Title: **Total Corbion PLA: An innovative Joint Venture making PLA innovations a reality**

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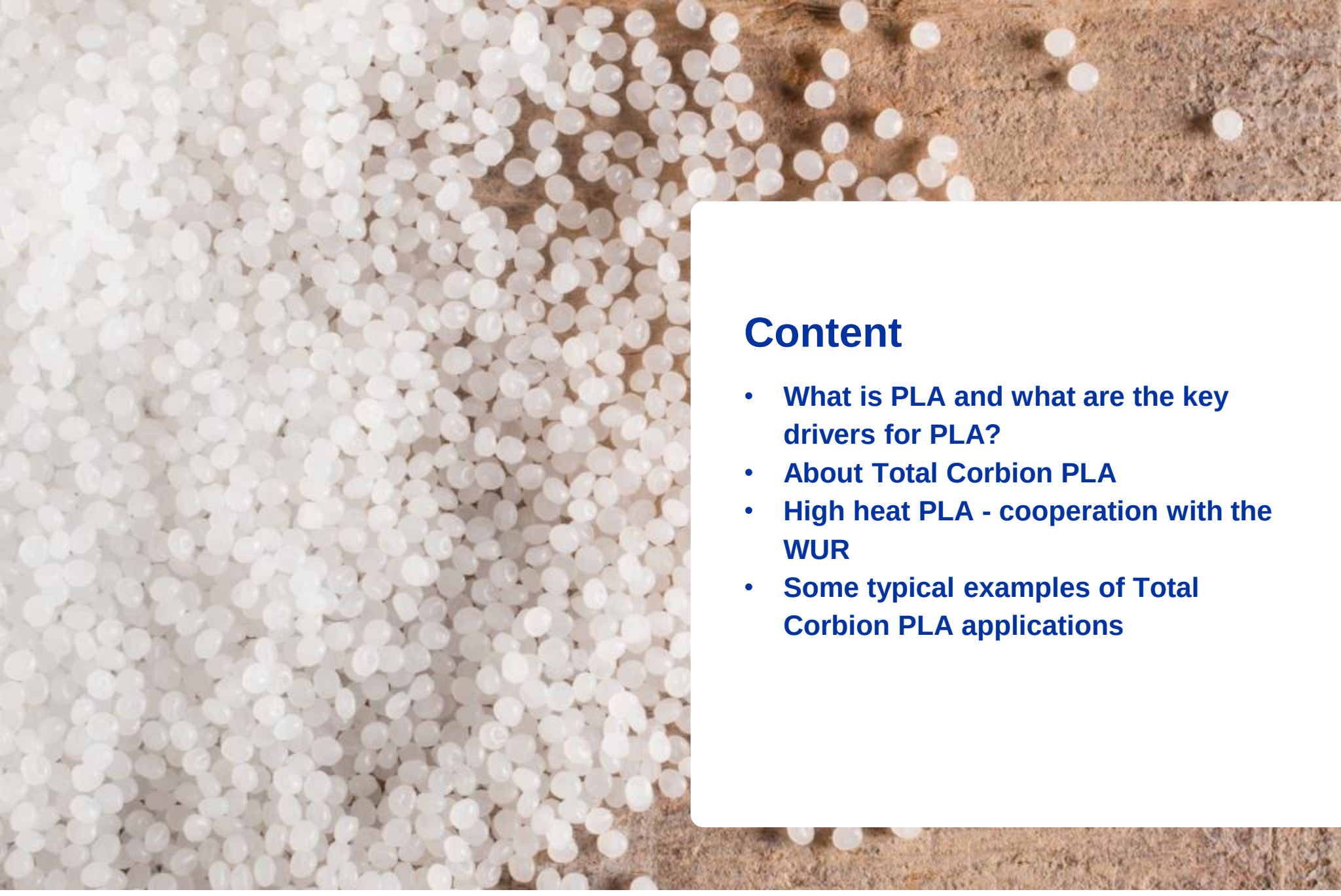
Curriculum:
Kees Joziasse studied at the Faculty of Chemical Technology and Material Science at Delft University. He obtained his doctorate at the Polymer Laboratory of the Faculty of Chemistry, University of Groningen. He has worked for Royal Philips Electronics of the Netherlands and Havells India Ltd in various global roles in different countries. In 2010, Kees joined Corbion as Sr. Director Innovation for the Market Unit PLA, responsible for the global product & application development portfolio, including PLA polymerization technology, compounding, injection molding, film blowing, fiber spinning, sheet extrusion and thermoforming. Since March 2017, he is Sr. Director R&D in Total Corbion PLA bv.

Abstract:
Total Corbion is a recently formed Joint Venture, with a strong focus on R&D, innovation and market development. During the presentation we will share some background about this JV. Many years ago Purac started to work on high heat PLA. Evaluating the different formulations to come to high heat PLA / PDLA compounds was done in close cooperation with the WUR. Following the initial scoping and compound development (done with the WUR) various specific application development processes were completed. This resulted in the commercial launch of a number of applications that make use of the PLA / PDLA technology: High heat coffee cups for Vending, single use coffee capsules, a durable computer mouse and a rain pipe system.

Total Corbion PLA

An innovative Joint Venture making PLA innovations a reality.

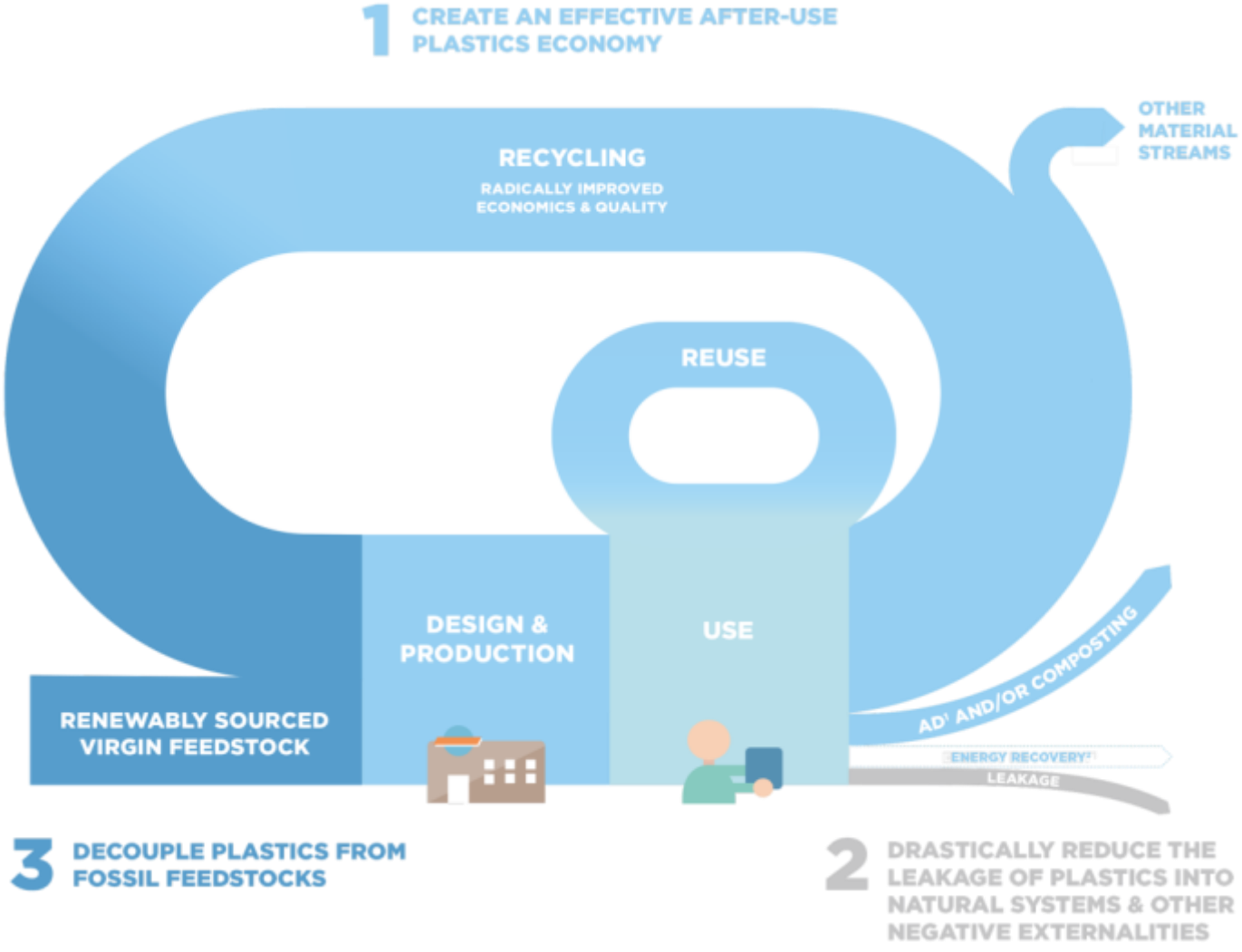
BPM symposium, June 2017
Kees Joziasse



Content

- What is PLA and what are the key drivers for PLA?
- About Total Corbion PLA
- High heat PLA - cooperation with the WUR
- Some typical examples of Total Corbion PLA applications

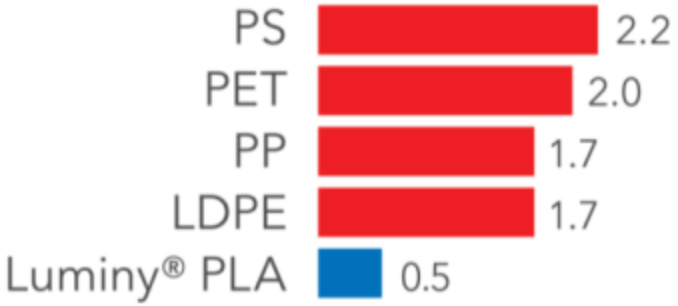
Ambitions of the new plastics economy:
Capturing the opportunity



Source: World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, *The New Plastics Economy – Rethinking the future of plastics* p.31 (2016, http://www.ellenmacarthurfoundation.org/publications).

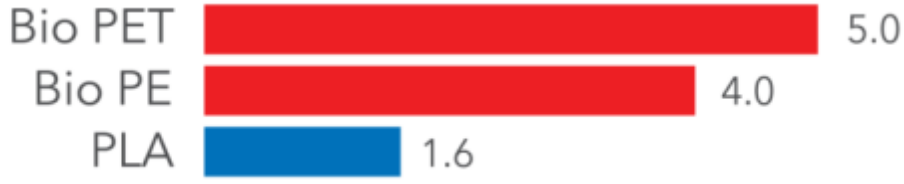
PLA carbon footprint & feedstock efficiency

Carbon Footprint Emissions from production of common polymers*



Carbohydrate Usage of Bioplastics

(kg sugar per kg plastic)

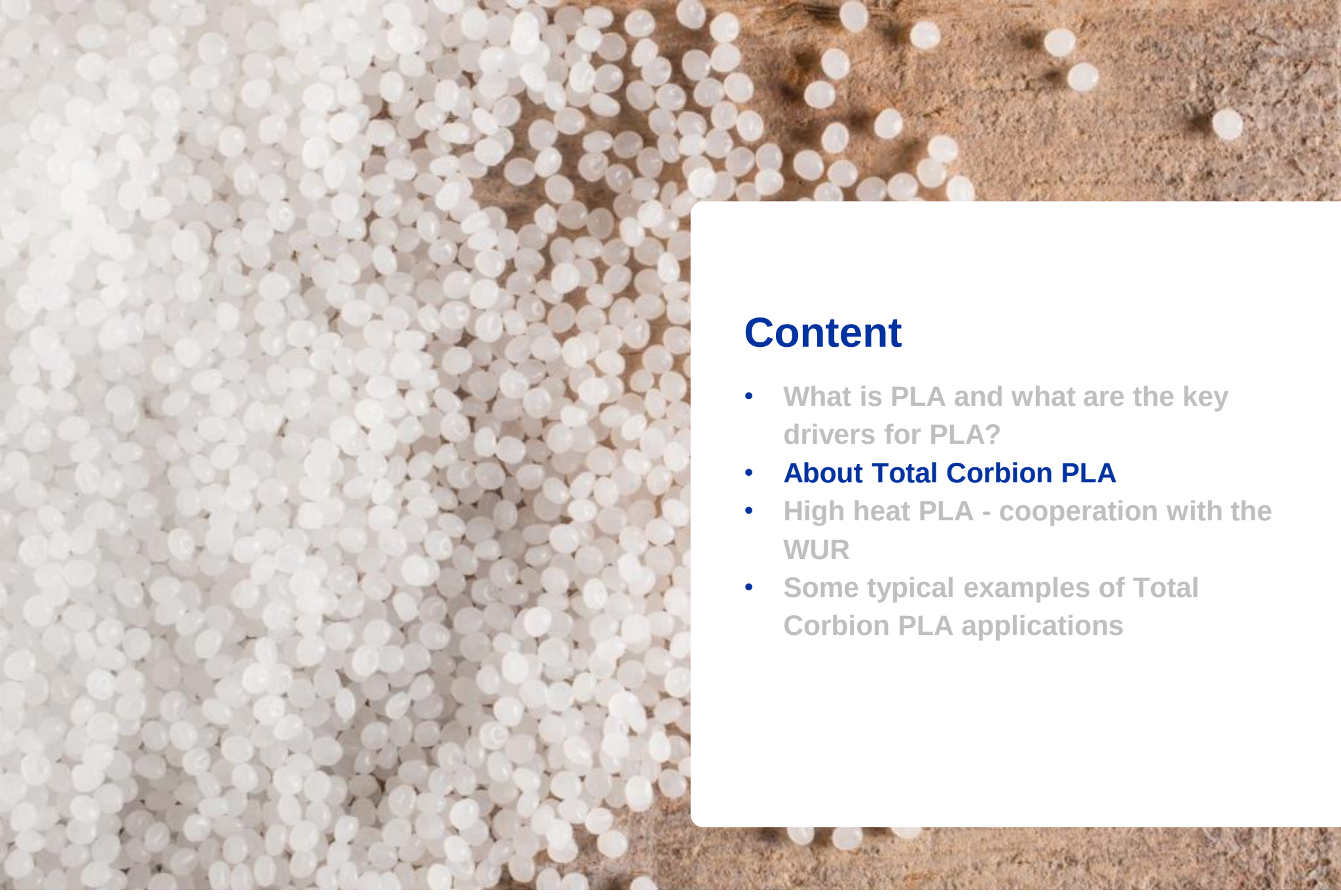


Sources: www.lca.plsaticseurope.org and Int. Journal Life Cycle Assessment, '*LCA of the manufacture of lactide and PLA…'* 3 Aug 2010.

TOTAL | Corbion

Advantages of PLA bioplastics

- Made from renewable raw materials
- Biodegradable/Compostable EN13432
- Recyclable
- Favorable CO_2 footprint
- Made from non-GMO raw materials
- High heat performance
- Commercially available
- Offers a unique branding opportunity



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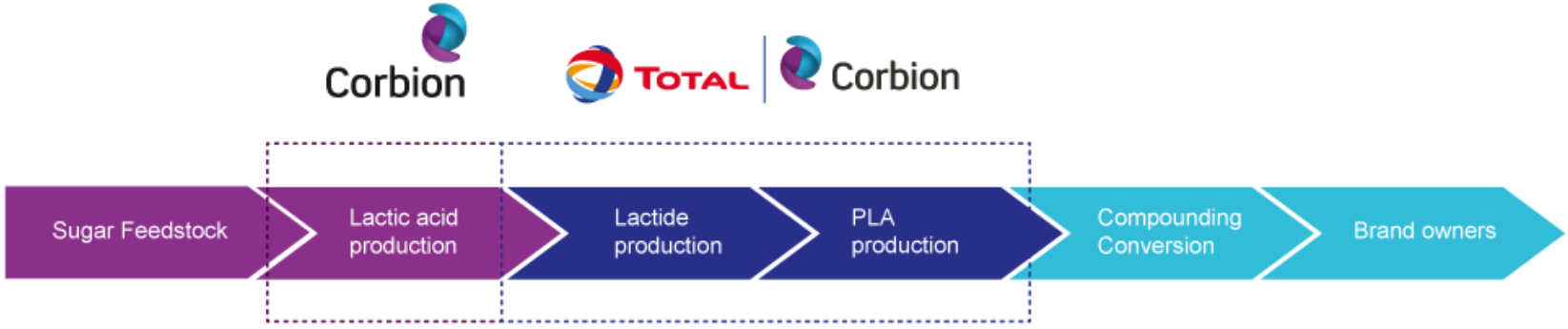
Two parent companies with complementary strengths

	TOTAL	Corbion
Position	World's 4th largest oil & gas company	World's largest lactic acid producer
Headquarters	Courbevoie, France	Amsterdam, the Netherlands
Revenue	$ 150 B	$ 970 M
Employees	98,000	1,700
Profit	$ 6 B	$180 M
Main businesses	Oil & Gas, Solar & Bioenergy, Commodity & Specialty Chemicals	Food Ingredients, Biochemicals, Bioplastics, Biomedical

Source: 2016 annual reports.

Total Corbion PLA: a 50/50 PLA joint venture

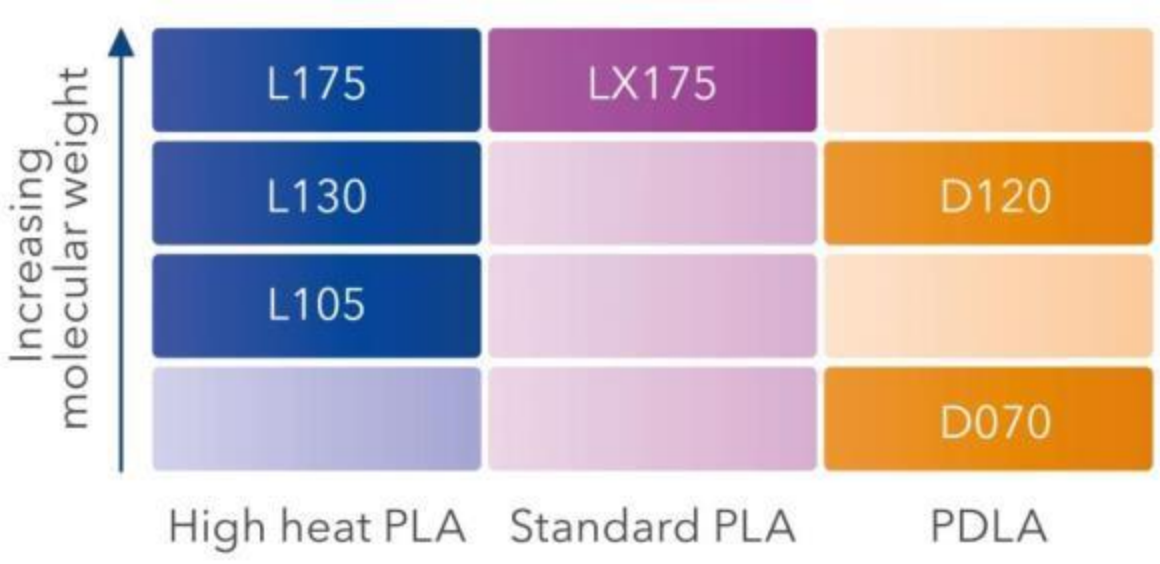
- The JV produces and markets PLA (Poly Lactic Acid) resins and lactides
- Total Corbion PLA launched operations 02 March 2017
- The JV owns the PLA polymerization plant with a global capacity of 75 kTpa, currently under construction on the Corbion site in Rayong, Thailand
- Corbion's existing PLA business and lactide production unit migrated to the JV
- Corbion supplies the lactic acid necessary for the production of PLA and lactide
- Your previous Corbion contact remains your key contact person.



Building a world scale PLA plant

Capacity	75 kTpa
Situation	Under construction, next to the world's largest lactic acid and lactide plants
Location	Rayong, Thailand
Timeline	Start of operations 2nd half 2018
Status	Groundbreaking ceremony took place 9 November 2016, construction is ongoing

Luminy® PLA portfolio: commercially available since 2016



PLA L105	High flow for injection molding
PLA L130	Medium flow for injection molding or fiber spinning
PLA L175	High viscosity for film extrusion, thermoforming or fiber spinning
PLA LX175	High viscosity, amorphous, transparent for extrusion/thermoforming
PDLA D070	Nucleating agent for PLA homopolymer resins
PDLA D120	Medium viscosity PDLA homopolymer

Luminy® neat resins are compliant with the most relevant regulations and requirements related to bioplastics:

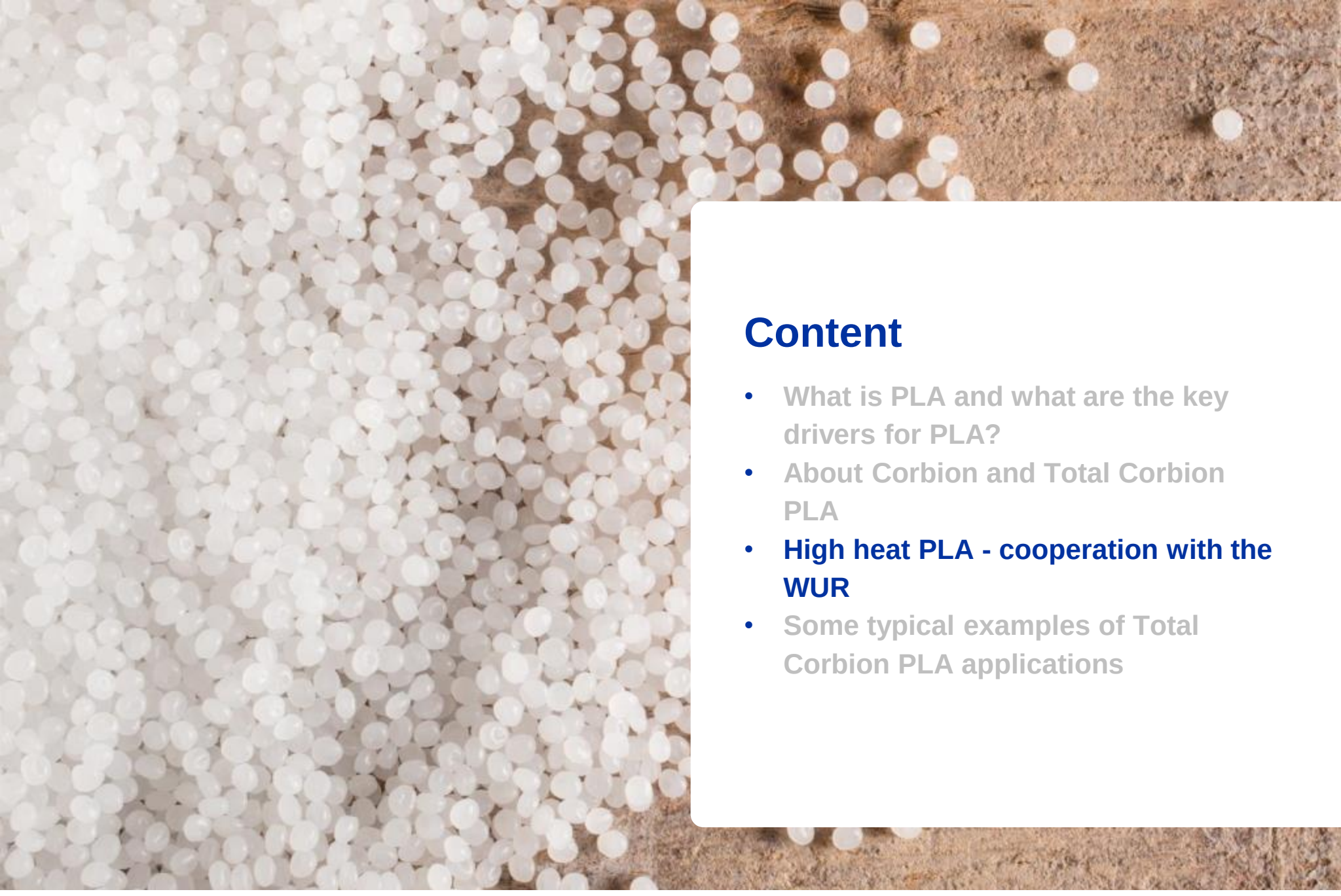
- EU food contact applications (EC No. 1935/2004 and No. 10/2011)
- EN13432 standard for industrial composting (OK Compost & Seedling)
- Biobased content 100% (EN16785-1)
- REACH compliant
- Reduced carbon footprint: LCA study available
- Made from European sugar beet and Thai sugarcane: these are always GMO-free crops

OK compost S478 VINÇOTTE

biobased %

7W2030 compostable

TOTAL Corbion



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- Some typical examples of Total Corbion PLA applications

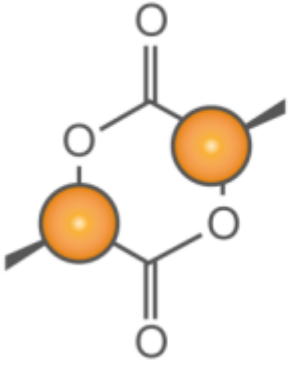
Our interest to develop the market for added value applications

Start with the best building blocks

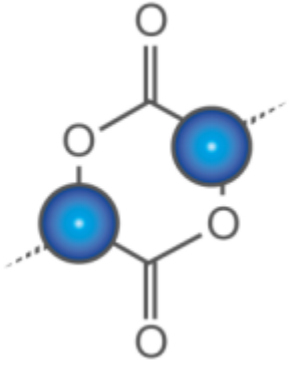
Stereochemically pure monomers make the difference

L-lactic acid ⟶ L-lactide

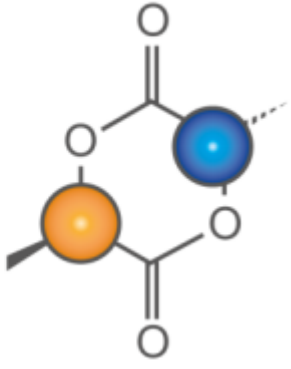
D-lactic acid ⟶ D-lactide



(R,R)- lactide
or D-lactide



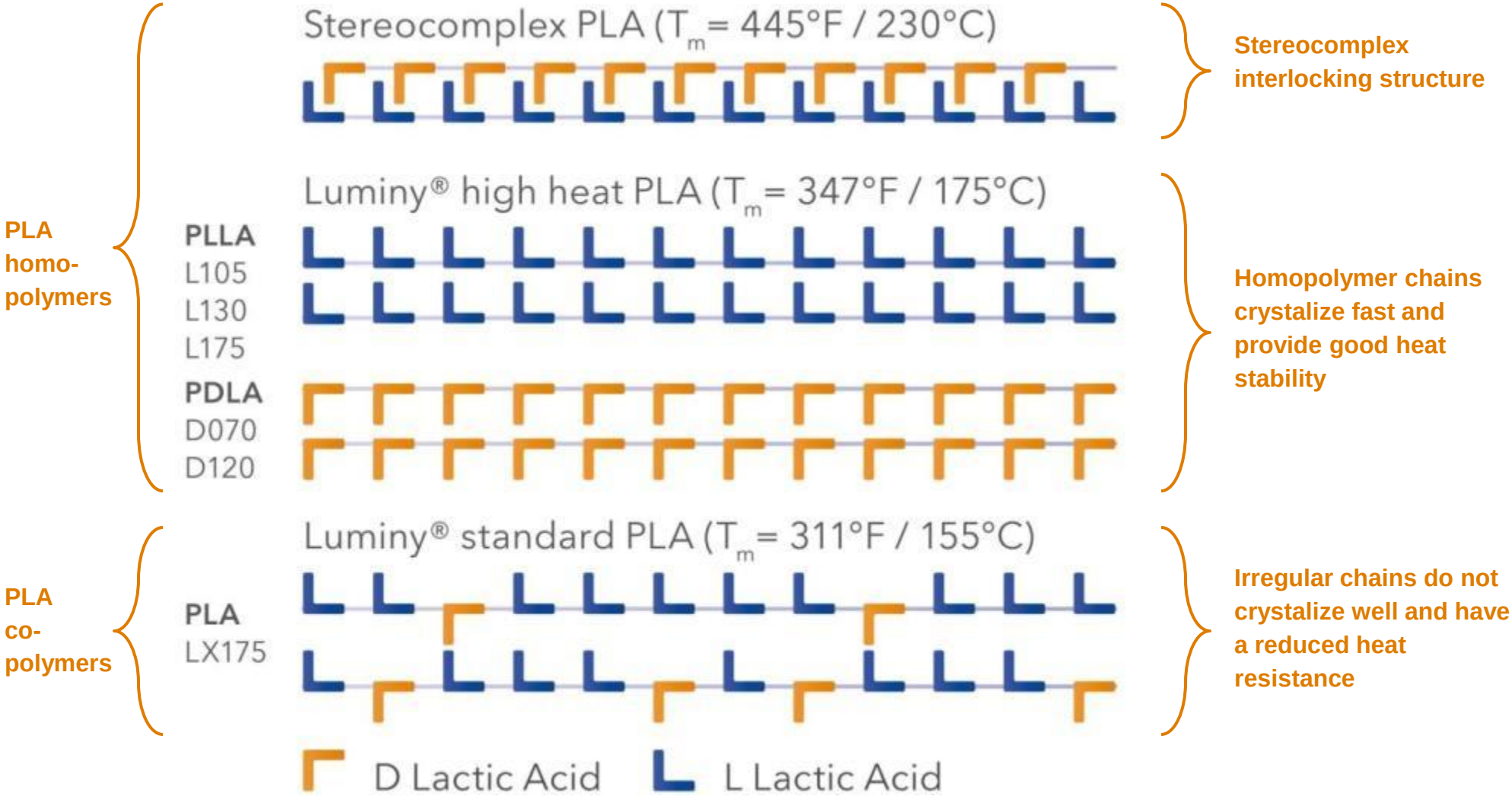
(S,S)- lactide
or L-lactide



(R,S)- lactide
or meso-lactide

Stereochemically pure lactide monomers:
building blocks used to make
Luminy® PDLA & PLLA homopolymers

Homopolymers: driving performance

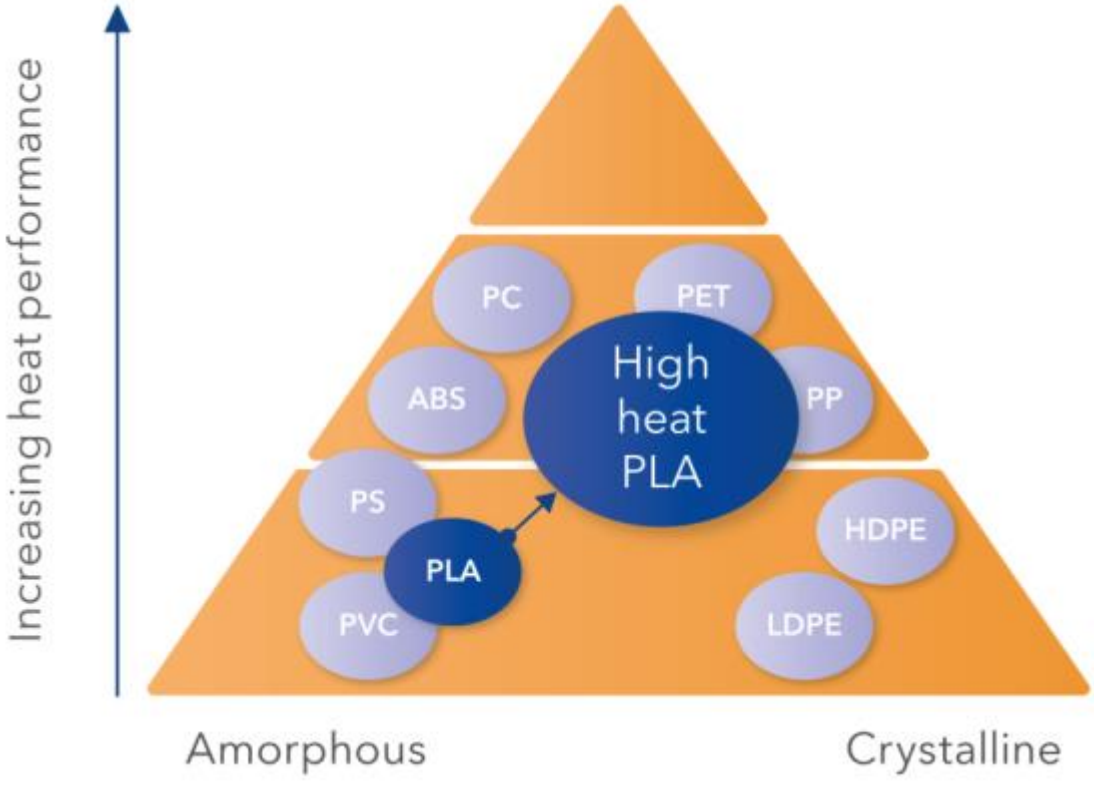


PLA homopolymers

The secret to obtaining high heat PLA

PLLA and PDLA homopolymers:

- Crystallize fast = improve processing economics
- Improve heat performance

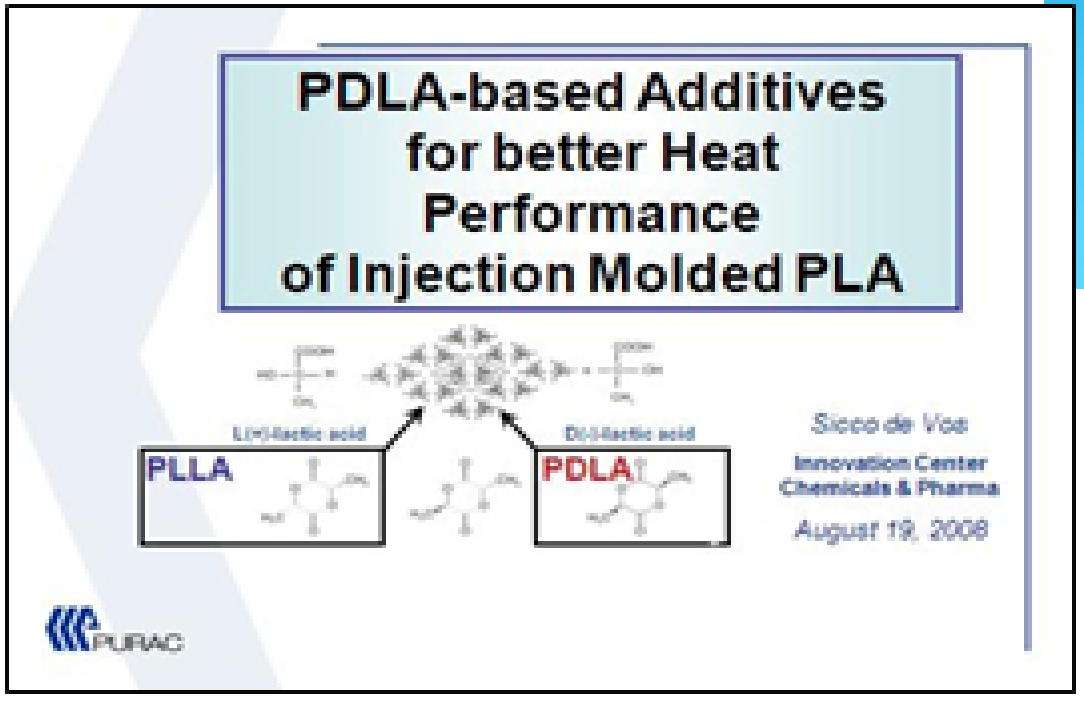


PLA technology from Total Corbion PLA can replace PS, PP and ABS-like materials in applications where heat performance is a key requirement.

Early cooperation with WUR on high heat PLA – 2008

Technology push - Origin of the project

- In 2008 Purac and Wageningen UR* start a project.
- PLLA/PDLA homopolymers
- Objectives: Develop high heat injection moulding compounds in PLA



purac
pure by nature

FOOD & BIOBASED RESEARCH
WAGENINGEN UR

*) Wageningen University & Research centre, Food & Biobased Research

How to make high heat PLA for injection molded applications?

In theory, the concept is easy

- Use PLLA homopolymers to allow for efficient crystallization
- Crystallinity will result in higher HDT/Vicat
- Nucleate with PDLA homopolymer to reduce cycle times
- Set the mold temperature to 90 – 100°C to prevent ‘freeze in’ of the amorphous structure

Example formulation:

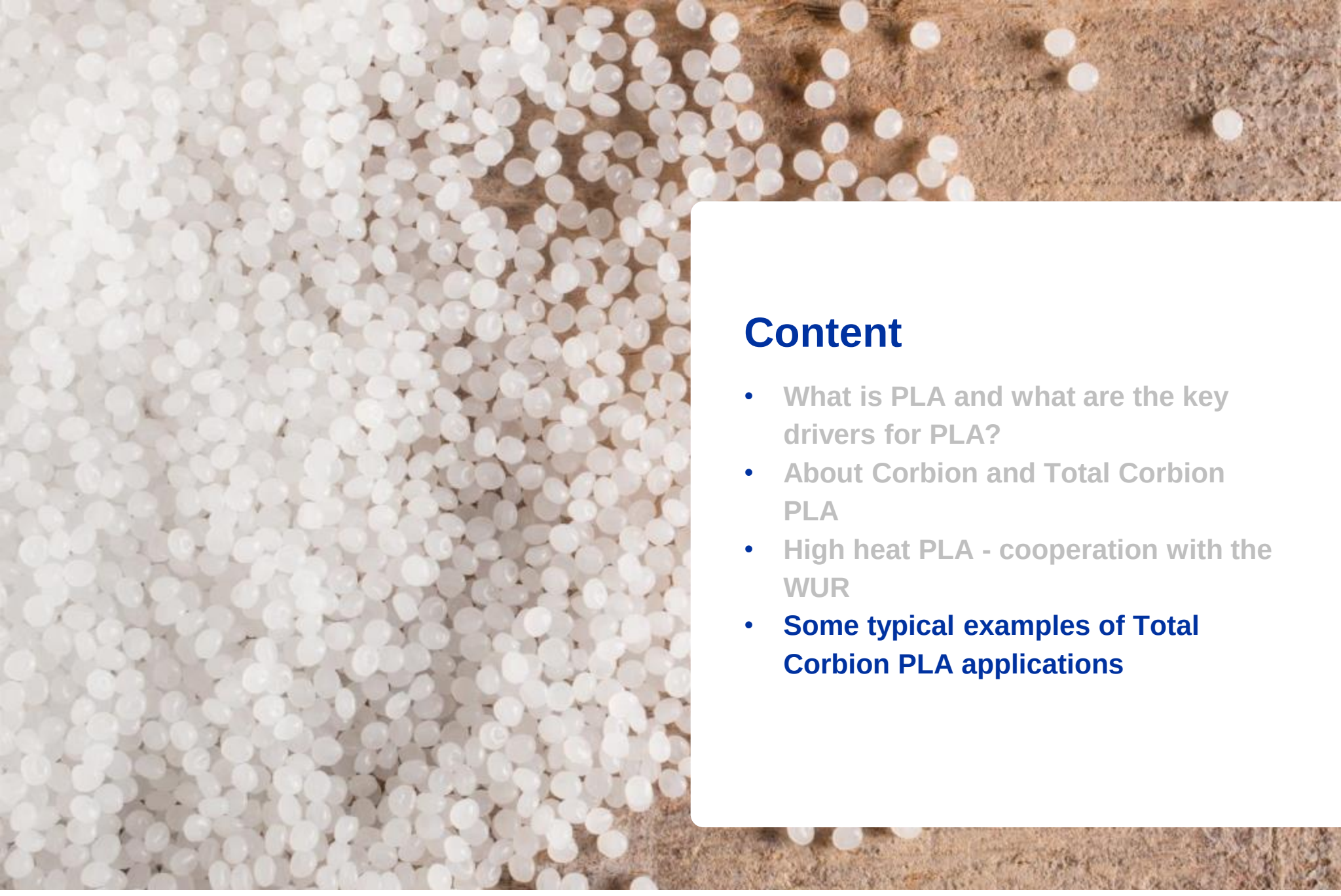
90% PLLA / 5% PDLA / 5% plasticizer

PLA compounds

Developmental samples available for testing

			HIPS	PLA	Total Corbion PLA sample compounds*					
					A	B	C	D**	E	K***
					General purpose	Mineral filled	Impact modified	Base compound	General purpose	Compostable
Market	Injection molding				•	•	•			•
	Extrusion/thermoforming							•	•	•
	Food contact				•	•		•	•	•
Physical	Density	g/cm³	1.05	1.24	1.25	1.37	1.27	1.39	1.34	1.29
	Clarity	yes/no	no	yes	hazy	no	no	no	no	no
Processing	MFI (210°C/2.16kg)	g/10min			12	10	6	6	5	8
	Melt temperature	°C	210-240	190-220	190-220	190-220	190-220	190-220	190-220	190-220
	Mold temperature	°C	30-60	25	90-100	90-100	90-100	90-100	90-100	90-100
	Pre-drying	yes/no	no	yes	yes	yes	yes	yes	yes	yes
Mechanical	Tensile modulus	MPa	2000	3300	3600	5500	4000	5500	5400	3600
	Tensile strength	MPa	35	48	60	60	40	60	60	50
	Strain at break	%	35	<5	<5	<5	47	<5	<5	8
Heat	HDT B, 0.45MPa, flatwise	°C	93	55	**90**	**110**	**90**	**120**	**120**	**80**
Impact	Charpy notched, 23°C	kJ/m2	8	3	**3**	**2**	**18**	**2**	**2**	**8**

* Developmental grades, all data is preliminary. Total Corbion PLA does not commercially produce these PLA compounds. ** For high heat applications it is recommended to add 3-7% Luminy® D070 (nucleating agent). *** Compliance with EN13432 to be verified on actual end product.



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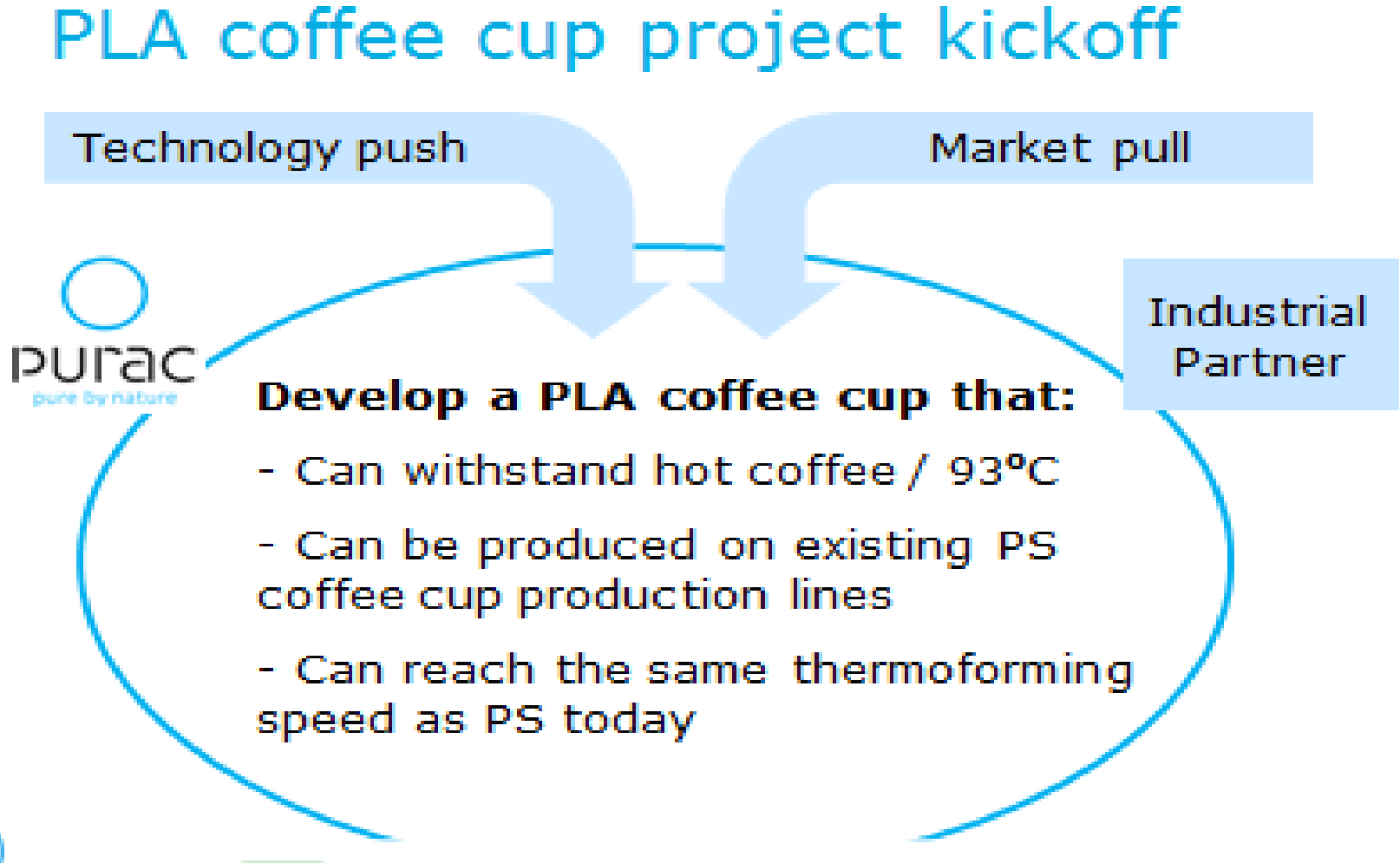
After Fundamental R&D – specific application development 2010-2016 with various industrial partners



purac
pure by nature

FOOD & BIOBASED RESEARCH
WAGENINGEN UR

PLA for high heat thermoformed coffee cups

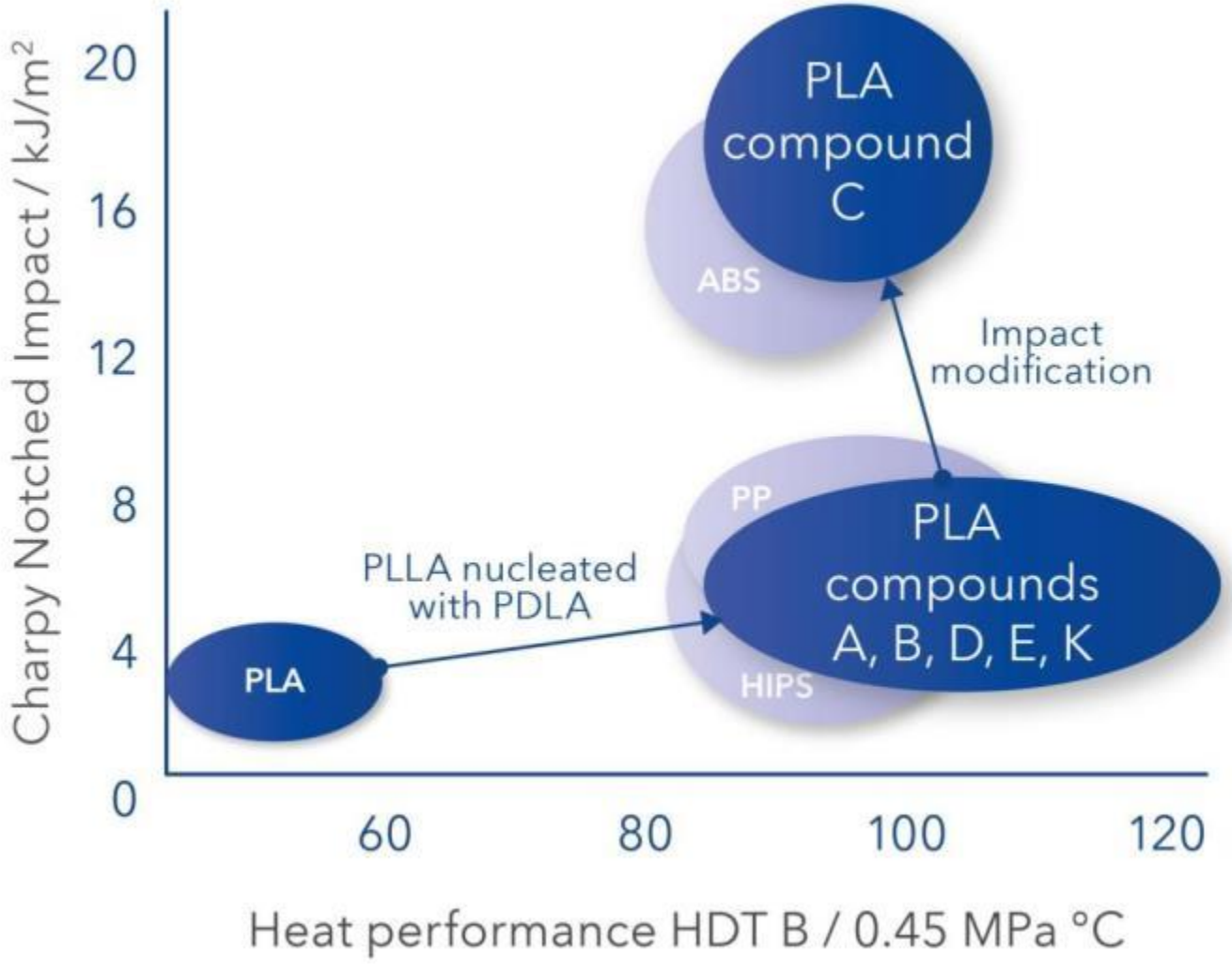
Benefits:

- Biobased
- High heat resistance
- Recyclable
- Good processing economics
- Can be processed on existing PS lines

naturesse® *by Pacovis*

TOTAL Corbion

Closing the performance gap vs PS, PP & ABS



PLA for injection molded cosmetics packaging

Benefits:

- Biobased
- Natural
- Stone/wood look & feel
- Weight of the part
- Processing economics

SULAPAC

TOTAL Corbion

PLA for injection molded consumer electronics housings

Benefits:

- Excellent impact resistance
- Biobased & recyclable
- High heat resistance
- Excellent high gloss finish
- High dimensional stability allows for tight tolerances

NAGER IT
für Faire Computermäuse

SUPLA

KUENDER

PLA for extruded and injection molded drain systems

Benefits:

- Biobased
- Durable
- Reduced carbon footprint
- Excellent surface appearance
- Good impact resistance

DYKA
PLASTIC PIPE SYSTEMS

PLA for high heat injection molded coffee capsules

Benefits:

- Biobased
- Compostable
- High heat resistance
- Good barrier properties
- Good processing economics

Advantages of PLA bioplastics

- Made from renewable raw materials
- Biodegradable/Compostable EN13432
- Recyclable
- Favorable CO_2 footprint
- Made from non-GMO raw materials
- High heat performance
- Commercially available
- Offers a unique branding opportunity

Key commercial contacts at Total Corbion PLA

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