PLA in durable applications

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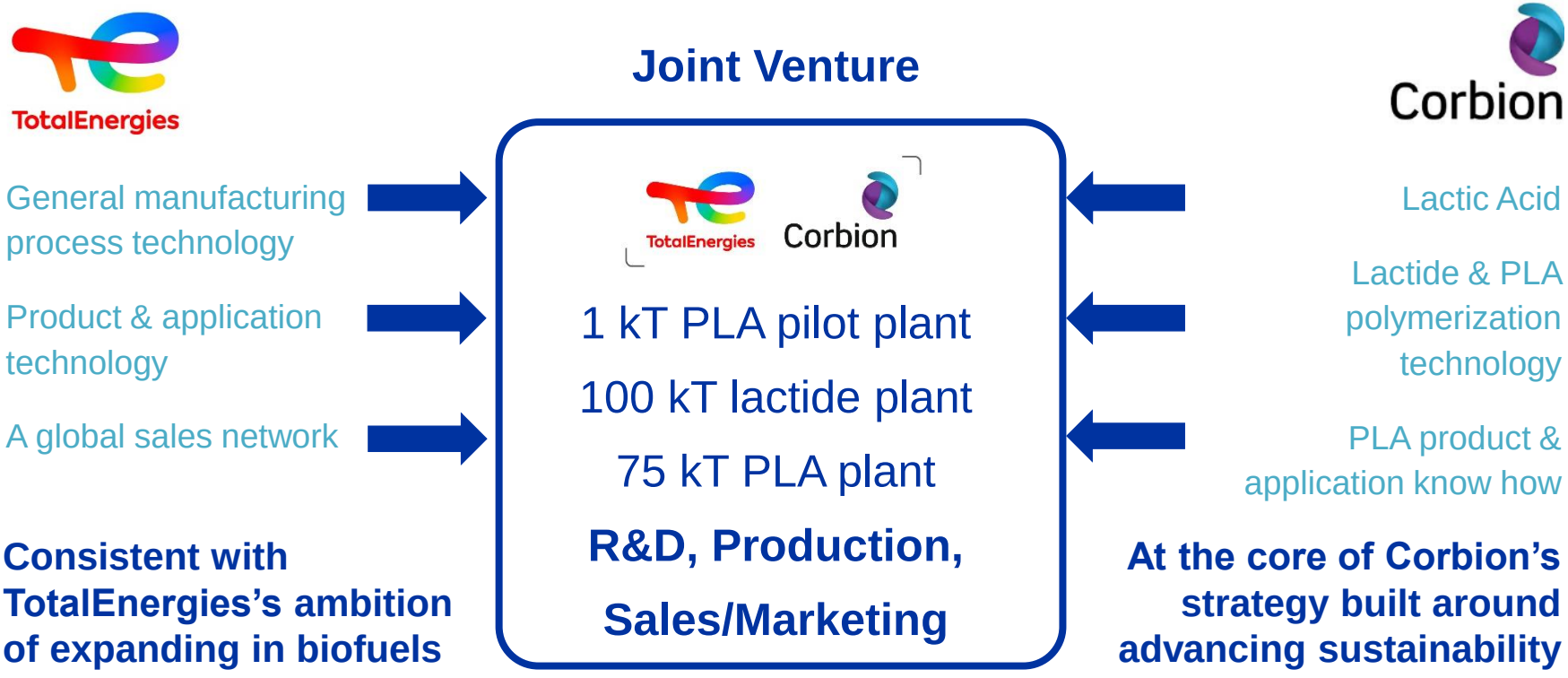
TotalEnergies Corbion

Who are we?

TotalEnergies Corbion

TotalEnergies Corbion

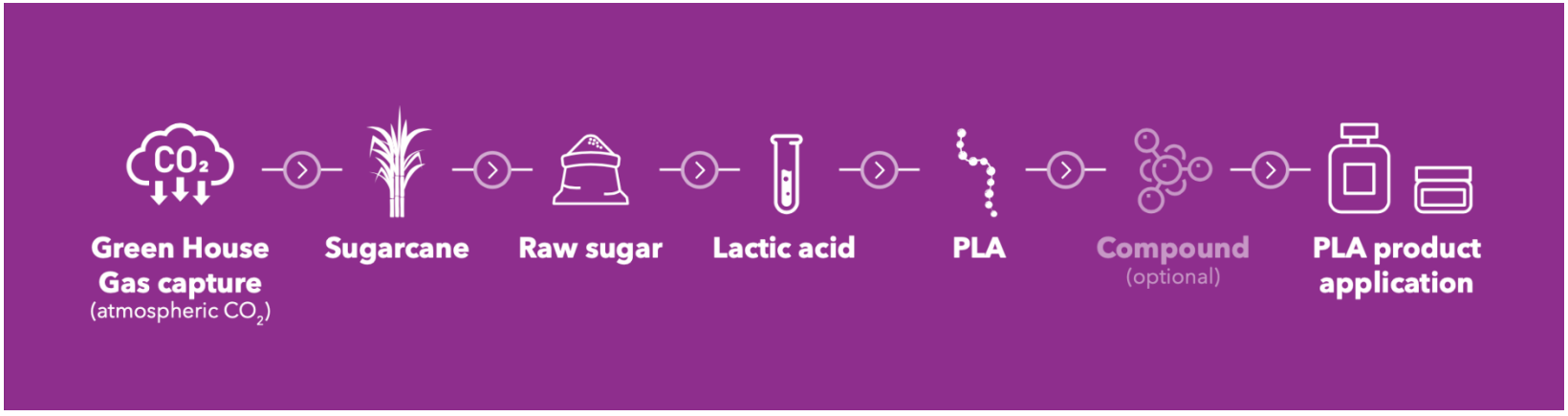
50/50 joint venture to become a major player in PLA – biobased, recyclable and biodegradable, with low carbon footprint & high feedstock efficiency - launched on 2 March 2017.



TotalEnergies Corbion - PLA plant in Thailand

- 50/50 Joint Venture between Total and Corbion
- World scale & brand new 75kTpa PLA polymerization plant in Rayong, Thailand.
- Sugar to PLA on integrated bio-refinery site
- Lactic acid supplied to the JV by Corbion, utilizing Thai sugarcane

The biobased origin of PLA



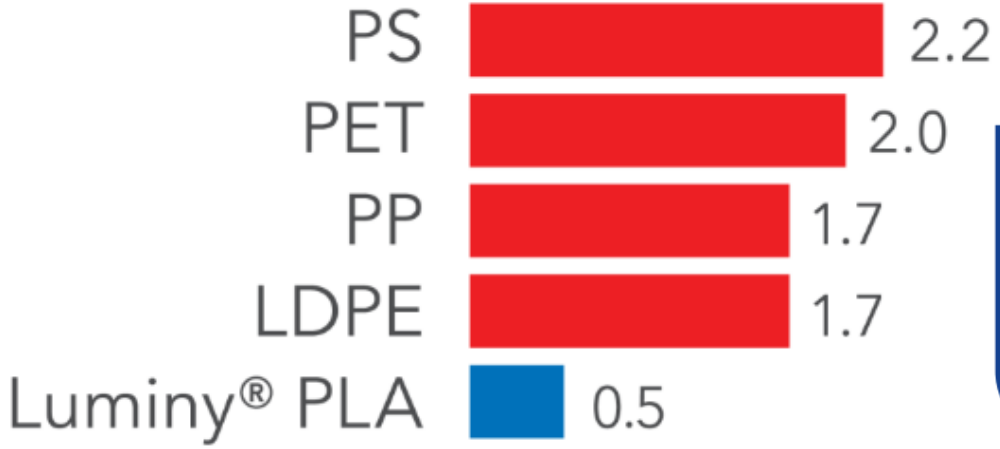
Sugarcane is the starting point for Luminy® PLA. The sugar extracted from the sugarcane is fermented using microorganisms to produce lactic acid, an organic acid also produced by the human body.

TotalEnergies Corbion converts the lactic acid into PLA, a biopolymer used in multiple applications from packaging to 3D printing to electronics.

Reduced carbon footprint with Luminy © PLA

- Peer reviewed Life Cycle Assessment. Confirms Low carbon footprint of Luminy® PLA
- From a cradle-to-gate the Global Warming Potential (GWP) of PLA is 0.5kg CO2/kg of PLA

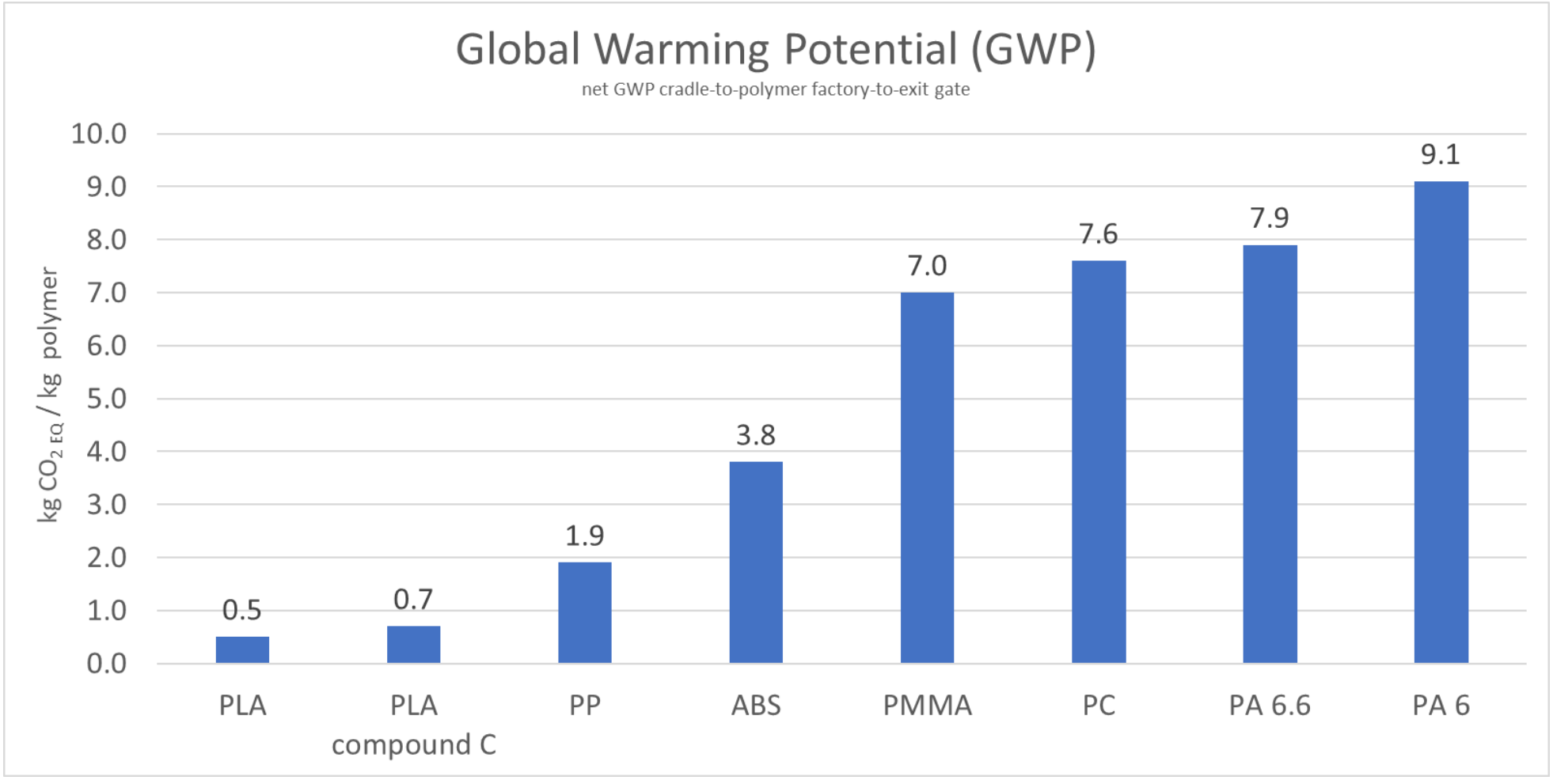
Carbon footprint in kg CO_2 /kg of polymer



PLA carbon footprint is on average,
75% lower
than fossil-based plastic resins

Sources: "Journal of Polymers and the Environment" November 2019, published by Springer nature and www.lca.plasticseurope.org

Carbon footprint reduction
raw material data



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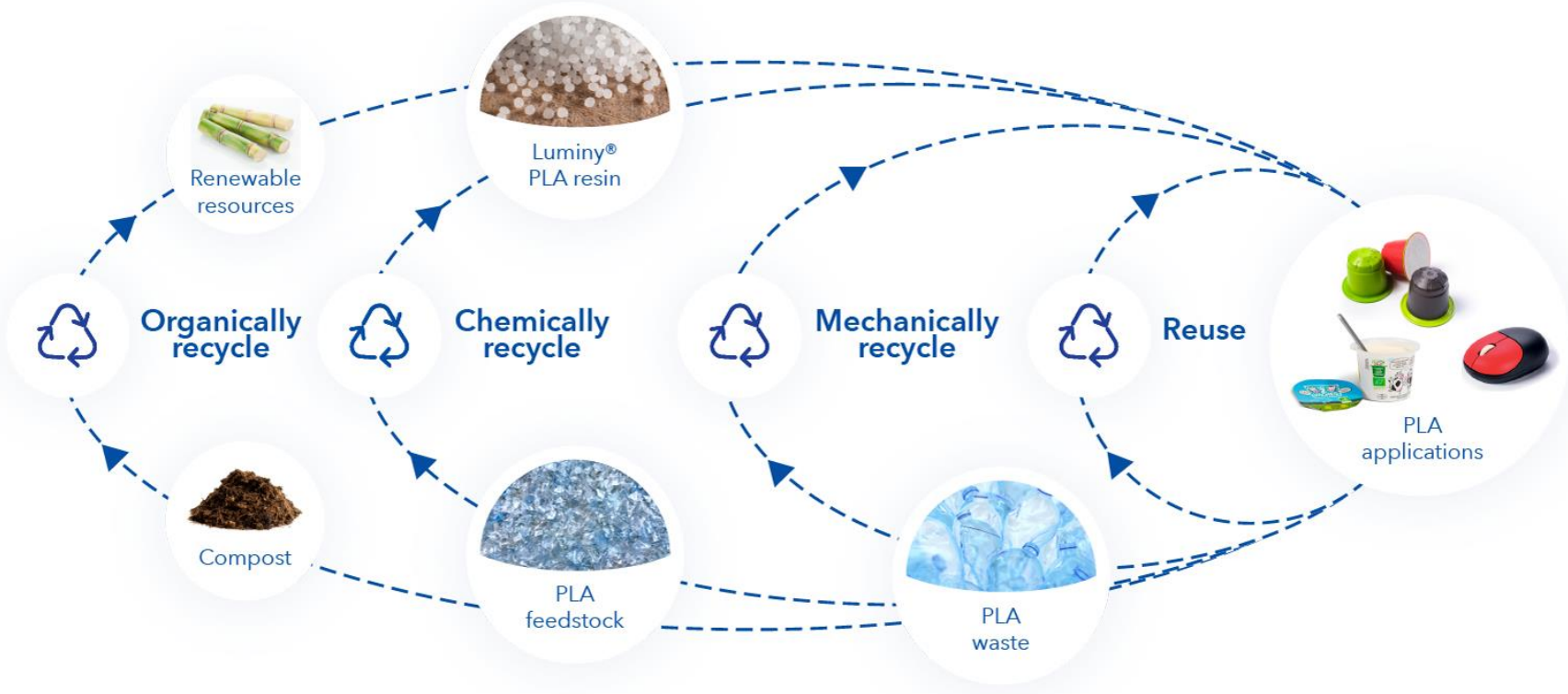
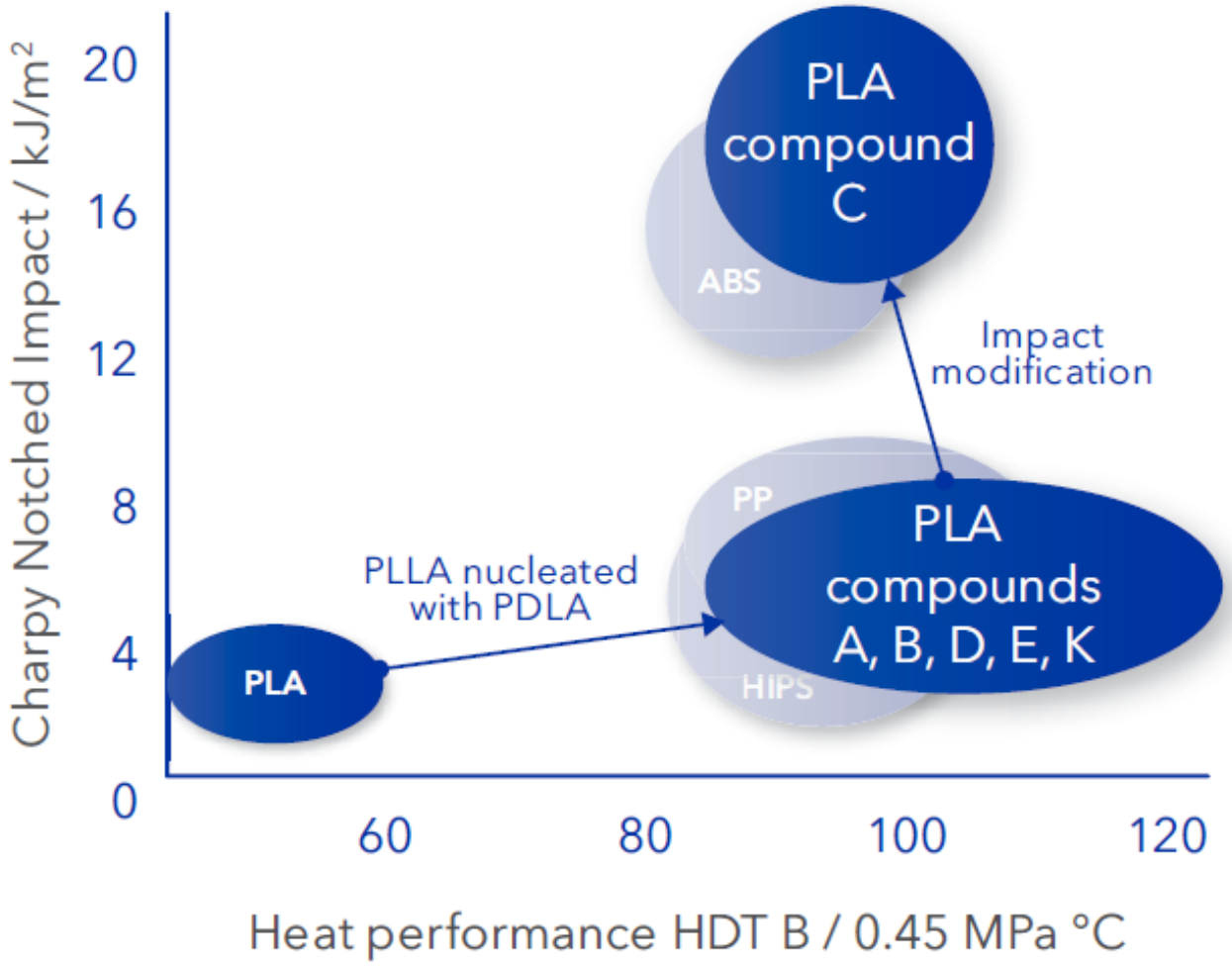
Closing the loop with Luminy PLA



From packaging to high added value markets

PLA compounds with improved performance



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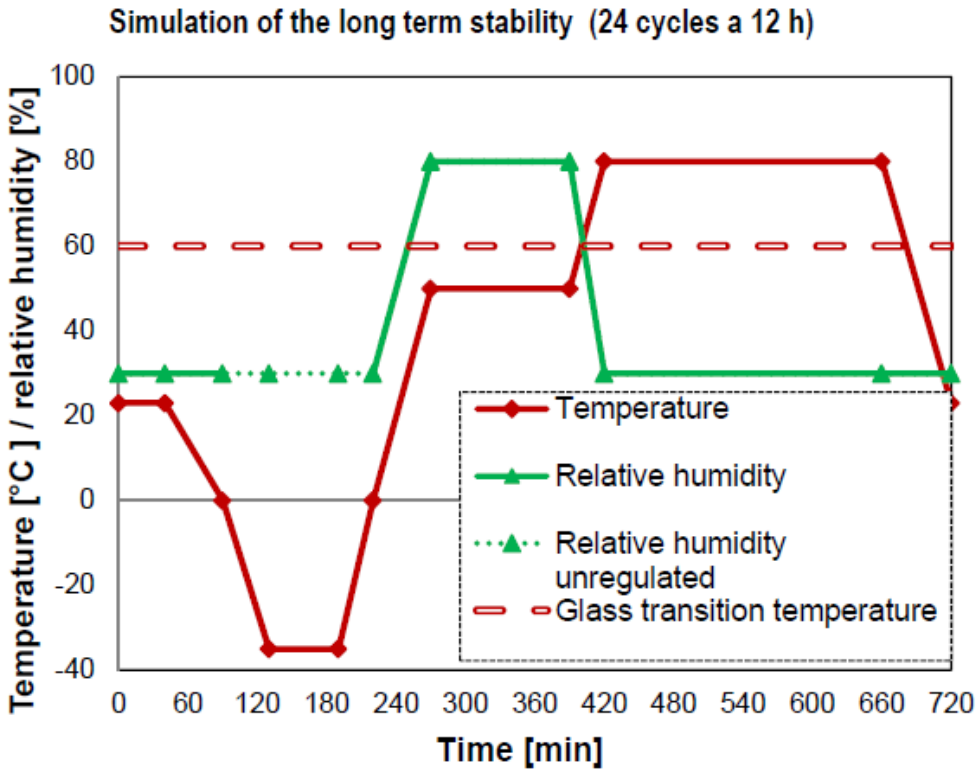
Environmental cycle test

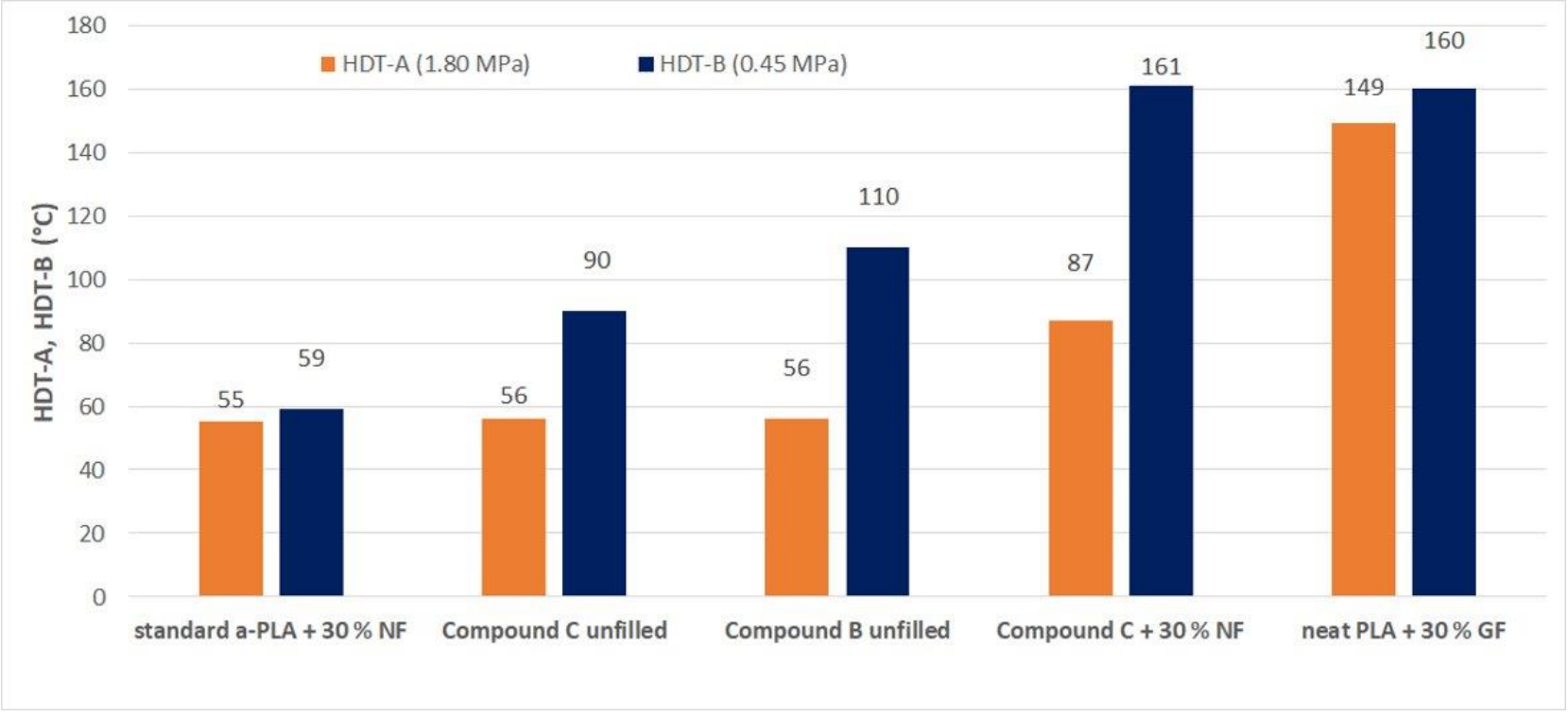


720 min = 12 h
24 cycles X 12 h = 12 days

Sample	Mw (g/mol) before	Mw (g/mol) after
PLA	60 000	18 250
PLA + stabilizer	60 450	61 400

Source: Dissertation Siebert-Raths: Modifizierung von Polylactid für technische Anwendungen

Fiber reinforcement for even higher heat resistance



Source: TotalEnergies Corbion

Durables - Benvic

PLANTURA






Majors applications

Automotive: substitution of PP GF, PA GF and ABS-PC for interior, exterior and interior.

Appliances, power tools, IoT, electrical device, medical : casing applications

Furniture: indoor and outdoor

Consumer : kitchenware, fashion accessories

Packaging: film or thin wall rigid packaging

Non recoverable product: agri supplies, cartridges wad...

Additive manufacturing

Automotive - Roechling

Engine compartment

Air Induction System

Engine Beauty Covers

Cowl Grille

Underbody & Aerodynamics

Active Grille Shutter

Deflectors and shields

Interiors & Exterior

High gloss parts

Interior trim

Bumper Grille

Source: Roechling

Automotive - Roechling

- **Environmental test**: thermal cycles -40/140°C
- **Aging**: tensile strength at break loss OK after 1000h, 150°C
- **Validation:** passed 150.000Km mounted in a vehicle

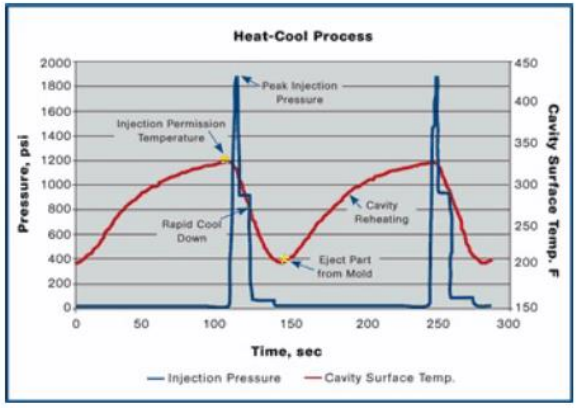
- **Environmental cycling test** – 8 cycles of:
- 23ºC @ 40min/ 90min to/ -35ºC @ 60min / 80min to/ 50ºC @ 120min/
- 30min to/ 80ºC @ 240 min/ 60min to 23ºC – acc. VW (PV 2005)

Source: Roechling

Roechling BioBoom Automotive Applications

Aesthetics: High-Gloss Feature

- BioBoom allows to reach a piano-black surface during the injection molding process → Heat&Cool technology
- Gloss level close to what paints can achieve
- Several colours are available



Out-of-Tool Aesthetics:	
	Gloss Units
Angle 20°	66 GU
Angle 60°	80 GU
Angle 85°	95 GU

Source: Roechling

Automotive - Roechling

Coupling with Bio-TPE

- Very good adhesion to BioBoom
- Successfully tested on a 2K Injection Molding process

2K Cowl Grille

Avg. stress at interface break

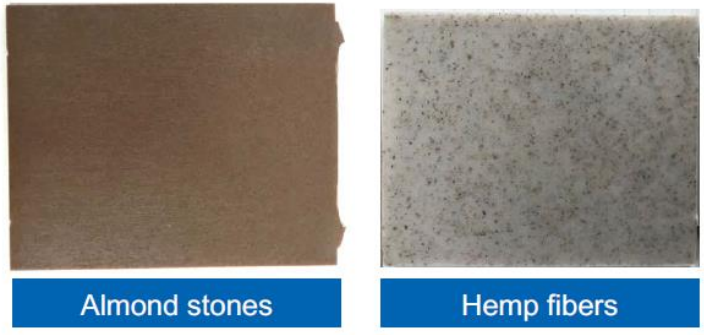
TPE-PLA T	TPV-PP T20
2,15 MPa ✓	1,15 MPa

Source: Roechling

Automotive - Roechling

Increasing Natural Content

- Almond stones and hemp fibers showed good processability with PLA
- Wooden fibers grade commercially available



Wooden Fibers Parts:

Source: Roechling

Durables - Benvic

PLANTURA

Success story: automotive

The challenge: Proposition bio based materials to substitute PA GF30 for automotive grille shutter. This exterior part is requiring specific thermomechanical resistance and resistance to climatic aggressions (UV, hydrolysis..) with aesthetics requirements.

The BENVIC proposition: PLANTURA 70FV6WRHC-BK associated to UV resistance.

Features: matches the PA GF30 performances

Benefits:, saving of from 9 CO2EQ/kg to 2.2 CO2EQ/kg without major technical deviation.

Impacts: several new projects with duplication of the solution: allow tier 1 to expands its presence in other cat makers

Source: Benvic

Durables - Benvic

PLANTURA

Success story: Furniture

The challenge: request to substitute colored ABS for furniture application by using same molds to develop a bio based range.

The BENVIC proposition: PLANTURA 67C1WRHI-N associated to right color matching and high scratch resistance.

Features: direct substitution from ABS without impact on tooling and reference colors. Process ability leads to the same cycle time.

Benefits:, development by customer of a sustainable range with biosourced content of 85% without new investment and low extra costs: possibility to test the market easily.

Source: Benvic

Durables - Benvic

DURABLE RANGE

WHAT'S MAKE PLANTURA DURABLE UNIQUE

PLA has significant weaknesses to compete against conventional techno-polymers:

- Low crystallization speed
- Brittle at ambient temperature
- High rigidity
- Moisture absorption
- Glass transition: 55°C-58°C
- Cold crystallization 90°C
- Low fatigue resistance
- Polymer fiber adhesion
- Compatibilization of different polymers
- Affected by hydrolysis
- UV stabilization

The PLANTURA proposal

Increased crystallization speed

Improved impact resistance >25J/M

Flexural modulus modulation from 6500MPa to 2500 MPa

Limited water absorption at equilibrium <0,5% by inclusion of hydrophobic co-polyester

High fatigue resistance

HDT from 95°C up to 140°C depending filler

Bio content above 80%

Additive to improve fiber wettability

Special compatibilizer to include other polymers

Proprietary UV package

BENVIC Compounding improvement leads to make PLANTURA range performing materials

Home and other appliances

Floreon targets electronics industry with launch halogen-free flame retardant bioplastic

Sustainable Plastics

TWEET SHARE SHARE EMAIL PRINT

Flame retardant compound

DATA SHEET: FLOREON THERMA TECH

floreon

Grade	Applications	Features	Benefits
Floreon Therma -Tech Flame Retarded Grade	Injection Moulding Extrusion 3D Printing Electronics and Electricals, home appliances, plug casings	Flame Retarded (UL94V-0) High HDT High Impact Strength High renewable content	Developed for applications requiring fire resistance. Durability comparable to flame retarded ABS

- PLA based compound with high renewable content
- Nucleated to allow high crystallinity and heat deflection temperature
- Contains elastomeric impact modifier (notched Izod 8 kJ/m^2)
- Flame retardant (UL94V-0)

Source: Floreon

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PLA for medical applications - Bottles

Biobased bottles

Benefits:

- Transparent
- Can be sterilized:
  - under high pressure
  - with alcohol
  - UV-rays
  - gamma rays

www.biofutura.com

biofutura

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PLA for medical applications – Petri dishes and labware

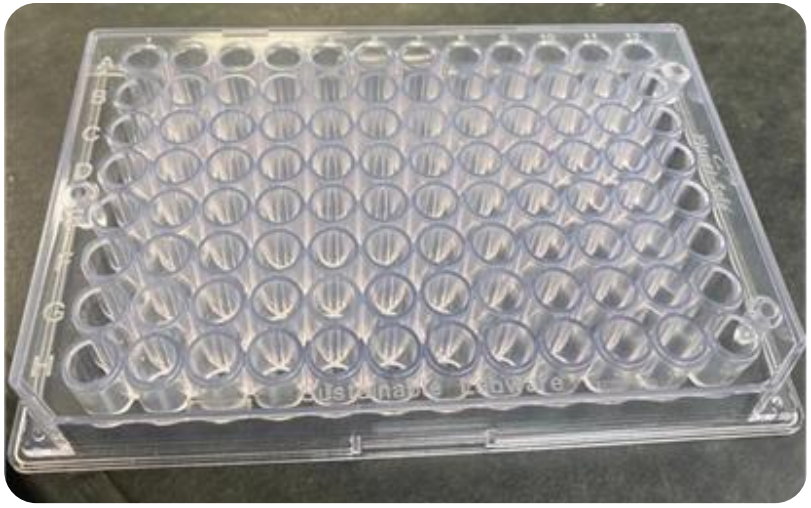
Biobased petri dishes and micro-pipette trays made from crystal clear Luminy PLA

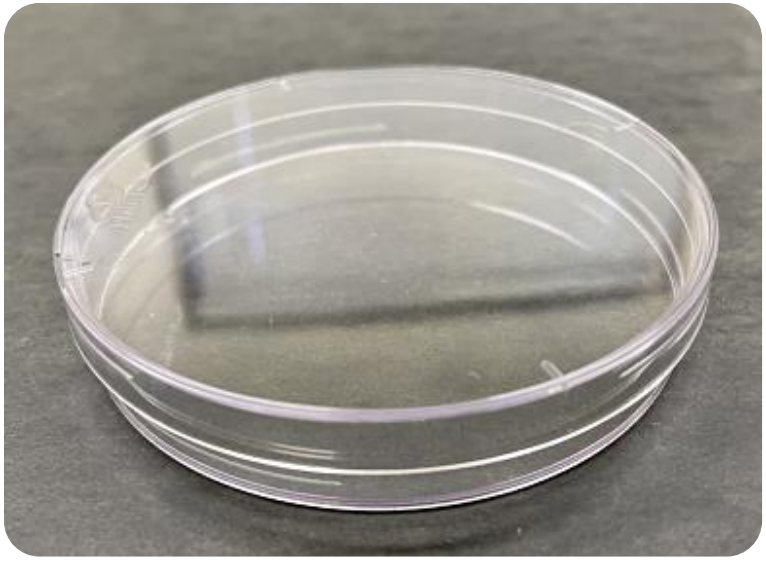
Benefits:

- Free from styrene and bisphenol A.
- Excellent optical transparency facilitates microscopic cell examination.
- PLA is significantly more hydrophilic than conventional plastics allowing excellent cellular growth in liquid culture without the need for additional coatings.
- Can be (E-beam) sterilized.
- Suitable for closed loop systems: recycling of PLA

Materials:

- Luminy L105 or Luminy L130





www.atacamausa.com

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Throughout our communications, unless otherwise specified, the terms 'biobased' and 'compostable' or 'biodegradable' refer to EN16785-1 and EN13432 standards respectively. It is the responsibility of the article producer to ensure that claims on final products are substantiated by testing against the relevant standards. Check your locally available end-of-life infrastructure to ensure that legitimate end-of-life claims are made on the final product.

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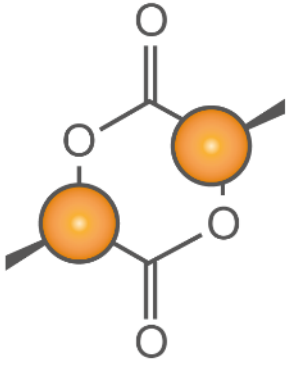
Appendix

Start with the best building blocks

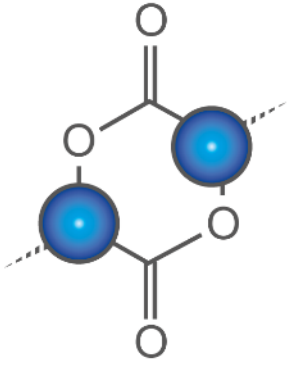
Stereochemically pure monomers make the difference

L-lactic acid → L-lactide

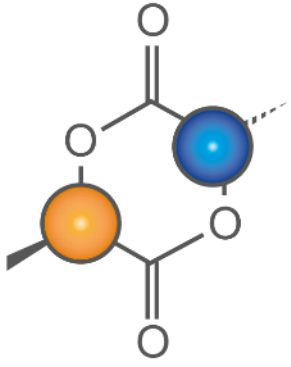
D-lactic acid → D-lactide



(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 homo-polymers

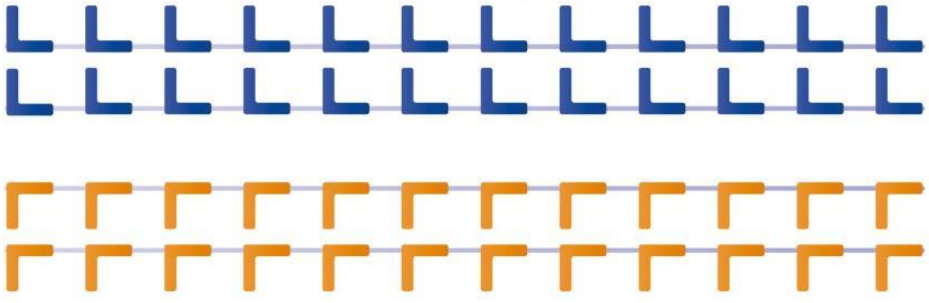
Stereocomplex PLA (T_m = 445°F / 230°C)

Stereo-complex interlocking structure

Luminy® high heat PLA (T_m = 347°F / 175°C)

PLLA
L105
L130
L175

PDLA
D070
D120

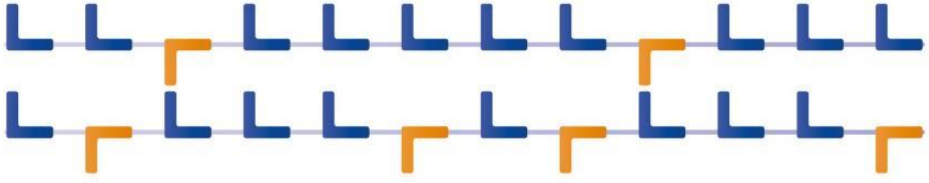


Homopolymer chains crystalize fast and provide good heat stability

PLA co-polymers

Luminy® standard PLA (T_m = 311°F / 155°C)

PLA
LX175



Irregular chains do not crystalize well and have a reduced heat resistance

D Lactic Acid L Lactic Acid

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PLA marketing compounds

			HIPS	PLA	Total Corbion PLA sample compounds*					
					A General purpose	B Mineral filled	C Impact modified	D** Base compound	E General purpose	K*** 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**

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