

# --- Impact Resistant PMMA



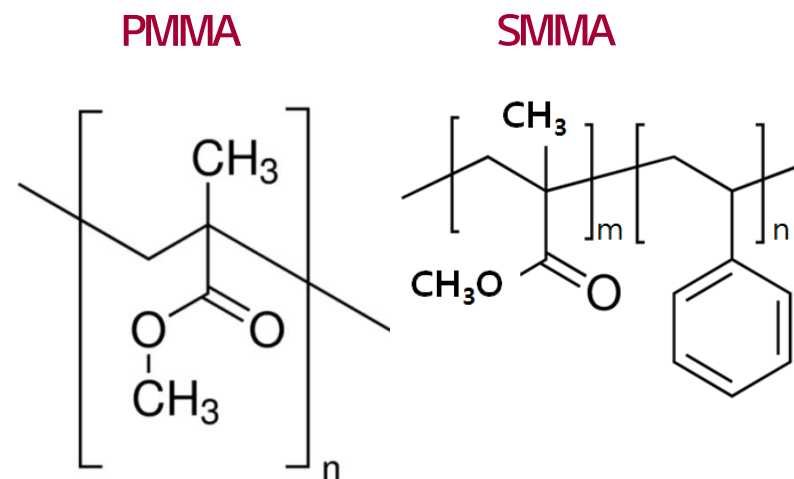
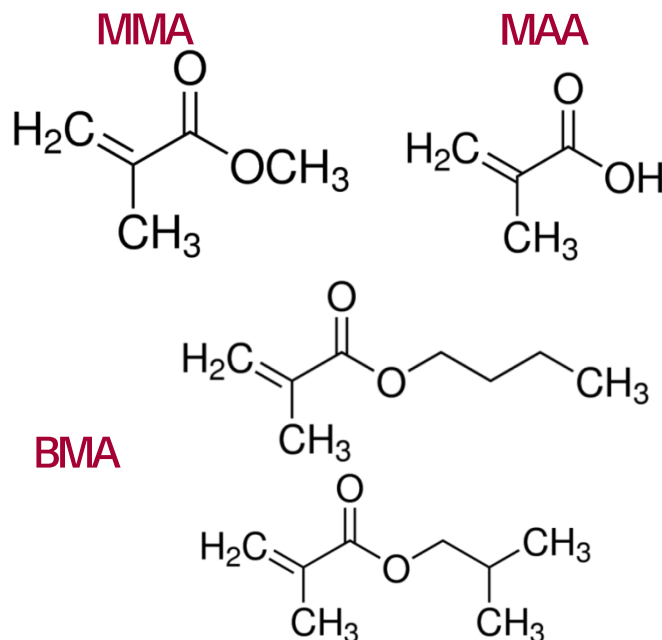
# LGMMA Overview

## Production Capacity

(unit: ton/year)

Capacity (`2018)	Monomers			Polymers	
	MMA	MAA	BMA	PMMA	SMMA
	180,000	45,000	15,000	120,000	

## Products



# Overview

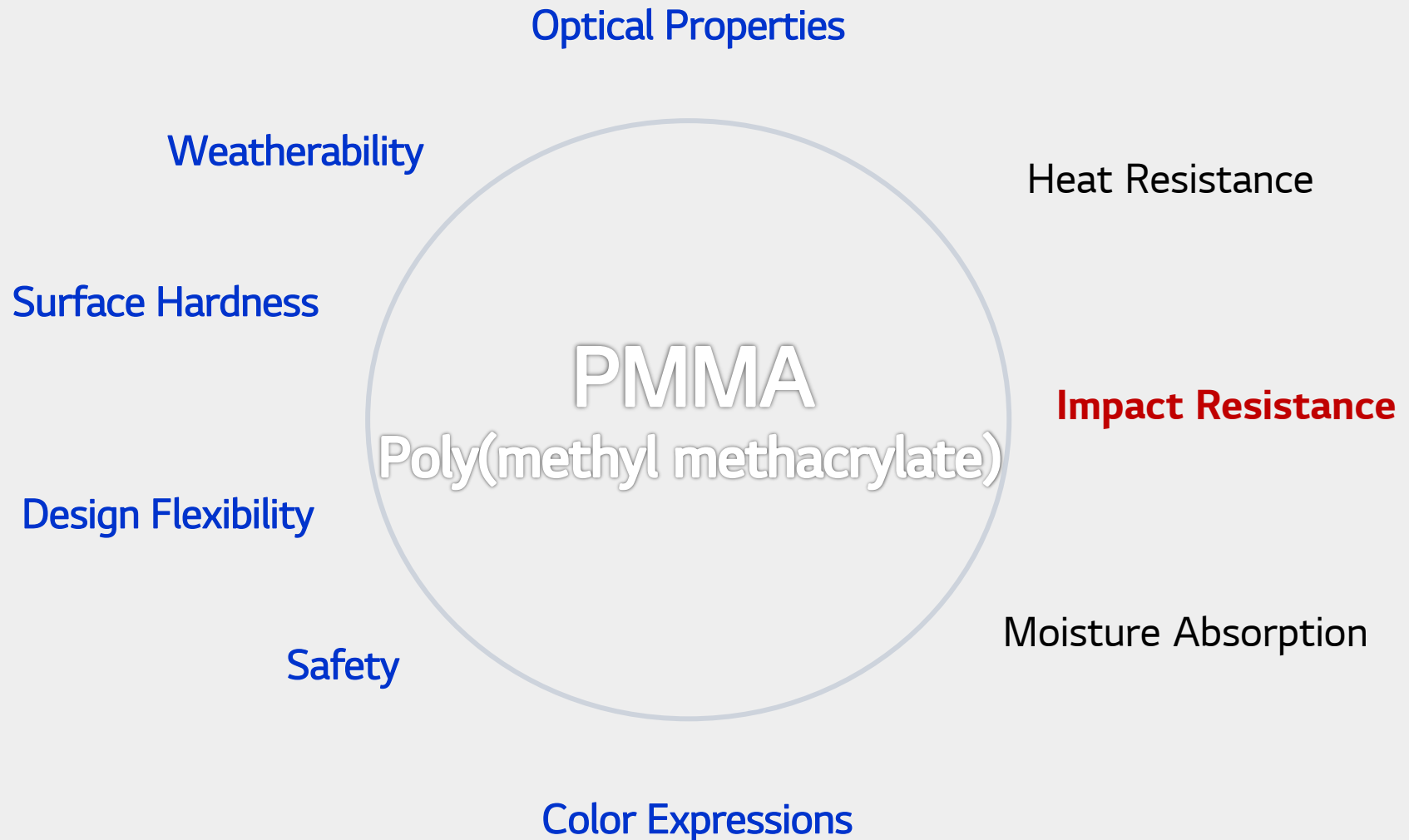
Manufacturing method of PMMA uses suspension polymerization and bulk polymerization.

## LG MMA Polymer Process

		Process	Products	Type	MT/Year
Current	PMMA No.1	Suspension Batch	PMMA Coating resin	Bead Pellet	70,000
	PMMA No.2	Bulk Continuous	PMMA SMMA	Pellet	50,000
Future (in preparation, 2021~)		Emulsion Batch	Acrylic impact modifier for PMMA	Bead Flake	5,000

# Introduction

Strength and weakness of PMMA are as follows.



# Introduction

Improved impact resistance using acrylic impact reinforcement material while maintaining excellent transparency and weathering resistance of the general PMMA.

## Outstanding Characteristics of PMMA

### Transparency

The most excellent transparency among all plastics  
(Transmits more than 92% of the visible ray area)

### Weatherability

The most excellent weatherability among plastics

### Scratch Resistance

Excellent scratch resistance with its high degree of surface hardness among plastics  
(Pencil hardness : 3H-4H)

### Non-toxicity & Eco-friendly

Does not contain toxic substances and can be used for tableware, denture, dental filler, artificial eyes and artificial bones

## Impact Resistant PMMA

Impact modified HI PMMA show that well balanced property profile such as high impact strength, high heat resistance and processability. Appropriate for parts that require impact strength such as smart phone window, signboard, lighting, display and vending machine and so on.

# Introduction : Acrylic Impact Modifier

We compound acrylic impact modifier with PMMA to improved impact resistance.

Impact modifiers can not be used alone because of difficulty of processing.

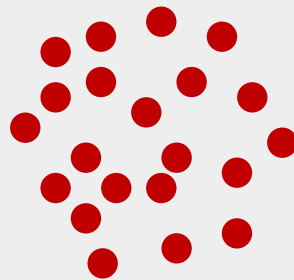
## Schematic Diagram of Impact Resistant PMMA

PMMA Matrix



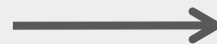
Brittle

Impact modifier  
: Acrylic Rubber

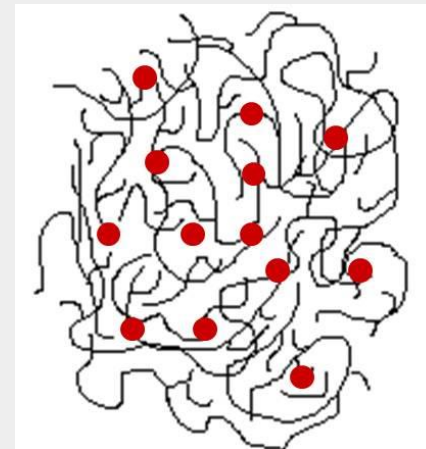


Soft  
(Low T<sub>g</sub>)

Compounding



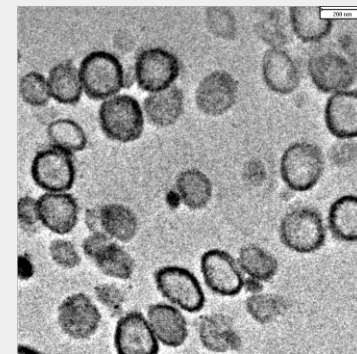
Impact Resistance PMMA



: Polymer matrix



: Impact modifier (rubber)

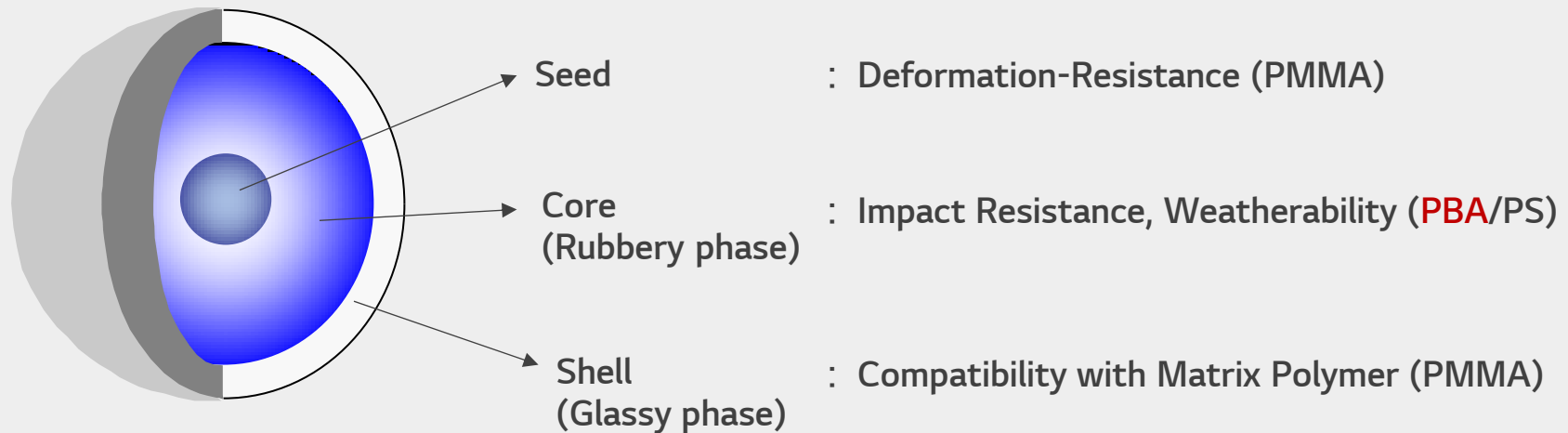


[TEM Image]

# Introduction : Acrylic Impact Modifier

Core-shell type of acrylic impact modifier was specially designed for compounding with PMMA.

## Acrylic Impact modifier with Core-Shell Structure for PMMA



## Refractive index : 1.49

- ✓ Refractive index is same as PMMA for transparency
- ✓ Solid core is introduced for improving impact strength without damaging transparency

# Properties

A variety of grades with different impact strength and fluidity is available, and the grade most suitable for the final product can be selected.

## Major properties

- ✓ Impact Strength  
: For end products that require impact strength
- ✓ Flowability (MFR)  
: Processability for extrusion or injection
- ✓ Heat Resistance (HDT)  
: For end products that require heat resistance

## Correlation of amount of impact modifier

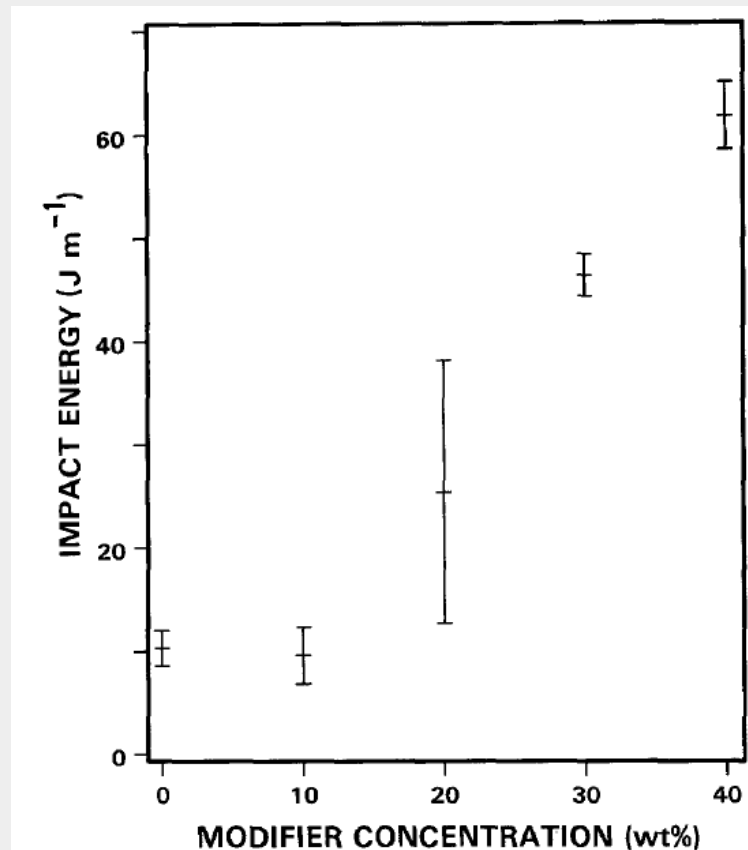


Figure 1 Variation of impact strength (in a Notched Izod test) with concentration of the modifier phase.



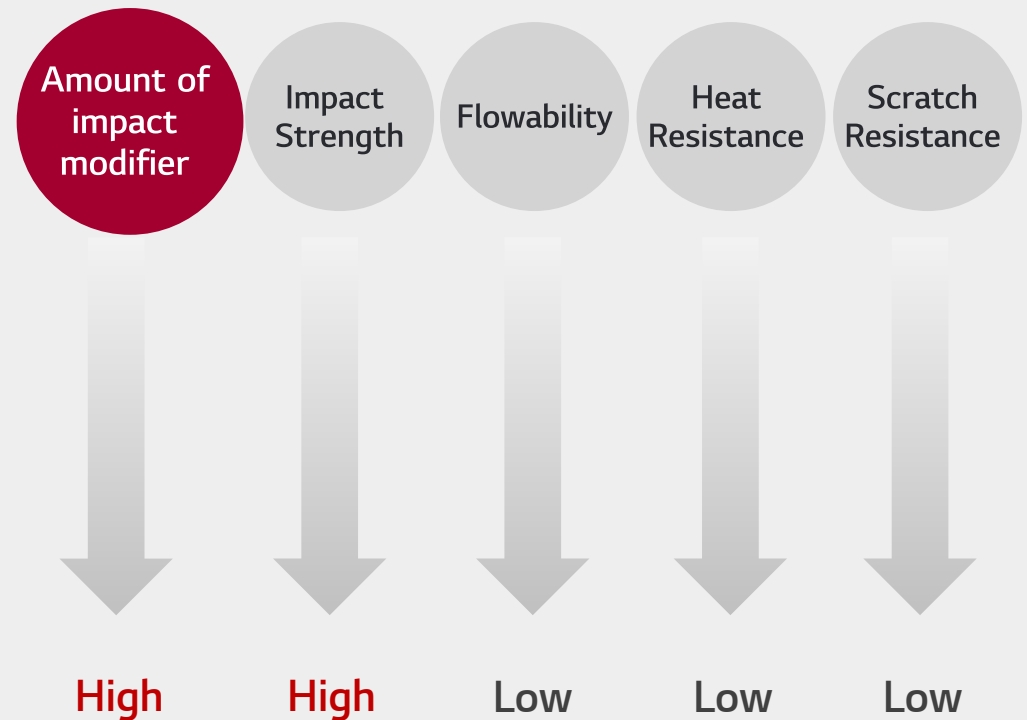
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## Correlation of amount of impact modifier and properties



# Properties

A variety of grades with different impact strength and fluidity is available, and the grade most suitable for the final product can be selected.

## Impact Resistant PMMA Lineup

	HI8 Series		HI5 Series		
Base PMMA	Good Heat Resistance	Good Flow	Good Heat Resistance	Good Flow	High Flow
Middle Impact  ↓  High Impact	HI835M	HI855M	HI533	HI553	HI572
	HI835S	HI855S	HI534	HI554	
	HI835H	HI855H	HI535	HI555	
			HI537	HI557	

# Properties

We developed HI 8 series first, HI 5 series was later developed.

The impact strength of HI 5 series is better than HI 8 series. So we are trying to promote HI 5 series.

## Comparison of HI8 and HI5

HI8  
series

- ✓ Acrylic impact modifier
- ✓ Color (Yellow index)

HI5  
series

- ✓ Acrylic impact modifier
- ✓ High impact strength
  - . heat resistance
  - . surface hardness

On the same level of impact value,  
differences in major properties

Properties	Unit	HI8 Series	HI5 Series
Mechanical			
Charpy Impact Strength	kJ/m <sup>2</sup>	4.0	4.0
Rockwell Hardness	-	61	70
Tensile Strength	Mpa	51	58
Tensile Elongation at break	%	40	28
Thermal			
Melt Flow Rate	g/10min	2.7	3.1
Vicat Softening Temp.	℃	92	97
Optical			
Light Transmittance	%	92	92
Haze	%	1.2	1.1
Yellow Index	-	0.8	1.2

# Properties

A variety of grades with different impact strength and fluidity is available, and the grade most suitable for the final product can be selected.

## Impact Resistant PMMA Lineup

	Low Flow (MFR : 1~3)				Medium Flow (MFR : 4~6)			High Flow (MFR > 10)	
Charpy IMP	LG MMA		Evonik	Arkema	LG MMA		Evonik	LG MMA	Arkema
3	HI835M	HI533	zk4BR	MI4T	HI855M	HI553		HI572	HFI-7
4	HI835S	HI534		MI7T	HI855S	HI554			
5	HI835H	HI535	zk5BR	HFI-10	HI855H	HI555	zk5HF		
6~7		HI537	zk6BR	DR101		HI557	zk6HF		

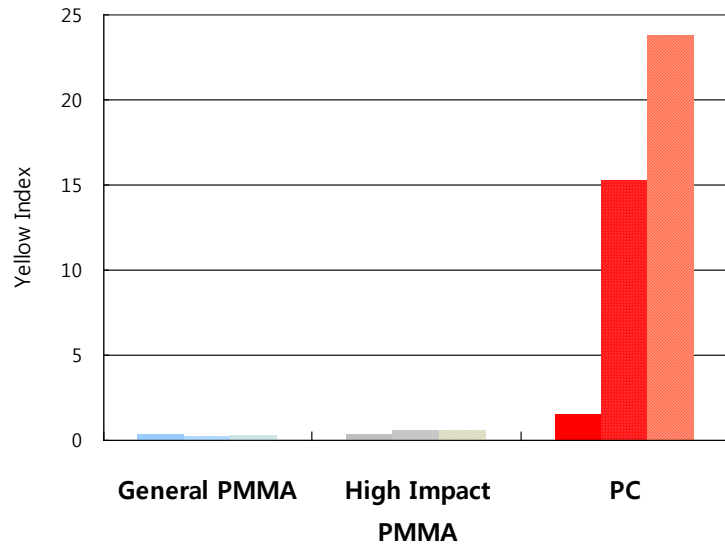
# Properties

Properties		Unit	HI8 Series							HI5 Series					
			HI835MS	HI835M	HI835S	HI835H	HI855M	HI855S	HI855H	HI533	HI535	HI537	HI553	HI555	HI572
Optical	Light Transmittance	%	91	91	91	91	91	91	91	91	91	91	91	91	91
	Haze	%	<1.5				<1.5			<1.5		<2.0	<1.5		<1.5
Thermal	Melt Flow Rate	g/10min	2.0	3.2	2.8	2.1	6.4	5.7	4.1	2.6	2.3	1.2	6.5	5.0	19
	VICAT Softening Point	℃	97	93	90	86	88	86	78	93	87	83	90	85	84
	Heat Deflection Temperature	℃	88	84	81	77	79	77	69	84	78	74	81	76	75
	Coefficient of Linear Expansion	1/℃	7X10 <sup>-5</sup>												
Mechanical	Charpy Impact Strength	kJ/m <sup>2</sup>	2.7	3.2	3.6	4.8	3.0	3.6	5.2	4.7	5.9	7.0	4.4	5.5	2.4
	Rockwell Hardness	-	83	71	59	47	61	53	40	78	64	46	63	45	76
	Tensile Strength at Break	MPa	49	40	39	37	38	35	33	42	37	34	42	37	39
	Tensile Strain at Break	%	28	34	46	54	46	49	41	26	33	35	26	33	3.5
	Tensile Modulus	GPa	2.5	2.0	1.8	1.5	2.0	1.8	1.5	2.2	1.7	1.5	2.2	1.7	2.4
	Flexural Strength	MPa	84	74	67	56	71	64	54	73	63	48	73	63	82
	Flexural Modulus	GPa	2.4	2.0	1.8	1.5	2.0	1.8	1.5	2.1	1.8	1.5	2.1	1.8	2.4
General	Density	g/cm <sup>3</sup>	1.17												
	Mold Shrinkage	%	0.4-0.8												
	Water Absorption	%	0.4												
	Flammability UL94	Class	HB												

# Weatherability

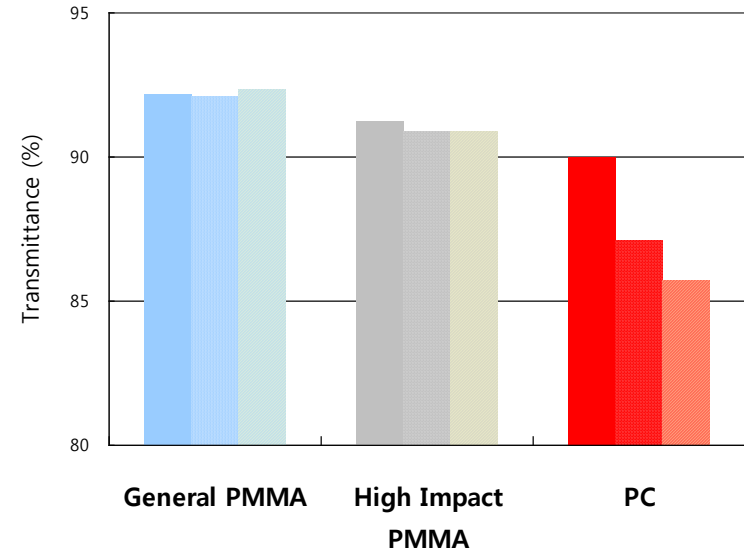
PMMA can preserve physical and optical properties without degradation from UV ray, rain and wind when used in outdoor environment for long time.

Change of Yellow Index by UV



		General PMMA	HI PMMA	PC
UV exposure	Initial	0.3	0.3	1.5
	500kJ/m <sup>2</sup>	0.2	0.4	15
	1,000kJ/m <sup>2</sup>	0.3	0.6	24
	3,000kJ/m <sup>2</sup>	0.3	0.8	-

Change of Transmittance by UV



		General PMMA	HI PMMA	PC
UV Exposure	Initial	92.2%	91.8%	90.0%
	500kJ/m <sup>2</sup>	92.1%	90.9%	87.1%
	1,000kJ/m <sup>2</sup>	92.4%	90.9%	85.7%
	3,000kJ/m <sup>2</sup>	92.0%	90.7%	-

# Applications

## Home Appliance Housing (Injection)

- ✓ Washing Machine Front Door  
(Clear PMMA/Deep blue MABS Multi-injection)
- ✓ HI855M
- ✓ Clarity, Scratch Resistance, Chemical Resistance, Good Flowability



# Applications

## Home Appliance Housing (Injection)



- ✓ Electric Cooker Cover Housing (Backside printing )
- ✓ HI835MS
- ✓ Clarity, Scratch Resistance



- ✓ DVD Housing
- ✓ HI532-S83387
- ✓ Transmits NIR for remote control, Scratch Resistance

- ✓ Air Conditioner Front Housing (Backside printing)
- ✓ HI572-01646
- ✓ Clarity, Scratch Resistance, High Flowability

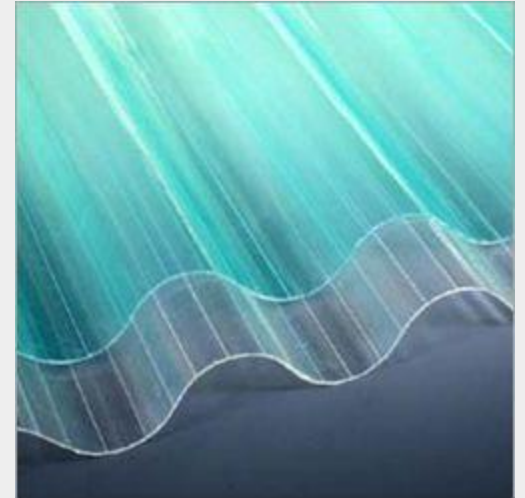




# Applications

## Sheet, Profile (Extrusion)

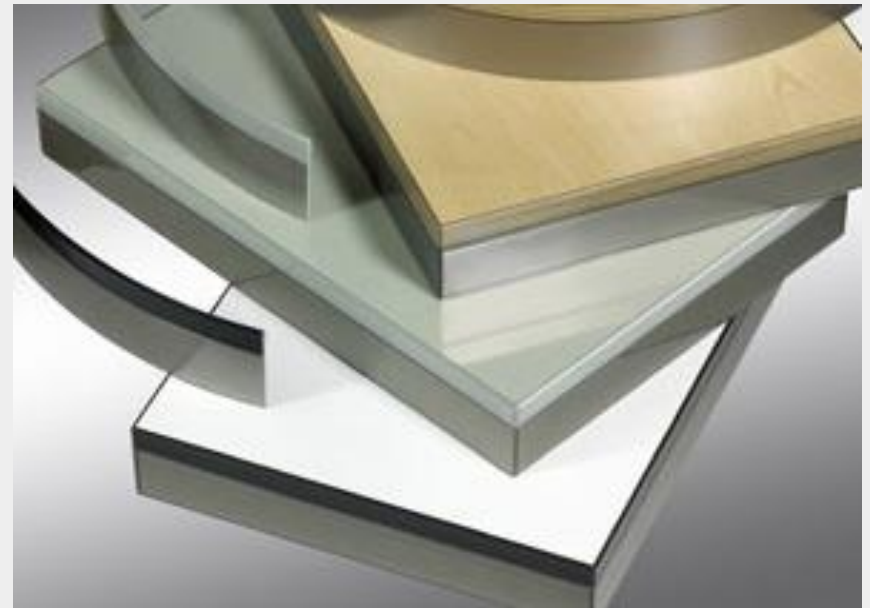
- ✓ Architectural Sheet : Solid sheet, Corrugated sheet, Multi-wall sheet
- ✓ HI835S, HI835H, HI532, HI534
- ✓ Clarity, Weatherability, Scratch Resistance,  
No hard coating required



# Applications

## Profile (Extrusion)

- ✓ Edgebands for Furniture
- ✓ HI835H, HI855H, HI537, HI517
- ✓ High Impact Strength & Bending Property, Clarity, Scratch Resistance



# Applications

## Profile (Extrusion)

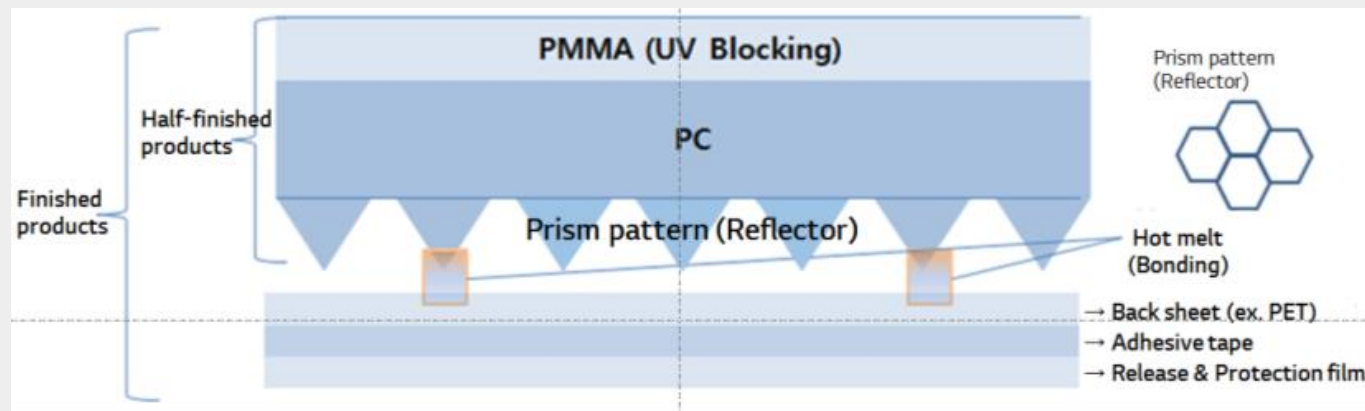
- ✓ Profile for Lighting
- ✓ HI835H, HI517
- ✓ High Transmittance & Diffusion, Weatherability



# Applications

## Film

- ✓ Film for Signboard (PC/PMMA co-extrusion)
- ✓ HI835MU, HI835HU
- ✓ UV-Blocking Property, Weatherability



# Applications

Film or PVC/PMMA co-extrusion

- ✓ Capstock for Window Profile (PVC/PMMA co-extrusion)
- ✓ Weatherability, Scratch Resistance, Gloss





# Applications

## ABS/PMMA Co-Extruded Sheets

- ✓ HI835S, HI855S, HI533, HI535, HI553
- ✓ UV resistance (Weatherability), Thermoforming properties, Gloss, Color Expression



- ▲ Various external parts for caravans (Roof-hoods, Front and rear panels, Side and decorative panels etc.)



- ▲ Bath tubs, Shower trays, cubicle walls, shower cubicles, bath panels, hand basins

### ► Furniture Film



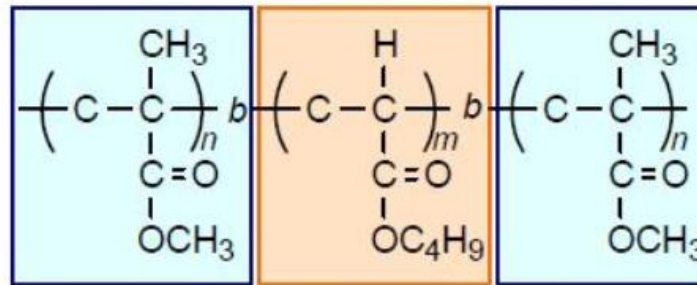
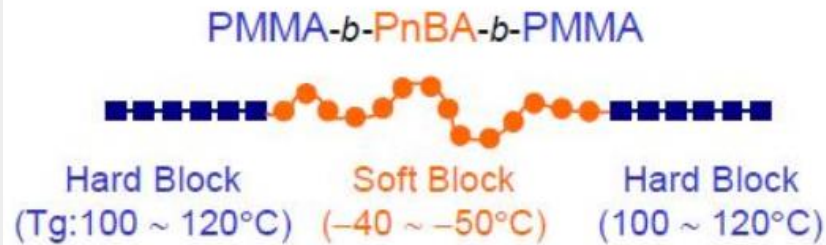
# ※ Appendix. New Technology – Acrylic Elastomer

Competitors, Arkema and Kuraray, are launching new products, acrylic elastomer, with block copolymer technology.

## ✓ ARKEMA NanoStrength



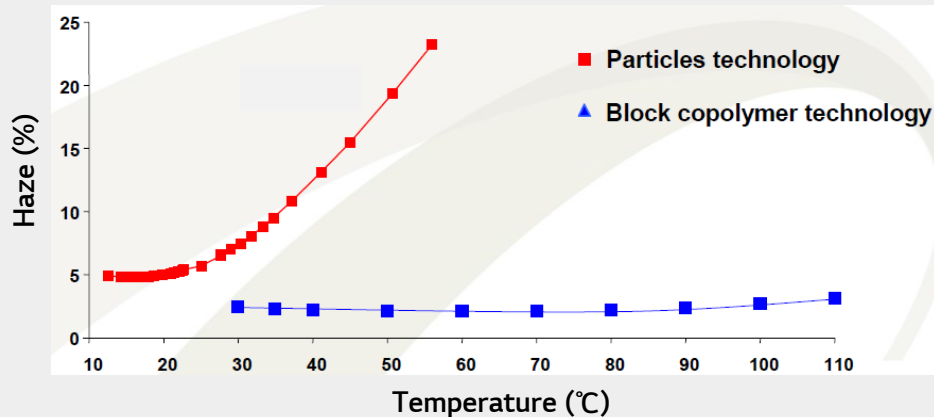
## ✓ KURARAY KURARITY



Light Guide



Transparent and elastic molding sheet





# Thank you



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