



Progress in processing of PDLA-nucleated PLA compounds

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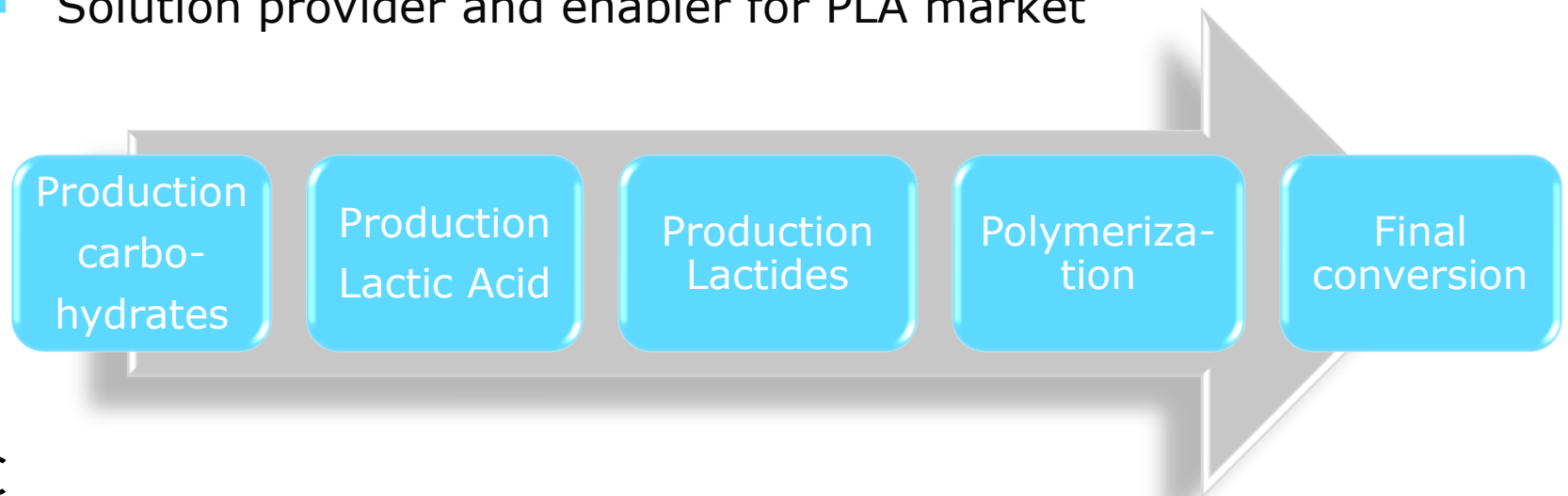
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Purac overview

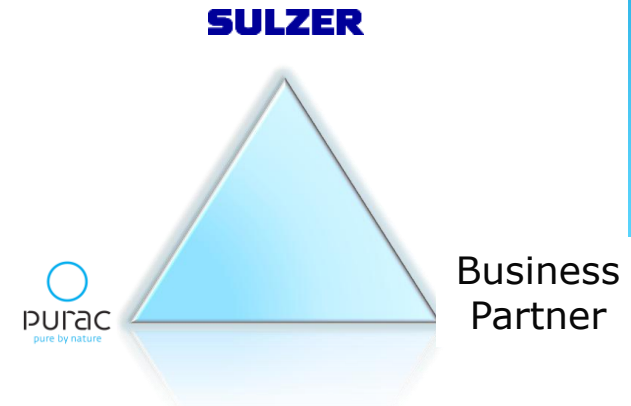
- 100% subsidiary of CSM
- 80 years experience in Lactic acid Chemistry
- >20 years experience in Lactides and PLA
- **2008**: 5,000 tpa Lactide pilot plant in Spain
- **2009**: PLA polymerization process developed with Sulzer Chemtech (CH)
- **2010**: First commercial PLA plant installed at Synbra (NL) for production of BioFoam (EPLA)
- **2011**: 75,000 tpa Lactide monomers plant in Thailand
- Solution provider and enabler for PLA market



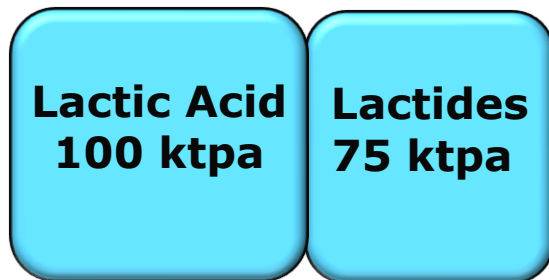
Purac value proposition in biobased plastics

Value proposition:

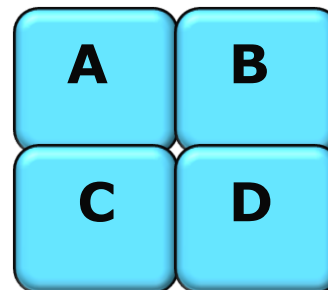
- Products with favorable CO₂ footprint
- Non-GMO raw materials
- Partnership model
- Scalable PLA polymerization process developed with Sulzer Chemtech
- Stereocomplex PLA resulting in improved high temperature resistance



Purac Thailand



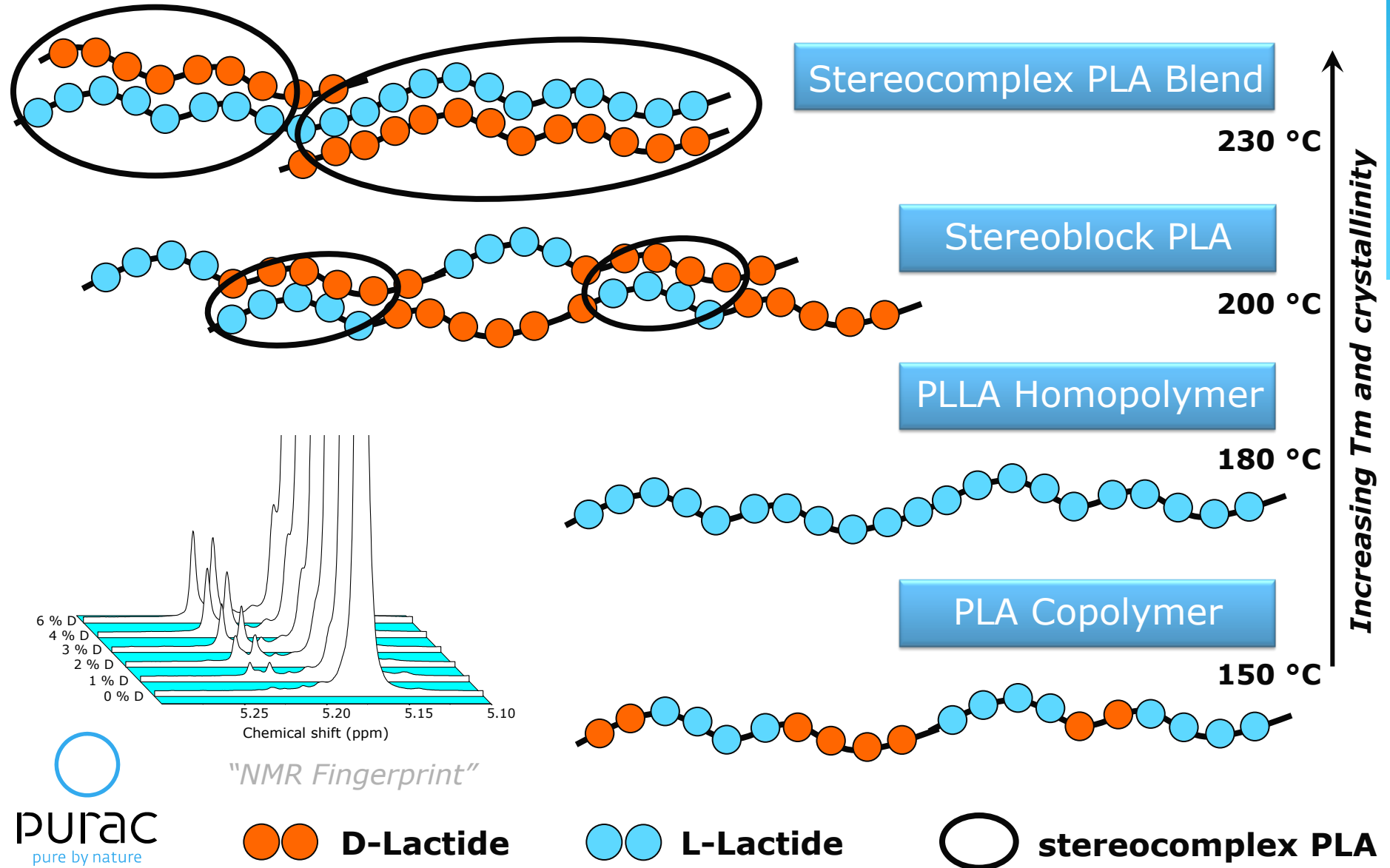
Purac partners



Products

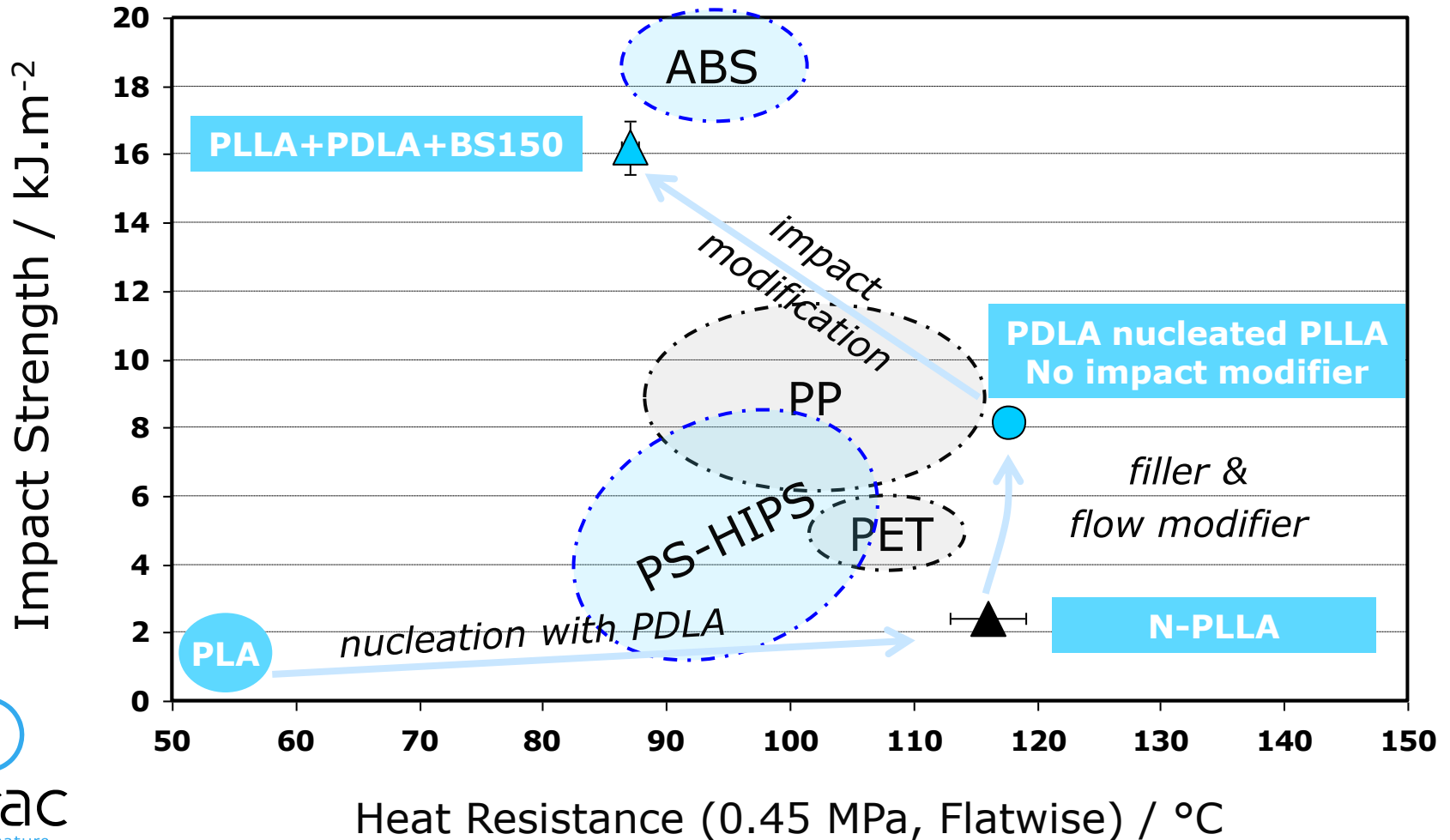
- L-Lactic Acid
- D-Lactic Acid
- L-Lactide
- D-Lactide

The PURALACT PLA family of (co-)polylactides



Improving PLA material properties

PDLA nucleated PLLA with biostrength 150 has excellent balance between toughness and heat resistance



Press Release 1 December 2010



PURAC
pure by nature

High new carbon content in PLLA compounds

Good control over mechanical properties

	Commercial reference compounds		Purac compounds	
	N-PLA	IM-N-PLA	N-PLLA	IM-N-PLLA
PLA content (%)	79	71	90	67.5
Additives (%)	21	19	5	18
Impact modifier (%)	0	10	-	10
PDLA (%)	-	-	5	4.5
Tensile strength (MPa)	29	27	56	30
Strain at break (%)	9	21	8	61
Charpy impact (kJ/m²)	1.9	7	2.4	16
HDT-B value (°C)	123	100	116	87
New carbon (%)	79	71	95	72

All samples made using mold temperature of 100°C;
reported values for 35sec cooling time



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Modification of PLA for technical applications

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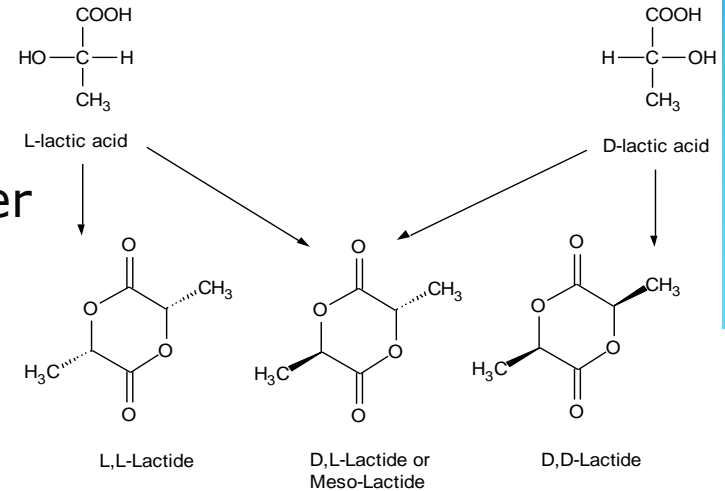
PURAC
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Bottlenecks of unmodified PLA

- Poor processing characteristics
 - Moisture sensitive polyester, predrying necessary
 - During processing sensitive to hydrolysis
 - Low crystallization rates, long cooling times
 - Sub-optimal demolding, low shrinkage
- Improvable performance characteristics
 - Low heat deflection temperatures
 - Low impact strength
 - Unknown long-term stability
 - Higher density

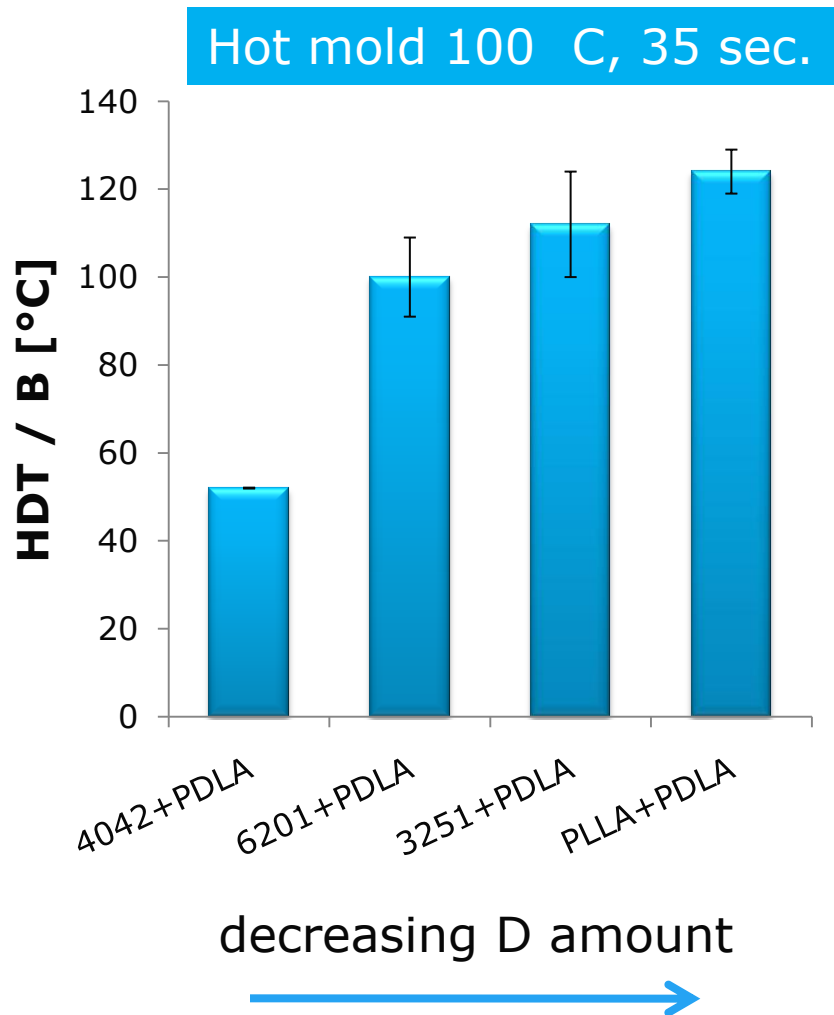
Injection molding heat resistant PLA

- Different types of PLA (copolymers of L- and meso-lactide)
- Homopolymer PLLA from Purac and Sulzer
- Additives
 - flow modifiers
 - PDLA as nucleating agent

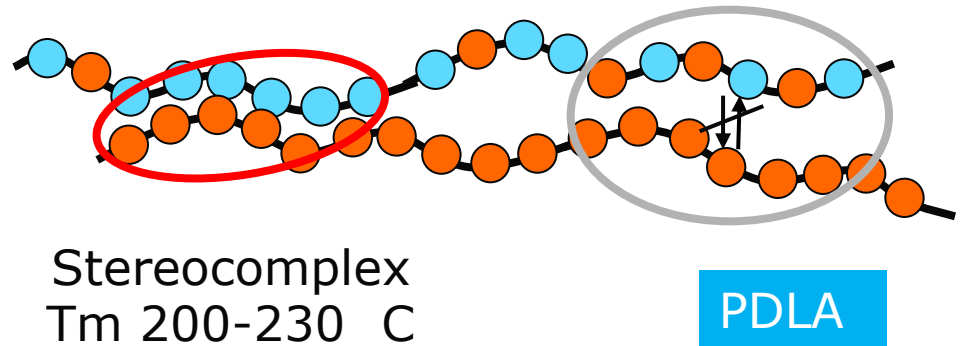


- Injection molding semi-crystalline PLA's in hot mold
- Tensile bars type 1A, 2 molds, ISO 527
- Investigation of thermal & mechanical properties
- First statements regarding long-term performance in environmental stress test

Highest heat resistance with N-PLLA



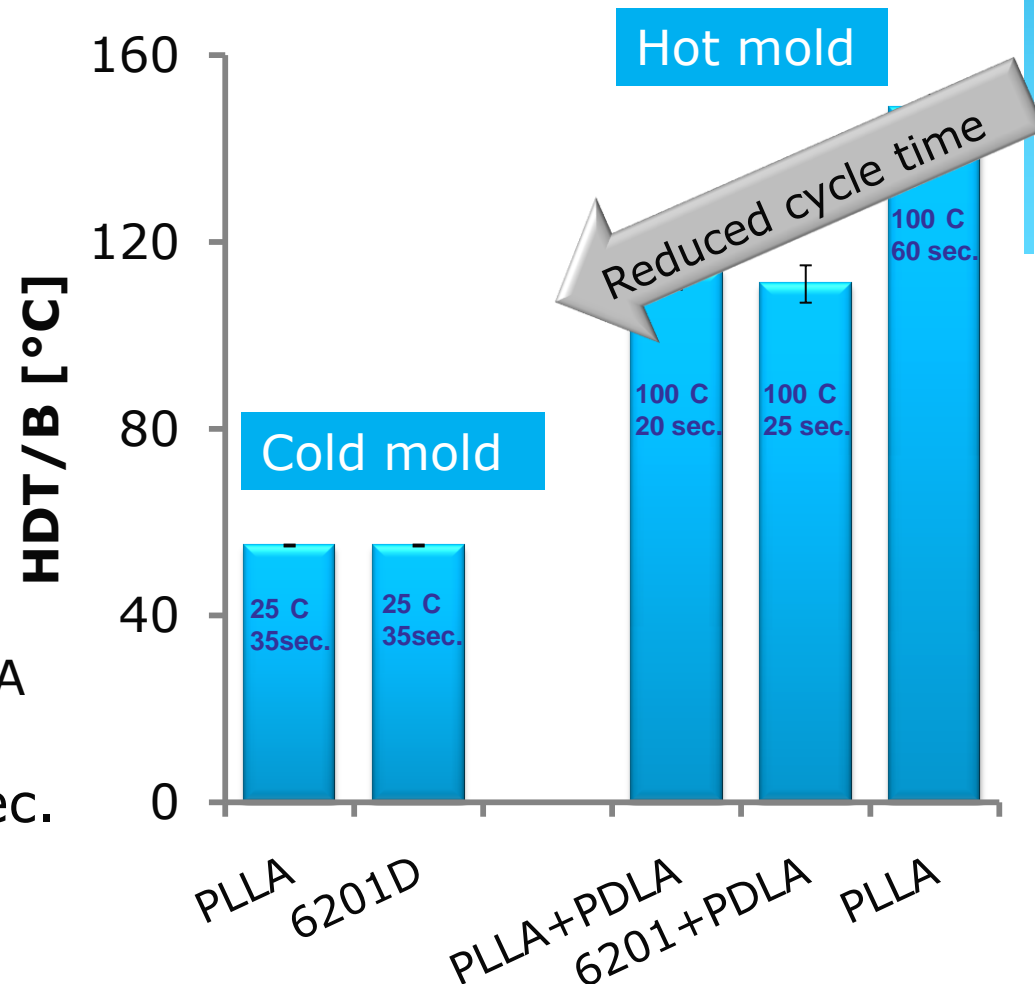
PLA with meso-lactide



- All 95/5 PLA/PDLA blends
- Results depend on PLA-type
- Best results with low D-amount in PLA resin

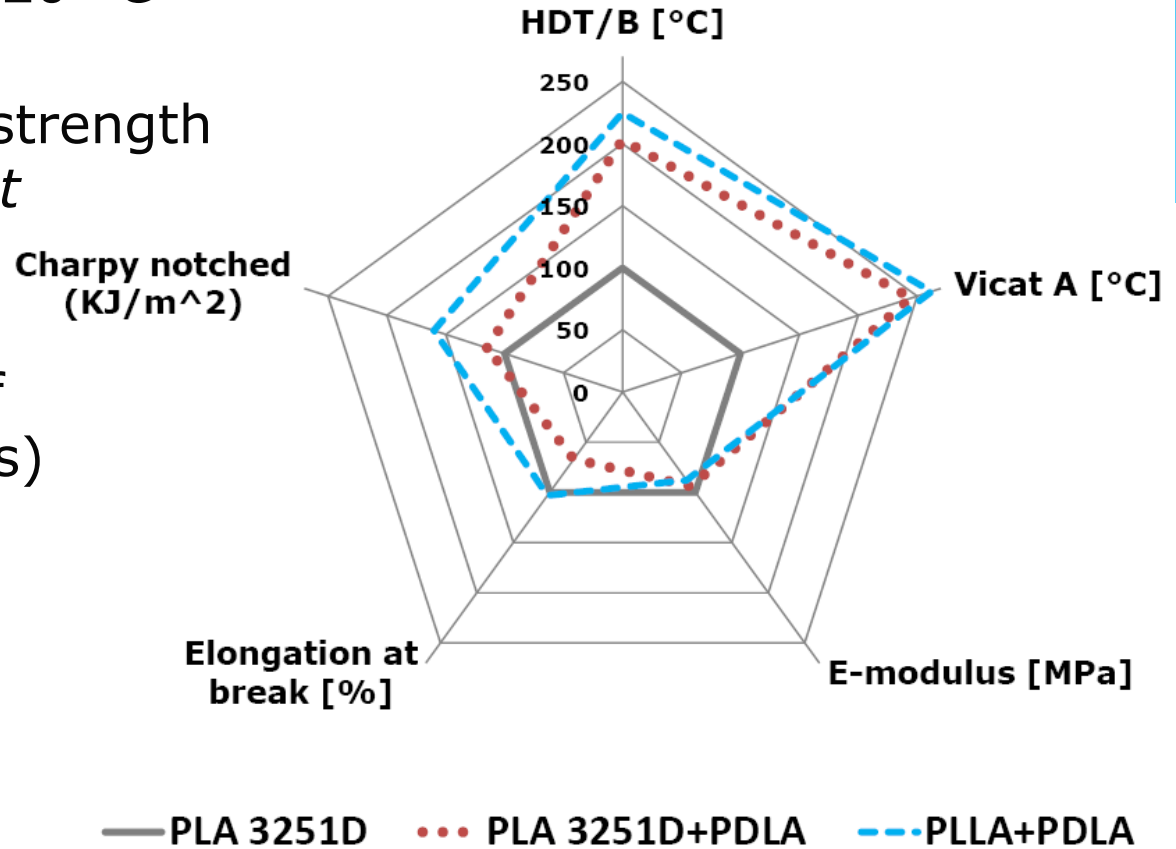
Excellent performance of PDLA nucleated PLA compounds

- Cold mold
 - Strong, clear PLA, but no heat resistance
- Hot mold
 - Crystallinity
 - High heat resistance with PDLA addition
 - Best processability with PDLA nucleated PLLA
- Full automatically run at short cooling times, 20 sec.



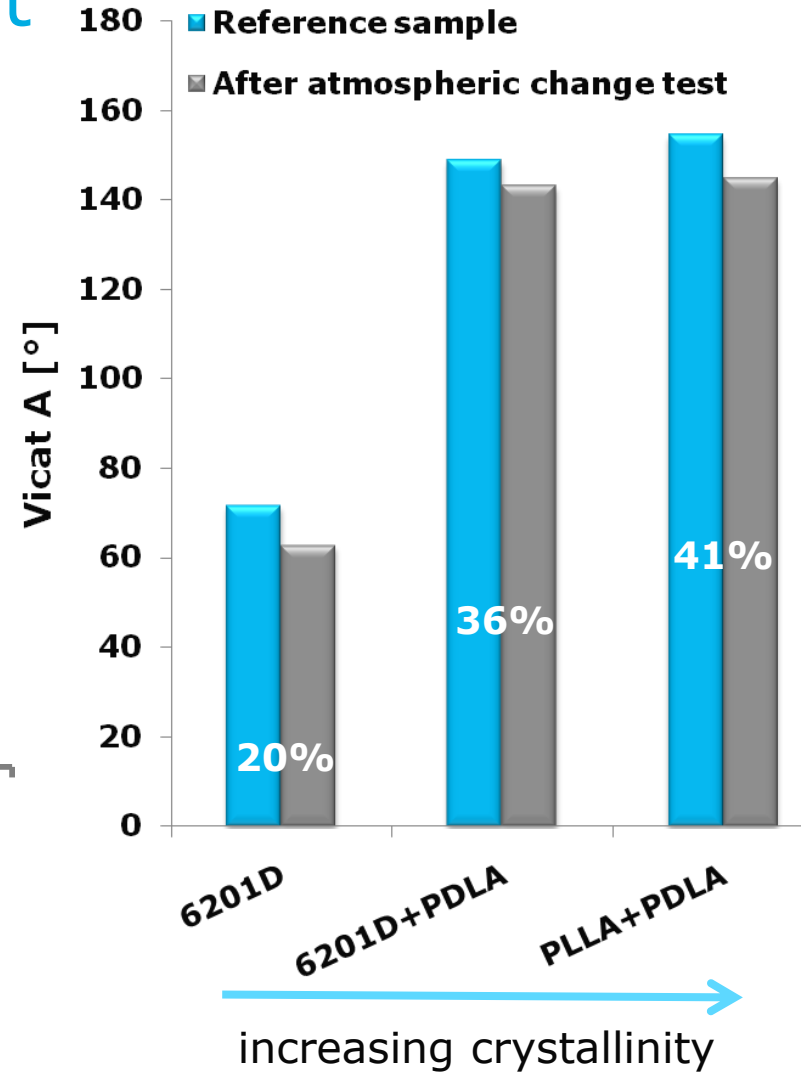
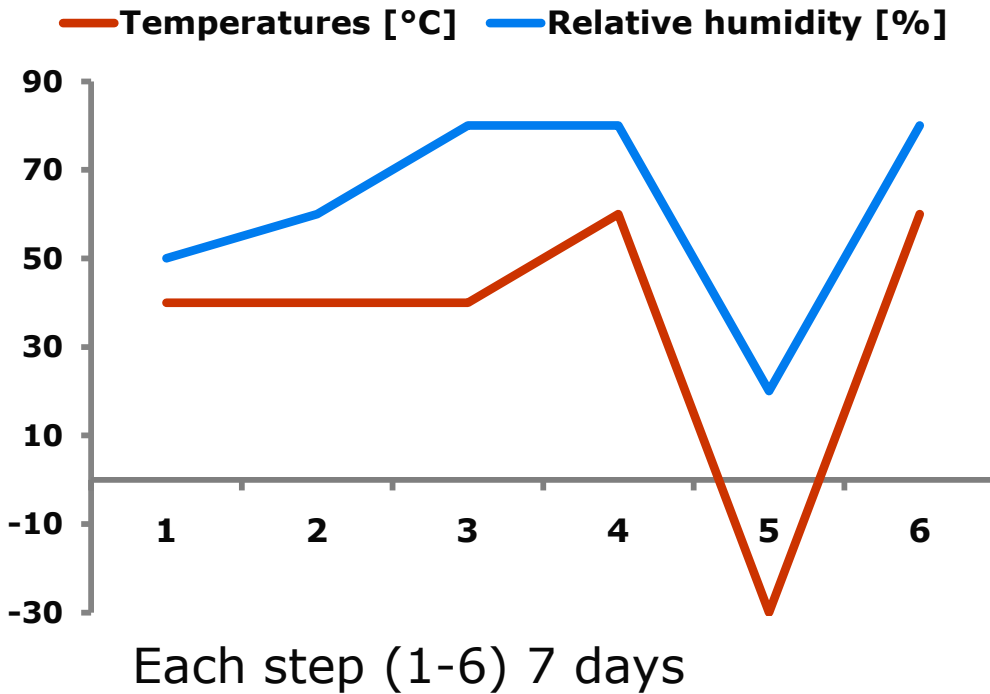
Improved mechanical properties with PDLA

- Significant increase of HDT/B from 50 to 120 °C
- Increase of impact strength and ductility *without* impact modifier
- Minimal decrease of stiffness (E-modulus)



Stereocomplex PLA shows durability in environmental stress test

Temperature /RH Profile



Conclusions

- Benefits of PDLA nucleated PLLA:
 - Renewable carbon content in PLLA/PDLA compounds maximized
 - Heat resistance greatly enhanced (Vicat A, HDT-B > 100 °C)
 - Fastest crystallization in Purac L-lactide homopolymer
 - Efficient impact modification with biostrength 150
- PLA processing conditions of key importance
 - Excellent processability in injection molding
 - Clear & rigid PLLA when using cold mold (also TF)
 - Hot mold (90-110 °C) allows for heat-resistant PLLA
 - Economical cycle times
- More info: visit our booth or www.purac.com

