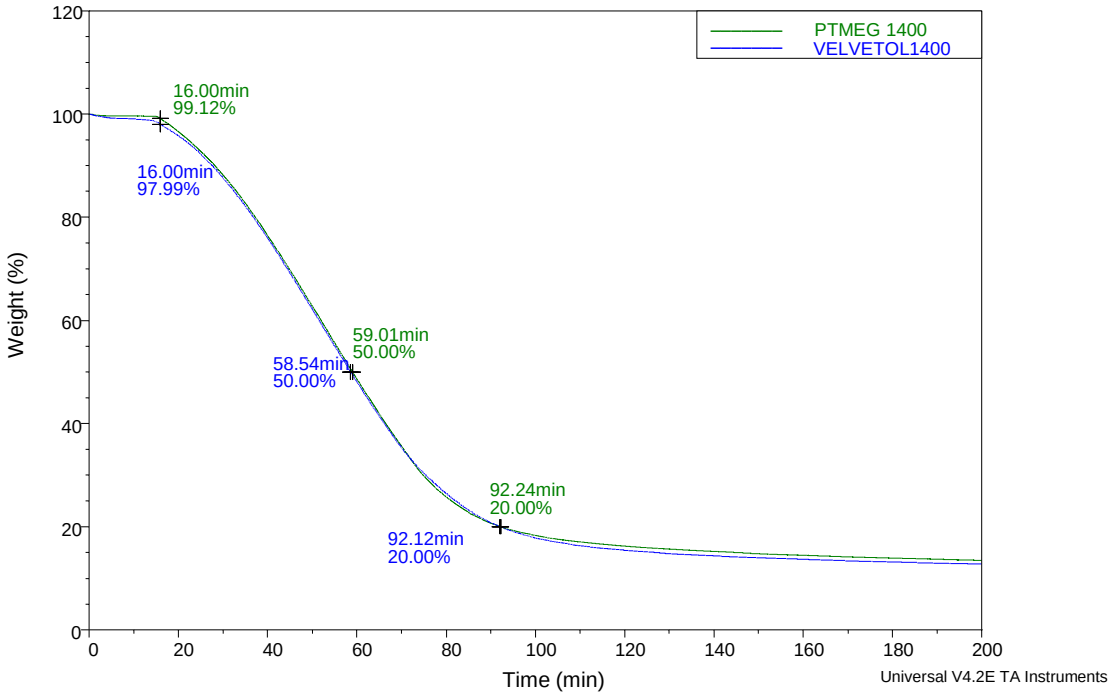
ALLESSA

Thermal Stability: VELVETOL® vs. PTMEG

TGA IN AIR



ISOTHERMAL AT 175 °C IN AIR

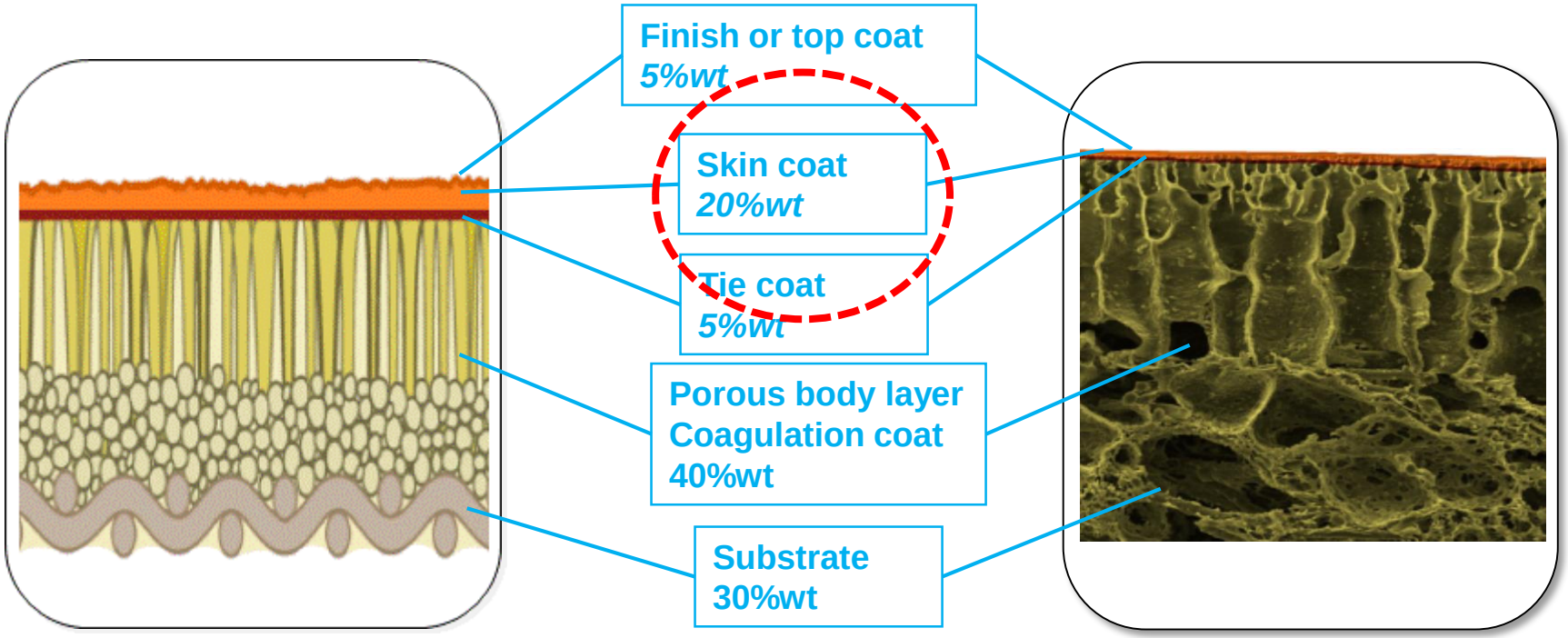


VELVETOL® has comparable thermo-oxidative stability vs. PTMEG in spite the higher ether links

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

Polyol	VELVETOL®	PTMEG	AA-PDO	Sb-PDO	AA-BDO	AA-HDO
Sample	H2000	PTMEG-2000	AA/PDO-2000	Sb/PDO-2000	AA/BDO-2000	AA/HDO-2000
Solid Content, %	38.9	39.7	40.6	40.7	40.6	40.1
pH	7.36	7.11	7.23	7.34	7.15	7.44
Viscosity, mPa·s	18.0 ✓	46.5	34,3	76.3	29.3	41.3
Particle Size, nm	76,8 ✓	72,3	74,8	68,2	65,6	73,9
PDI	0,081	0,081	0,099	0,095	0,073	0,046

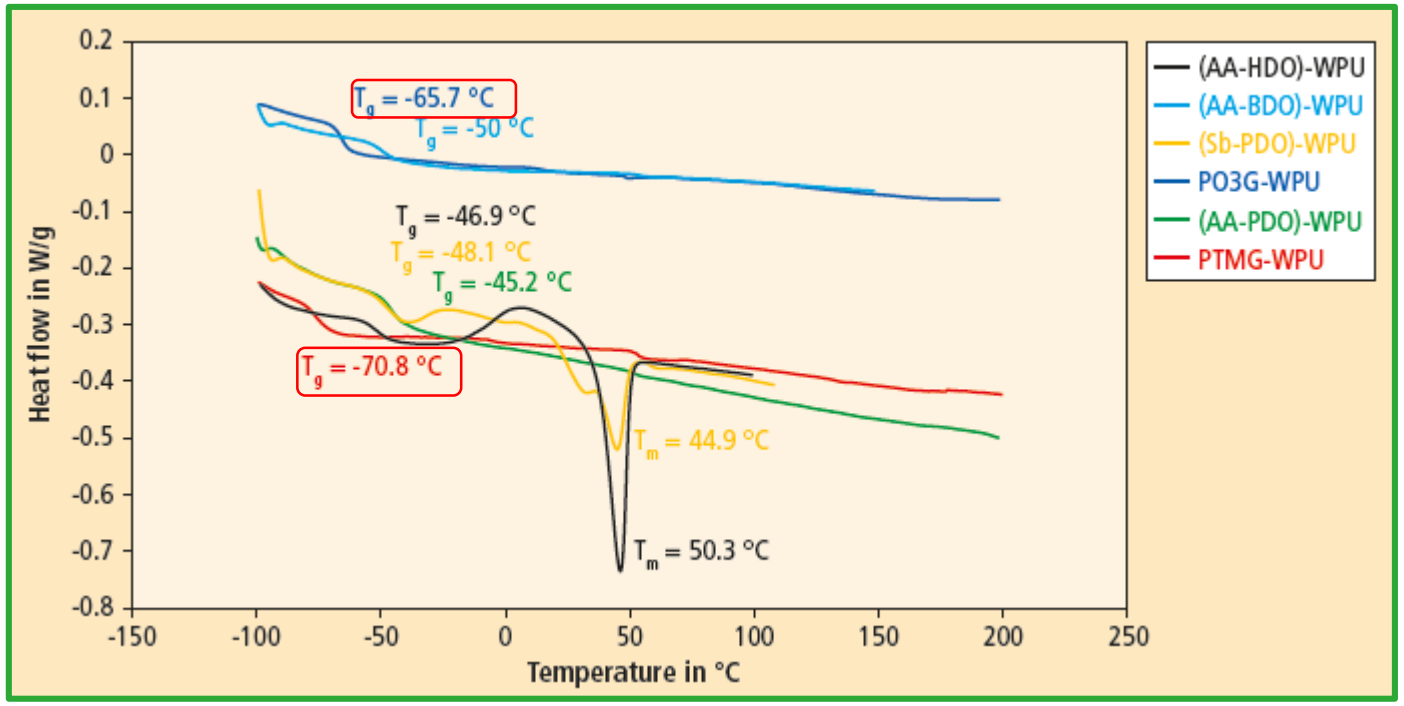
The viscosity of the VELVETOL® sample is the lowest among all of the waterborne PUD samples due to its high particle size!

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

ALLESSA

VELVETOL®: Waterborne PUDs

DSC curves of waterborne WPU films



	Tg in °C
VELVETOL®	-65,7
PTMEG	-70,8
AA-PDO	-45,2
Sb-PDO	-48,1
AA-BDO	-50,0
AA-HDO	-46,9

Tg^{PTMEG} ≈ $Tg^{VELVETOL®}$ - Flexibility and cold resistance performance should be improved.

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

VELVETOL®: Waterborne PUDs

Physical test results of waterborne PU leather samples

Polyol	VELVETOL®	PTMEG	AA-PDO	Sb-PDO	AA-BDO	AA-HDO
Sample	H2000	PTMEG-2000	AA/PDO-2000	Sb/PDO-2000	AA/BDO-2000	AA/HDO-2000
MEK (30 min)	Pass	Pass	Pass	Pass	Pass	Pass
-20°C (100000 cycles)	Pass	Pass	Slight damage	Pass	Crack	Pass
Taber abrasion (H22 1 kg) cycles	10000	7500	850	2100	700	1700

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

BDO/AA
0% bio-content

PDO/AA
~22% bio-content

PDO/Sb
~70% bio-content

PO3G
~70% bio-content

PUDs comprising PO3G had 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®: Performance Coatings

Gravelometer Test Results

Red Base Coat	3 pints stones room temp.	1 pints stones frozen
Primer A *(VELVETOL®)*	5	6
Primer B *(VELVETOL®)*	3	4
Primer C	1	2

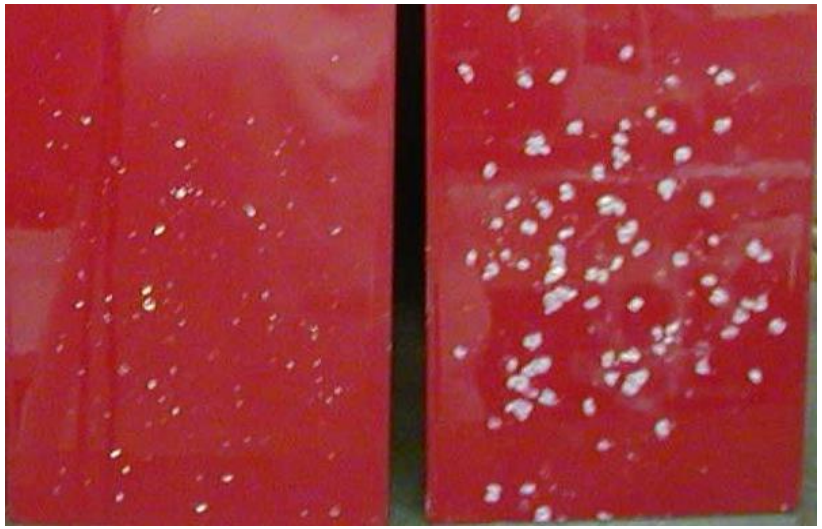
Blue Metallic Base Coat	3 pints stones room temp.	1 pints stones frozen
Primer A *(VELVETOL®)*	5	7
Primer B *(VELVETOL®)*	3	5
Primer C	3	4

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.

VELVETOL®: Performance Coatings

Gravelometer Test

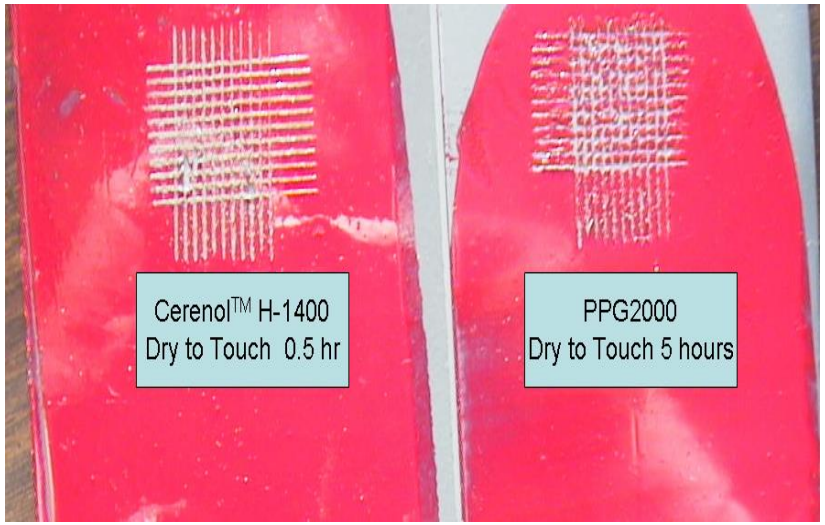
PO3G	EO



- 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 resitance)
- 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

David Hess
Sales & Marketing Manager

Allessa GmbH
Alt-Fechenheim 34
60386 Frankfurt am Main
Germany

+49 (0) 69 4109 2643

david.hess@allessa.com
www.weylchem.com/allessa-gmbh.html