Bioplastic Processing & Properties

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Unique Purac Lactides for improved PLA production and properties

PLA technology developed with Sulzer Chemtech

Robert Haan,
Senior Polymer Technician
PURAC Biochem, Gorinchem, The Netherlands

Presentation outline

- PURAC
- PLA from Puralact® L-Lactide and D-Lactide
- Purac Business model: Partnerships
- PLA processing: Improving properties

PURAC

- Since 1935
- Subsidiary of CSM
- World leader in the field of Lactic acid and Lactic acid derivates
- Headquarters and R&D in The Netherlands
- Experience with lactides and PLA since late 1960s
- 3-5 kton/year lactide plant in Spain since 2008

PURAC Locations

Blair-Nebraska, USA

Gorinchem - Netherlands

PURAC Thailand

Campos – Rio, Brazil

Montmelo, Spain

Map Tha Put, Thailand

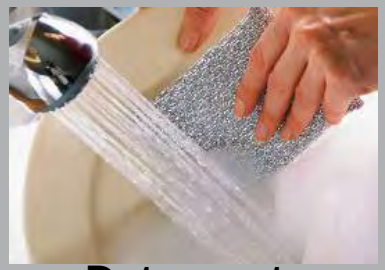
PURAC Headquarters (The Netherlands)

PURAC plants

PURAC sales offices

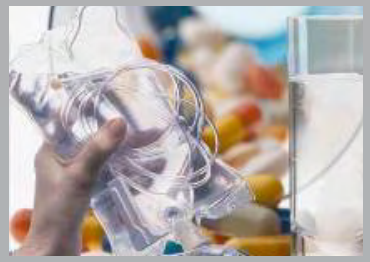
Lactic Acid A World of Applications

Food

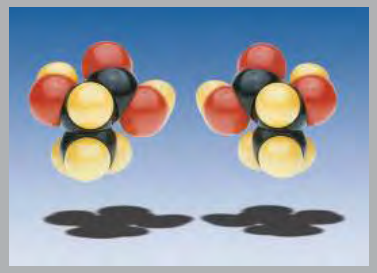


Detergents

Cosmetics



Pharma



Bioplastics

Medical

Industrial

Feed

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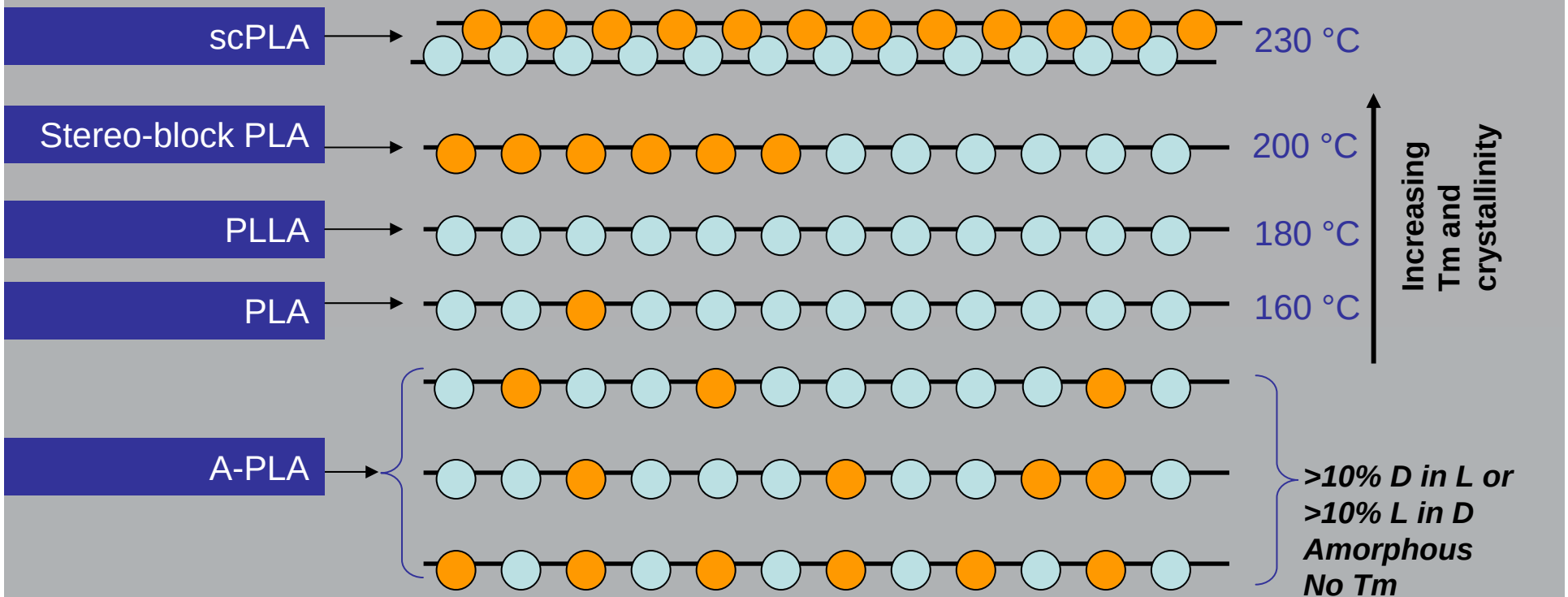
PLA is actually a family of (co-) polymers of D- and L-Lactic units



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Why PURAC L-lactide and D- lactide?

- **Blending of Lactides or blending of PLLA and PDLA**
- **1-10% sc-PLA in PLA acts as nucleating agent: HDT >100°C**
- **80-100% sc-PLA (40-50% PDLA in PLA): Tm > 200°C and HDT >150°C**

Flexibility with Puralact® L and D

Puralact® L and D increases PLA product portfolio

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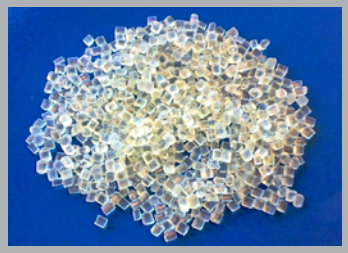
PURAC Business Model

Production chain of PLA

Production Carbo-hydrates → Production Lactic Acid → Production Lactide → Polymeri-zation → Final Conversion

Carbohydrate | Lactic Acid | Lactide | PLA Resin

PURAC POSITION



PURAC PARTNERS

PURAC (Thailand)

LACTIC ACID

Lactide

Transport

PLA1 | PLA2 | PLA3 | PLA4

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Plant in Thailand is running at full capacity

- Capacity 100.000 tons of non-GMO lactic acid
- 20 months construction period
- Running at full capacity since March 2008

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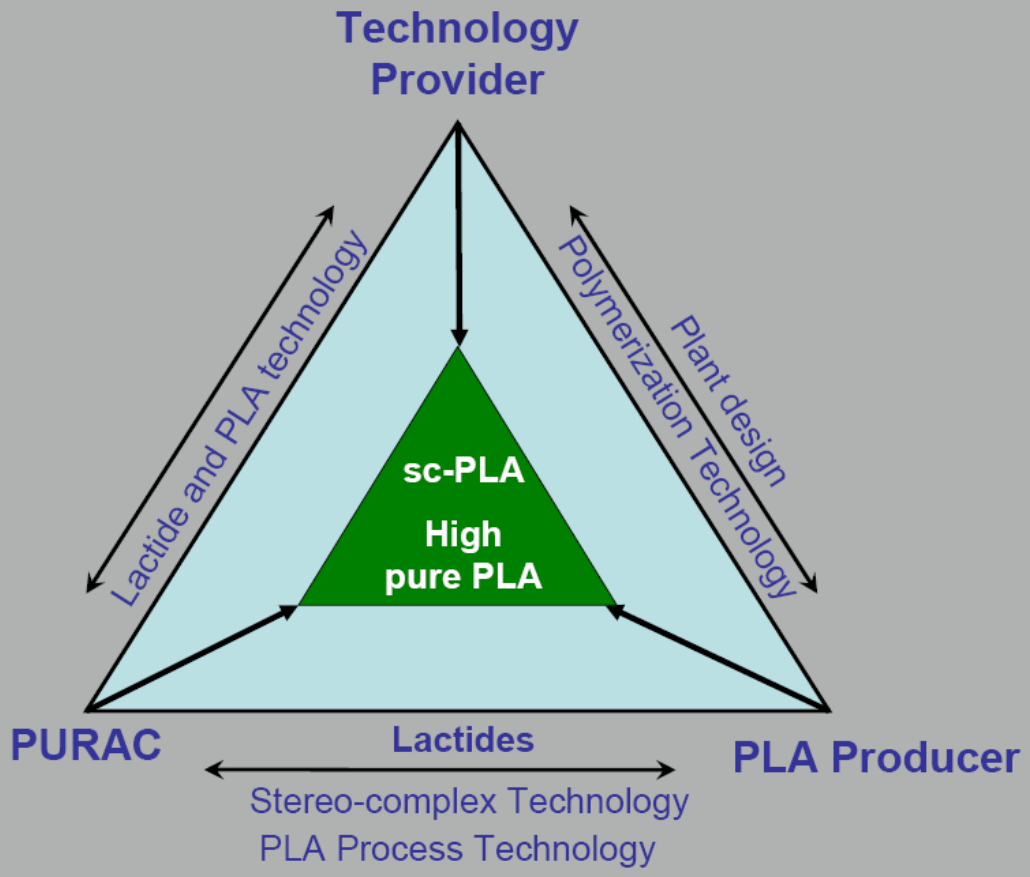
The PURAC PLA Solution



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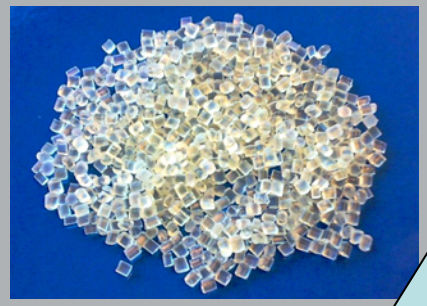
Partnership between PURAC, Sulzer and Synbra for PLA foams

SULZER



PLA

BIOFOAM

PURAC

Synbra

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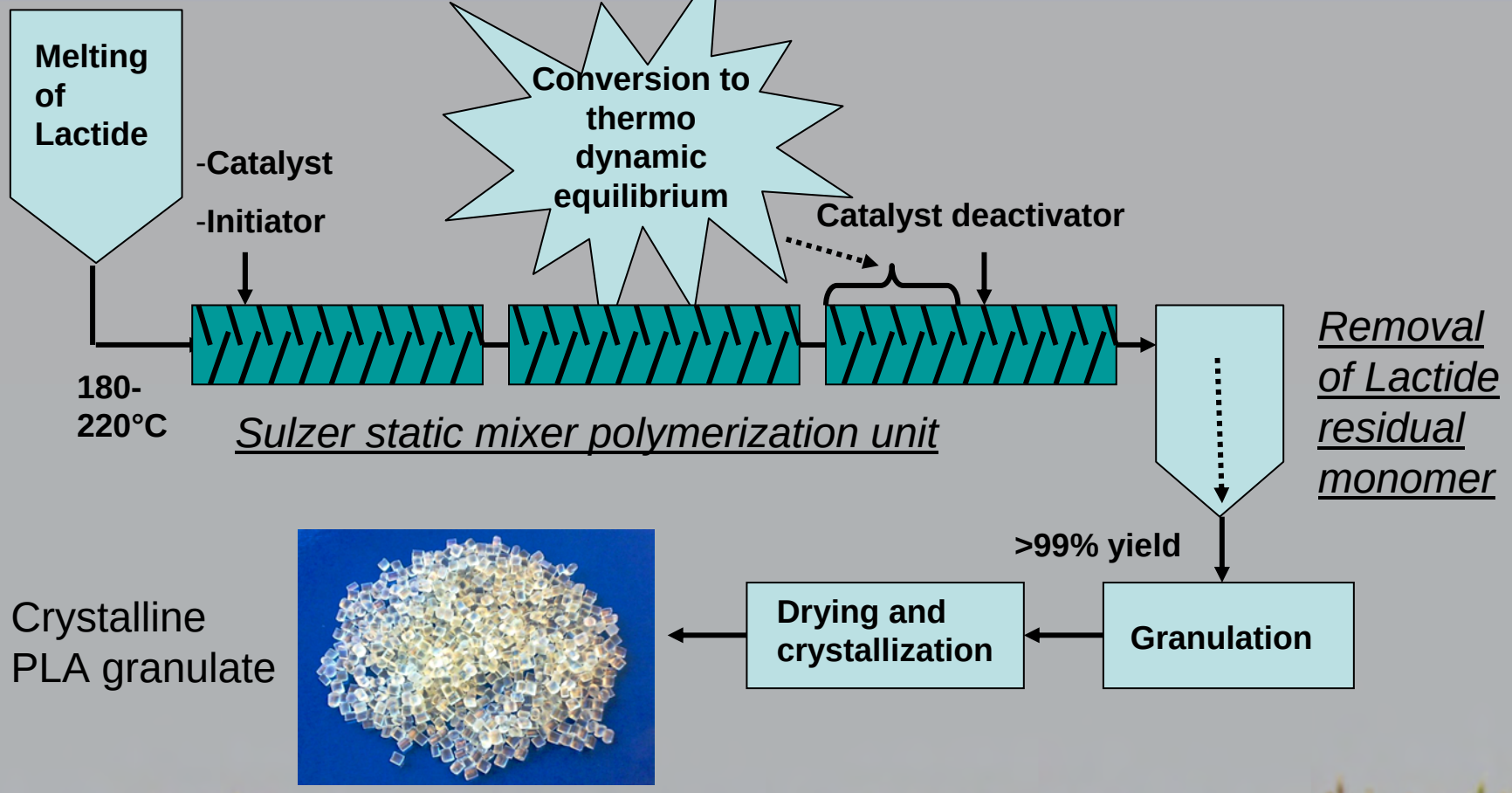
Sulzer polymerization and devolatilization technology

- Puralact® D and L from Purac Spain
- Polymerization of Lactide
- Devolatilization of Lactide residual monomer
- Fast track development since early 2008
- 5 kton/year production scale at Synbra at the end of 2009

Sulzer polymerization and devolatilization plant



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Characteristics of Sulzer-PURAC PLA polymerization process

Sulzer static mixer polymerization unit

- Static mixer system
- Intensive mixing
- Efficient polymerization reactors
- Target residence time: <1 hour
- Viscosity increases from mPas (Lactide) to kPas (PLA) !!
- Efficient heat removal (exothermal reaction gives ~130°C adiabatic temperature rise)

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Properties of PLA influenced by recipe and processing

Properties to improve for Amorphous PLA

- **Heat Deflection Temperature 50-60ºC**
  - Poor resistance to heat
  - Sticking of pellets during transport, storage, and processing
  - Deformation during transport and use of trays, preforms, cups, etc.
- **Poor Impact Resistance**
  - Engineering applications
- **Gas Barrier Properties**
  - Bottles
  - Packaging film

Hot coffee in PLA cup for cold drinks

Improvable properties of PLA are limiting range of applications

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How to process PLA?

- Can be processed on common process equipment
- Melt temperature ~180-200°C (~240°C for sc-PLA)
- Drying (<250 ppm H_2O)
- Crystallized granulate

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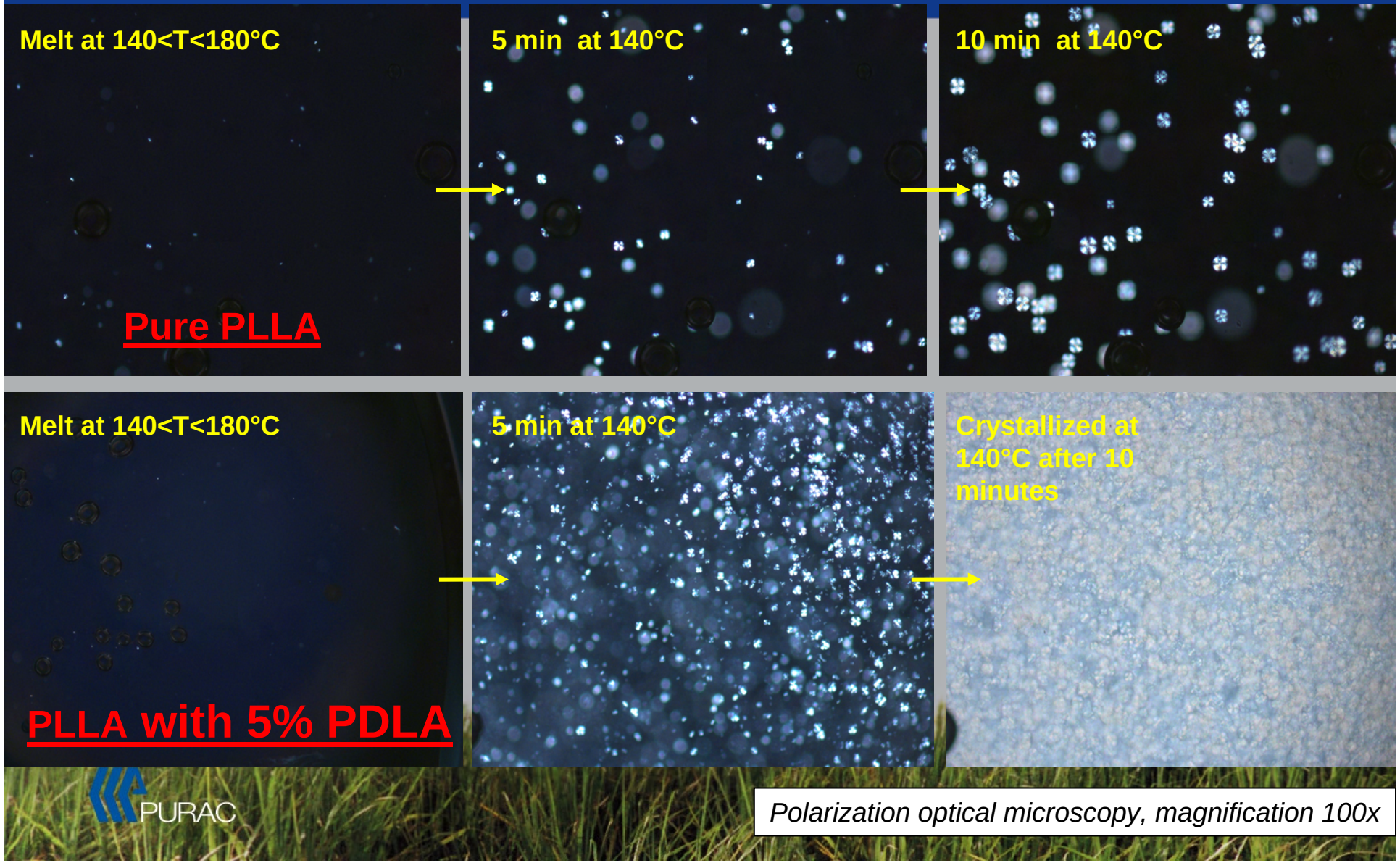
Faster crystallization from the melt with PDLA nucleating agent



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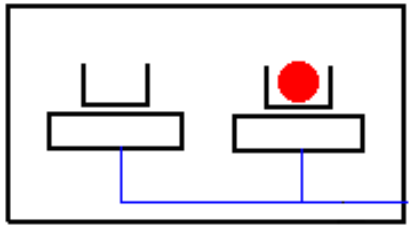
Polarization optical microscopy, magnification 100x

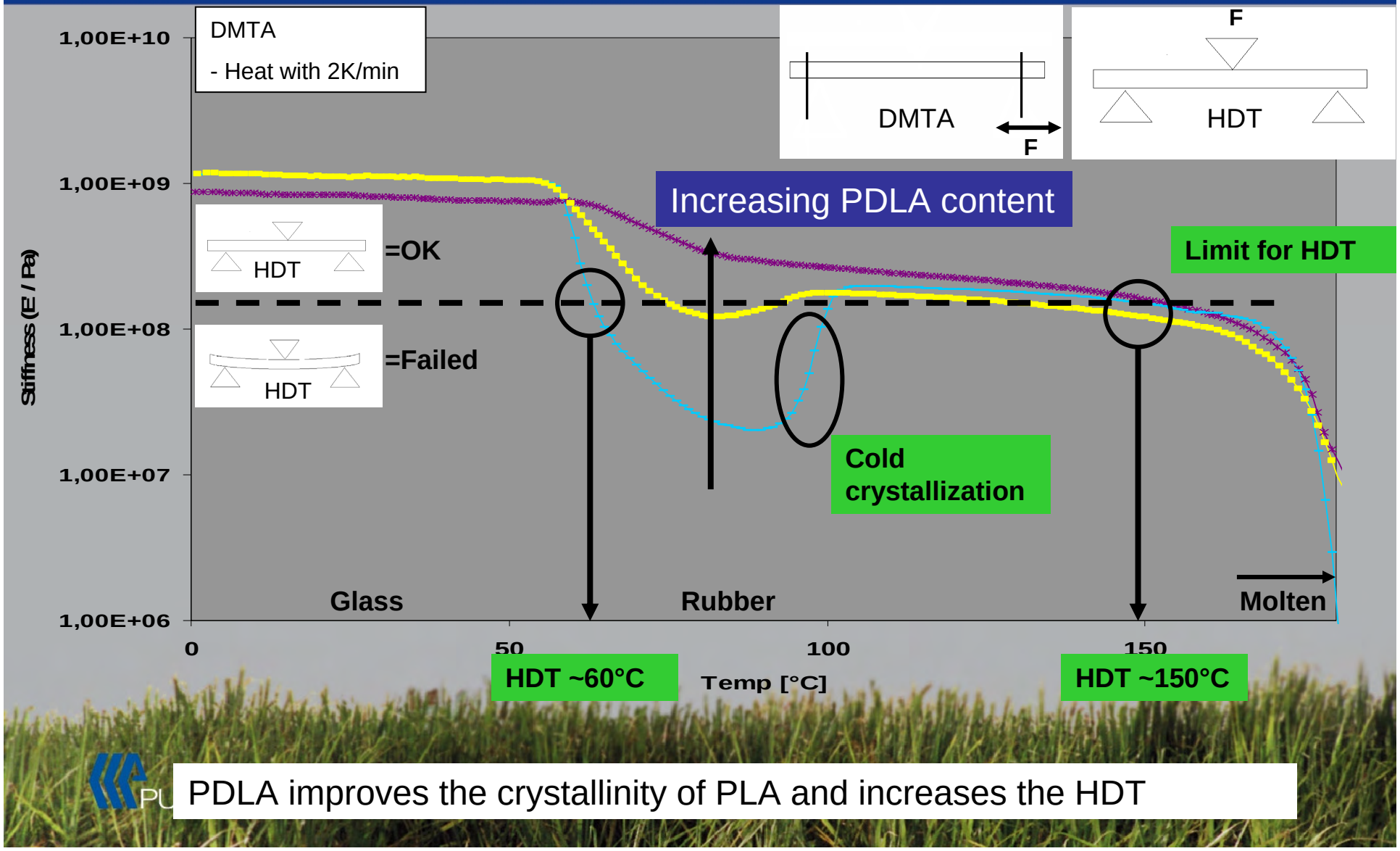
What has happened with PLA during cooling from the melt?



DSC

- 1st heating
- Heat with 10K/min

Stiffness of PLA bars by increasing temperature



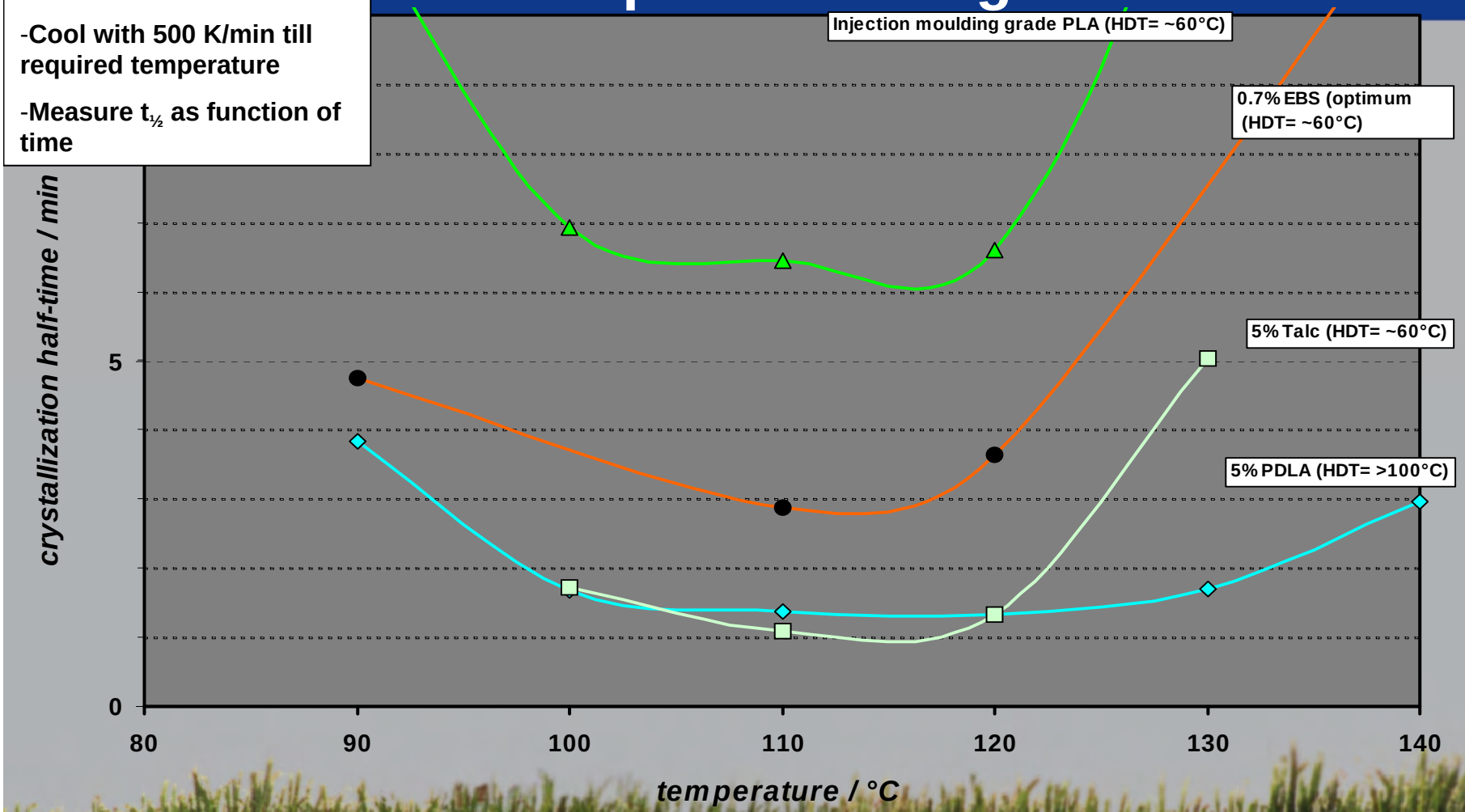
PDLA improves the crystallinity of PLA and increases the HDT

PDLA is efficient nucleating agent over a broad temperature range

-Melt material

-Cool with 500 K/min till required temperature

-Measure $t_{½}$ as function of time



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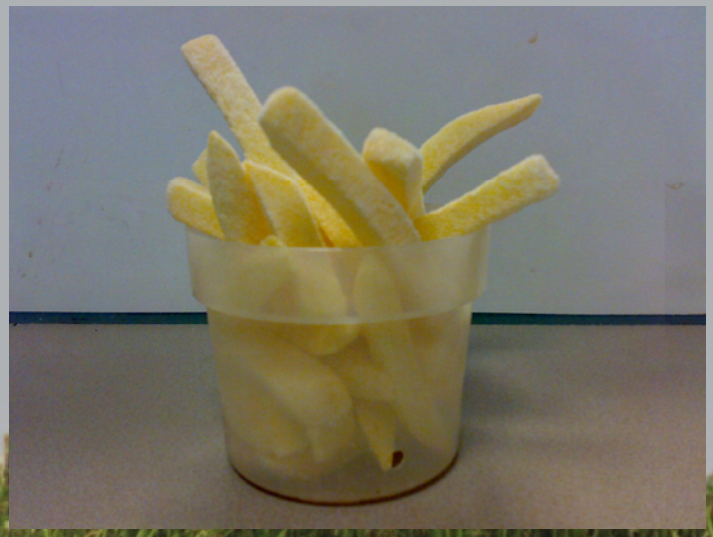
Sc-PLA improves HDT

Now

Coffee
70°C

Future with
sc-PLA??



Yes!!!

By mixing 40 % PDLA with PLA we can make cups that can be used till 190°C without distortion.
(e.g. Fried chips)

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Frying of chips

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