



LG Chem ABS & ASA

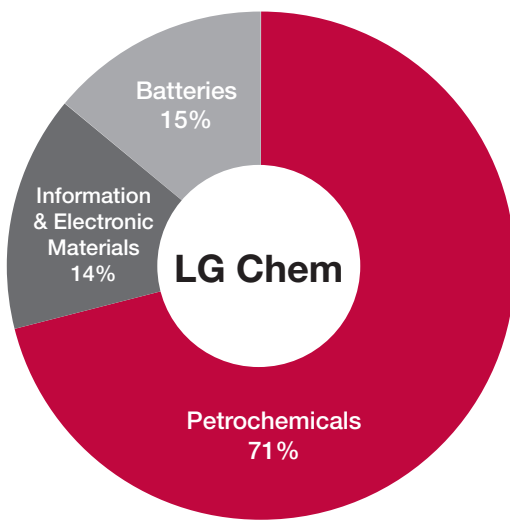
for Automotive

ABS Business & Market Share

ABS, the core business of LG Chem, continues to expand its market presence globally by offering cost competitiveness & operational excellence.

• ABS is today the core business of LG Chem

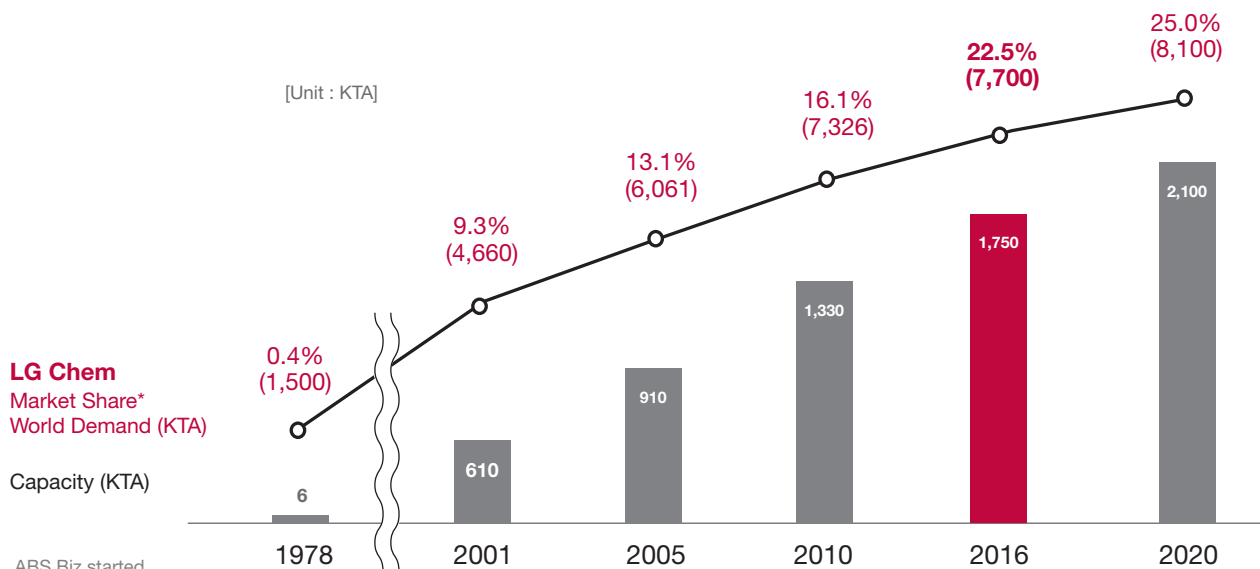
Petrochemicals account for 71% of the total LG Chem sales and ABS for 19% of Petrochemicals sales. ABS is one of the core business in LG Chem with continuous investment plans.



Division	Products
ABS	ABS, ASA, SAN, GPPS, HIPS
EP	PC, PC+ABS, PBT, TPEE, Nylon, Modified PP, PPS
NCC	Ethylene, Propylene, Butadiene, Benzene, SM, Phenol, BPA
PO	HDPE, LDPE, PP, EVA, Elastomer
PVC / Plasticizers	PVC, Plasticizer, Caustic Soda, CNT
Acrylates / SAP	Acrylates, SAP, Alcohol, NPG, PSA
Rubber / Specialty Polymers	BR, SBR, SSSBR, NBR, MBS, SBL

• ABS to reach global market share of 25% and more

LG Chem's goal is to be a global market leader of ABS by bringing new solutions with outstanding quality into the market and by reaching 25% of global market share by year 2020.



ABS Biz started
 - Korea, 1978
 - China, 1998

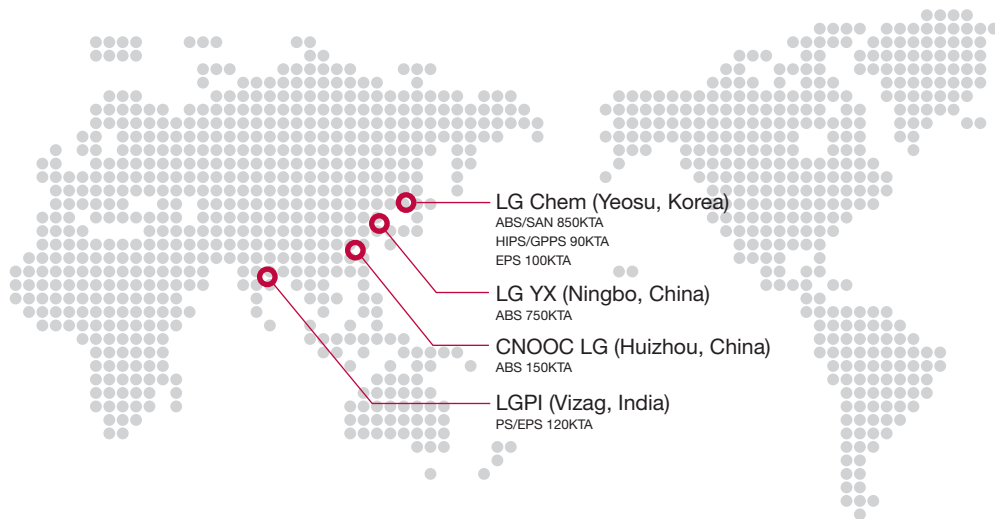
*Market Share : Sales of domestic and overseas subsidiary are included.

Production Site & Integration

LG Chem's multi-site production capability ensures stability and flexibility of reliable supply.

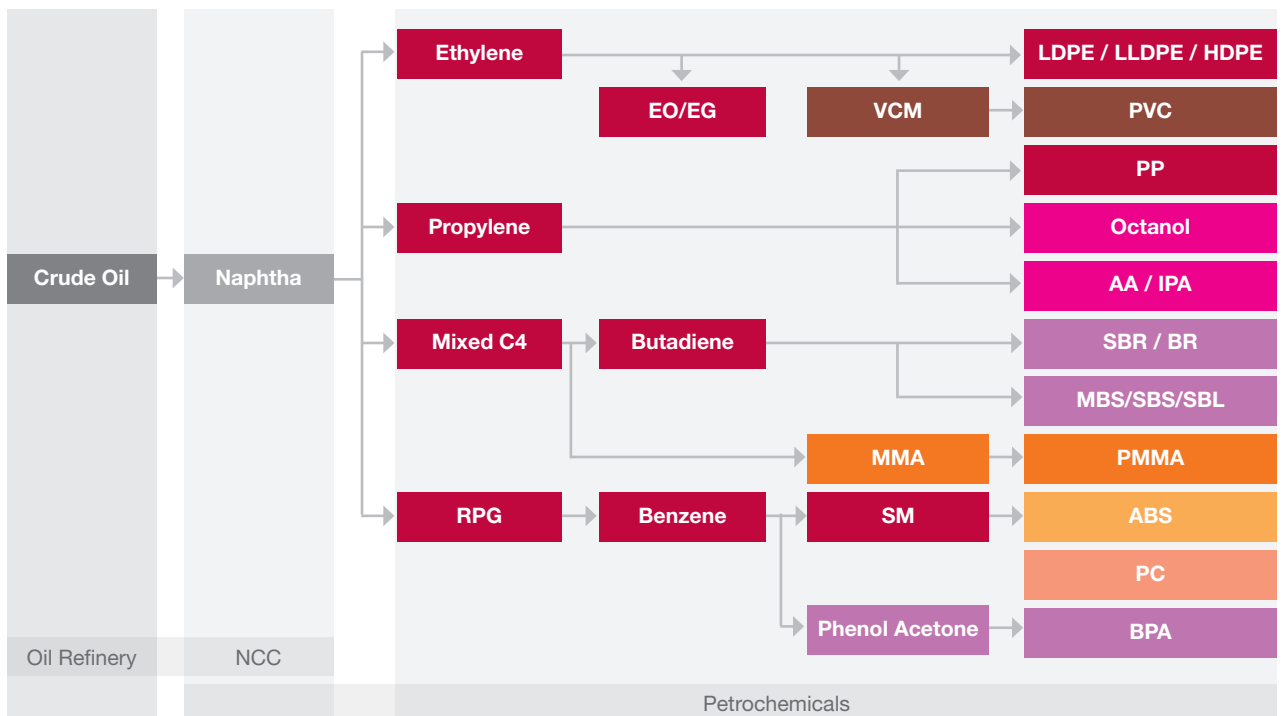
• ABS production sites

LG Chem is today the Global No. 1 ABS manufacturer who has continuously invested on ABS production capacity expansion & studies feasibility for new plants.



• Petrochemical Schematic

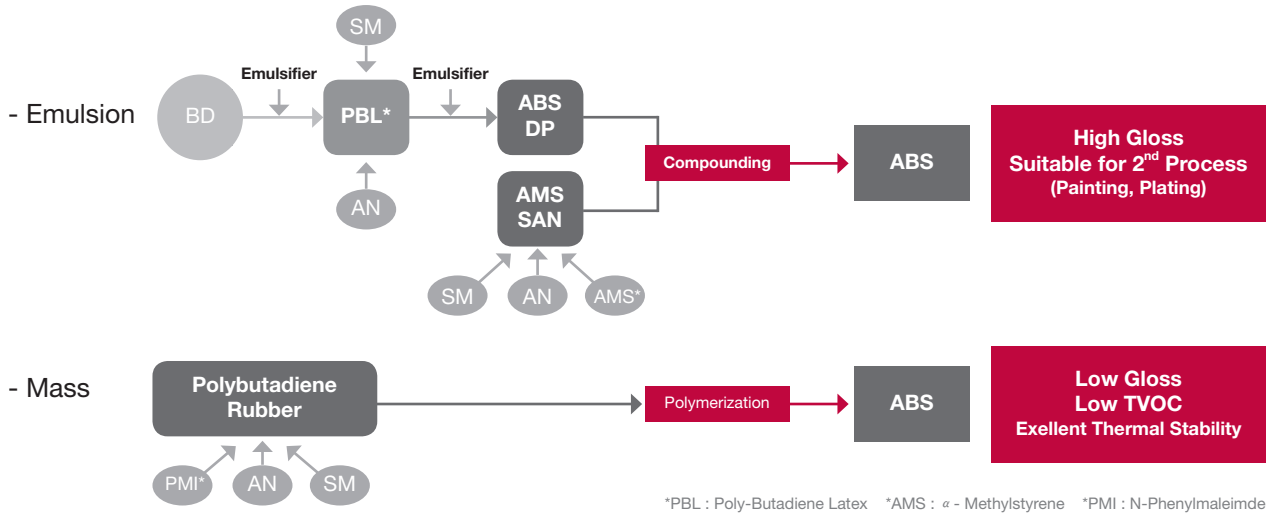
LG Chem's completely vertical integration is the key for stable supply and cost competitiveness.



ABS Type & Grade Selection

LG Chem has 2 types of ABS polymerization processes and offers various types of ABS grades from low gloss to high gloss according to customer's requirement.

• Polymerization Process



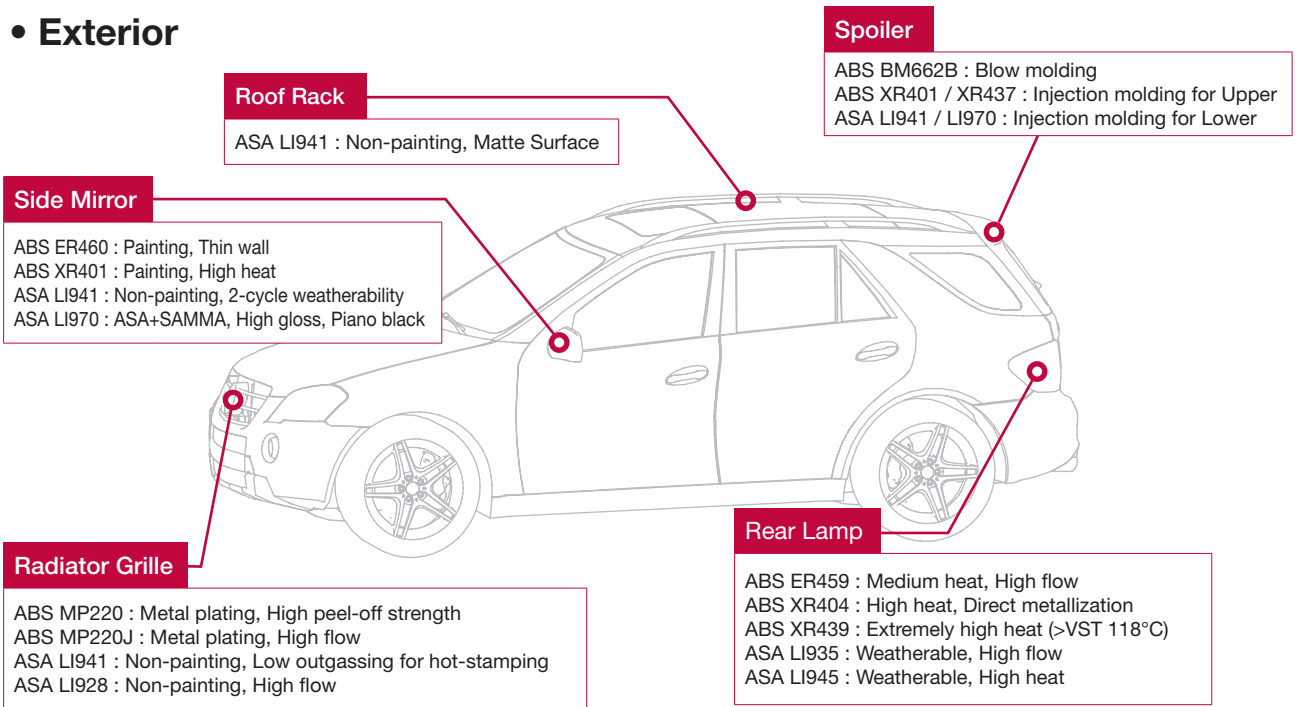
• Guide for Grade Selection

Interior	Door Trim Console	ER400 XR410	Low Gloss ABS - Low TVOC & good thermal stability	Low TVOC ABS			
		XR440 XR490	Low Gloss & Extremely High Heat ABS - Low TVOC & good thermal stability				
		XR409H XR474	Extremely High Heat ABS - Alternative to PC/ABS with higher VST*				
Exterior	Cluster Housing Center Stack	ER460 ER461 XR401 XR401B	High Flow Paintable ABS - Low outgassing & oligomer - Good chemical resistance	Paintable ABS			
		ER459 XR404	Low Outgassing High Heat ABS - High surface quality after molding				
	XR439	Extremely High Heat ABS for Rear Lamp - Alternative to PC/ABS with higher VST*	Metal Plating ABS				
	XR437	Extremely High Heat ABS with Good Surface					
	Outside Mirror	Rear Lamp	MP220 MP220J MP230	Metal Plating ABS - High peel-off strength - Great surface quality with fewer pit-marks			
			BM662B	Blow Molding ABS - High melt strength for 2 cavity blow molding	Blow Molding ABS		
			Front Grille	Tail Gate Garnish	LI928	High Flow & Low Outgassing ASA	ASA
					LI912 LI941	High Impact & High Heat ASA - 2-cycle weatherability	
					LI935 LI945	High Flow & High Heat ASA - Low outgassing & low haze	
	Spoiler	LI970	High Gloss ASA				
Pillar, Exterior Pillar							

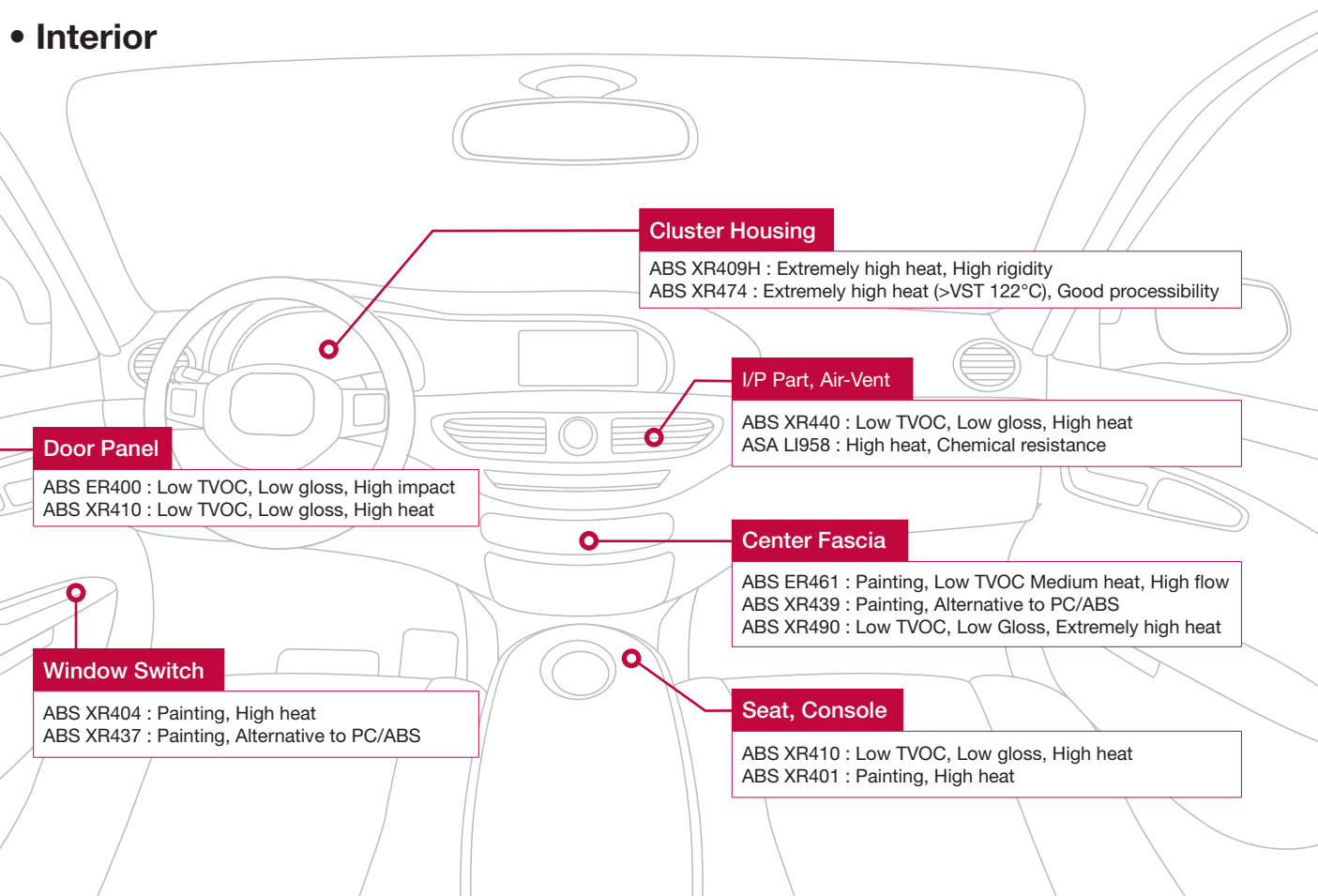
* VST : Vicat Softening Temperature

Application

• Exterior



• Interior



Low TVOC & Low Gloss ABS

ER400 / XR410 / XR440 / XR490

Low TVOC ABS is manufactured by mass polymerization using LG Chem’s own technology and it can be used for various types of automotive applications since it offers very low TVOC* as well as low gloss property.

*TVOC : Total Volatile Organic Compounds

Benefits

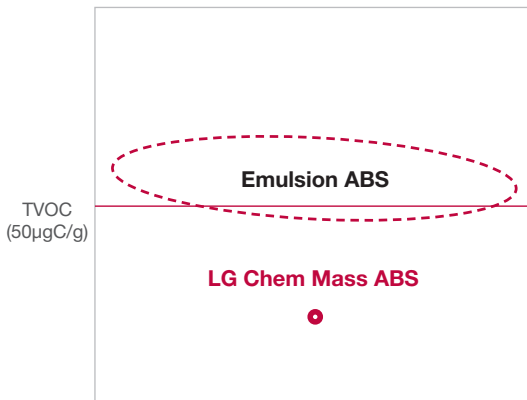
- Low TVOC
Meet all OEM’s requirements
- Excellent thermal stability
- Wide range of product portfolio
VST* from 101°C ~ 115°C
- Available for supply in pre-colored
Match to OEM’s specific colors

*VST : Vicat Softening Temperature

Application

- Interior
Door Trim
Glove Box
Console
- Exterior
Spoiler

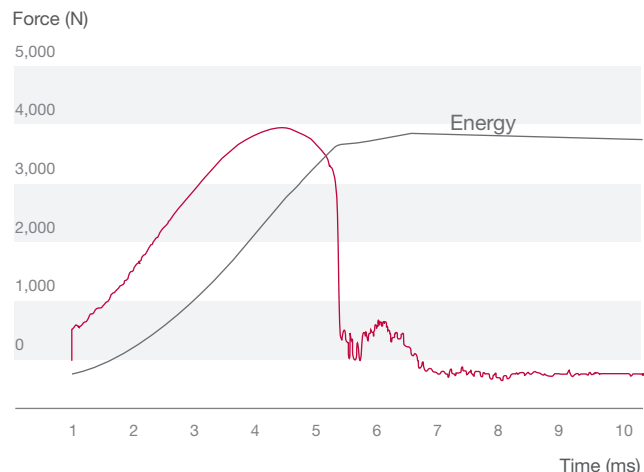
• Low TVOC



	OEM	VW	FORD	GM
Spec		PV 3341	FLTM BZ 157-01	GMW 15634
Temp (°C)		120°C	120°C	90°C
Time		5 hr	5 hr	0.5 hr
Spec		≤50µgC/g	≤90µgC/g	≤50µgC/g
Test Result	ER400	29	29	23
	XR410	25	25	19

• Multi Axial Impact

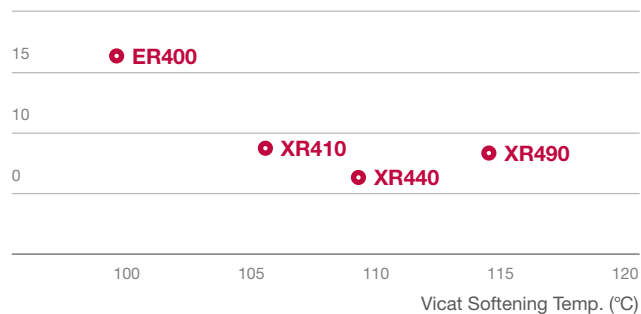
ASTM Method	ER400	XR410
Energy to max load (J)	35	30
Total Energy (J)	50	40



* Condition : ASTM Method

• Grade Line-up

ER400	Medium heat, Low gloss
XR410	High heat, Low gloss
XR440	High heat, Low gloss
XR490	Extremely high heat, Low gloss

Charpy IMP (kJ/m²)

• Properties

Properties	Test Method	Test Condition	Unit	Low TVOC & Low Gloss			
				ER400	XR410	XR440	XR490
Physical Properties							
Density	ISO 1183		g/cm ³	1.04	1.05	1.07	1.07
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	8	7	5	3
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties							
Tensile Strength @Yield	ISO 527	50mm/min	MPa	52	50	50	50
Tensile Modulus	ISO 527	1mm/min	MPa	2,350	2,300	2,300	2,300
Flexural Strength	ISO 178	2mm/min	MPa	79	70	75	75
Flexural Modulus	ISO 178	2mm/min	MPa	2,400	2,350	2,400	2,400
Izod Impact Strength (Notched)	ISO 180/1A	23°C	kJ/m ²	21	16	11	13
		-30°C	kJ/m ²	10	8	6	6
Charpy Impact Strength (Notched)	ISO 179/1eA	23°C	kJ/m ²	21	14	11	13
		-30°C	kJ/m ²	9	8	6	6
Rockwell Hardness	ISO 2039		-	112	110	114	113
Thermal Properties							
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa	°C	95	97	104	107
		0.45MPa	°C	98	100	108	110
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa	°C	85	87	93	97
		0.45MPa	°C	92	94	100	104
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	101	107	110	115
Processing Guide							
Cylinder Temperature			°C	230~260	230~260	230~270	230~270
Mold Temperature			°C	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4

Disclaimer 1) Typical values are only for material selection purpose, and variation within normal tolerances are for various colors.
2) Values given in the table should not be interpreted as material specification and it can not be used for part or tool design.

High Heat Paintable ABS

ER460 / ER461 / XR401 / XR401B

LG Chem offers an optimized ABS line-up with well-balanced properties and high performance in painting processes. High quality paintable ABS has been developed from accumulated experience by performing actual painting test at LG Chem's in-house painting facility in the R&D center.

Benefits

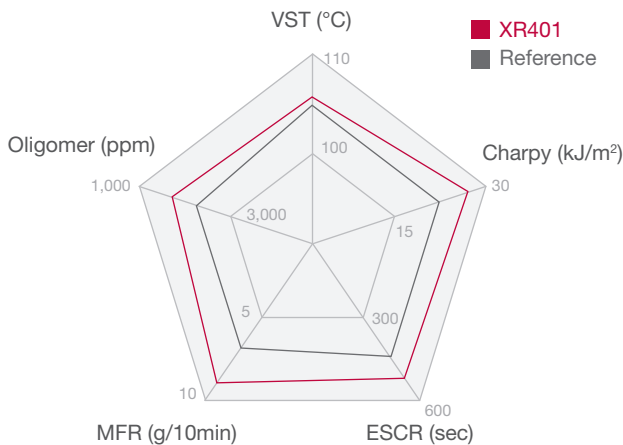
- Excellent paintability
- Great surface quality after molding
- Low outgassing during molding
- Good chemical resistance
- Low residual stress after molding
- Optimized rubber morphology

Application

- Interior
 - Gear Shift Cover
 - Window Switch Cover
- Exterior
 - Outside Mirror
 - Trunk Lid Garnish
 - Spoiler Upper

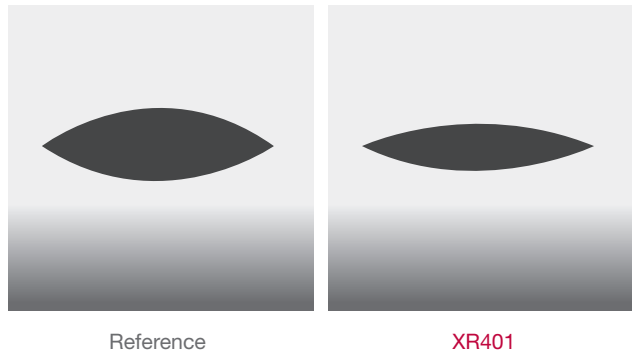
• Comparison of Properties

Well balanced properties



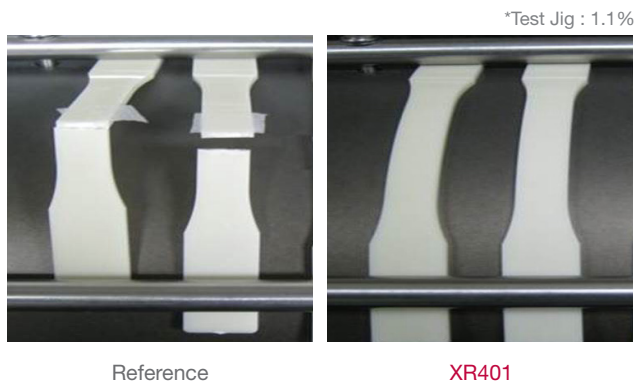
• Paintability

Low contact angle & good wetting property



• Chemical Resistance

No crack by painting thinner (600 sec)



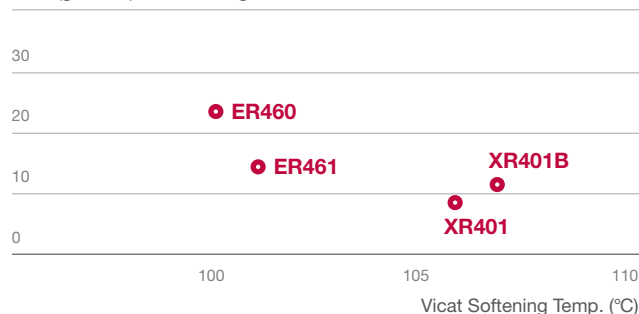
• LG Chem In-house Painting Shop



• Grade Line-up

ER460	Medium heat, High flow
ER461	Medium heat
XR401	High heat, High Impact
XR401B	High heat, High flow

MFR (g/10min) 220°C, 10kg



• Properties

Properties	Test Method	Test Condition	Unit	Medium Heat		High Heat	
				ER460	ER461	XR401	XR401B
Physical Properties							
Density	ISO 1183		g/cm ³	1.04	1.05	1.05	1.05
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	23	14	9	11
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties							
Tensile Strength @Yield	ISO 527	50mm/min	MPa	45	49	49	50
Tensile Modulus	ISO 527	1mm/min	MPa	2,200	2,300	2,300	2,350
Flexural Strength	ISO 178	2mm/min	MPa	65	73	75	79
Flexural Modulus	ISO 178	2mm/min	MPa	2,300	2,350	2,350	2,450
Izod Impact Strength	ISO 180/1A	23°C	kJ/m ²	22	23	23	15
(Notched)		-30°C					
Charpy Impact Strength	ISO 179/1eA	23°C	kJ/m ²	22	25	23	14
(Notched)		-30°C					
Rockwell Hardness	ISO 2039		-	112	112	112	113
Thermal Properties							
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa	°C	94	97	99	101
		0.45MPa	°C	98	101	103	105
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa	°C	82	85	88	90
		0.45MPa	°C	89	92	95	97
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	100	101	106	107
Processing Guide							
Cylinder Temperature			°C	220~250	230~260	230~260	230~260
Mold Temperature			°C	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4

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Extremely High Heat ABS

XR407E / XR409H / XR437 / XR474

Extremely high heat ABS is designated for use in automotive interior parts which need higher heat resistance, and it consists of PMI* which has higher Tg* than Polycarbonate to realize extremely high heat resistance and it can be widely used for painted parts without primer coating.

*PMI : N-Phenylmaleimide *Tg : Glass Transition Temperature

Benefits

Excellent thermal stability
Alternative to PC+ABS

Good processibility
Easy molding

Good paintability

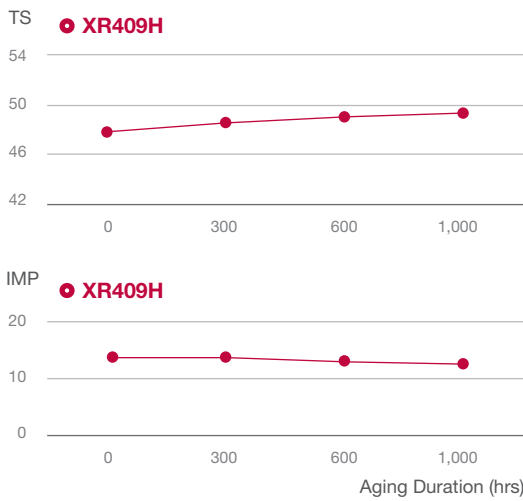
Application

Interior
Cluster Housing
I/P Components
Seat Belt Buckle

Exterior
Tail Gate Garnish

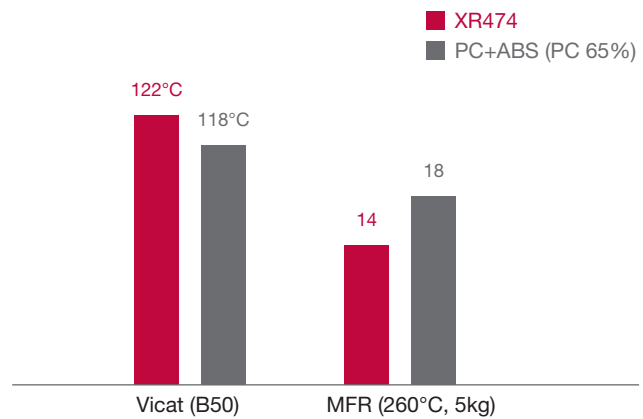
• XR409H Aging Test

Less property changes after aging test

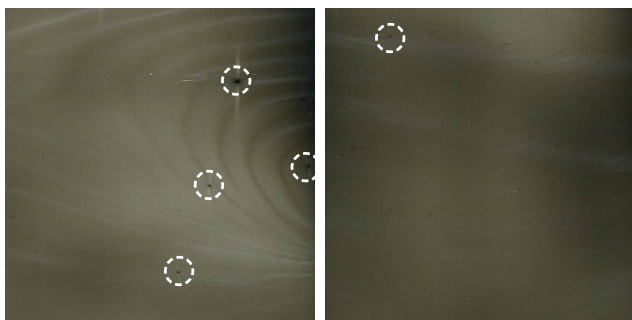


• XR474 Comparison with PC/ABS

High heat resistance



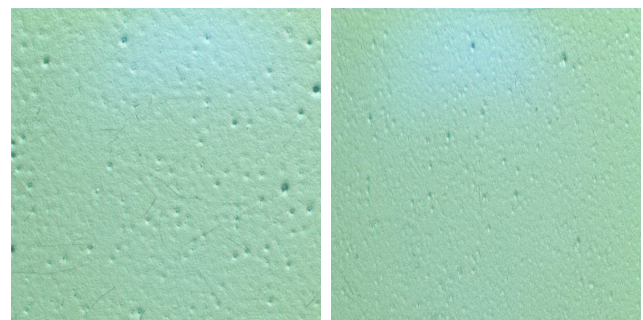
• XR437 Gel Content



Reference

XR437

• XR437 Surface Quality



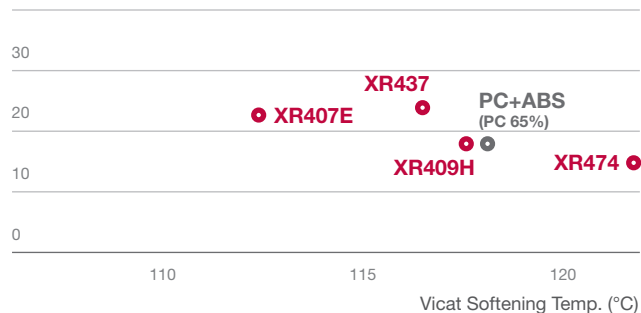
Reference

XR437

• Grade Line-up

XR407E	Super high heat, High impact
XR409H	Extremely high heat
XR437	Super high heat, Low surface pit-mark
XR474	Extremely high heat, Good processibility

MFR (g/10min) 220°C, 10kg



• Properties

Properties	Test Method	Test Condition	Unit	Extremely High Heat			
				XR407E	XR437	XR409H	XR474
Physical Properties							
Density	ISO 1183		g/cm ³	1.06	1.07	1.06	1.08
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	6.5	7	3	3
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties							
Tensile Strength @Yield	ISO 527	50mm/min	MPa	42	45	49	46
Tensile Modulus	ISO 527	1mm/min	MPa	2,300	2,500	2,350	2,750
Flexural Strength	ISO 178	2mm/min	MPa	67	76	77	74
Flexural Modulus	ISO 178	2mm/min	MPa	2,350	2,600	2,400	2,750
Izod Impact Strength	ISO 180/1A	23°C	kJ/m ²	17	15	16	12
(Notched)		-30°C	kJ/m ²	8	7	8	6
Charpy Impact Strength	ISO 179/1eA	23°C	kJ/m ²	16	14	15	12
(Notched)		-30°C	kJ/m ²	8	7	8	6
Rockwell Hardness	ISO 2039		-	112	110	114	114
Thermal Properties							
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa	°C	105	105	108	110
		0.45MPa	°C	108	108	111	113
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa	°C	95	95	99	102
		0.45MPa	°C	102	102	106	109
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	112	116	117	122
Processing Guide							
Cylinder Temperature			°C	230~260	230~260	230~260	230~260
Mold Temperature			°C	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4

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Metal Plating & Blow Molding ABS

MP220 / MP220J / MP230, BM662B

LG Chem is accumulating technology for how to design ABS materials to meet the requirements for post processing such as metal plating processes and also for blow molding. LG Chem has improved metal plating ABS by conducting metal plating at the same condition as our customers and obtained the acknowledgement & technology to design an optimized product line-up.

Benefits

High peel-off strength
Optimized rubber morphology
Good shaped anchors after etching

Gorgeous surface quality
Less pit-marks & gels

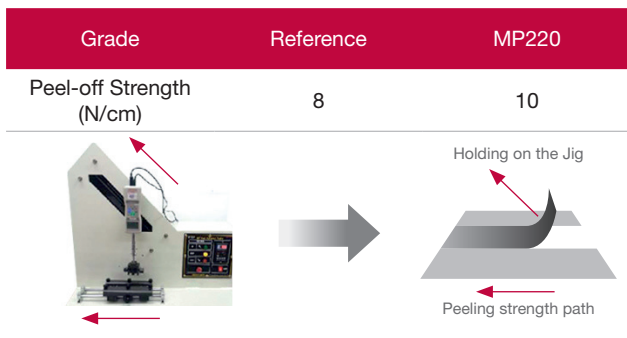
Low outgassing during molding
Lowered residual oligomers

Application

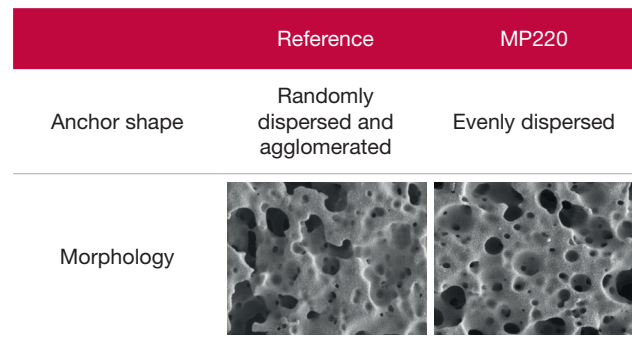
Interior
Inside Door Handle
Decorative Part

Exterior
Radiator Grille
Exterior Garnish
Logo & Emblem

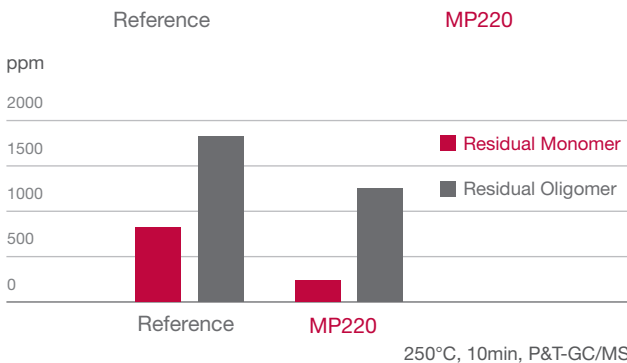
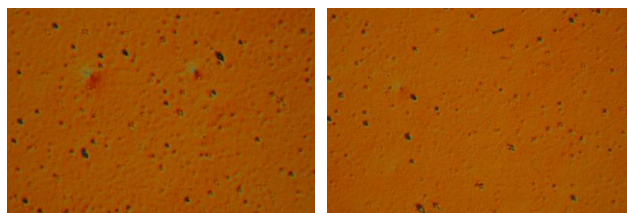
• Peel-off Strength



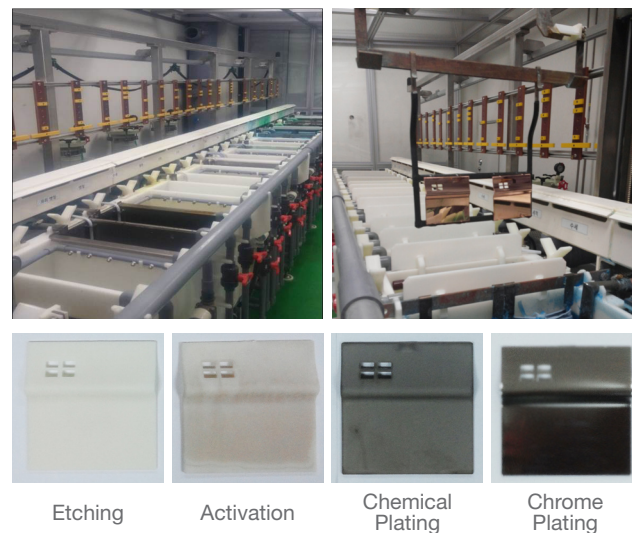
• Optimized Rubber Morphology



• Great Surface Quality



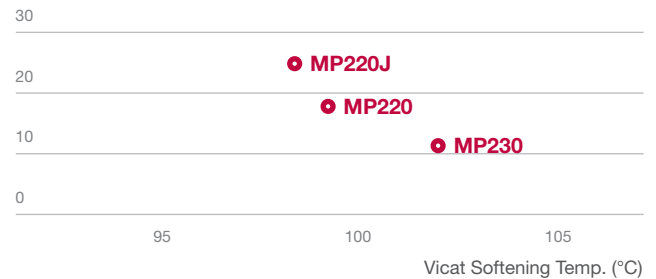
• LG Chem In-house Plating Facility



• Grade Line-up

MP220	High peel-off strength
MP220J	High flow, Low pit-mark
MP230	Medium heat, Plating
BM662B	Extremely high heat, High melt strength

MFR (g/10min) 220°C, 10kg



• Properties

Properties	Test Method	Test Condition	Unit	Metal Plating			Blow Molding
				MP220	MP220J	MP230	BM662B
Physical Properties							
Density	ISO 1183		g/cm ³	1.04	1.04	1.05	1.06
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	18	24	11	2
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties							
Tensile Strength @Yield	ISO 527	50mm/min	MPa	44	43	45	45
Tensile Modulus	ISO 527	1mm/min	MPa	2,200	2,150	2,350	1,900
Flexural Strength	ISO 178	2mm/min	MPa	65	64	67	72
Flexural Modulus	ISO 178	2mm/min	MPa	2,300	2,250	2,300	1,950
Izod Impact Strength (Notched)	ISO 180/1A	23°C -30°C	kJ/m ² kJ/m ²	27 14	24 12	30 15	16 7
Charpy Impact Strength (Notched)	ISO 179/1eA	23°C -30°C	kJ/m ² kJ/m ²	27 14	24 11	30 15	15 7
Rockwell Hardness	ISO 2039		-	110	109	105	100
Thermal Properties							
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa 0.45MPa	°C °C	94 98	93 97	97 100	103 106
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa 0.45MPa	°C °C	83 89	82 88	87 93	93 100
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	99	98	102	110
Processing Guide							
Cylinder Temperature			°C	220~250	220~250	230~260	200~210
Mold Temperature			°C	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4

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ABS & ASA for Lighting

ER459 / XR404 / XR439, LI935 / LI945

LG Chem offer various types of ABS grades for lamp application from high flow ABS for the complicate-shaped lamps to extremely high heat ABS as an alternative to PC+ABS. LG Chem also supply ASA grades for the customers who want higher weatherability materials for exterior lamp application.

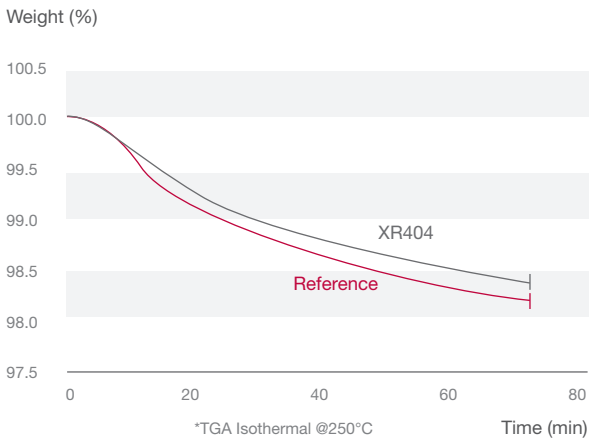
Benefits

- Wide product line-up
From high flow to extremely high heat
Alternative to PC+ABS
- Optimized welding properties
High viscoelasticity for hot plate welding
Less dust during vibration welding
- Excellent surface quality
Low emission & outgassing

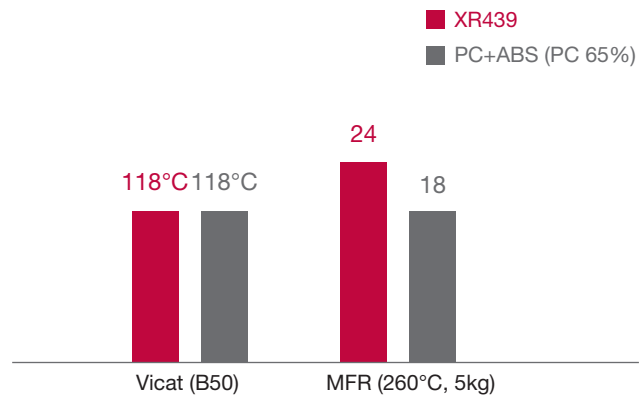
Application

- Interior
Room Lamp
Top-mount Lamp
- Exterior
Rear Lamp

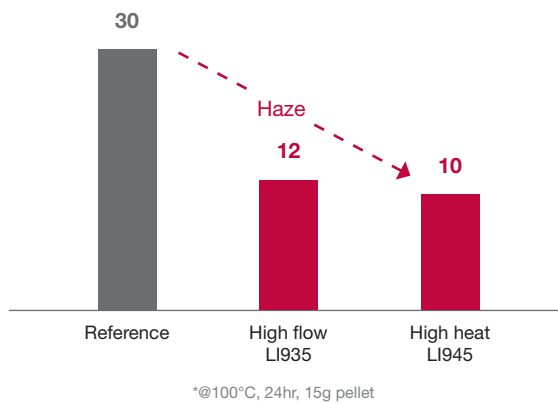
• Low outgassing



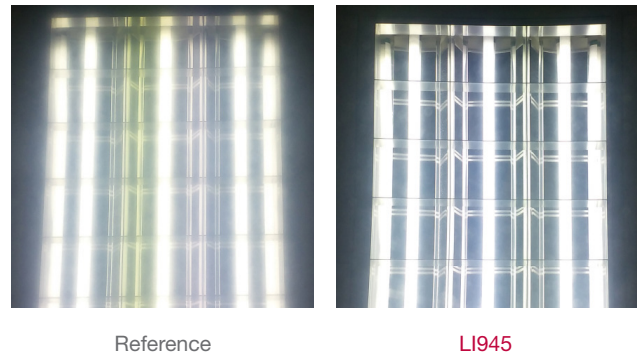
• XR439 Comparison with PC+ABS



• Haze after fogging test



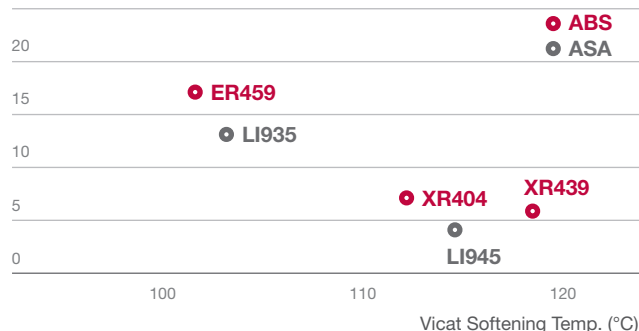
• Surface haze after metallization



• Grade Line-up

ER459	Medium heat, High flow
XR404	High heat, Low outgassing
XR439	Extremely high heat
LI935	High flow, Good weatherability
LI945	High heat, Good weatherability

MFR (g/10min) 220°C, 10kg



• Properties

Properties	Test Method	Test Condition	Unit	Medium / High Heat ABS			High Heat ASA	
				ER459	XR404	XR439	LI935	LI945
Physical Properties								
Density	ISO 1183		g/cm ³	1.05	1.05	1.06	1.08	1.09
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	17	7	6	13	4
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties								
Tensile Strength @Yield	ISO 527	50mm/min	MPa	50	54	46	53	60
Tensile Modulus	ISO 527	1mm/min	MPa	2,400	2,450	2,400	2,100	2,750
Flexural Strength	ISO 178	2mm/min	MPa	78	82	76	76	95
Flexural Modulus	ISO 178	2mm/min	MPa	2,600	2,550	2,400	2,400	2,900
Izod Impact Strength (Notched)	ISO 180/1A	23°C	kJ/m ²	23	13	13	8	6
		-30°C	kJ/m ²	9	6	6	3	3
Charpy Impact Strength (Notched)	ISO 179/1eA	23°C	kJ/m ²	24	12	13	8	6
		-30°C	kJ/m ²	9	6	6	3	3
Rockwell Hardness	ISO 2039		-	110	114	108	112	115
Thermal Properties								
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa	°C	96	104	108	96	103
		0.45MPa	°C	100	106	110	98	105
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa	°C	84	93	98	85	93
		0.45MPa	°C	92	101	105	93	100
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	102	112	118	102	114
Processing Guide								
Cylinder Temperature			°C	220~250	230~260	230~260	230~250	230~270
Mold Temperature			°C	40~60	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4	3~4

Disclaimer 1) Typical values are only for material selection purpose, and variation within normal tolerances are for various colors.
2) Values given in the table should not be interpreted as material specification and it can not be used for part or tool design.

High Performance ASA

LI912 / LI928 / LI941 / LI970

LG Chem is one of major suppliers and increasing manufacturing capacity to serve automotive customers with supply consistence. Since LG Chem has in-house raw material sourcing, it is possible to provide stable quality of products as well as consistent supply.

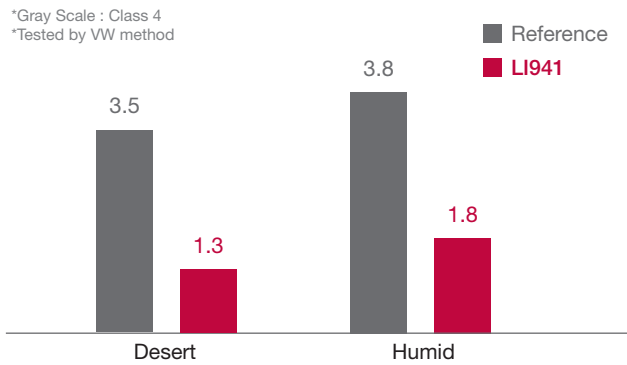
Benefits

- Excellent weatherability
Meets 2-cycle weatherability
- Various product line-up
High flow, High heat & High gloss
- Super high gloss for exterior
Piano black, Scratch resistance
- Low outgassing & mold deposit
Optimized for hot stamping process

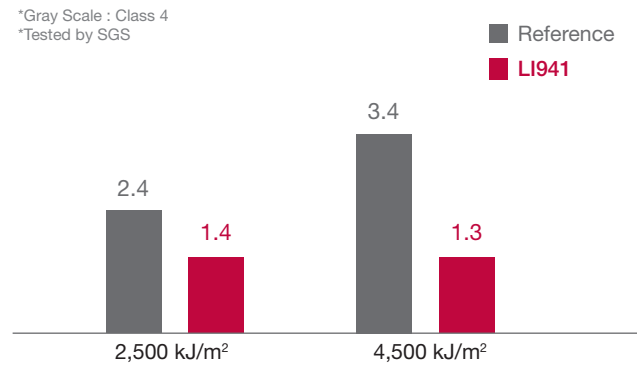
Application

- Interior
Air-vent Grille
- Exterior
Radiator Grille
Outside Mirror
Roof Rack Cover
Exterior Pillar

• VW 2-Cycle Weatherability (ΔE)



• GM Weatherability (ΔE)

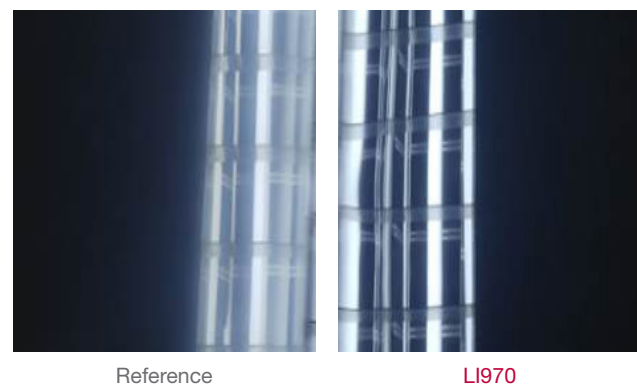


• Scratch Resistance



Gloss	Before	After	Retention	ΔL
Reference	93	83	89.2 %	-0.15
LI970	98	90	91.8 %	-0.01

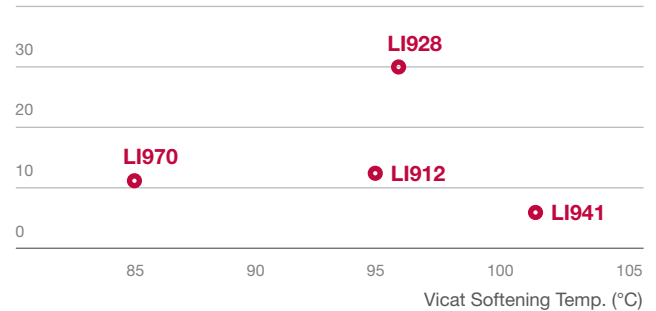
• Surface Haze



• Grade Line-up

LI912	High impact
LI928	High flow, Good surface quality
LI941	High heat, Excellent weatherability
LI970	Super high gloss, Low haze

MFR (g/10min) 220°C, 10kg



• Properties

Properties	Test Method	Test Condition	Unit	ASA			Super Gloss
				LI912	LI928	LI941	LI970
Physical Properties							
Density	ISO 1183		g/cm ³	1.07	1.08	1.08	1.11
Melt Flow Rate	ISO 1133	220°C/10Kg	g/10min	12	30	6.5	11
Mold Shrinkage	ISO 294-4		%	0.4~0.7	0.4~0.7	0.4~0.7	0.4~0.7
Mechanical Properties							
Tensile Strength @Yield	ISO 527	50mm/min	MPa	45	45	48	43
Tensile Modulus	ISO 527	1mm/min	MPa	2,000	2,300	2,200	1,800
Flexural Strength	ISO 178	2mm/min	MPa	70	76	75	65
Flexural Modulus	ISO 178	2mm/min	MPa	2,100	2,400	2,400	1,800
Izod Impact Strength (Notched)	ISO 180/1A	23°C -30°C	kJ/m ² kJ/m ²	13 3	9 4	12 5	10 2
Charpy Impact Strength (Notched)	ISO 179/1eA	23°C -30°C	kJ/m ² kJ/m ²	13 3	9 4	11 5	10 2
Rockwell Hardness	ISO 2039		-	103	104	104	102
Thermal Properties							
Heat Deflection Temp. (Annealed @80°C, 4 hrs)	ISO 75/Af	1.8MPa 0.45MPa	°C °C	93 93	94 97	98 100	89 92
Heat Deflection Temp. (Unannealed)	ISO 75/Af	1.8MPa 0.45MPa	°C °C	79 88	80 89	88 95	75 83
Vicat Softening Temp.	ISO 306	50N, 50°C/hr	°C	95	96	102	85
Processing Guide							
Cylinder Temperature			°C	220~250	220~250	230~260	200~230
Mold Temperature			°C	40~60	40~60	40~60	40~60
Pre-drying		80°C	hrs	3~4	3~4	3~4	3~4

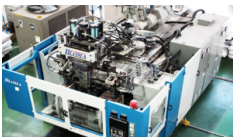
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Tech Center

LG Chem provides excellent technical service for customers through its Tech Center, which is an internationally accredited facility.

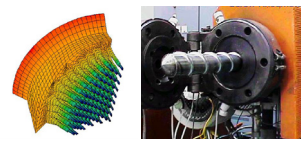
• Injection Molding

- Optimization of mold design
- Flow analysis and troubleshooting



• Extrusion

- Screw / Die design
- Process analysis by CFD*

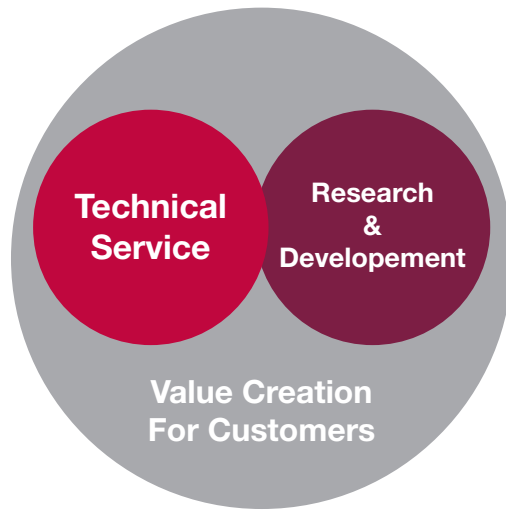


*CFD : Computational Fluid Dynamics

• Material Properties Evaluation

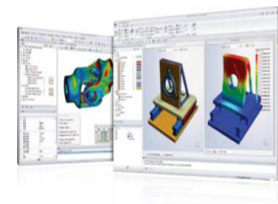
- Material database
- Long-term material properties
- Reliability evaluation
- KOLAS* acquisition

*Korea Laboratory Accreditation Scheme



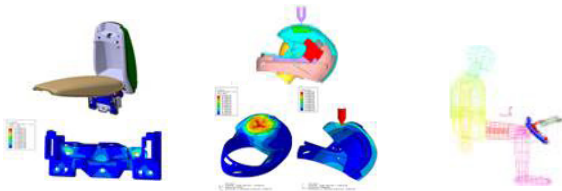
• Product Design

- Structural analysis
- Thermal analysis
- Design of plastic parts



LG Chem's advanced analysis techniques and well-equipped devices enable full technical support for customers.

• Structural Analysis / Impact & Crash Design

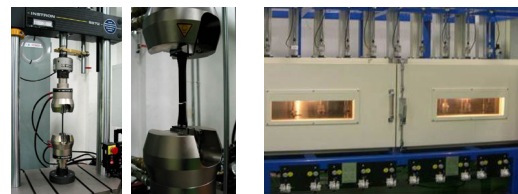


Arm rest

Motorcycle helmet

Safety

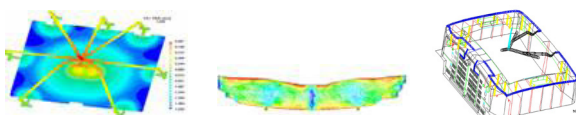
• Material Properties



Fatigue property

Creep resistance

• Injection Molding Analysis

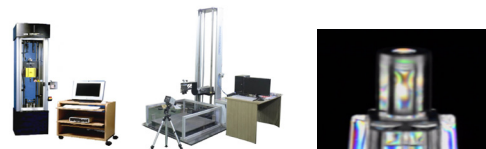


Gate & runner optimization

Material Orientation

GAIM

• Product Reliability



Falling weight impact tester

Residual stress measurement

Color Design Center

With its 20 years of experience, the LG Chem Color Design Center's color matching competence can save customers valuable time. Through its Central Color Data System, identical color is available regardless of manufacturing location.

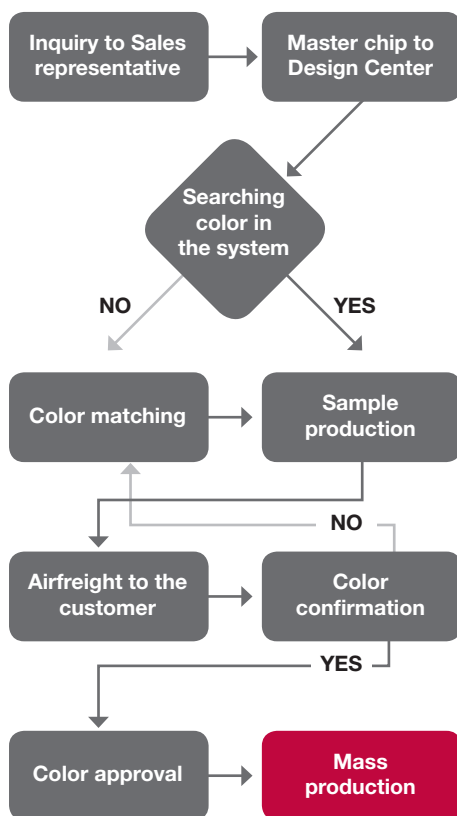
Color Design Center

Speed	Average of 5.6 days for color development
Accuracy	Less than 7% of re-coloring until approval
Capacity	Annually 6,300 color-matching



Color Development Process

Global On-line Order System : www.lgcolor.com



1 Weighing colorant



2 Mixing colorant



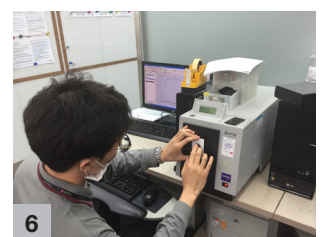
3 Sample production



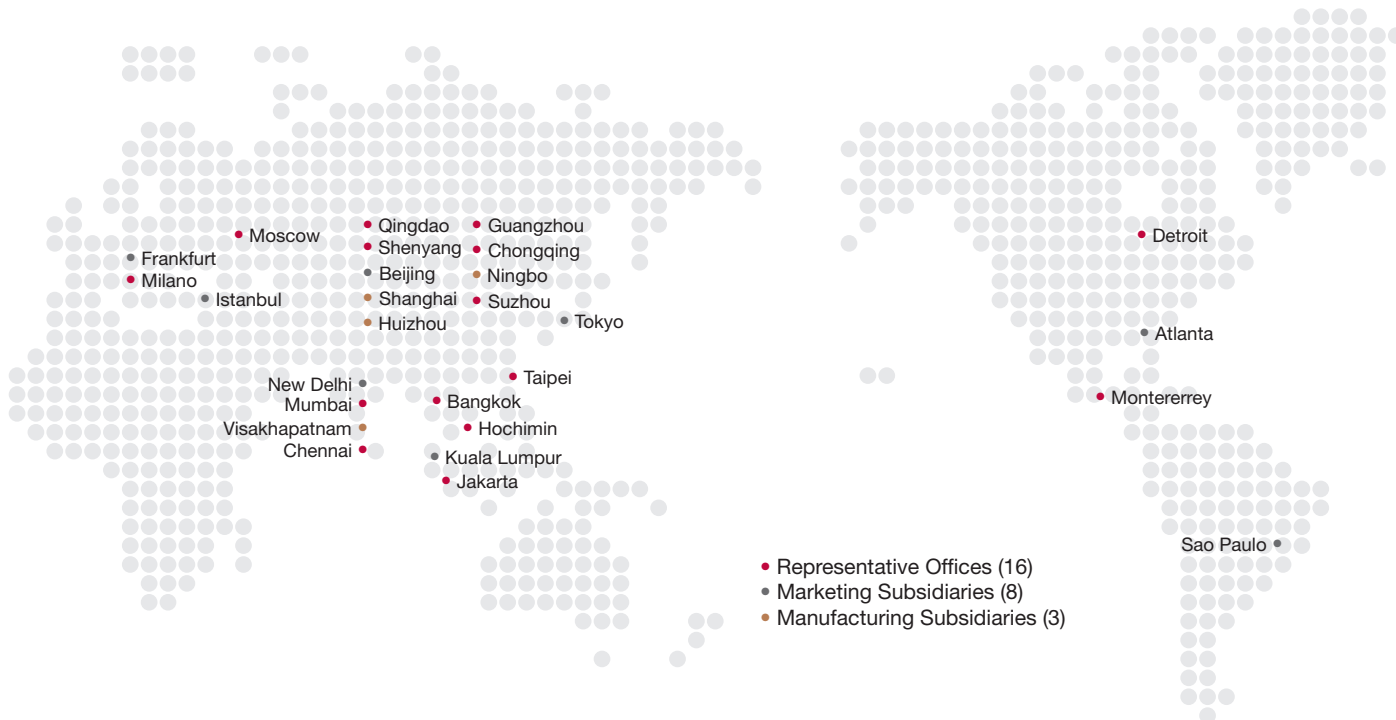
4 Preparing color chips



5 Visual inspection



6 Approval by spectrophotometer



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