

Introduction of SK Chemicals' Compounded Materials

June, 2015

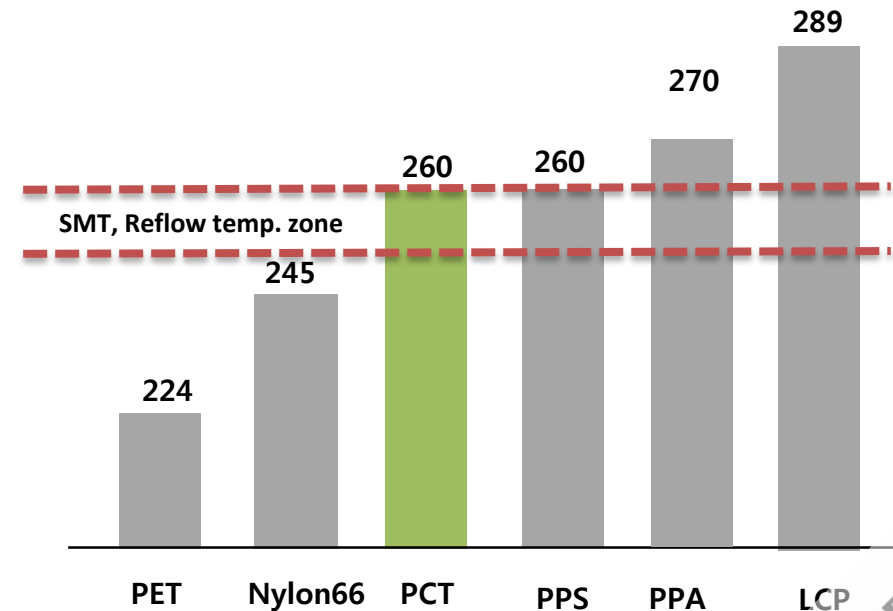
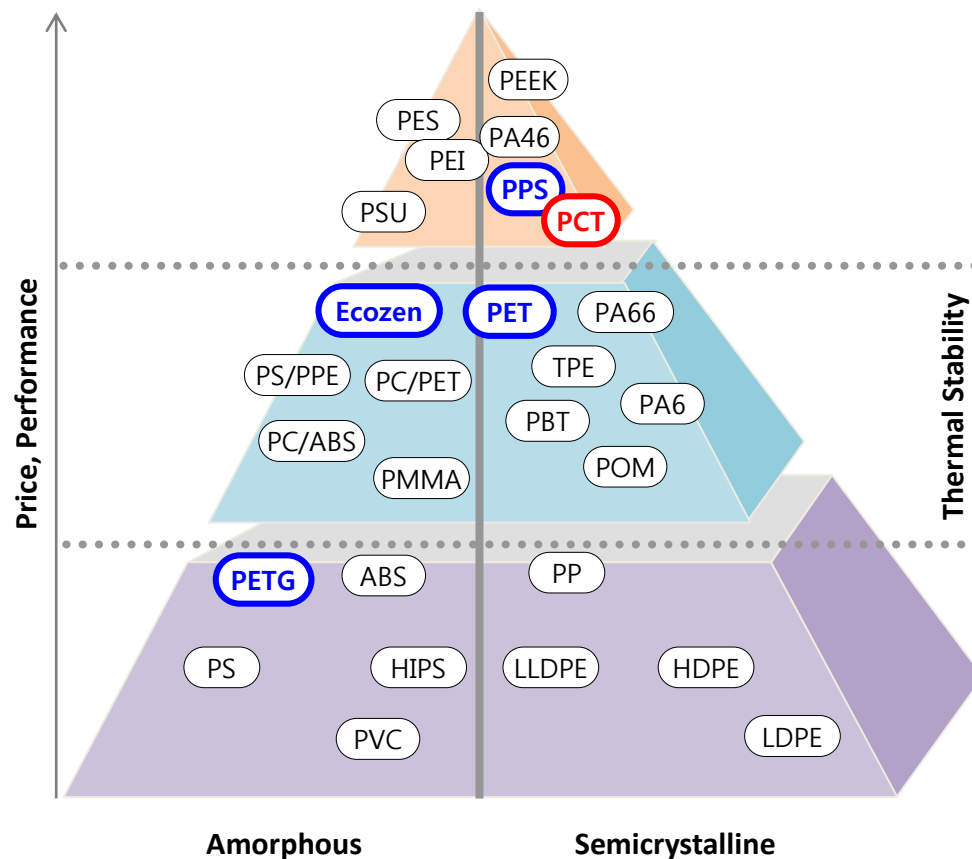
EP Business Team



Introduction of Products (Base Resins)



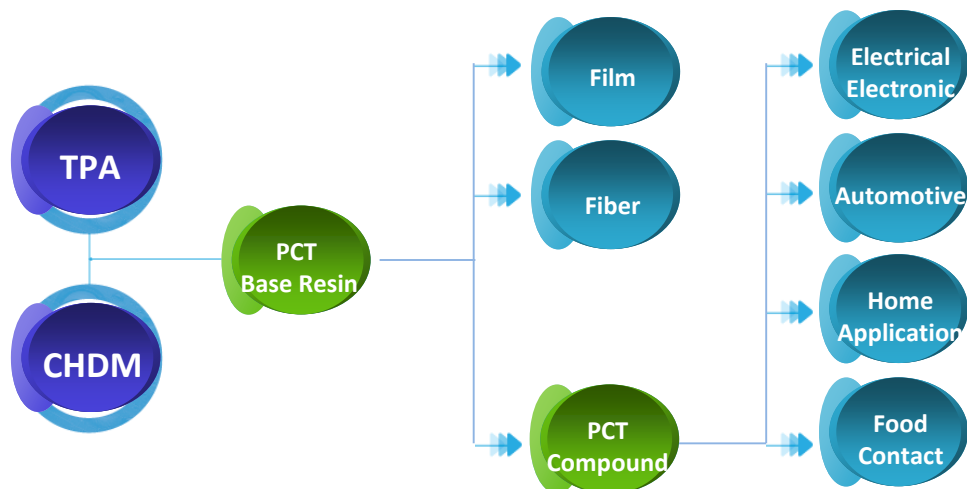
- ◆ **SkyPURA PCT** is a high performance engineering plastic with excellent thermal stability, toughness and fast crystallization half time.
- ◆ **SkyPURA PCT** has outstanding thermal resistance property that can tolerate high temperature of SMT reflow process.



HDT for engineering plastics

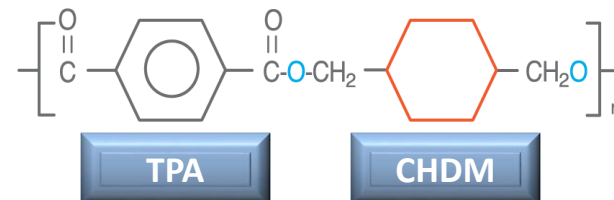
◆ **SkyPURA PCT** base resin is produced by reacting TPA and CHDM (1,4-cyclohexane dimethanol).

◆ SK Chemicals is the only vertically integrated company that produces PCT using captive TPA and CHDM in Korea.



**SkyPURA
Main Properties**

- ❖ High Reflectivity and Durability
- ❖ Long Term Heat Resistance
- ❖ Low Moisture Absorption
- ❖ Reflow and Lead-free Soldering Capable Resin
- ❖ Chemical Resistance
- ❖ Cleanliness : Free of Particles, Low Oligomers
- ❖ Excellent metal adhesive
- ❖ Obtain out-of-mold surfaces with high gloss, metal effect and specialty colors
- ❖ Lightweight



◇ **LED Reflector**

- ❖ High Reflectivity and Durability
- ❖ Long Term Heat Resistance
- ❖ Low Moisture Absorption



◇ **PC/PCT Alloy**

- ❖ Good compatibility
- ❖ Excellent light transmission
- ❖ Excellent chemical resistance

◇ **Connectors**

- ❖ Reflow and Lead-free Soldering Capable Resin
- ❖ Long Term Heat Resistance
- ❖ Good Electrical Properties
- ❖ Low Moisture Absorption



◇ **NMT**

- ❖ Excellent metal adhesive
- ❖ Good pre-colored
- ❖ Long Term Heat Resistance



◇ *Film*

- ❖ Good thermal, Color, Hydrolytic Stability
- ❖ Good Electrical Properties
- ❖ Low Moisture Absorption



◇ *Fiber*

- ❖ Good laundry durability at high temperature
- ❖ Excellent chemical resistance/ hydrolytic stability
- ❖ Shape/performance stability and durability



◇ *Oven Tray*

- ❖ Long Term Heat Resistance
- ❖ FDA Approval

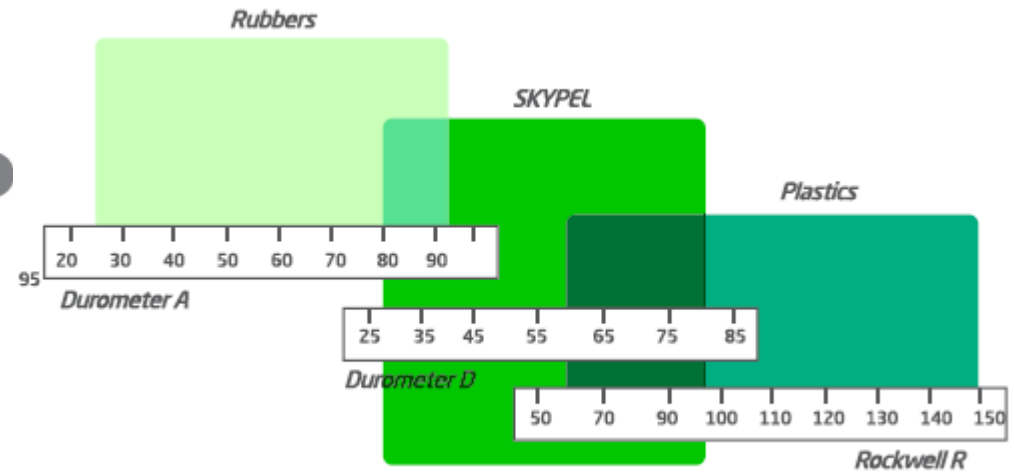


◆ SK Chemicals commercialized PCT in 2012, with the current application of **LED reflectors** and **engineering plastics**.

Grade	1631	2631	3631	0302	0502	0502HC	3302	3502	Remark
Target Applications	Film (Transparent)	Fiber	Alloy with PC	LED Reflector			EP compound & Alloy		
Intrinsic Viscosity (dl/g)	≥ 0.80	≥ 0.80	≥ 0.80	0.65	0.75	0.75	0.65	0.75	
Mn(kg/mol)	≥ 25	≥ 25	≥ 25	22.5±3	28.0±3	28.0±3	22.5±3	28.0±3	GPC, reference PS with X- PS column
Polydispersity (Mw/Mn)	≥ 2.20	≥ 2.20	≥ 2.20	2.15	2.20	2.20	2.15	2.20	
Melting point (Tm(°C))	≤ 280	≤ 280	≤ 280	286±3	286±3	295±2	286±3	286±3	
Crystallization temperature under cooling (Tmc(°C))	≤ 215	≤ 215	≤ 215	235±5	235±5	258±5	235±5	235±5	DSC scan r ate 10°C/min
Glass transition temperature (Tg(°C))	≤ 89	≤ 89	≤ 89	89	89	89	89	89	
Color-L*	88±4	—	88±4	88±4	90±4	90±4	—	—	After crystallizati on @ 150°C, 1hour
Color-a*	0±3	—	0±3	0±3	0±0.3	0±3	—	—	
Color-b*	b* < 6	—	b* < 6	b* < 6	b* < 6	b* < 6	—	—	

- Polyester-based thermoplastic engineering elastomer. **(TPEE)**

- Polyester elastomer that has intermediate property between rubber and engineering plastic.



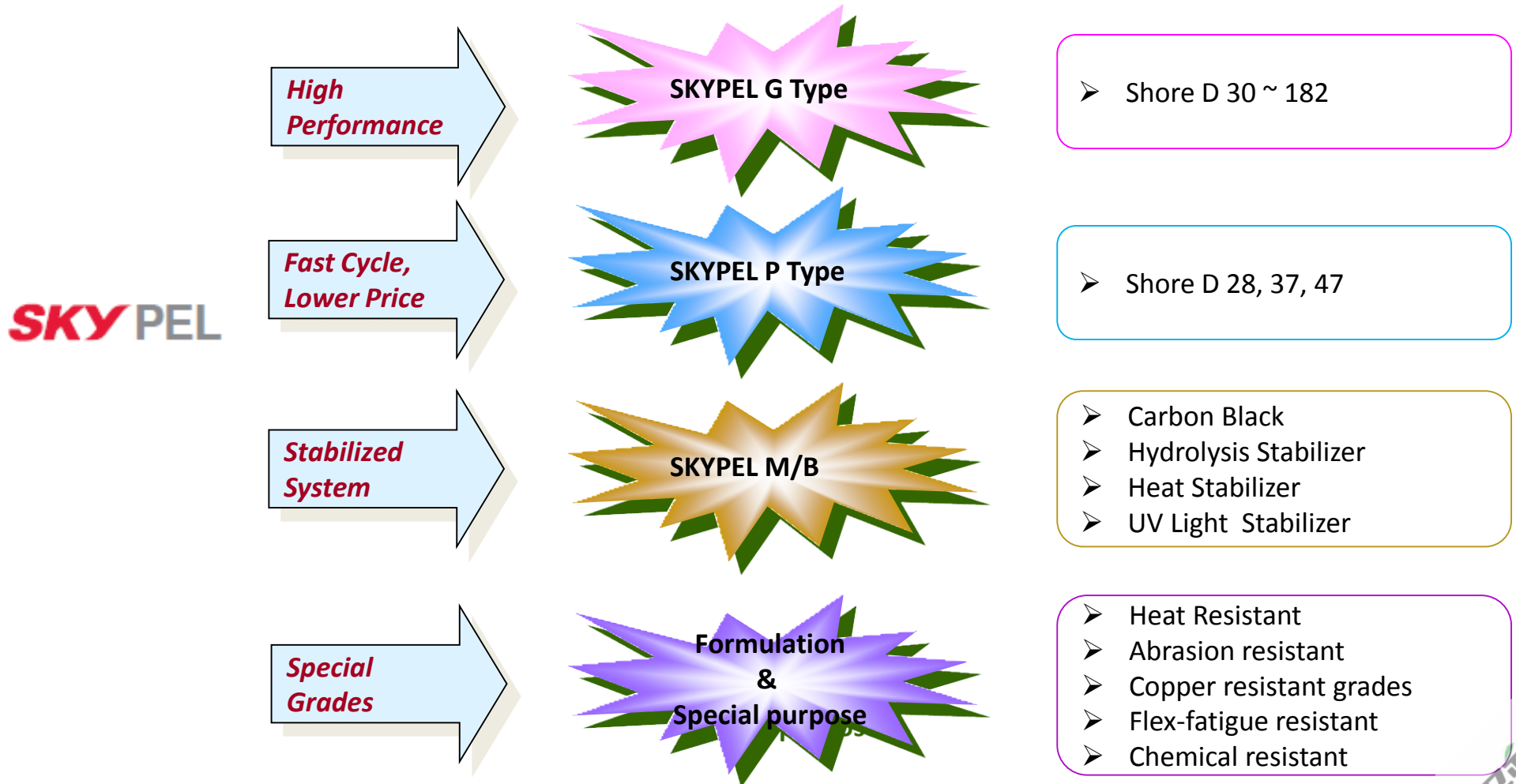
- Characteristics

- ✓ Exceptional Toughness and Resilience
- ✓ High Resistance to Creep, Impact and Flex-fatigue
- ✓ Good Thermal Stability at High Temperatures
- ✓ Excellent Flexibility at Low Temperatures
- ✓ Excellent Resistance to Chemicals, Oils and Solvents

- Applications



• Product Portfolio

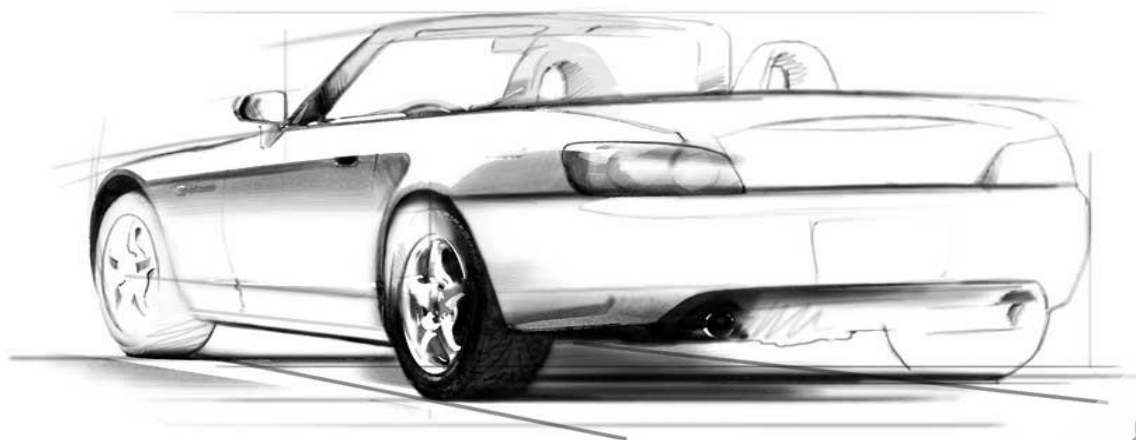


Introduction of Compounded Product

SKYTRA (Customized for Automotive)

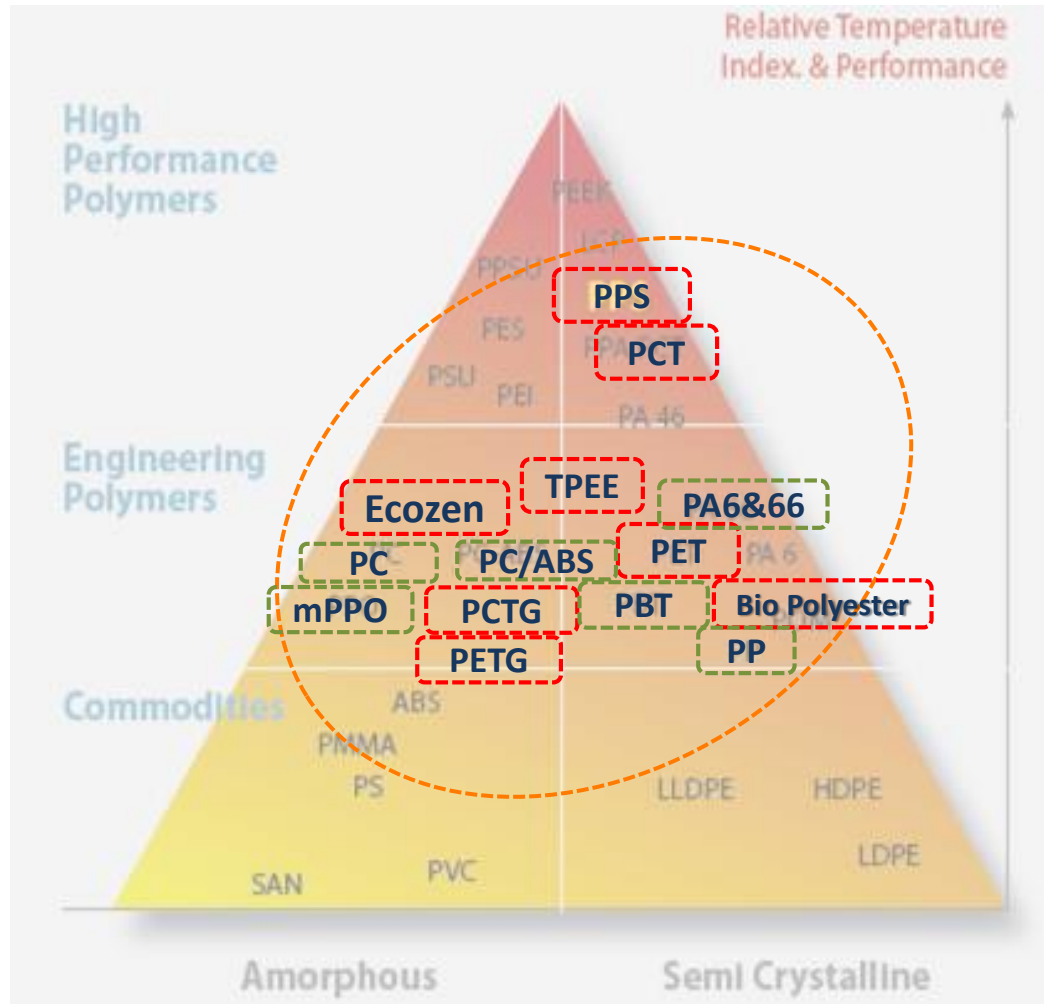


Eco-friendly Materials
Solutions Provider



Our Specialty Polymers

Specialty Polymers is one of the core business of SK chemicals.



- PPS (ECOTRAN)
- PCT (PURATAN)
- PET / PETG (SKYGREEN)
- Bio Co-polyester (ECOZEN)
- Bio Polyester
- TPEE (SKYPEL)
- Compound Product (SKYTRA)

Advanced Materials Solution Provider



Weight Reduction

The reduction of fuel consumption and CO₂ emissions is one of the most important challenges facing the automotive industry.

- Metal Replacement
- Improvement Fuel Efficiency
- CO₂ Reduction



High Performance

Automotive makers have been dedicated to developing high-performance versions of their cars.

- Heat Resistance
- Chemical Resistance
- High Strength and stiffness

Eco Friendly (Bio-sourced)



One of the most important developments in future is the increasing number of vehicles made of eco-friendly materials.

- Bio Based material
- Low Out gas and VOC
- No Chlorine

Premium Design

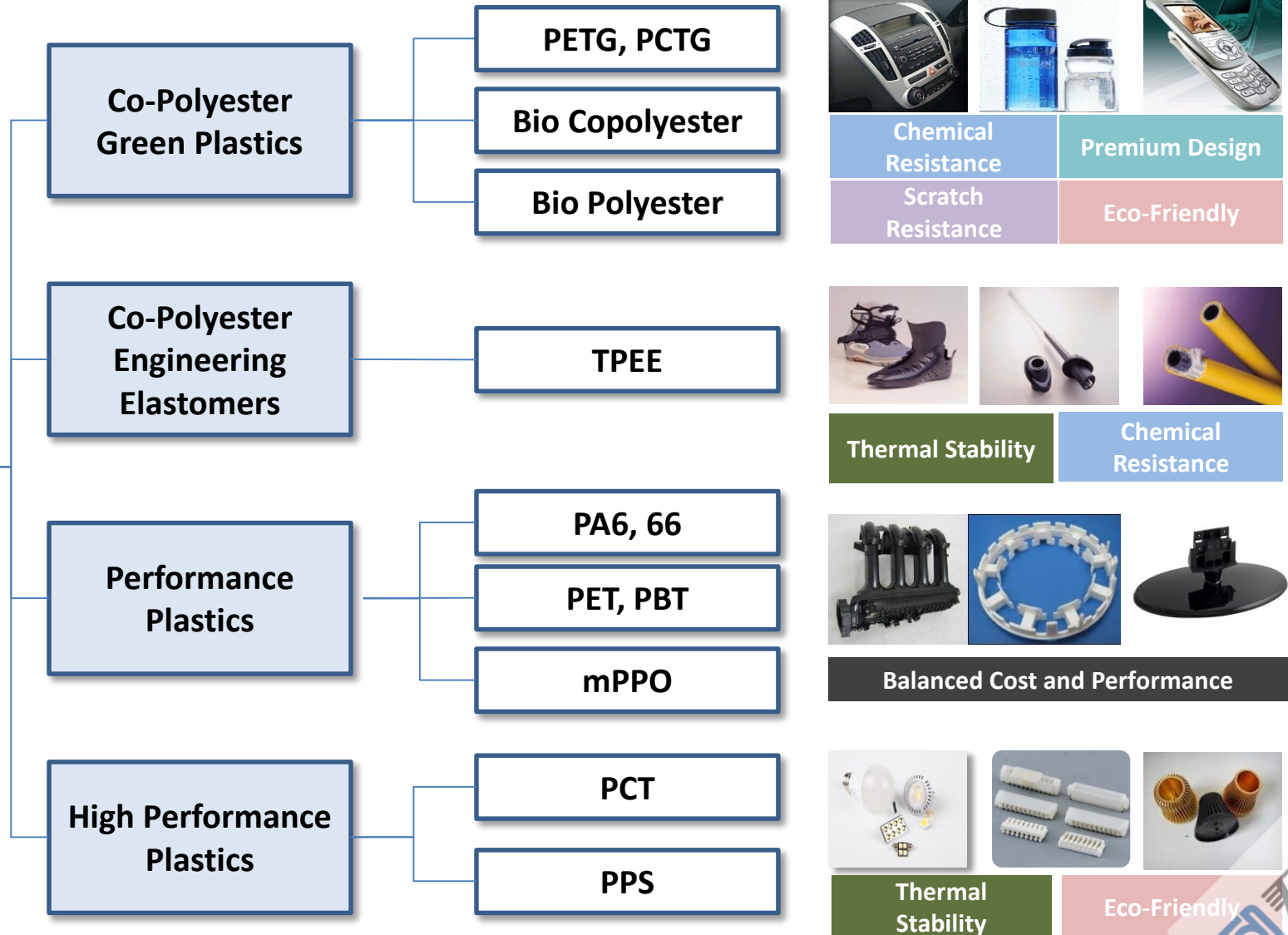


The design makeover seems to focus on meeting the sophisticated tastes of customers and it can compete with other imported luxury sedans.

- Non Paintable
- High Gloss / Low Gloss
- Scratch Resistance

SKY TRA Product Family w/ values

SKY TRA



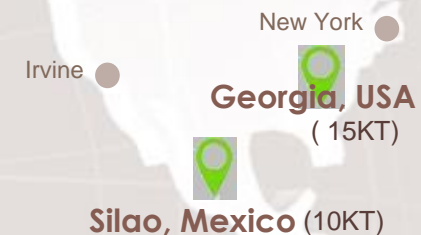
Manufacturing Facilities and Global Branches

Total Compound capacity

Total capacity	100KT
Korea	65KT
USA	15KT
Mexico	10KT
Malaysia	10KT



- Eco-friendly Polymer : PET, PETG, PCT, PPS, Bio-Copolyester, Bio-Polyester
- Composite Materials
- Bio Materials
- Functional Materials



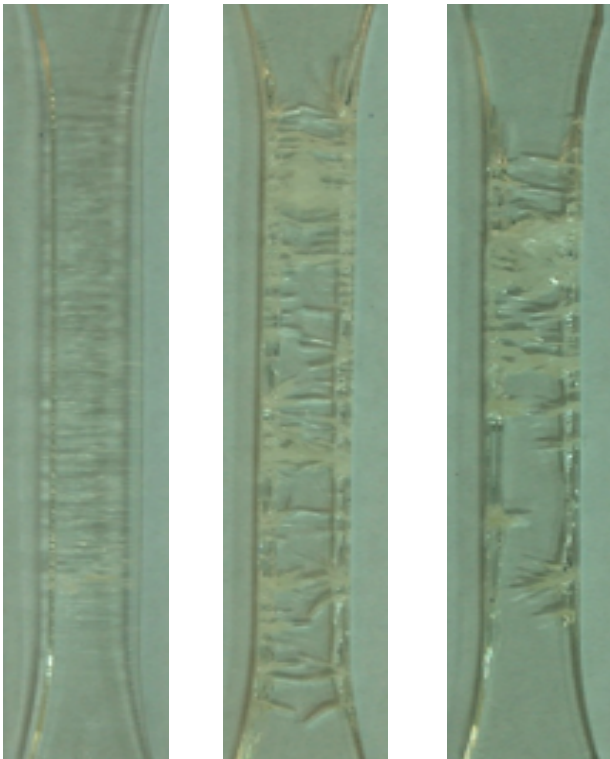
Segment Overview

Chemical Resistance

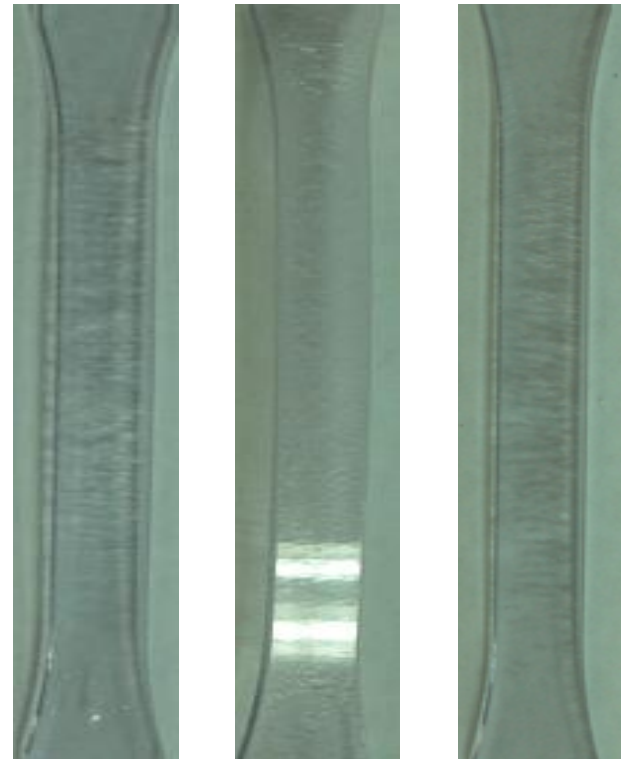


✓ Chemical resistance

▷ Comparison of appearance after treatment of amine chemicals on test sample surface



< Typical Polycarbonate >



< Bio Co-polyester >

✓ Chemical resistance

Test Condition

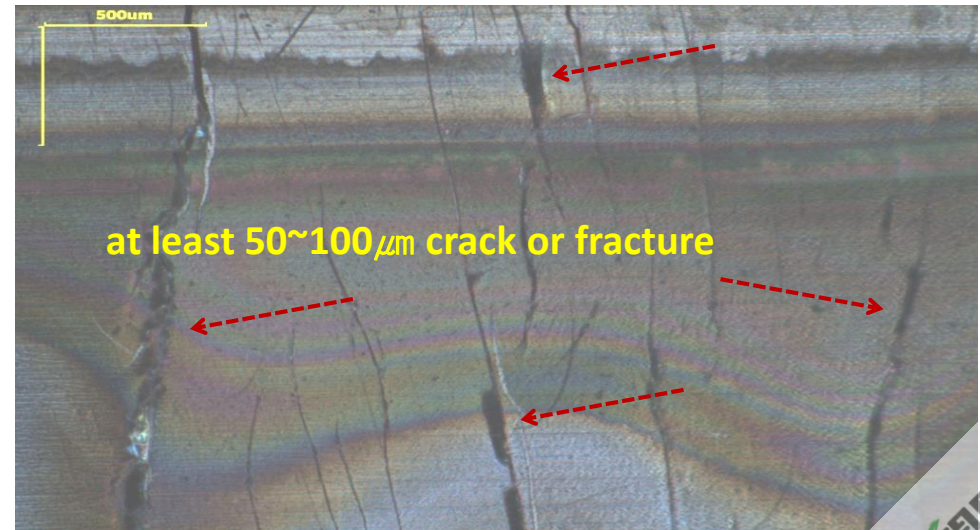
- 2% Strain , 23°C , 168 hrs
- Test sample is covered by soaked cotton(1 min)
- Chemicals : Air Fresheners for Automobile,
Gasoline, Methanol, Acetone, Ethyl Acetate,
Acetic Acid, Oleic acid (Hand cream)



■ Optical spectroscopy picture of specimen surface after testing (Aromamate “Innocent”)



< SKYTRA Bio-Copolyester/ABS >



< Conventional PC/ABS , PC 70wt% >

- **Material : Bio-Copolyester/ABS**

- **Current Material : PC/ABS**

- **Benefit**

- Preventing crack occurrence from contact **with polyurethane foam or air fresheners/Sun block**
- Eco-friendliness

- **Key Features**

- Chemical resistance against **“various chemicals”**
- Excellent impact strength at room & low temp.

- **Grade**

- SKYTRA 3101(W), 3201

- **Material : Copolyester/PC**

- **Current Material : PC**

- **Benefit**

- Preventing crack occurrence from assembled parts having contact with **air fresheners/Sun Block**
- Eco-friendliness

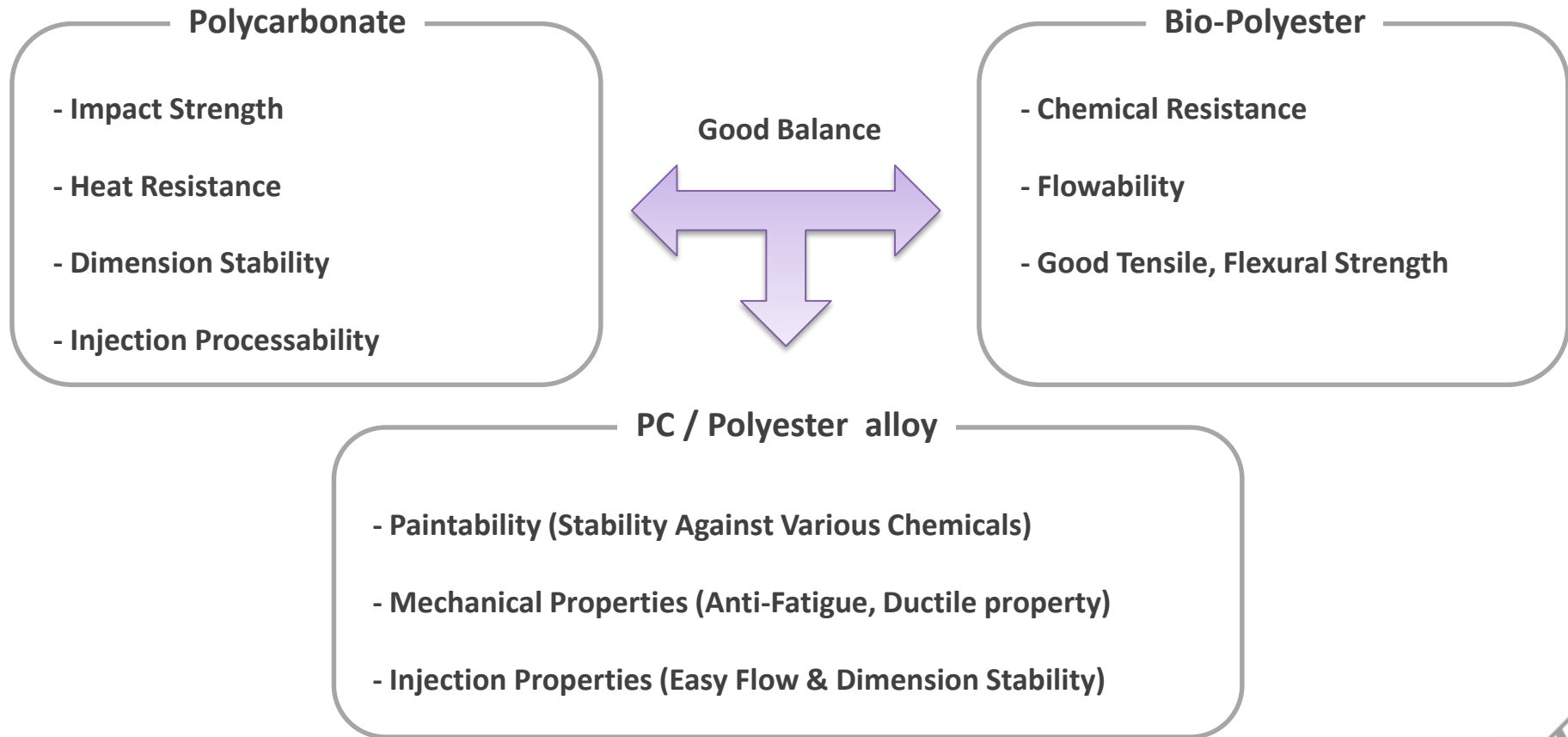
- **Key Features**

- Chemical resistance
- Good impact strength

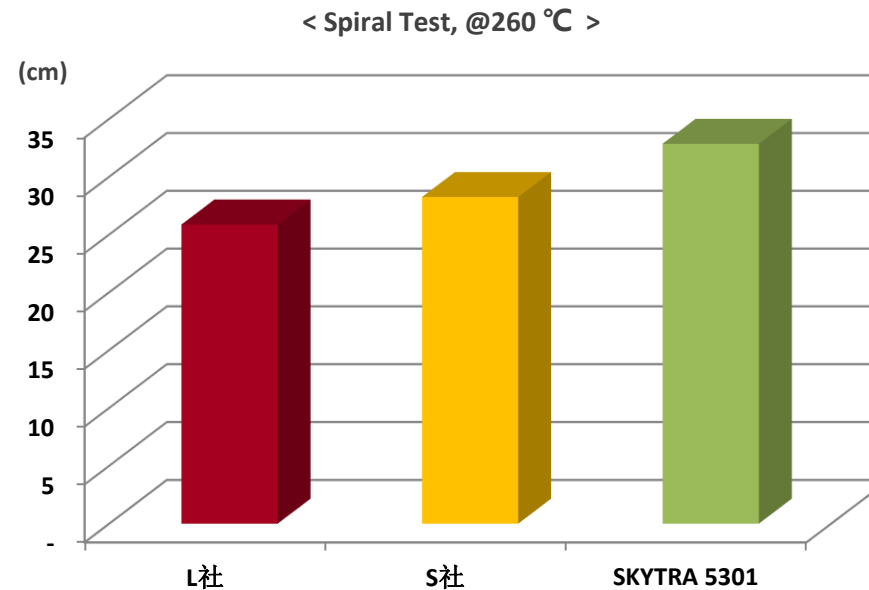
- **Grade**

- SKYTRA 1101

✓ **Bio-Polyester/PC**
Development Concept



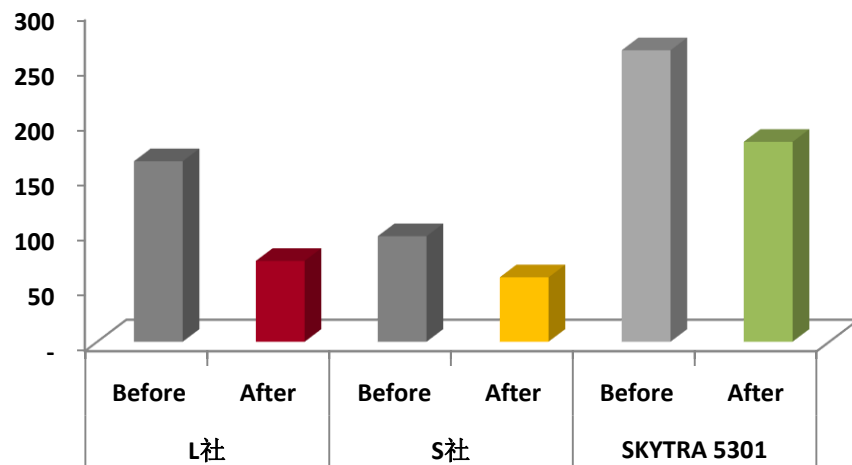
✓ Good Processability (Spiral Flow)



- SKYTRA 5301 has good flowability than above competitors resulting from spiral test.
- Good flowability of SKYTRA 5301 makes the injection process easier and the dimension stability better due to low residual stress.

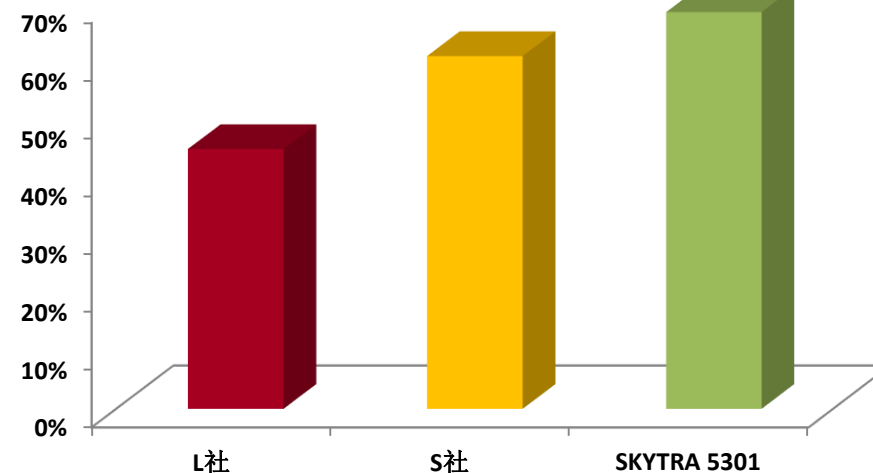
✓ Impact strength before & after painting (3.2 T, @ -20°C)

< Impact Strength, 3.2T @ -20 °C >



< Maintenance of Impact Strength(Painting) >

(Before value = 100%)



Item	L社	S社	SKYTRA 5301
Maintenance %	45%	61%	69%

- **Material : Bio-polyester/PC**
- **Current Material : PC or PBT/PC**
- **Benefit**
 - Productivity Enhancement
 - Eco-Friendliness
- **Key Features**
 - good paintability
 - good chemical resistance
 - good processability
- **Current Status**
 - Under Testing in Tier-1 (Part evaluation)
- **Grade**
 - SKYTRA 5301

Scratch Resistance



Material

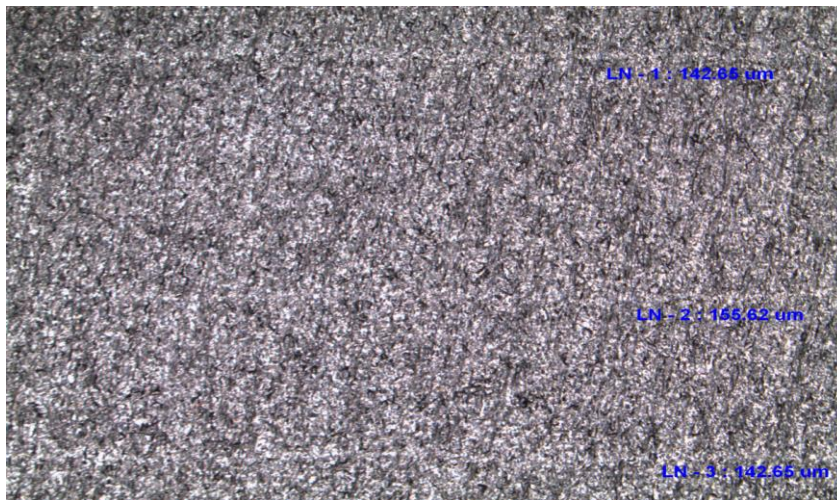
- Bio-polyester GF or Bio-PA GF

Advantages

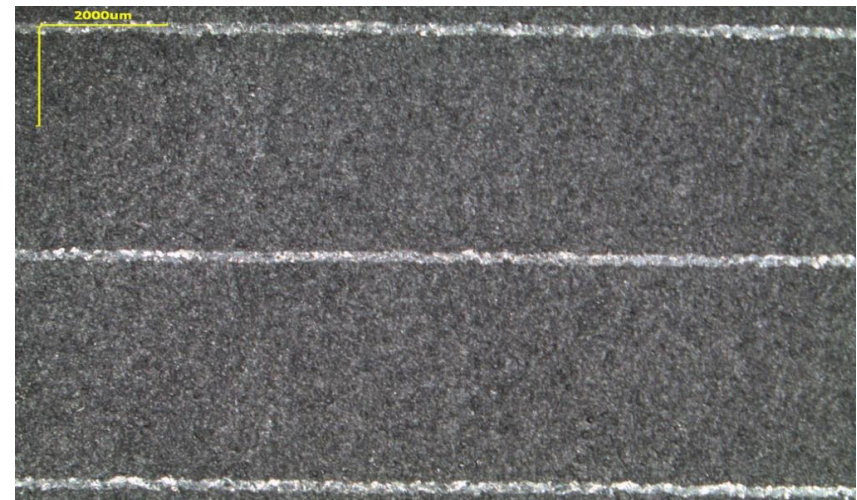
- Improved Scratch Resistance
- Eliminating Painting Process
- Surface Appearance
- Bio Contents (25% and Up)

Cost Reduction

Premium Design



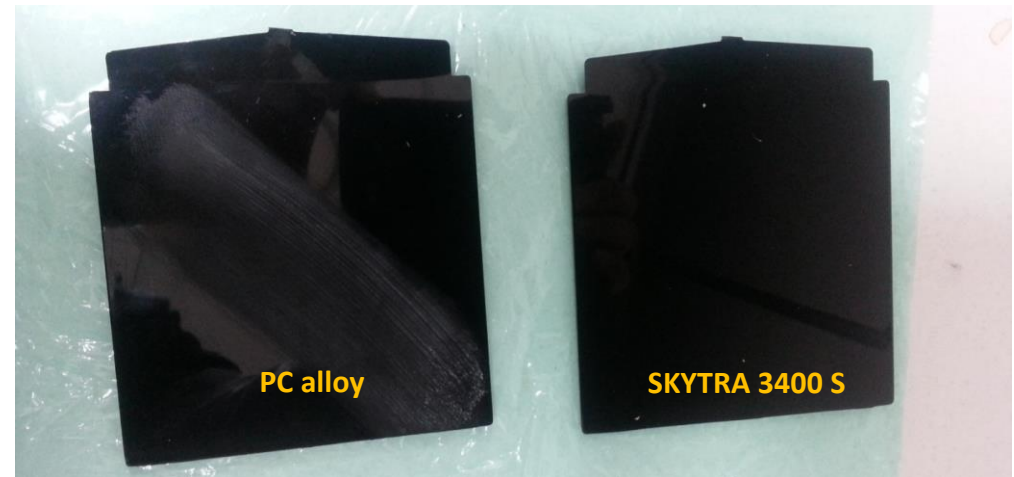
SKY TRA



Conventional PET/PBT/GF 20%

- **Material : Bio-Polyamide alloy**
- **Current Material : PC alloy**
- **Benefit**
 - Cost efficiency by reducing painting process
 - Eco-Friendliness
- **Key Features**
 - high gloss & Deep black
 - Anti-scratch
 - good chemical resistance
- **Grade**
 - SKYTRA 3400 S

✓ **Chemical Resistance**
(after acetone treatment)



- **Material : Bio-polyester/GF or Bio-PA/GF**
- **Current Material : PC/PBT/GF**
- **Benefit**
 - Cost efficiency by eliminating painting process
 - Eco-Friendliness
- **Key Features**
 - non-painting & low gloss
 - good scratch resistance
 - excellent chemical resistance
 - good processability

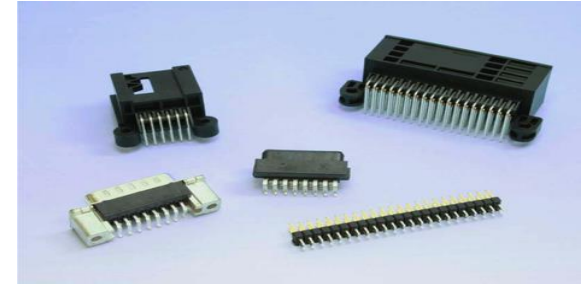
Electrical & Electronics

- **Thermal stability**
 - Tm 287°C, over HDT 250°C
 - RTI 130-150 °C
 - Reflow soldering (SMT)

	Tm (°C)	HDT (°C)
PCT	287	262
PET	255	233
PBT	225	210

※ GF30% reinforced grade

- **Electric properties**
 - Arc-tracking resistance in high-voltage
 - Continue service of Dielectric strength in high temperature
 - Ignition plug and HEV power supply parts
 - CTI PLC 1 (560V)
- **Chemical resistance**
 - Automobile oil resistance
 - Excellent to Epoxy adhesive strength
- **Colorability / Productivity**
 - Easy coloring with pigment
 - PBT mold could be used without amendment



Advantages

- No warpage that LCP may occur after SMT processing.
- Due to the higher T_m , no partial melting during SMT processing.
- PPA may bring blisters due to the high moisture absorption.
- Due to high dielectric strength & dissipation factor and low dielectric constant induced by the stability under high voltage & high frequency, it is suitable for the parts of wireless communication devices such as antennas.
- Due to high PLC grade at CTI, it's suitable for power supply parts of EV or HEV.

✓ Technical Data Sheet

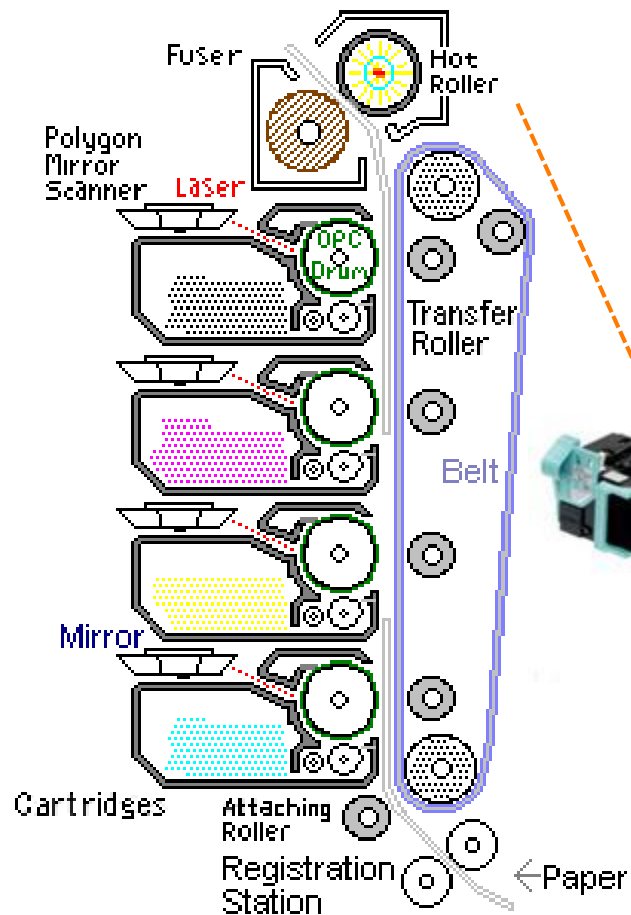
Items	Method (ASTM)	Condition	Unit	SKYTRA 7110 PCT/GF20	SKYTRA 7120 PCT/GF30	SKYTRA 7121F FR PCT/GF30	SKYTRA 7220 PCT alloy/GF30
Physical Properties							
Density	D 792	23°C		1.34	1.42	1.62	1.59
Melt Flow Index		300°C, 2.16kg	g/10 min	42	32	45	42
Rockwell hardness	D785	R-Scale		117	117	117	117
Mold Shrinkage MD		%		-	0.2	0.2	0.3
Mold Shrinkage TD		%		-	0.9	0.9	0.6
Water absorption	D638	%		0.15	0.15	0.1	0.2
Mechanical Properties							
Tensile Strength	D 638	23°C, 50mm/min	kg/cm ²	950	1,250	1,070	1,330
Elongation	D 638	23°C, 50mm/min	%	2.0	2.1	1.3	1.3
Tensile Modulus	D 638	23°C, 50mm/min	Kg/cm2	57,700	82,300	99,900	102,000
Flexural Strength	D 790	23°C, 10mm/min	kg/cm ²	1,190	1,580	1,580	1,780
Flexural Modulus	D 790	23°C, 10mm/min	kg/cm ²	42,000	56,200	95,000	115,000
Izod Impact Strength	D 256	23°C, 1/8"	J/m	70	85	70	80
Thermal property							
Heat Distortion Temp.	D 648	18.6kg/cm ² , 1/4"	°C	255	260	255	255



- **Material** : FR PET/GF and FR PBT/GF
- **Current Material** : FR PET/GF and FR PBT/GF
- **Benefit**
 - Balanced Costs and Performance
- **Key Features**
 - **Good FR Rating (150°C RTI, V0)**
 - Long-term thermal stability
 - Dimensional stability
- **Current Status**
 - Approved by OEM

Fuser Unit

Balanced Cost and Performance



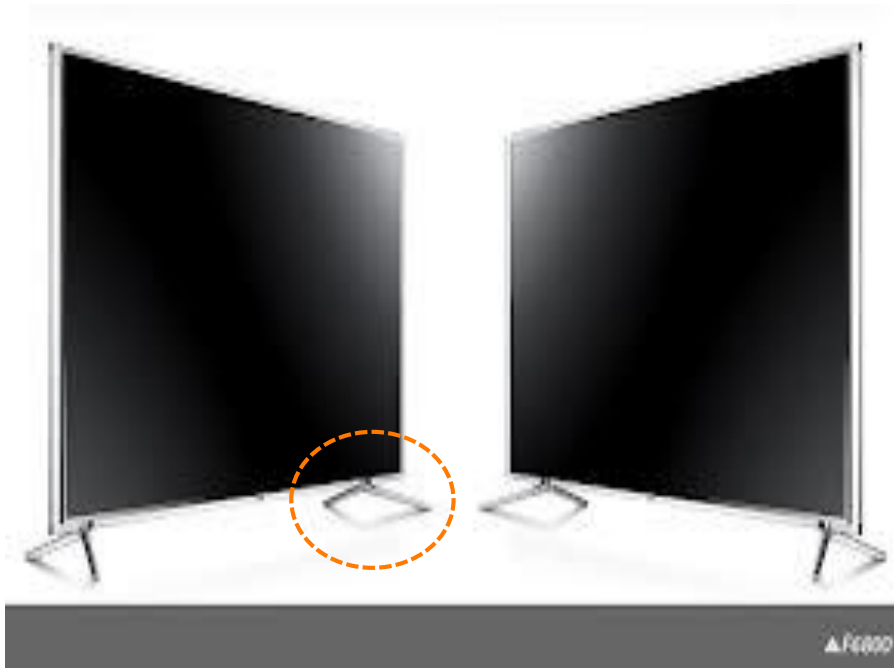
- **Material : FR PET/GF**
- **Current Material : FR PET/GF**
- **Benefit**
 - Balanced Costs and Performance
- **Key Features**
 - **Good FR Rating (150°C RTI, V0)**
 - Long-term thermal stability
 - Dimensional stability
- **Current Status**
 - Approved by OEM

✓ Technical Data Sheet

Items	Method (ASTM)	Condition	Unit	SKYTRA 5220F (FR PET/GF)	Rynite FR530 (FR PET/GF)	SKYTRA 5120F (FR PBT/GF)	SKYTRA 5120 (PBT/GF)	‘L’ 社
Physical Properties								
Density	D 792	23°C		1.68	1.67	1.70	1.54	1.62
Mold Shrinkage , MD	D 955	23°C	%	0.15	0.20	-	-	-
Mold Shrinkage , TD	D 955	23°C	%	0.80	0.80	-	-	-
Melt Flow Index	D 1238	265°C, 2.16kg	g/10 min	16	6	16	21	10
Mechanical Properties								
Tensile Strength	D 638	23°C, 50mm/min	kg/cm ²	1,430	1,350	1,350	1,470	1,350
Elongation	D 638	23°C, 50mm/min	%	1.9	2.0	3.0	3.2	2.0
Flexural Strength	D 790	23°C, 10mm/min	kg/cm ²	2,000	-	1,900	2,100	1,950
Flexural Modulus	D 790	23°C, 10mm/min	kg/cm ²	112,000	107,000	91,500	80,200	90,000
Izod Impact Strength	D 256	23°C, 1/8"	J/m	75	-	105	130	78
Thermal property								
Heat Distortion Temp.	D 648	18.6kg/cm ² , 1/4"	°C	215	225	209	210	210
RTI (Tensile/Impact/Strength)	UL746B		°C	150 / 150 / 150	150 / 150 / 150	-	-	-
Flammability	UL94	0.8mm		V-0	V-0	V-0	V-0	V-0



- **Material : Co-Polyester Alloy/GF**
- **Current Material : ABS/GF**
- **Benefit**
 - Low Mold Shrinkage
 - Adhesion to Metal
- **Key Features**
 - excellent chemical resistance
 - excellent surface finish
 - good FR Rating (V0, 150°C RTI)
 - good processability(insert injection can be)
- **Current Status**
 - OEM evaluation in progress



- **Material : Polyester Alloy/GF**
- **Current Material : PPA/GF**
- **Benefit**
 - Cost reduction
 - Easy to process
- **Key Features**
 - **Creep Resistance (over 120,000kgf/cm² FM)**
 - V1 @3mm
 - Izod Impact(over 10kgf/cm @1/8 inch,notched)
 - Dimensional stability
 - Good surface
- **Current Status**
 - Commercial by OEM

- ✓ SK chemical proposed a new material solutions for High Structural Strengthened TV Stand Base.

Trend Cost Reduction

- Similar Properties, Low Price material

SKYTRA 5240 NF

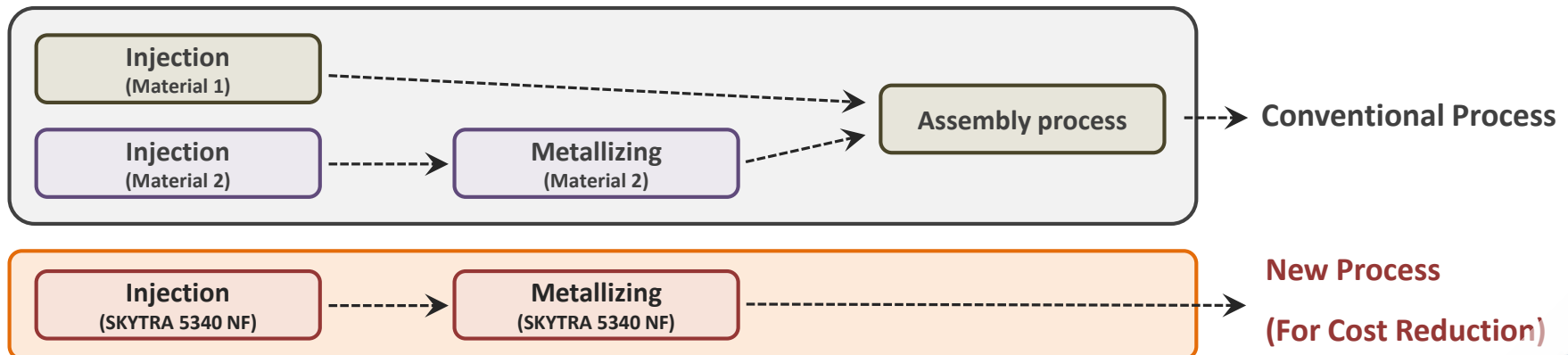
Flexural Modulus : 130,000 (kgf/cm²)



PPA / GF Grade

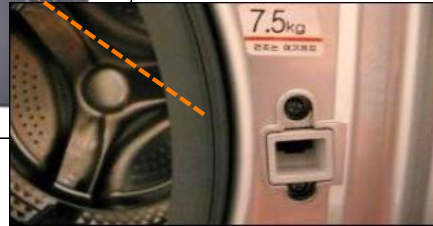
Flexural Modulus : 112,000 ~ 170,000 (kgf/cm²)

- Processing Simplification



✓ Technical Data Sheet

Items	Method (ASTM)	Condition	Unit	SKYTRA 5240NF	SKYTRA 5360NF
Physical Properties					
Density	D 792	23°C		1.75	-
Mold Shrinkage , MD	D 955	23°C	%	0.2	-
Mold Shrinkage , TD	D 955	23°C	%	0.6	-
Melt Flow Index	D 1238	265°C, 5kg	g/10 min	60	-
Mechanical Properties					
Tensile Strength	D 638	23°C, 50mm/min	kg/cm ²	1,450	-
Elongation	D 638	23°C, 50mm/min	%	1.2	-
Flexural Strength	D 790	23°C, 10mm/min	kg/cm ²	1,800	2,150
Flexural Modulus	D 790	23°C, 10mm/min	kg/cm ²	130,000	145,000
Izod Impact Strength	D 256	23°C, 1/8"	J/m	85	-
Thermal property					
Heat Distortion Temp.	D 648	18.6kg/cm ² , 1/4"	°C	180	95
Flammability	UL94	0.8mm		V-0	V-0



- **Material : TPEE Alloy**
- **Current Material : EPDM, TPU, TPO**
- **Benefit**
 - Recycling(EPDM Non-Recycling)
 - Eco-Friendliness
- **Key Features**
 - excellent chemical resistance
 - excellent surface finish
 - good processability (injection can be)
- **Current Status**
 - 'S' 社 being used

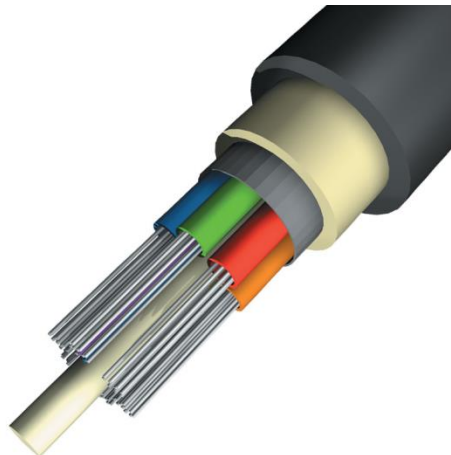
✓ Technical Data Sheet

Items	Method (ASTM)	Condition	Unit	SKYTRA 5700	SKYTRA 5701
Physical Properties					
Density	D 792	23°C		1.02	1.06
Mold Shrinkage , MD	D 955	23°C	%	-	-
Mold Shrinkage , TD	D 955	23°C	%	-	-
Shore Hardness (Shore A)	D 2240			79	83
Mechanical Properties					
Tensile Strength (at Elongation 500%)	D 638	23°C, 50mm/min	kg/cm ²	65	85
Elongation	D 638	23°C, 50mm/min	%	500 ↑	500 ↑
Thermal property					
Heat Distortion Temp.	D 648	18.6kg/cm ² , 1/4"	°C	-	42

wire insulation



cable jacket



- **Material : TPEE alloy**
- **Current Material : PVC, mPPE**
- **Benefit**
 - Non-halogen flame retardancy
 - Eco-Friendliness
 - Excellent mechanical properties
- **Key Features**
 - meet VW1 requirement
 - 105°C temperature rating (UL 1581)
 - Chemical resistance
- **Current Status**
 - OEM evaluation in progress

✓ Technical Data Sheet

Chemical Resistance

Eco-Friendly

Items	Method (ASTM)	Condition	Unit	SKYPEL JI	SKYPEL J
Physical Properties					
Density	D 792	23°C		1.2	1.2
Mold Shrinkage	-	23°C	%	0.4~0.7	-
Shore Hardness (Shore A)	D 2240			95	85
Mechanical Properties					
Tensile Strength at Break	D 638		MPa	20	20
Tensile Elongation at Break	D 638		%	200	210
Flexural Modulus	D 790		MPa	150	150
Flexural Strength at Break	D 790		Mpa	22	22
Impact					
Izod Impact	D 256	Notched, 23°C	kJ/m²	NB	NB
Thermal property					
Heat Distortion Temp.	D 648	1.8MPa	°C	65	65
Flammability					
Flame Rating	UL 94	3.2mm		V-0	V-0
Electric					
Surface Resistivity	D 275		Ω.cm	1E ¹⁵	1E ¹⁵

Others

SKYTRA 5500~5600 Series are engineering plastics based on PA6 & 66. Owing to SK Chemicals' procurement & production management system, our PA compounds are extremely cost competitive maintaining their physical properties.



Target applications

- Auto Exterior & Under The Hood

Characteristics

- Cost Competitiveness
- Long Term Heat Resistance
- Low Warpage
- Dimensional Stability

Grades

SK Grade	Material
SKYTRA5510I	PA+ABS GF15%
SKYTRA5512	PA6+GF/MF20%
SKYTRA5510	PA6+GF20%
SKYTRA5520	PA6+GF30%
SKYTRA5520FM	PA6+GF30%
SKYTRA5600I	PA66 High impact
SKYTRA5601I	PA66 impact
SKYTRA5611LF	PA66_LGF 15%+BaSO4 50%
SKYTRA5630C	PA66+612+GF33%
SKYTRA5640	PA66+GF/MF38%
SKYTRA5610I	PA66+GF20%(Impact
SKYTRA5620	PA66+GF30%

SK Grade	Material
SKYTRA5602I	PA66 Impact Modified
SKYTRA5603I	PA66 Very high Impact
SKYTRA5610	PA66+GF15%
SKYTRA5620FR	PA66+GF25+FR (Flame Retardancy)
SKYTRA5630	PA66+GF35%
SKYTRA5660	PA66+GF50%
SKYTRA5680	PA66+GF60%
SKYTRA5605	PA66+PA6+PE
SKYTRA5630C	PA66+PA612+GF33%
SKYTRA5540	PA6-M25+GF15
SKYTRA5500I	PA6 High Impact
SKYTRA5520	PA6+GF30%
SKYTRA5512	PA6+MF/GF 20%
SKYTRA5511	PA6+MF25%
SKYTRA5640	PA66+GF/MF 40%