

# High Crystallinity Polypropylene



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## 1. Who is KPIC ?

- ▶ Pioneer of Petrochemical industry in Korea (Founded in 1971)
- ▶ Leading company on the Korea market as a provider of HDPE & PP(HCPP, Terpolymer, Random Copolymer, Block Copolymer)
- ▶ Export more than 50% products to all over the world
- ▶ Achieve Leadership Position in Worldwide PP & HDPE Market
- ▶ Produce Tailor-made products with Controlled Morphology, Tacticity, Density & MW
- ▶ Total Quality and Environmental System ( ISO9002 & ISO14001 Certified )

## Location & Capacity

### Head Office

Sales  
Technical Service  
Commitment to Total Quality



### Onsan Plant

#### Naphtha Cracking Center

Ethylene	400,000 MT/yr
Propylene	210,000 MT/yr
Mixed C4s	132,000 MT/yr
Pyrolysis Gasoline	278,000 MT/yr



### Ulsan Plant , R&D Center

Commercial Production(700,000 MT/yr)  
7 Manufacturing Facilities  
2 PP Facilities  
2 HDPE Facilities  
2 PP/HDPE Facilities  
1 Compounding Facility

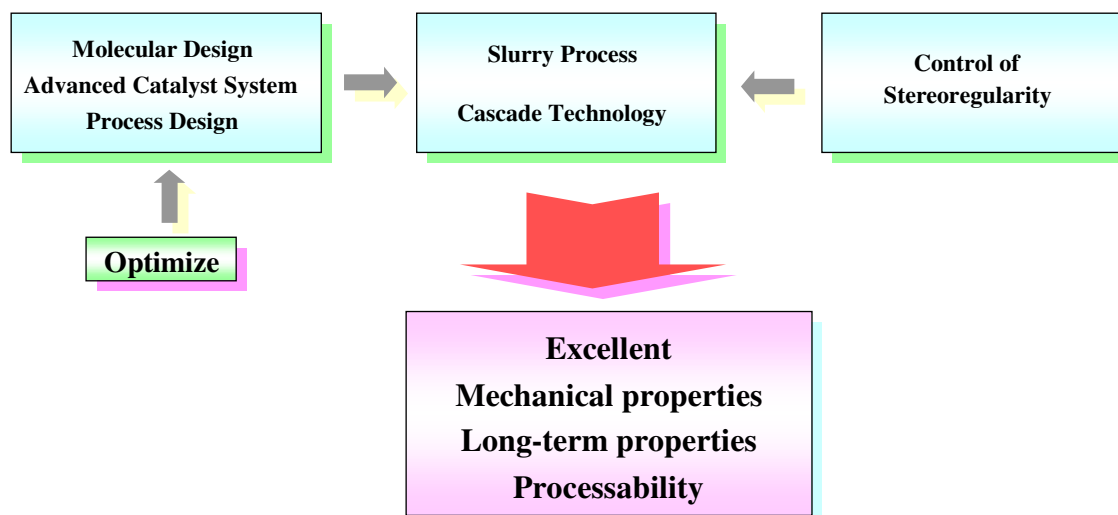
Polypropylene	310,000 MT/yr
High Density Polyethylene	390,000 MT/yr



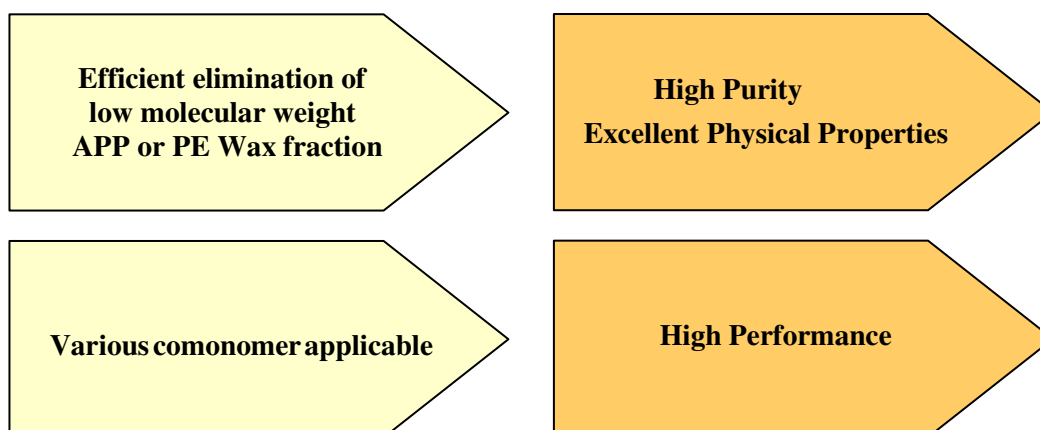
## 2.What is HCPP ?

<b>Polymerization</b>	☞ Advanced Ziegler-Natta catalyst
<b>Molecular Structure</b>	☞ High stereoregularity (Isotactic Index >> 99%)
<b>MWD</b>	☞ Broad and easy-tailored (PDI ≒ 8~11)
<b>Crystallization</b>	☞ High crystallinity(HCPP ≒ 70%), High rate of crystallization Reduction in size of spherulites
<b>Processing</b>	☞ Injection, Sheet, PP compound
<b>Stability</b>	☞ High resistance to heat and chemicals

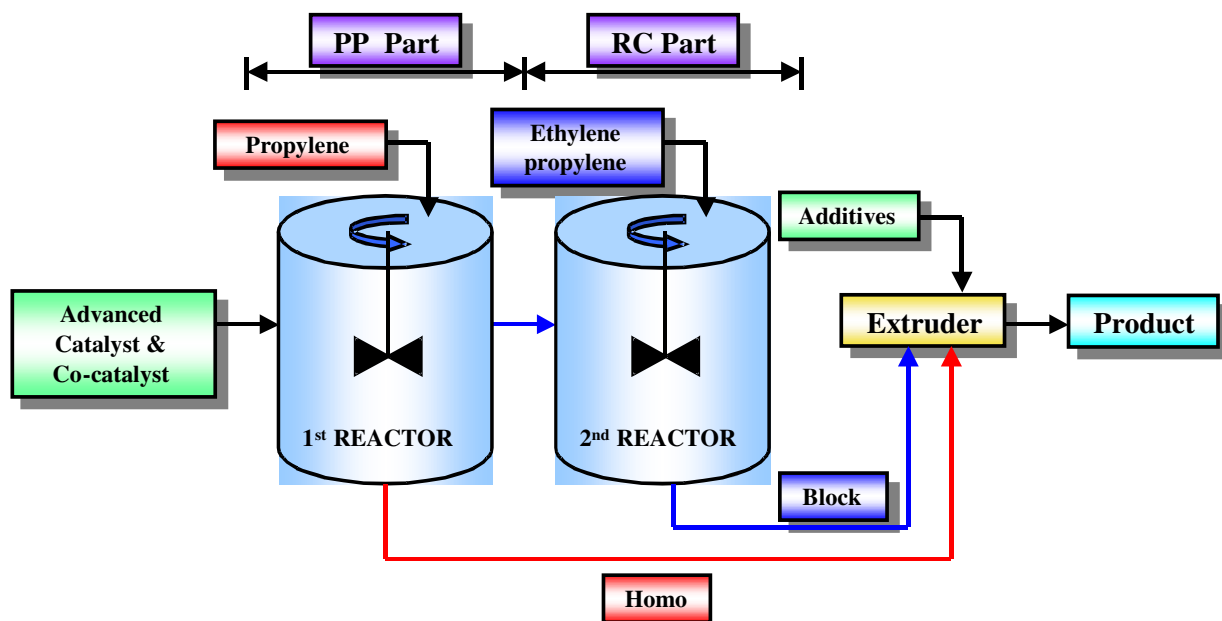
## HCPP Design Concept



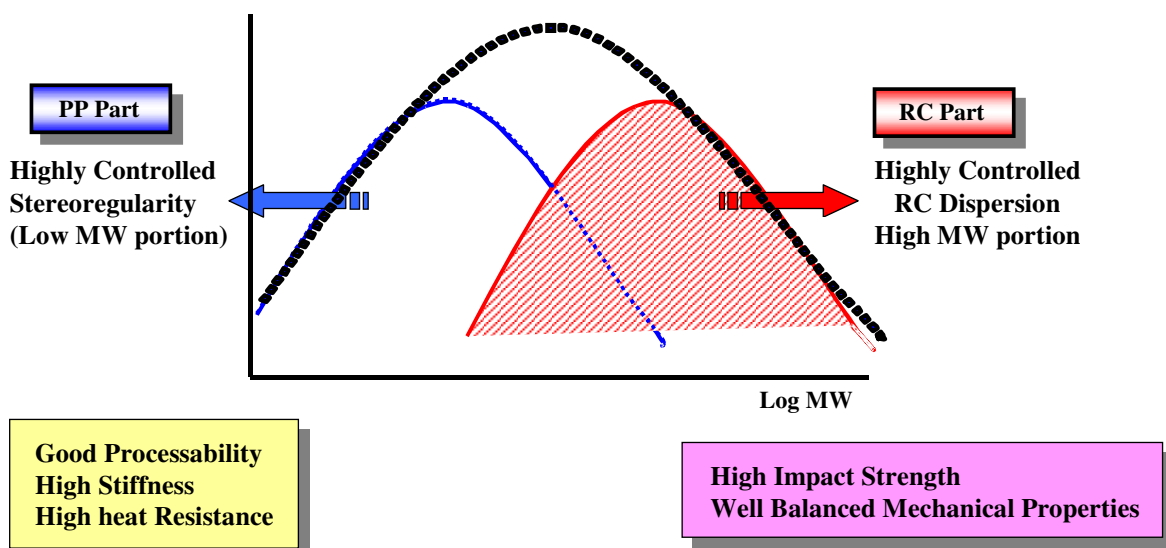
## Advantages of slurry process



## Concept of HCPP Process – Slurry Process



## Advantages of Cascade process



## Characteristics of HCPP

		Unit	General PP	HCPP
Degree of crystallization		%	60	70
Density		g/cm <sup>3</sup>	0.90	0.91
Isotactic Index	NMR(pentad)	-	92-95	>96
	IR	-	0.930	0.974
Crystallization temperature		°C	109-117	>125
Melting Temperature		°C	163	169
Number of Nuclei (at 130 °C)		n/mm <sup>3</sup>	34	~ 400
Growth rate of Spherulites		μm/min	4.5	5.4
MWD	Mn	-	28000	18800
	Mw	-	174000	195000
	Mz	-	882000	1330000
	Mw/Mn	-	6.2	10.4

## HCPP Homo Grade

Properties	Method (ASTM)	Unit	Film		Injection				Sheet	General Homo
			HF5003	HF5103	HJ4006	HJ4012	HJ4045	HJ4112	HS3045	
Melt Index	D1238	g/10min	3	3	6	14	45	13	0.45	14
Tensile Strength (at Yield)	D638	kgf/cm <sup>2</sup>	390	390	420	430	430	420	410	370
Elongation	D638	%	>500	>500	80	50	40	20	>100	>500
Flexural Modulus	D790	kgf/cm <sup>2</sup>	19,000	18,500	23,000	24,000	24,000	23,000	21,000	16,000
Izod Impact (notched, 23°C)	D256	kgfcm/cm	3	3	4	4	4	4	6	4
Hardness (Rockwell)	D785	R	101	100	110	110	112	110	110	100
HDT	D648	°C	125	125	140	140	140	140	135	110
Application	Packaging : Film, Sheet		●	●					●	
	Compound Base					●	●			
	Industrial Parts				●	●	●	●		
	Electric & Electronic				●	●	●	●		
	Automobile				●	●	●			
Characteristics						UL746B RTI 125°C		Transpa- -rency'		

## HCPP Block Grade (I)

Properties	Method (ASTM)	Unit	Injection							General Block
			CB5108	CB5108H	CB5230	CB5290	SB9108	SB9108H	SB9230	
Melt Index	D1238	g/10min	10	10	30	100	10	10	30	10
Tensile Strength (at Yield)	D638	kgf/cm <sup>2</sup>	330	330	350	350	330	330	300	200
Elongation	D638	%	>200	>200	>200	30	>200	>200	>200	>150
Flexural Modulus	D790	kgf/cm <sup>2</sup>	18,000	18,000	18,000	18,000	16,500	16,500	16,000	13,000
Izod Impact (notched, 23°C)	D256	kgfcm/cm	10	10	7	6	10	10	12	10
Hardness (Rockwell)	D785	R	102	102	102	105	102	102	98	85
HDT	D648	°C	135	135	135	130	130	130	131	110
Application	Compound Base		●		●	●	●		●	
	Electric & Electronic			●	●			●	●	
	Automobile		●		●	●	●		●	
	Industrial Parts		●	●	●	●	●	●	●	
Characteristics			UL746B RTI 125°C				UL746B RTI 125°C			

## HCPP Block Grade (II)

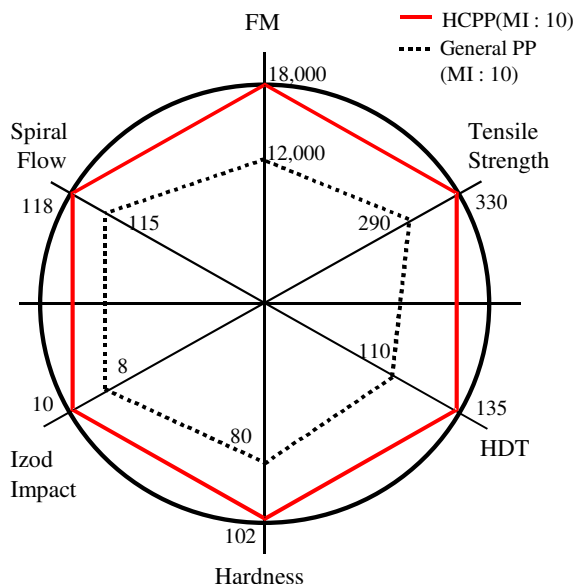
Properties	Method (ASTM)	Unit	Sheet	Injection					General Block
			SB1930	SB9302	SB9304	SB9310	SB9430	SB9440	
Melt Index	D1238	g/10min	0.5	2	4	10	30	40	10
Tensile Strength (at Yield)	D638	kgf/cm <sup>2</sup>	270	250	250	250	250	245	200
Elongation	D638	%	>400	>500	>500	>500	50	50	>150
Flexural Modulus	D790	kgf/cm <sup>2</sup>	12,500	12,500	12,500	13,500	14,000	13,000	13,000
Izod Impact (notched, 23°C)	D256	kgfcm/cm	75	50	37	20	13	13	10
Hardness (Rockwell)	D785	R	82	85	85	90	90	90	85
HDT	D648	°C	100	100	110	122	127	121	110
Application	Compound Base					●	●	●	
	Packaging : Sheet,Closure		●						
	Electric & Electronic					●	●	●	
	Automobile		●	●	●	●			
	Industrial Parts		●	●	●	●	●	●	
Characteristics									

## Property Balance of HCPP Block Copolymer

The most important characteristics of HCPP impact copolymer can be described as a significant improvement in both physical properties and processability.

As shown in the graph, when compared to a general PP, HCPP block is superior in all properties characterizing processability and physical properties.

Improvement in stiffness without compromising the toughness is important advantage of HCPP Grade

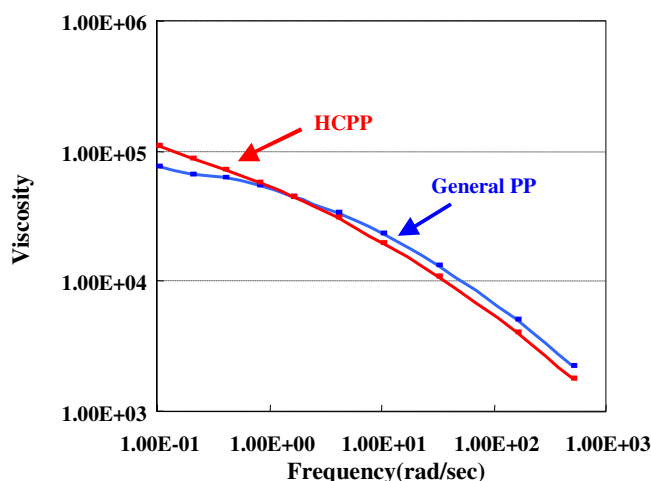


## MWD(Molecular Weight Distribution) of HCPP

This figure shows shear thinning effect as a function of frequency between HCPP and General PP

HCPP has very broad MWD compared with general PP.

It is well understood that high molecular weight portion contribute to enhance physical properties while low molecular weight portion helps to enhance the flowability.

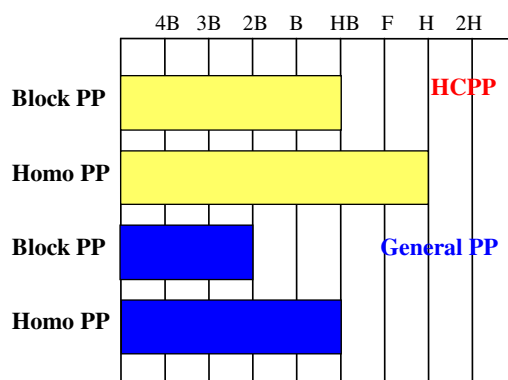




## Pencil Hardness (Scratch Resistance)

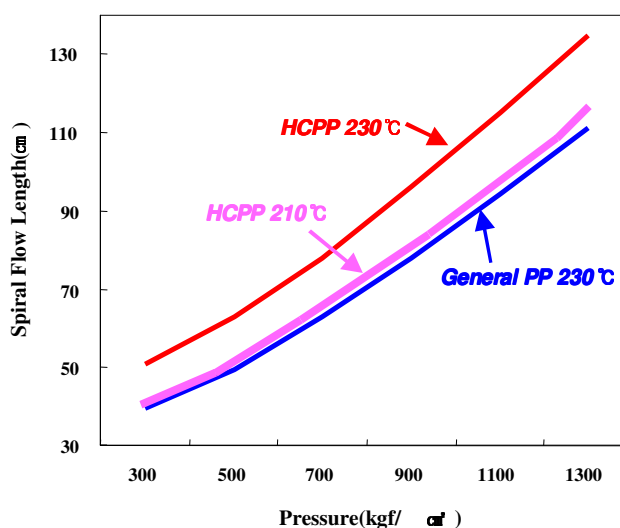
This shows pencil hardness comparison between HCPP and general PP.

HCPP offers excellent scratch resistance compared to general PP.



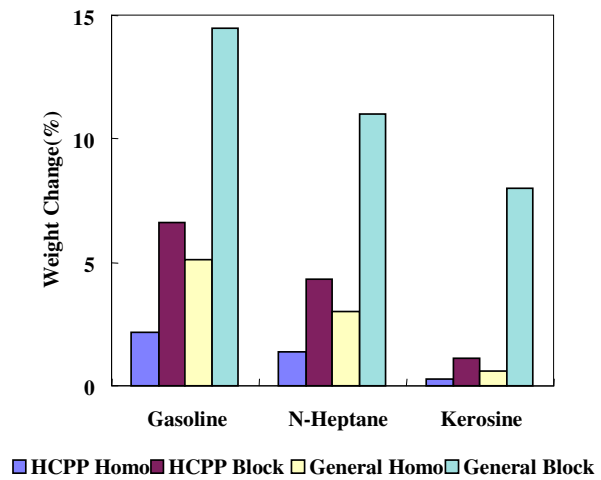
## Processability

This figure indicates that HCPP shows longer flow length compared with general PP as a function of injection pressure, the injection temperature can be lowered as much as 15~20 °C, still showing the same flow length as general PP.



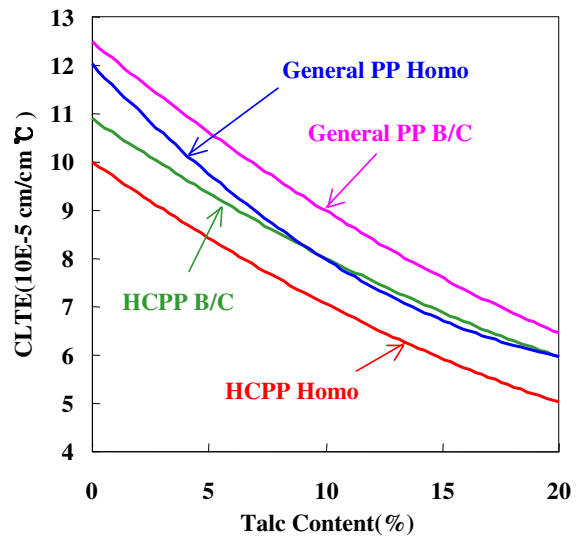
## Chemical Resistance of HCPP

When HCPP and general PP soak in solvent such as gasolin, n-heptane, kerosine, HCPP shows little change of weight compared with general PP, so HCPP have a good chemical resistance



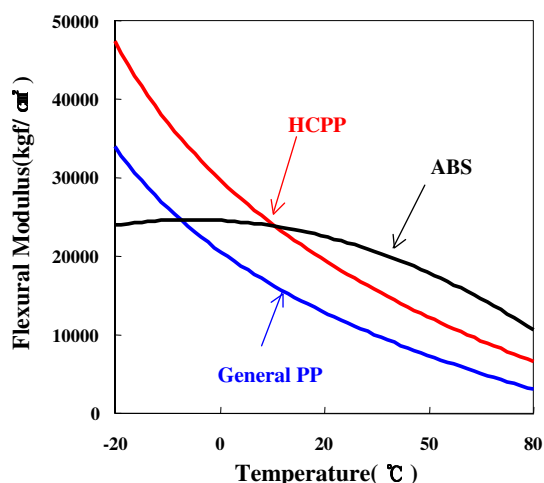
## Comparison of CLTE (Coefficient of Linear Thermal Expansion)

This graph shows the CLTE variation as a function of Talc content. Some parts of automobiles are assembled with other parts. Thermal expansion cause many troubles such as warpage of product, peeling off from body, and so on. HCPP shows good dimensional stability compared with general PP.



## Temperature dependance of Flexural Modulus

This graph shows that HCPP have a comparable stiffness to ABS at working temperature.  
 In the case of limited application, ABS can be substituted by neat HCPP or HCPP compound.



## Certificate of UL



E93311

Mtl Dsg	Col	Min Thk (min)	UL 94 Flame Class	Elec	RTI			H		
					Mesh		HWI	HAI	CTI	VAR
					w/Imp	w/o Imp				
HJ4006	ALL	3.0	HB	65	65	65	-	-	-	-
HJ4012	RD	0.75	HB	120	125	125	16	125	-	-
	All	1.5	HB	120	125	125	-	-	-	-
HJ4112	All	3.0	HB	120	125	125	48	150	600	-
	RD	0.75	HB	65	65	65	20	112	-	-
CB5108	All	3.0	HB	65	65	65	69	150	600	-
	RD	0.75	HB	65	65	65	-	-	-	-
CB5108H	All	3.0	HB	65	65	65	-	-	-	-
	RD	0.90	HB	120	115	120	12	108	-	-
	All	1.5	HB	125	125	125	12	108	-	-
CB5230	All	3.0	HB	125	130	130	262	105+	480	-
	NC,WT,RD	0.87	HB	65	65	65	-	-	-	-
CB5290	All	3.0	HB	65	65	65	-	-	-	-
SB9108	All	0.75	HB	65	65	65	-	-	-	-
SB9108H	All	1.5	HB	65	65	65	-	-	-	-
	NC	0.75	HB	120	125	125	-	-	-	-
		1.5	HB	120	125	125	-	-	-	-
SB9230	All	3.0	HB	120	125	125	-	-	-	-
SB9230	All	1.5	HB	65	65	65	-	-	-	-

## Application for Films



## Characteristics

HCPP is polymerized using SLURRY process and advanced catalyst system so that final product satisfies mechanical and optical properties required for film product. In order to minimize residual solvent and volatile matter and meet all regulations, we equipped upgraded drying system.

- ▶ Good processability, High clarity, High stiffness, Low thermal shrinkage
- ▶ Less drop of wetting tension after metallization, Superior Heat Resistance
- ▶ Higher Melting Temperature
- ▶ Extremely low content of volatile matter, non-toxic and odorless

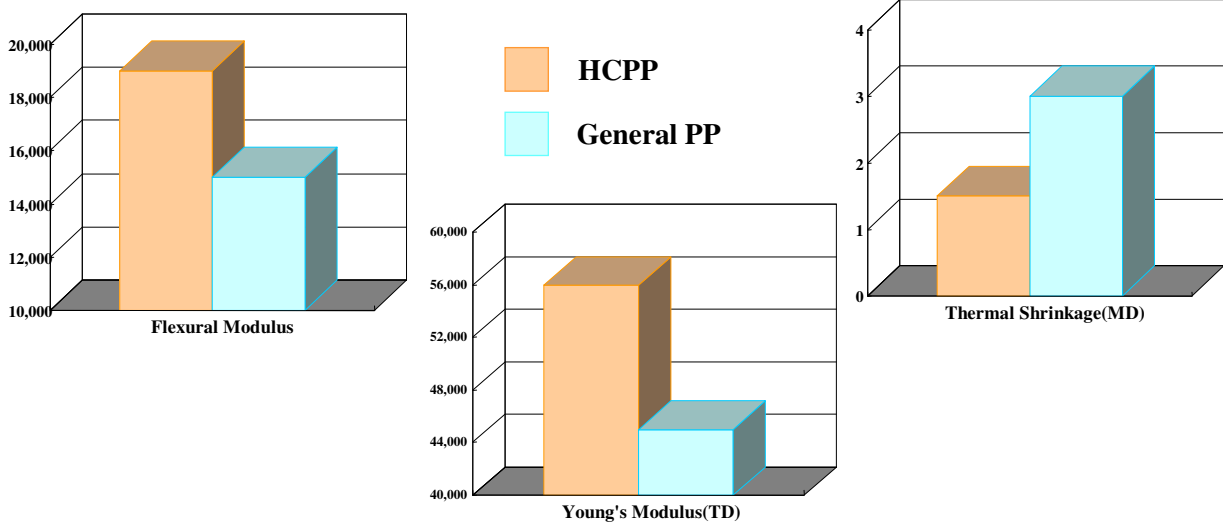
## Physical Properties (Material)

ITEM	TEST METHOD	UNIT	HF5103	HF5003	General OPP	1077	1077M	General CPP
MI	ASTM D1238	g/10mm	3.0	3.0	3.0	8.0	8.0	8.0
Density	ASTM D 792	g/cm <sup>3</sup>	0.91	0.91	0.90	0.91	0.91	0.90
Tensile at Yield	ASTM D 638	kgf/cm <sup>2</sup>	385	390	340	380	400	340
Flexural Modulus	ASTM D 790	kgf/cm <sup>2</sup>	18,500	19,000	15,000	17,500	18,000	15,000
Hardness(Rockwell)	ASTM D 785	R scale	100	101	96	100	103	96
Additives	Antioxidant		●	●	●	●	●	●
	Neutralizer		●		●	●		●
	Neutralizer(for metallizing)			●			●	
	Antistatic Agent		●					

## Physical Properties (Film)

ITEM	TEST METHOD	UNIT	HF5103	HF5003	General OPP	1077	1077M	General CPP	
Thickness	-	μm	20	20	20	25	25	25	
Haze	ASTM D1003	%	0.7	0.7	0.9	1.2	1.2	1.3	
Tensile Strength	ASTM D 882	kgf/cm <sup>2</sup>	MD	1,500	1,500	1,300	-	-	-
			TD	3,400	3,400	3,000	-	-	-
Young's Modulus	ASTM D 882	kgf/cm <sup>2</sup>	MD	28,000	30,000	20,000	Ave. 1,100	Ave. 1,100	Ave. 800
			TD	53,000	56,000	45,000			
Thermal Shrinkage	ASTM D1204	%	MD	1.5	1.5	3.0	-	-	-
			TD	0	0	0.5	-	-	-
Uses	FDA		●	●	●	●	●	●	
	OPP		●	●	●				
	CPP					●	●	●	

## Comparison of Physical Properties between HCPP and General PP



## Application for PP Compound



## Properties

Thanks to the superior mechanical and thermal property, HCPP have achieved a rapid growth as base resin for PP compounds in domestic market.

Using HCPP as a base resin for PP compounds, one can reduce the amount of filler addition, resulting in reduced part weight and better color dispersion without sacrificing the thermal and scratch resistance. In the case of putting a limited application, PP compounds can be directly substituted by neat HCPP.

## Physical Properties

Properties	Method (ASTM)	Unit	HJ4012	HJ4045	CB5108	CB5230	CB5290	SB9108	SB9230	SB9310	SB9430
			HOMO		BLOCK						
Melt Index	D1238	g/10min	14	45	10	30	100	10	30	10	30
Tensile Strength (at Yield)	D638	kgf/cm <sup>2</sup>	430	430	330	350	350	330	300	250	250
Elongation	D638	%	50	40	200<	200<	30	200<	200<	500<	50
Flexural Modulus	D790	kgf/cm <sup>2</sup>	24,000	24,000	18,000	18,000	18,000	16,500	16,000	13,500	14,000
Izod Impact (notched, 23℃)	D256	kgfcm/cm	4	4	10	7	6	10	12	20	13
Hardness (Rockwell)	D785	R	110	112	102	102	105	102	98	90	90
HDT	D648	℃	140	140	135	135	130	130	131	122	127

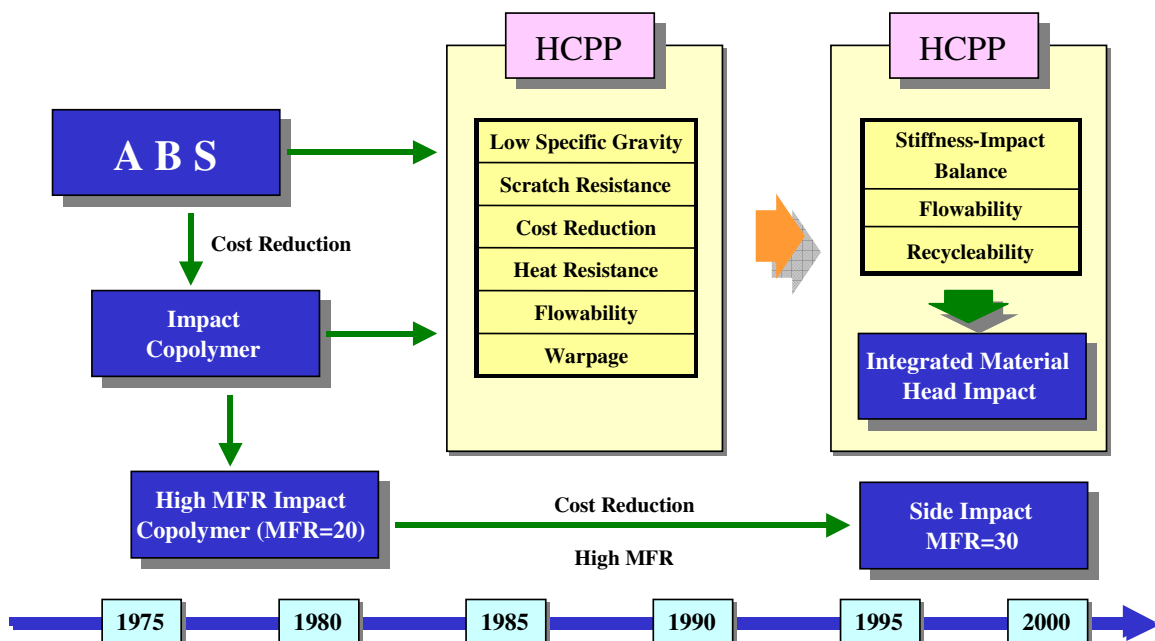


## Advantage of HCPP for Automotive Parts

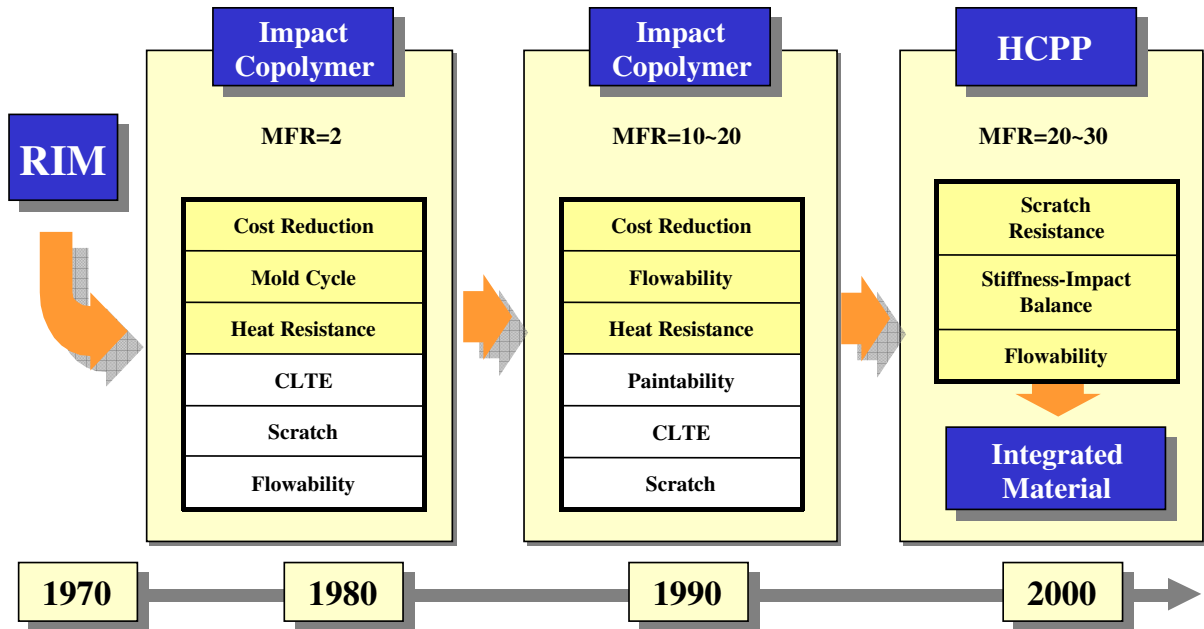
	Bumper	Pillar & Trim	Instrumental Panel	HVAC	Lamp Housing
Stiffness		○	○	○	○
Hardness	○	○	○		○
Scratch Resistance	○	○	○		
Impact Strength					
Flowability	○	○	○	○	
Dimensional Stability	○	○	○	○	○
Warpage					
Appearance	○	○	○		
Paintability					

○ : Advantage of HCPP      □ : Requirement

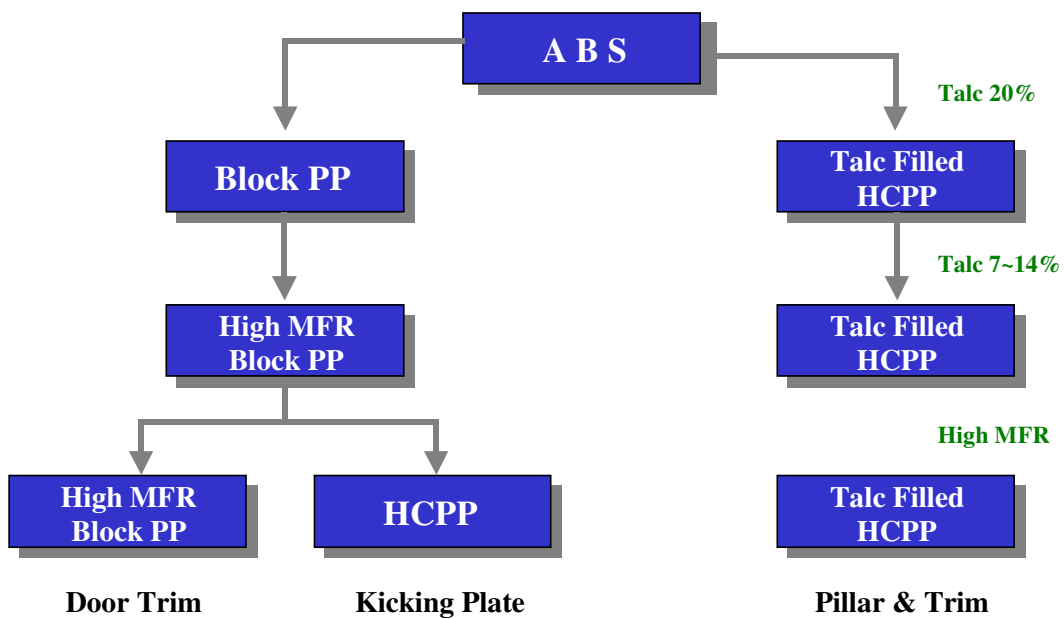
## Trend of Interior Parts Material



## Trend of Bumper Fascia

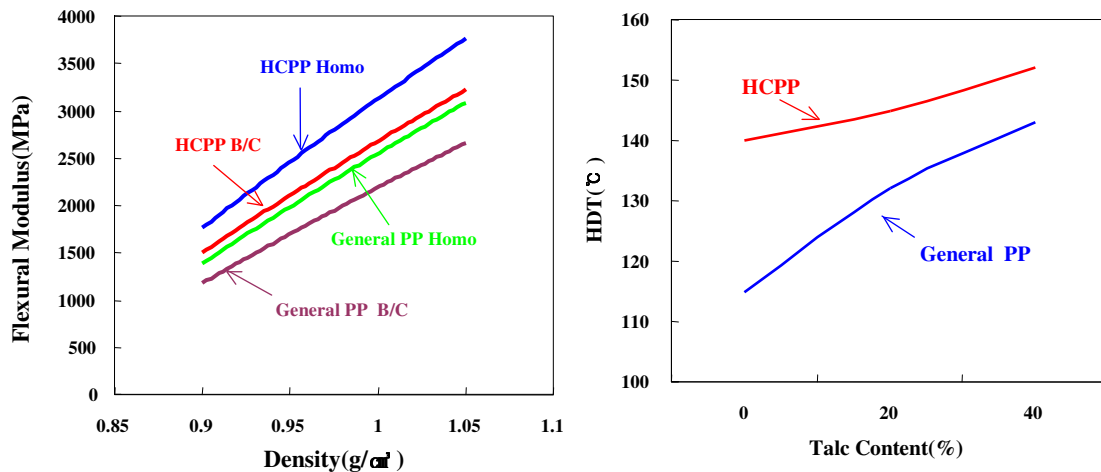


## Changes of Automotive Interior Parts



## Physical Properties of Talc Filled Compound

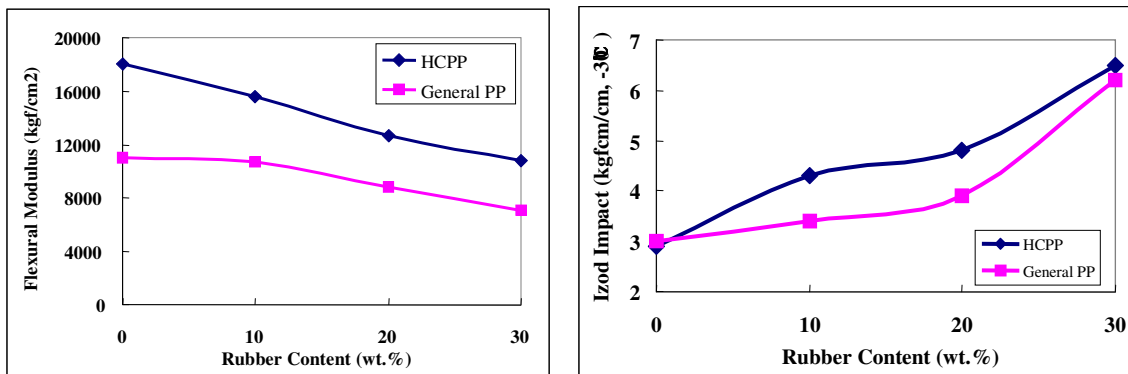
Superior rigidity and thermal resistance of HCPP gives an opportunity for significant weight reduction and it is very easy for HCPP to meet physical requirement from car maker.



## Physical Properties of Rubber Filled Compound

HCPP is a good substrate for PP compound requiring high stiffness and impact strength altogether.

Even though large amount of addition of rubber, HCPP still retains high rigidity compared with general PP in compound.



## Scratch Resistance

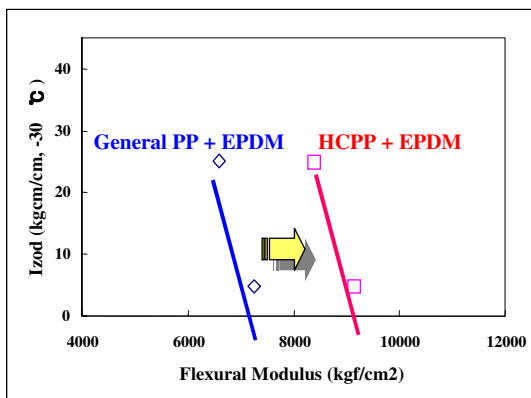
Good Scratch Resistance using HCPP in compound

Item	Formulation (wt.%)			Rockwell Hardness	Pencil Hardness		
	PP	Talc	Rubber		4B	3B	2B
General PP	60	25	15	64	△	×	×
	65	25	10	77	△	×	×
	65	20	15	69	△	△	×
HCPP	65	20	15	75	○	○	△

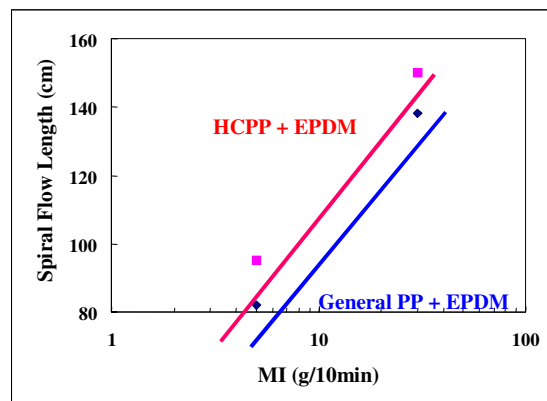
× : Weak    △ : Moderate    ○ : Hard

## Mechanical Property and Processability

HCPP/EPDM compounds give substantially higher flexural modulus and melt flowability compared to general PP/EPDM compounds with equivalent composition.



Comparison of FM and Izod (EPDM Modified PP)



Flow Length in same MI

## Adoption of HCPP for Automobile Parts

Grade	Car Maker	Brand Name	Application Part
SB9310	DAEWOO	Musso	Garnish
SB9230	KIA	Rio SF	Door Trim
	KIA	Sorento	Door Trim, Glove Box, Cover Seat Side
CB5108	KIA	CarensII, Carnival, Carstar	Front, Center, Rear Pillar Trim
	KIA	Click, Rio, Sorento	
CB5230	KIA	Spectra	Door Trim
	HYUNDAI	Click	Door Trim
CB5290	HYUNDAI	Avante	Bumper, Glove Box
	HYUNDAI	Sonata, Grandeur	Door Trim
HJ4045	KIA	Sorento	Console body

## Application for Electrics & Electronics



## Characteristics

HCPP homo - and block -grades are rapidly gaining popularity in electric and electronic application. High stiffness, high heat deflection temperature, and enhanced scratch resistance make HCPP an ideal candidate for replacing mineral -filled compound in these area. Physical properties improvement is often achieved at the cost of sacrifice in the productivity. However, HCPP grades offers benefit in both physical strength and productivity. Low blooming and good color dispersion are also important features of HCPP

## Physical Properties

Properties	Method (ASTM)	Unit	HJ4012	CB5108H	SB9108H
Melt Index	D1238	g/10min	14	10	10
Tensile Strength	D638	kgf/cm <sup>2</sup>	430	330	330
Flexural Modulus	D790	kgf/cm <sup>2</sup>	24,000	18,000	16,500
Izod Impact (notched, 23℃)	D256	kgfcm/cm	4	10	10
Hardness (Rockwell)	D785	R	110	102	102
HDT	D648	℃	140	135	130
RTI	UL746B	℃	125	125	125

## Washing Machine – Exterior Parts



No.	Part Name	Grade	Characteristics
1	Lid T.C(U/L)	CB5108	High Gloss
2	Cover T.C		
3	Control Panel	CB5230	Good Processibility
4	Top Cover	SB9230	
5	Base	SB9108	High Resistance to Scratch
			Good Impact Strength
			Dimensional Stability

## Washing Machine – Interior Parts

No.	Part Name	Grade	Characteristics
6	Detergent Case	SB9108	High Gloss
7	Spin Tub	SB9230	
8	Guide W/F	SB9108	Good Processibility
9	Out Tub	SB9230	
10	Cover Tub	SB9440	High Resistance to Scratch
11	Pulsator	SB9108	
12	Bowl	SB9230	Good Impact Strength
13	Balance U/L	SB9108	
			Dimensional Stability





## Refrigerator

No.	Part Name	Grade
1	Tray Ice, Cube	CB5108, SB9108
2	Mid-Shelf	CB5230, SB9230
3	Box Vegetable	CB5230, SB9230
4	Kick Plate	CB5108, SB910
5	Evaporating Dish	HJ4012
6	Guard Bottle	CB5230, SB9230
	Top Plate	SB9108



## Vacuum Cleaner

No.	Part Name	Grade
1	Body Base	CB5230 SB9230
2	Body Mid	
3	Cover Dust	
4	Case Motor	
5	Cover Brush	
6	Wheel Back	CB5108
7	Cover Attachment	SB9108



## Small Home Appliances

### Required Properties

- Long term heat stability (RTI 125°C)
- High Heat Resistance & Gloss
- Dimensional Stability
- Scratch Resistance

Item	Part	Grade
Rice Cooker	Lid, Base	HJ4012
Jar Pot	Lid, Base	
Iron	Body	CB5108H
Toaster	Housing	SB9108H



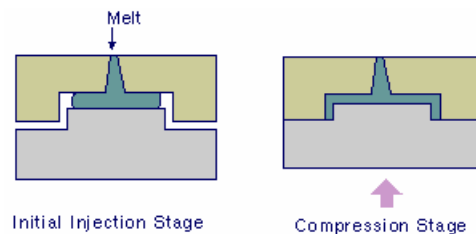
# Application for Automobile

Door Trim, Sirocco Fan, Battery Case, Oil Reservoir Tank, Sheet



## Characteristics for Injection Compression Molded Door Trim

- ▶ High flowability without loss of physical properties compare to compounded grade.
- ▶ Eliminates high labor content and low productivity.
- ▶ Saving energy costs owing to the lower pressures and relatively low temperatures.
- ▶ Light-weighting of total product and cost effectiveness.



## Physical Properties – Door Trim

Classification	Unit	CB5290	Competitor
MI	g/10min	100	110
Density	g/cm <sup>3</sup>	0.910	1.05
Hardness	R scale	105	87
<b>Flexural Modulus</b>	<b>kg f/cm<sup>2</sup></b>	<b>18,000</b>	<b>17,400</b>
Flexural Strength	kg f/cm <sup>2</sup>	525	380
<b>Impact Strength</b>	<b>kg fcm/cm</b>	<b>6.0</b>	<b>3.4</b>
Tensile Strength(at Yield)	kg f/cm <sup>2</sup>	350	210
Tensile Strength(at Break)	kg f/cm <sup>2</sup>	200	205
Elongation	%	30	10
Heat Distortion Temperature	℃	130	124

Note : A is Compounded Material with Talc 20%

## Applied Model



### STAREX

Substrate : HCPP(CB5290), SKIN- PP Foam(RS3402 KPIC) + Cloth  
 Characteristic : 2 Pieces(Upper and Lower Part)



### EF SONATA

Substrate : HCPP(CB5290), Skin-PP Foam(RS3402 KPIC)  
 Characteristic : Center Panel



### SANTAMO

Substrate : HCPP(CB5290), Skin-PP Foam(RS3402 KPIC)+Cloth  
 Characteristic : Separate Center Panel

## Physical Properties – Sirocco Fan

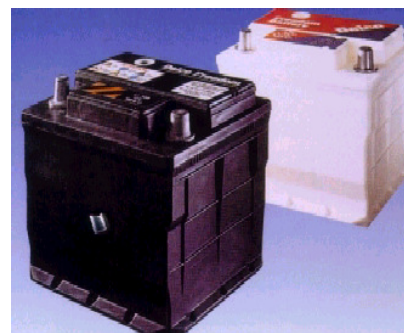
Property	Unit	HJ4006	HJ4012	Competitor
Melt Index	g/10min	6	13	6
Density	g/cm <sup>3</sup>	0.91	0.91	0.94
Hardness	R scale	110	110	93
Flexural Modulus	kgf/cm <sup>2</sup>	23000	23000	20,500
Izod Impact Strength	kgf.cm/cm	4	4	9
Tensile Strength	kgf/cm <sup>2</sup>	420	420	350
HDT	℃	140	140	125



Note : A is Compounded Material with Talc 10%

## Physical Properties – Battery Case

Property	Unit	SB9310	CB5108	Competitor	
Melt Index	g/10min	10	10	10	
Hardness	R scale	90	102	85	
Flexural Modulus	kgf/cm <sup>2</sup>	13500	18000	14,500	
Izod Impact Strength	23 ℃	kgf.cm/cm	20	10	12
	-20 ℃		5.5	4	6
Tensile Strength	kgf/cm <sup>2</sup>	250	330	310	
HDT	℃	122	135	118	



## Physical Properties – Oil Reservoir Tank

Property	Unit	CB5108H	Competitor	
Melt Index	g/10min	10	10	
Hardness	R scale	102	94	
Flexural Modulus	kgf/cm <sup>2</sup>	18000	16000	
Izod Impact Strength	23 ℃	kgf.cm/cm	10	6.5
	-20 ℃		4	1.5
Tensile Strength	kgf/cm <sup>2</sup>	330	300	
HDT	℃	135	120	



## Physical Properties - Sheet

Property		Unit	SB1930	Competitor
Melt Index		g/10min	0.5	0.5
Hardness		R scale	85	80
Flexural Modulus		kgf/cm <sup>2</sup>	13,000	10,000
Izod Impact Strength	23 ℃	kgf.cm/cm	NB	51
	-20 ℃		10	2
Tensile Strength		kgf/cm <sup>2</sup>	300	280
HDT		℃	102	100

