Samsung's Bioplastics For Automobile

Biobased • Sustainable • Renewable Source

SAMSUNG
Chemical R&D Center
Cheil Industries INC.

Why We Promote the BIO-based Plastics?

- **Good in many environmental aspects**
  - Oil saving
  - CO_2 Gas Reduce
- **Paradigm shift from Oil to biomass**
  - Practical alternative to a Petroleum-based plastics
- **Customers' interest**
  - Customers can look and touch by using as casing
- **GHG emission restrictions**
  - Kyoto Protocol, the EU ETS

Eco-Product Logo

the biomass mark

The Japan Organic Resources Association (JORA http://www.jora.jp/)

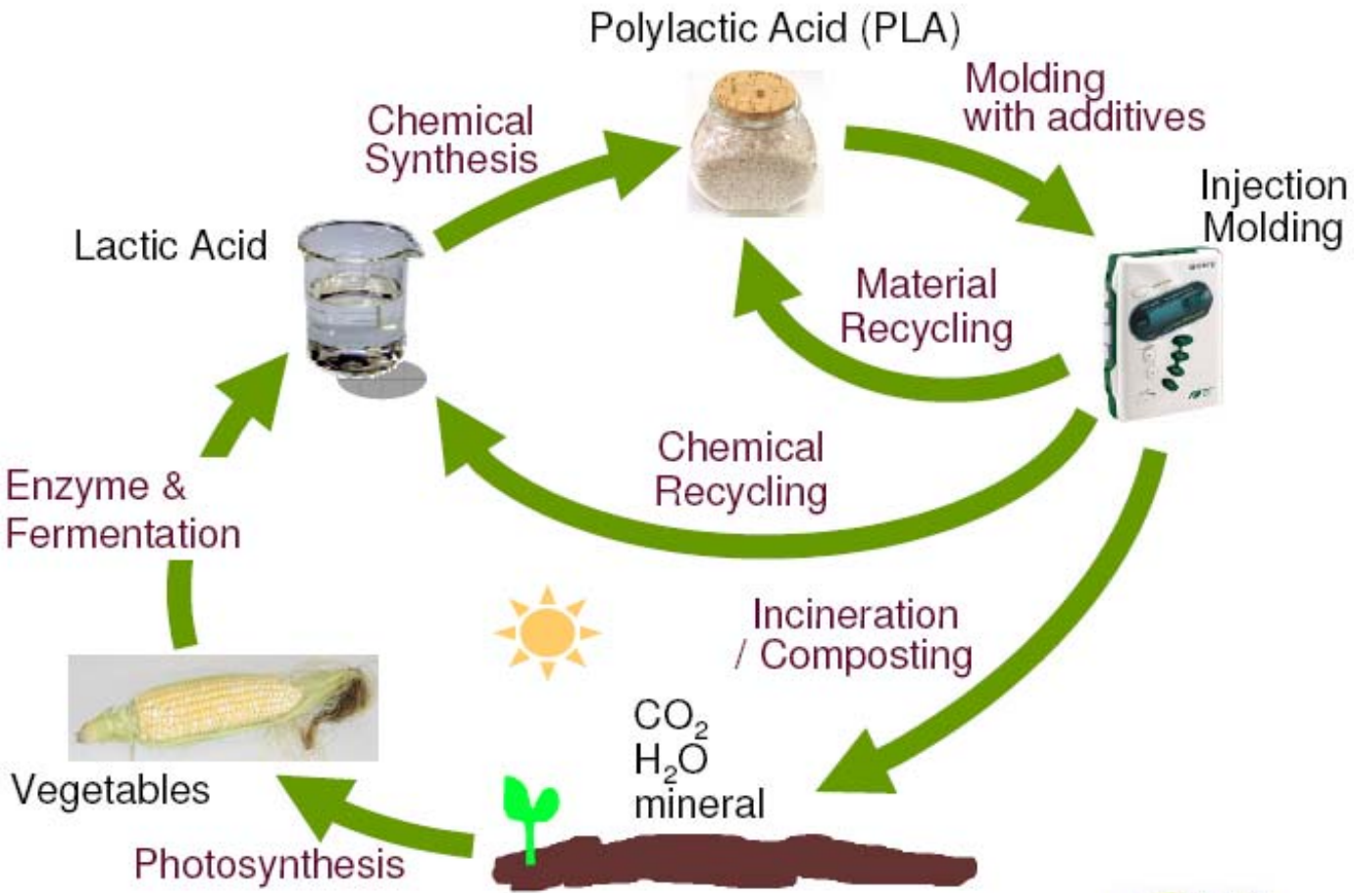
NatureWorks' PLA resin

Green Tags

Product Content Label for BEF *Zephyr Energy*TM – 2006
Zephyr Energy Green Tags from the Bonneville Environmental Foundation (BEF) are a renewable energy certificate product.

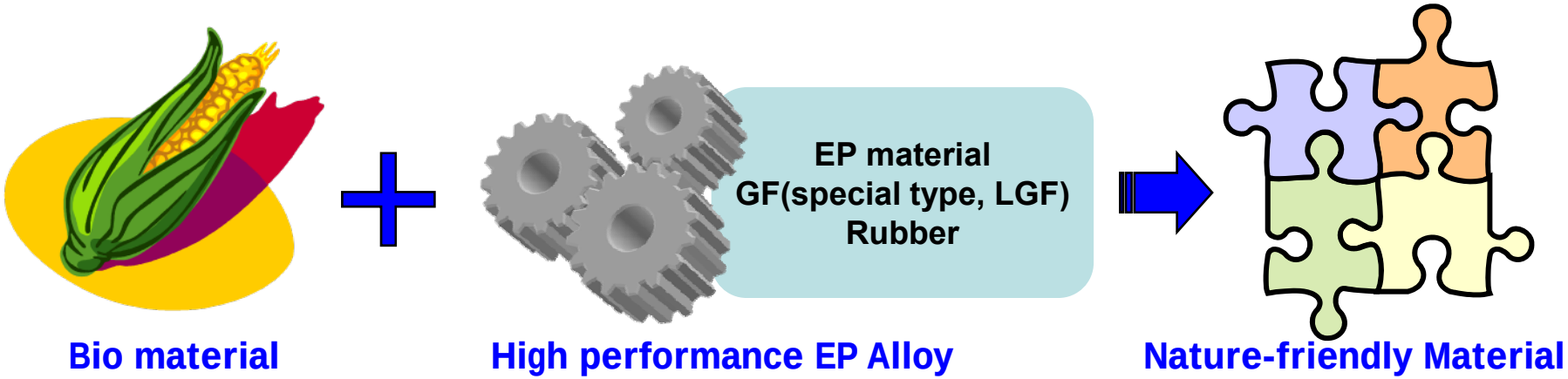
The Green Purchasing Network (GPN)

Life Cycle of Poly Lactic Acid (PLA)



EP/Bio-alloy Materials

- Realization of Environmental Friendly Material by EP(Engineering Plastics)/Bio-alloy
- PLA (Poly Lactic Acid) correspond with the move towards green, but PLA is mechanically and thermally weak to use a housing material.



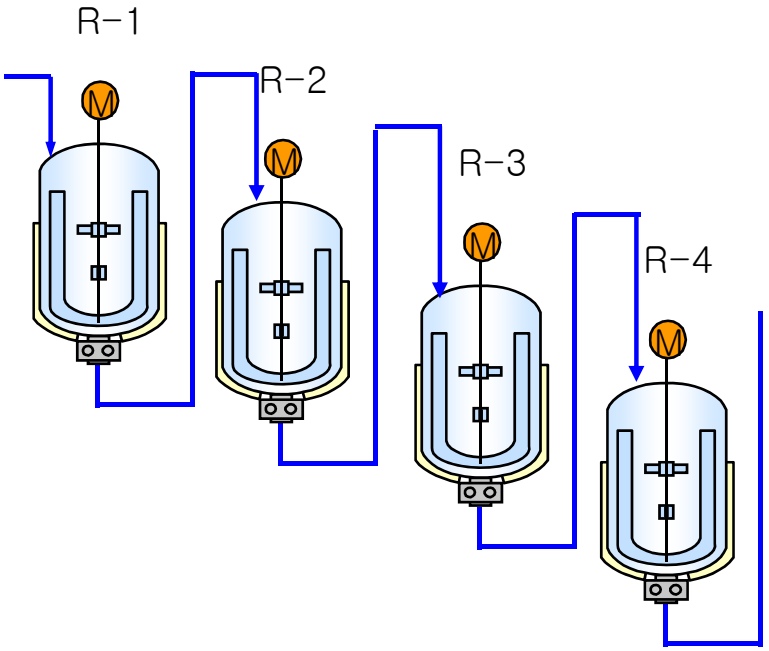
- By combination with Bio material and EP, high performance of mechanical properties and nature-friendly characteristics can be achieved.
- Biomass target is at least 50%.

Samsung's Technology

Continuous Process Technology

- **Development of Continuous Polymerization Process**
  - **PS, HIPS, SAN, ABS, PMMA, PC**

- **Development of Polymerization Process for Optical Transparent Materials**
  - **Copolymerization technology**
    - **→ New base resin can be produced**
    - **→ Impact modifier for PLA**
    - **→ Compatibilizer for PC/PLA, ABS/PLA**



- **PLA Synthesis (Lab Scale)**
  - **→ Research & Development for Stereocomplex PLA**

Samsung's Technology

Engineering Plastics

Samsung Cheil industries produces over than 100 thousands ton/year engineering Plastics.

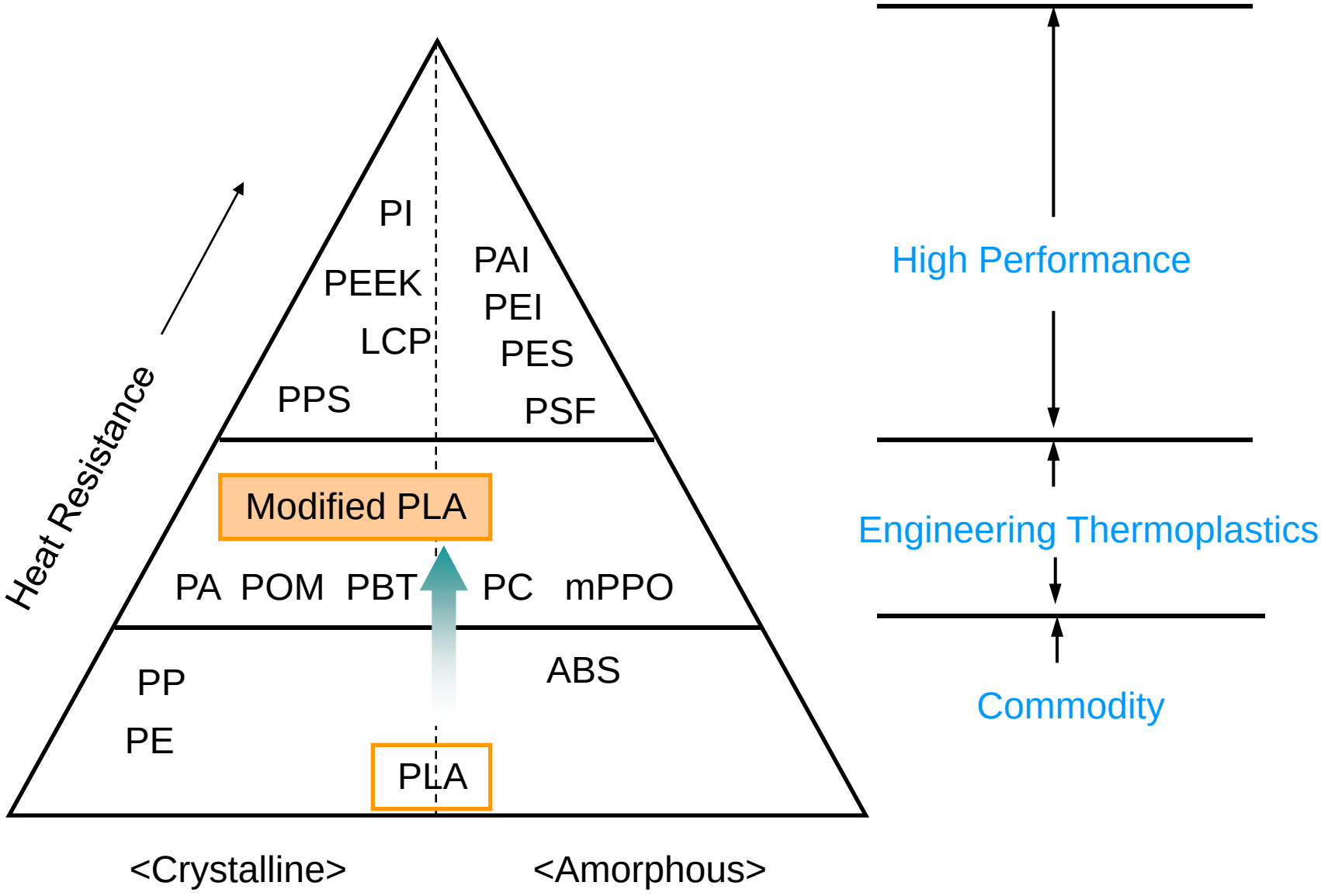
→ Great store of knowledge about formulation, surface modification, producing technology, technical service.

Products: PC, PC/ABS, PC/GF, PPS, LCP, MPPE, High Temperature Nylon

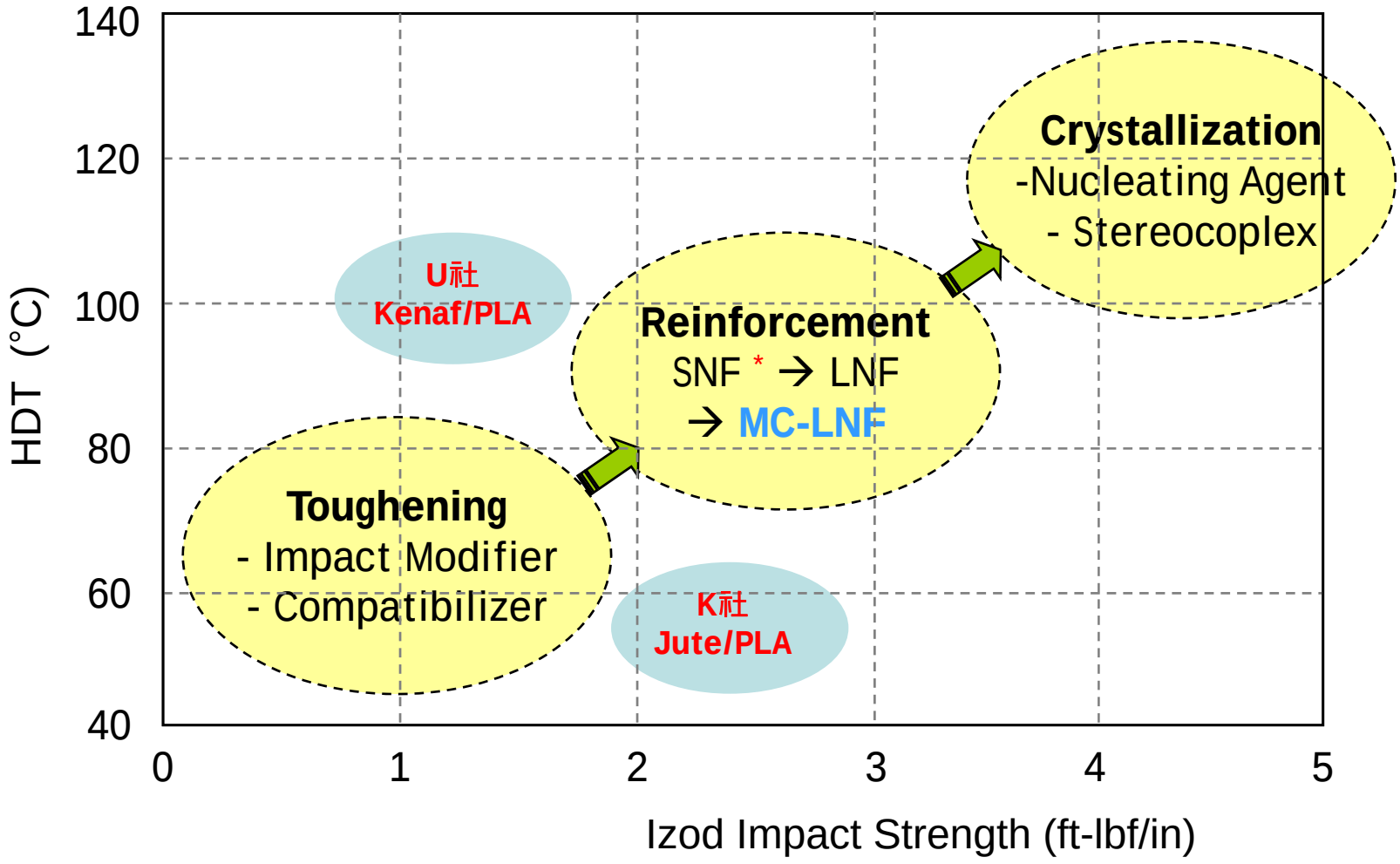
Achievement

- High Value-Added Engineering Plastics
  - Mobile Phone Housing : World M/S 18% (2nd)
  - LCD Back Light Unit Frame : World M/S 20% (2nd)

Our Technical Goal



Key Technologies to our goal

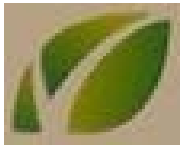


* SNF - Short Natural Fiber
LNF - Long Natural Fiber
MC-LNF; Multi-Component Long Natural Fiber

Mobile Phone Application

◇ **Vegetable base Mobile Phone**

- Sony have plans to use bioplastics to replace conventional plastics in some parts of Mobile phone.



◇ **Kenaf/PLA Composite**

Developing an highly heat-resistant PLA composite by the combination with kenaf fiber (Maintaining high biomass ratio: 90%)

Automotive Eco-Design Examples

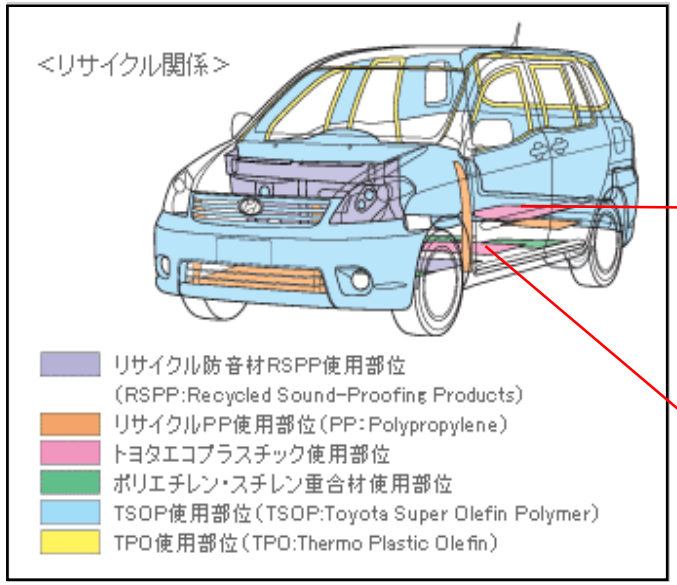
Mazuda

A new bio-fabric from Mazda will trade in synthetic fibres for an all-natural upholstery product containing 100% PLA.
(2007. 9. 13 日刊自動車新聞)

Premacy Hydrogen RE Hybrid

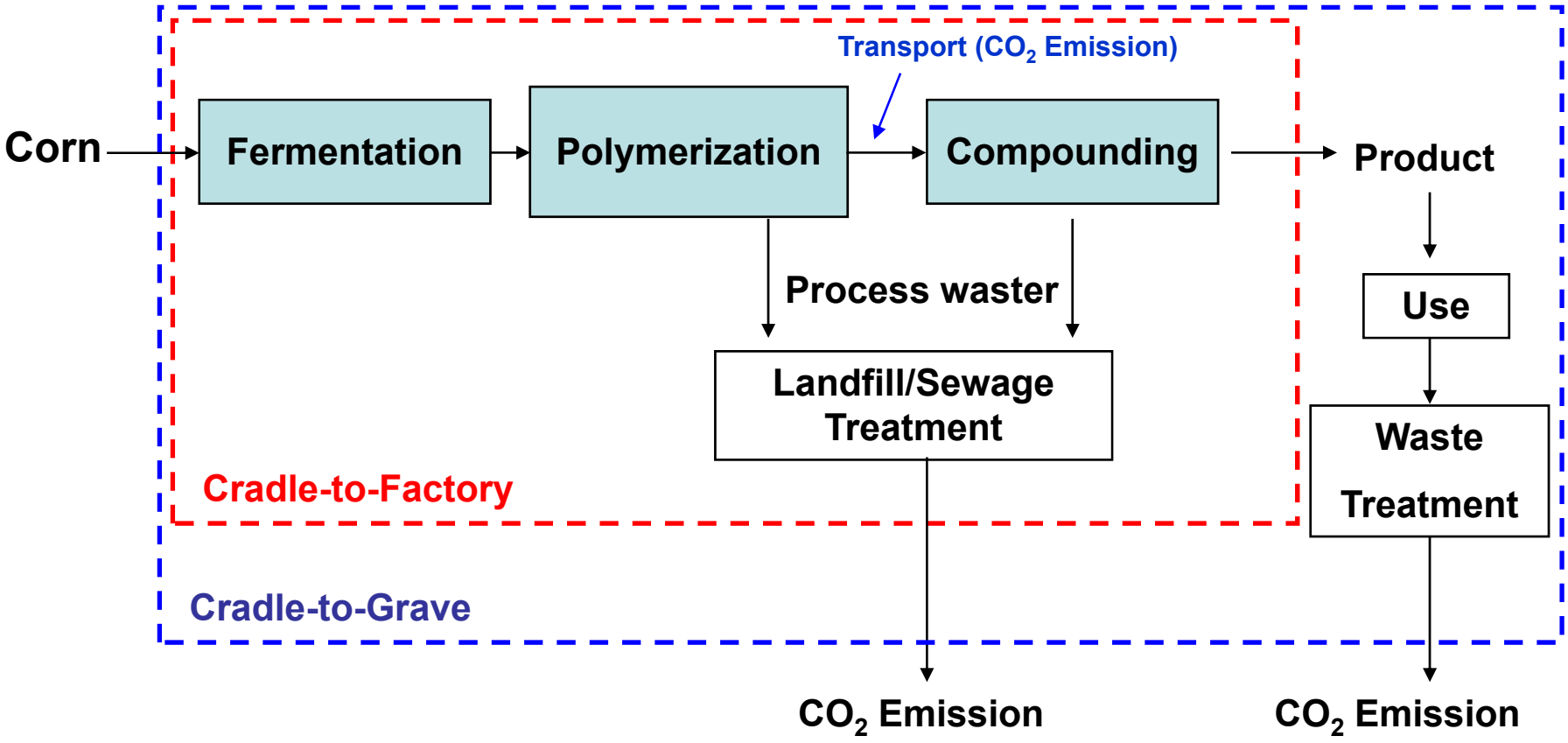
Toyota

Toyota unveiled the Raum SUV in 2003, which had floor mats and a spare-tire cover made from Toyota's Eco-Plastic PLA reinforced with kenaf plant fiber
(2007. 9. 6 日刊自動車新聞)



Life Cycle Assessment

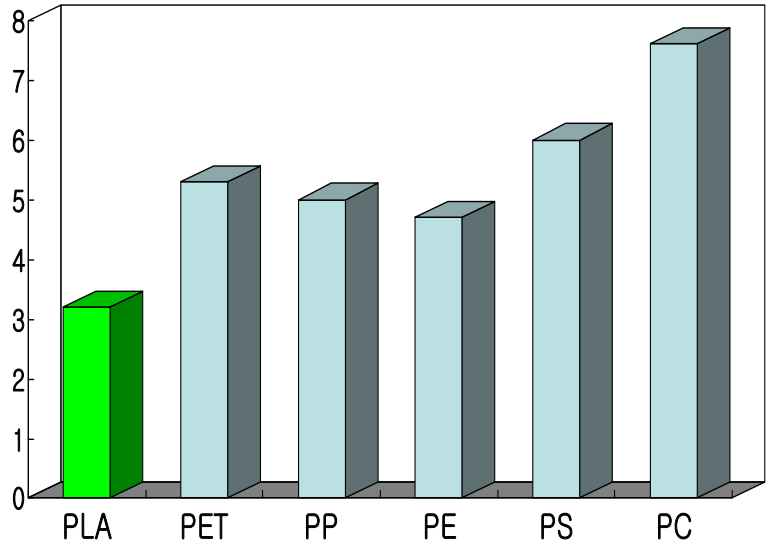
System Boundaries of LCA for Bioplastics



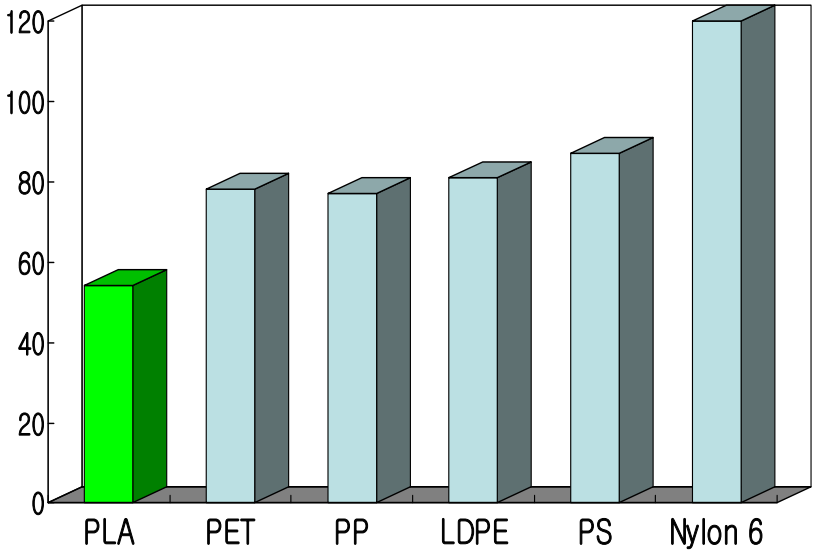
LCA (Life Cycle Assessment): A scientific approach to measure quantitatively the environmental performance of a product or system

Environmental Impact

Greenhouse Gas Emission
(g-CO_2/g-Resin)



Production Energy Consumption
(MJ/kg)

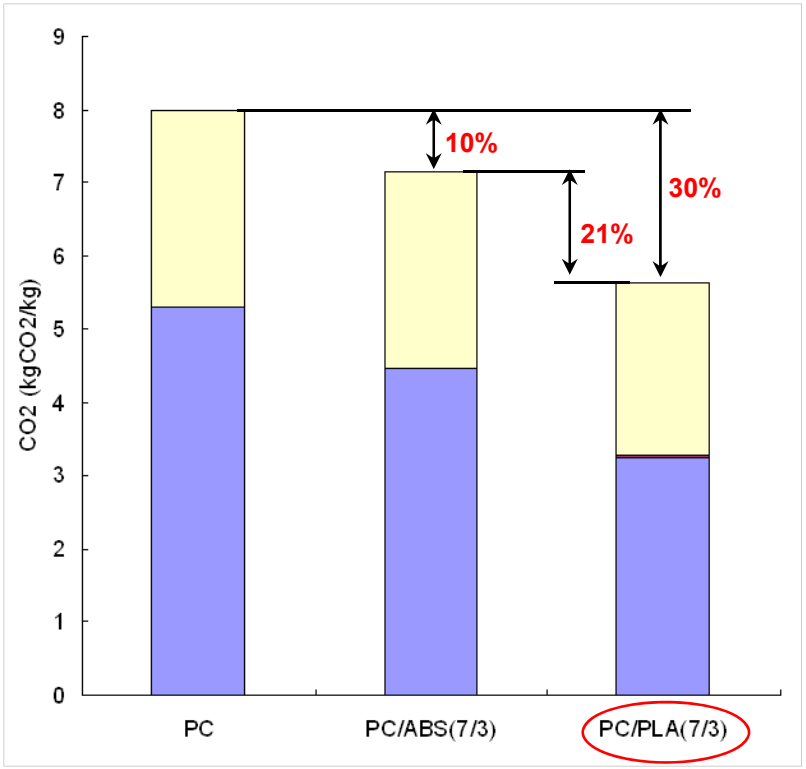


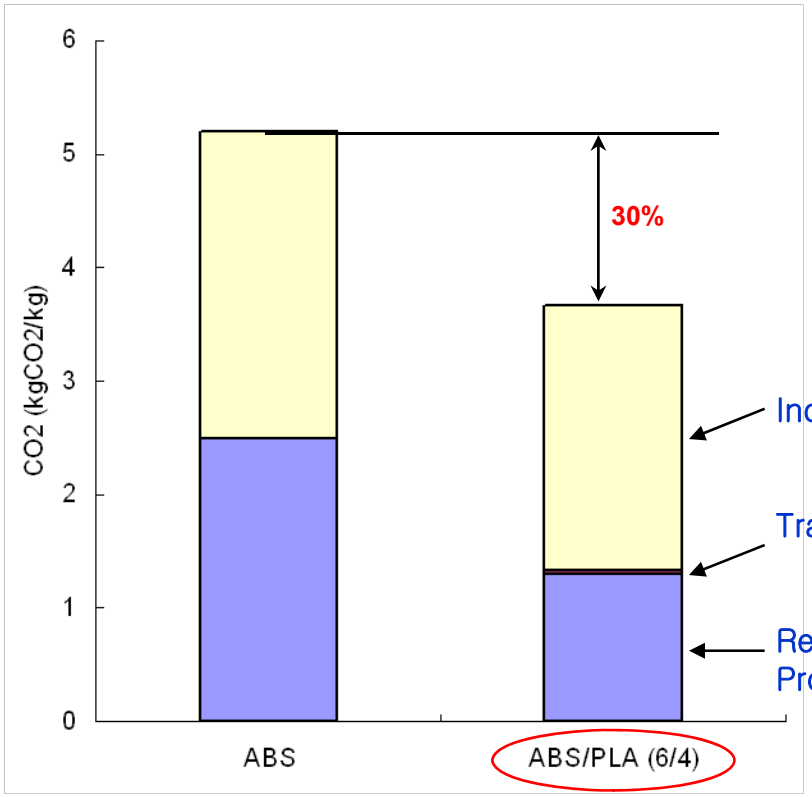
Clear advantage for bioplastics: GHG emissions ↓, Energy ↓
(compared to conventional polymers & bioenergy)

Ref. Dr. Martin Patel, Utrecht University

Eco-Efficiency

LCA calculation focused on CO_2 Gas reduction

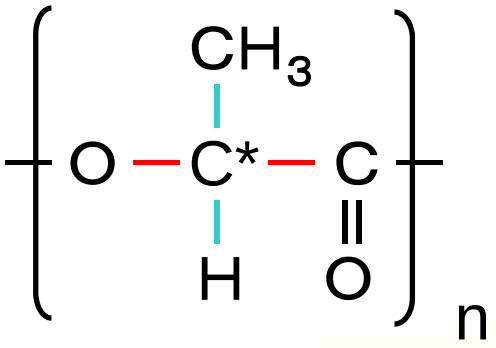




Lower Density → Lighter Part → Lower CO_2 Emission ← High Performance of Biomass

Stereocomplex of PLA

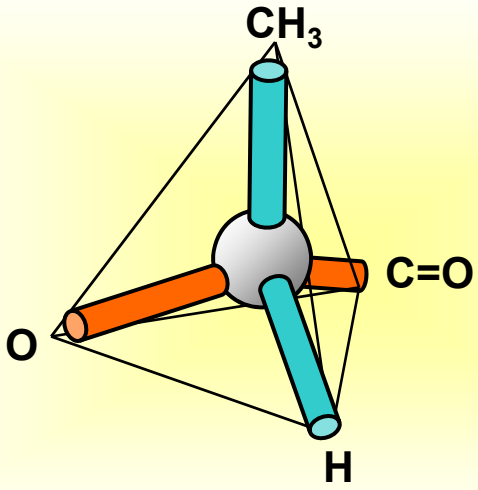
Sterocomplex PLA



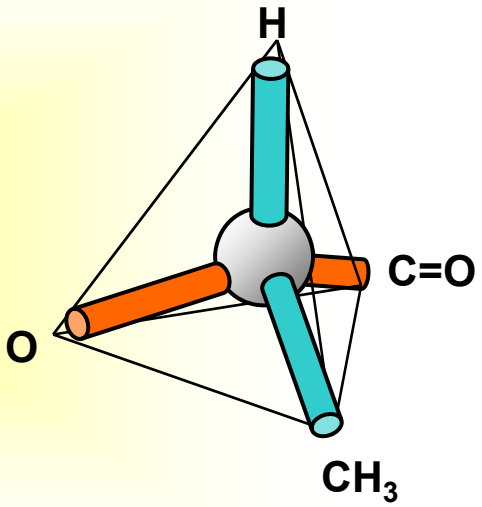
C* : asymmetric carbon

→ L-lactide, D-lactide

PLA: PLLA, PDLA, PLDLA



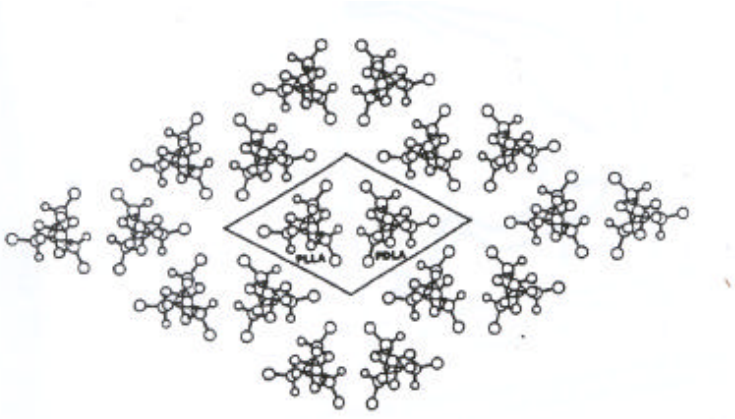
L-lactide



D-lactide

Properties of Stereocomplex PLA

	Pure PLLA	Sc-PLA (PLLA/PDLA 50/50)
T_g (°C)	50 ~ 60	65 ~ 72
T_m (°C)	170-180 (depending on D-content)	220-230
ΔH_m (J/g)	93	100 ~ 140



Definitions :

PLLA = pure L(+)-lactic acid (poly(L-lactide)

PDLA = pure D(-)-lactic acid (poly(D-lactide)

sc-PLA = 1/1 PDLA and PLLA (50/50 w/w)

Practical Benefits of Stereocomplex PLA

- Injection molding PLA: cycle time reduction
- Better heat stability
- Better mechanical properties
- Better durability, slower degradation
- Engineering Applications for PLA

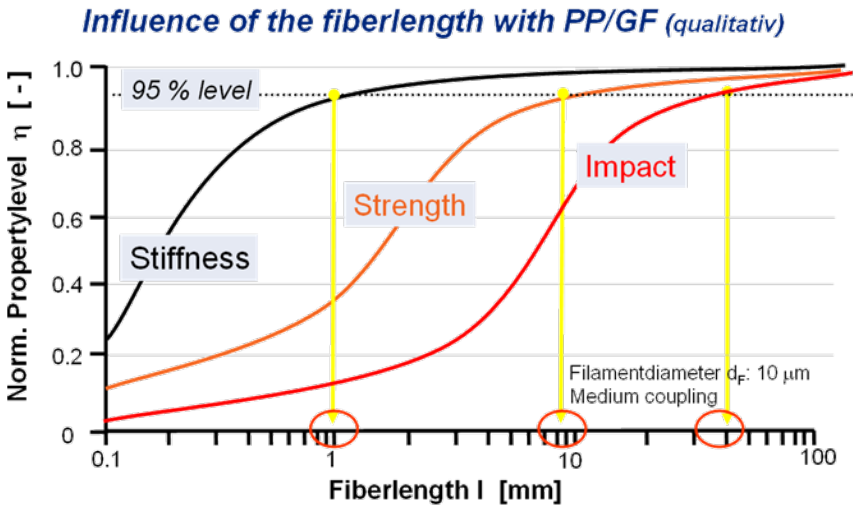
PDLA widens the application window of PLA

Long Fiber Technology

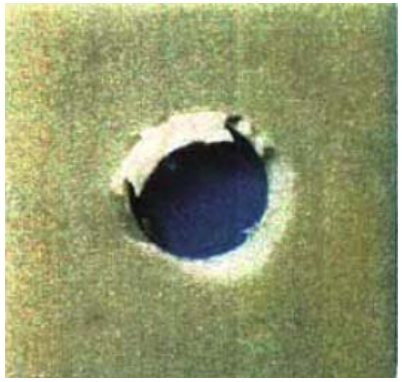
Advantages of Long Fiber Technology(LFT)

Representative Enhanced Properties

- High Strength
- Enhanced Modulus
- Superior Creep Resistance
- Excellent Fatigue Resistance
- Improved Dimensional Stability
- Better Heat Resistance



PP/SGF 30%



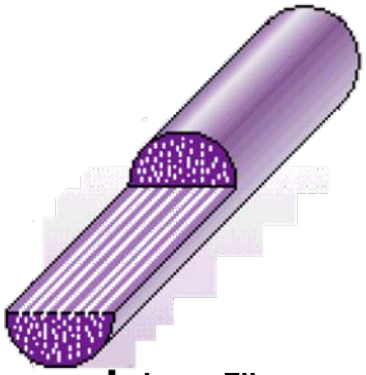
PP/LGF 30%

Total Penetration energy

2.32 J/mm

7.31J/m

Short Fiber

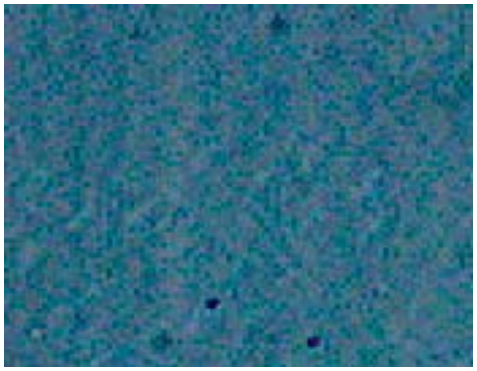
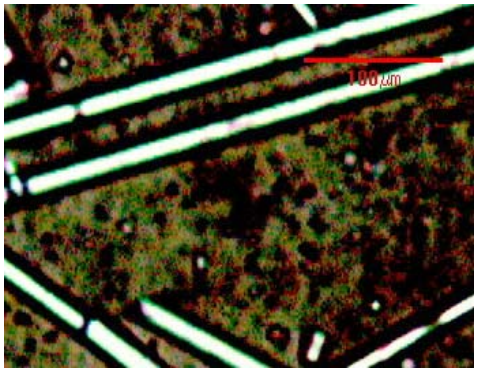
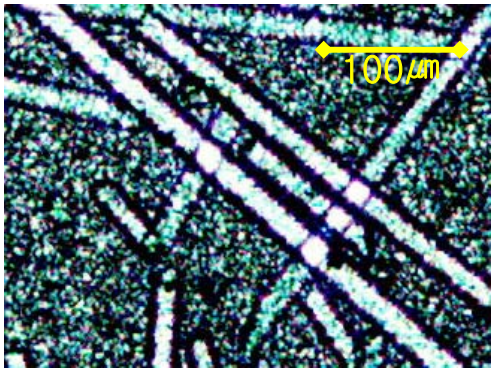


Long Fiber

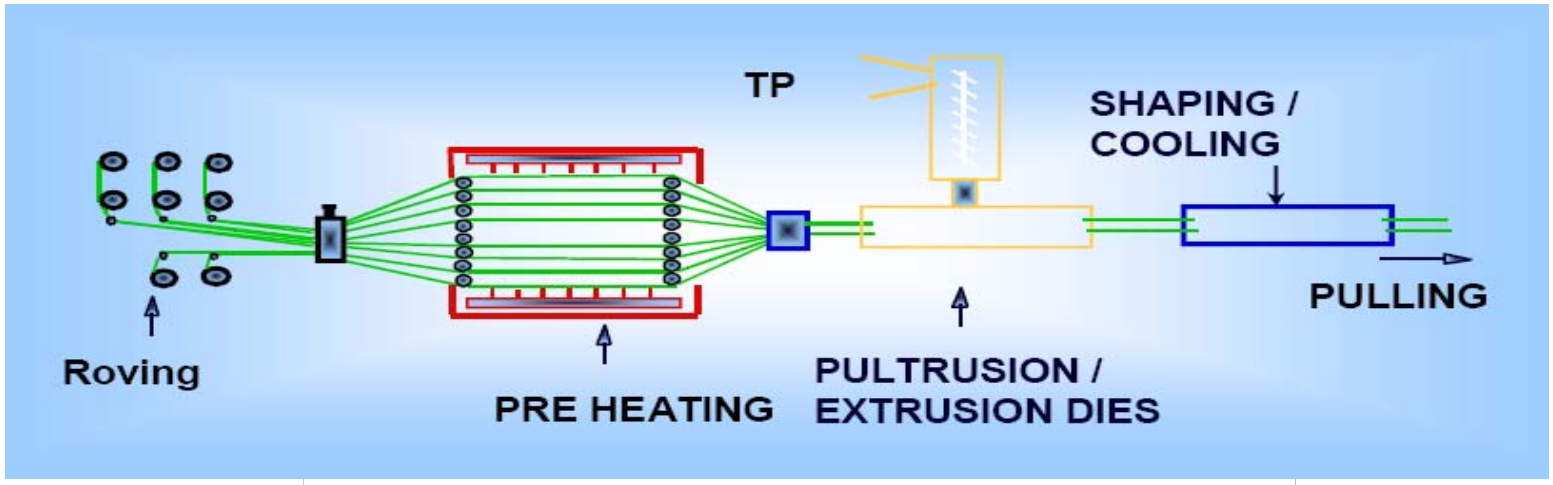
Improving Crystallization of PLA/LGF Composites

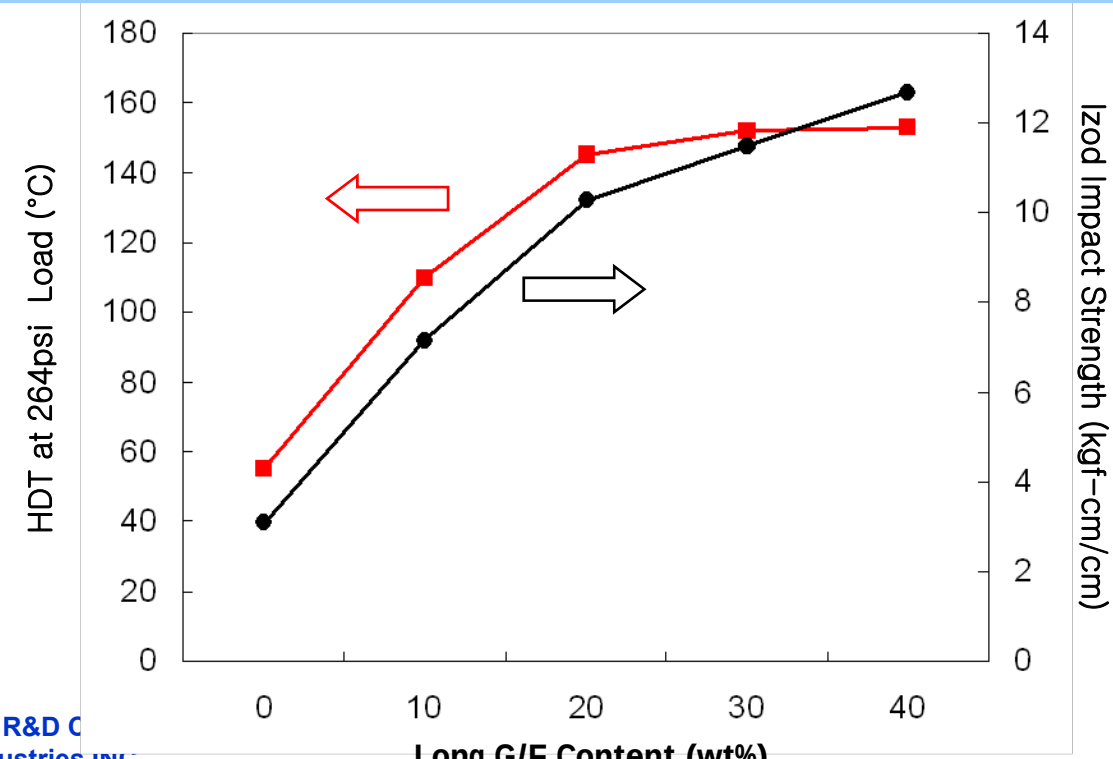
Special Nucleating Agent for PLA

Test conditions: 200 ℃ → 140 ℃ cooling with10℃/min rate

	Neat PLA	PLA + G/F	PLA + G/F +Nucleating Agent
HDT (°C)	55	60	150
IZOD (ft-lbf/in)	0.6	3	3.3
Optical Microscope			

PLA/Long Glass Fiber (LGF) Composites





General Properties

Properties of PC/PLA Alloy

General Properties	Unit	Grade	GL-1355S	GL-1455S	PC/ABS (HP-1001N)
		Biomass cont.	35 %	45%	0 %
Tensile Strength	Psi		7,100	7,700	7,800
Flexural Strength	Psi		10,700	11,400	11,100
Flexural Modulus	Psi		291,000	335,000	298,000
Impact Strength	Ft-lbf/in (1/8”)		12.8	12.8	8.3
HDT	deg.F (264 psi)		230	167	232
Melt Flow Index	g/10min (250℃, 10kg)		45	30	40
Density	g/cm^3		1.18	1.18	1.15
Mold Shrinkage	%		0.8 ~ 1.0	0.8 ~ 1.0	0.5 ~ 0.7
Hydrolysis Stability	FS retention(%) after 150hr at 80°C & 95%RH		95%	95%	100%

Long Glass Fiber(LGF) Reinforced PLA Composites

General Properties	Unit	Grade	GL-0505G	GL-0755G	PC/GF (HF-3200)
		Biomass cont.	50%	75%	0%
Tensile Strength	Psi		14,100	16,600	4,200
Flexural Strength	Psi		20,900	20,700	24,100
Flexural Modulus	Psi		1,623,000	880,000	795,000
Impact Strength	Ft-lbf/in (1/8")		2.6	3.1	3.7
Density	g/cm^3		1.6	1.37	1.33
HDT	deg.F (264psi)		302	302	289
Hydrolysis Stability	FM retention(%) after 150hr at 80°C & 90%RH		95%	95%	100%
Remark			G/F 40% Reinforced	G/F 20% Reinforced	G/F 20% Reinforced

Properties of ABS/PLA Alloy

General Properties	Unit	Grade	GL-3405H	GL-3405S	ABS (SR-0325)
		Biomass cont.	40%	40%	0%
Tensile Strength	Psi		6,400	6,500	7,000
Flexural Strength	Psi		9,500	9,500	9,900
Flexural Modulus	Psi		285,000	317,000	312,000
Impact Strength	Ft-lbf/in (1/8")		5.5	1.1	2.8
Density	g/cm^3		1.11	1.12	1.06
MI (230 °C, 2.16kg)	g/10min		8	20	8
VST	deg.F (5kg)		226	234	230
HDT	deg.F (66 psi)		216	230	266
Hydrolysis Stability (Retention of FS)	After 8 days at 60°C and 90%RH		~ 92%	~ 93%	100%
Remark			High Impact ABS/PLA	Standard ABS/PLA	High Temp. ABS

Properties of Reinforced ABS/PLA

General Properties	Unit	Grade	GL-3503N	GL-3203G	ABS (SR-0325)
		Biomass	50%	50%	0%
Tensile Strength	Psi		6,800	10,800	7,000
Flexural Strength	Psi		9,800	15,900	9,900
Flexural Modulus	Psi		398,000	440,000	312,000
Impact Strength	Ft-lbf/in (1/8")		0.9	1.7	2.8
Density	g/cm^3		1.16	1.25	1.06
MI (230 °C, 2.16kg)	g/10min		15	4	8
VST	deg.F (5kg)		212	194	230
HDT	deg.F (264 psi)		194	221	212
Hydrolysis Stability (Retention of FS)	After 8 days at 60°C and 90%RH		~ 80%	~ 96%	100%
Remark			Natural Fiber Reinforce	G/F 10% Reinforce	Standard High Temp. ABS

Yeosu Plant (Synthetic Resin)

Uiwang R&D Center