Mitsui Chemicals

The Transparent Resin to Make It Possible.

APEL™

Mitsui Chemicals

Mitsui Chemicals, Inc.

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Jun.2020

Have More Freedom in Optical Design
Have Clearer View of the Futu re.

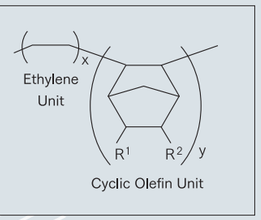
APEL™, cyclic olefin Copolymer of Mitsui Chemicals product, is amorphous and transparent resin with excellent optical properties.

APEL™ has been contributing to “smaller and lighter lens design”, with its highest refractive index and lowest birefringence among amorphous polyolefins, and enables replacement of conventional lens materials such as glass or PMMA.
APEL™ maintains its performance in the severe environment such as high humidity, high temperature, hence it is suitably adopted for new applications such as lenses for Automotive Camera and Head Mounted Display (HMD).
In addition, APEL™’s excellence in moisture barrier, electric properties, and chemical resistance has been perfectly fit for food and medical packaging.

APEL™ stays innovative and is fitting to various advanced market needs.
“Have Freedom in Optical Design, Have Clearer View of the Future” is the key message of APEL™ to the industry and society.

Cyclic Olefin Copolymer

APEL™ is Cyclic Olefin Copolymer (COC) produced by copolymerization of ethylene and cyclic olefins. APEL™ has the highest refractive index and lowest birefringence among amorphous polyolefins.



Cyclic Olefin Unit

[Characteristics of APEL™]

- Dimensional Stability
- High Refractive Index
- Low Birefringence
- Electrical Characteris-tics
- High Moisture Resistance
- High Transparency
- High Heat Resistance
- Easy Moldability

Enhances Optical Design Freedom
Multi-functional, Transparent Resin.

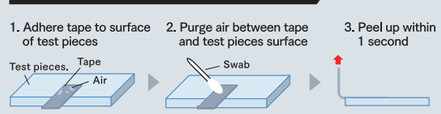
APEL™ realizes clear image without bleeding and distortion in optical lens application.
The contribution derives from APEL™'s excellence in high refractive index, low birefringence that enables engineers to make more various optical design.

Application sample **Head Mounted Display**

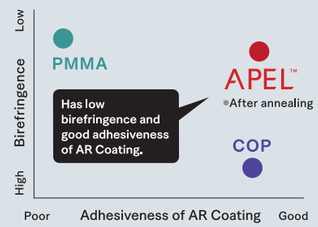
Achieves distortion-free vision, even up close distance.

- Enables image formation with little blurring/ distortion right to the edge.
- Achieves thinner, or lighter lenses.
- Good adhesiveness of AR coating and resists peeling.

Tape Test for AR Coating Adhesive

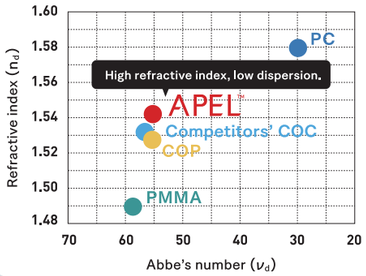


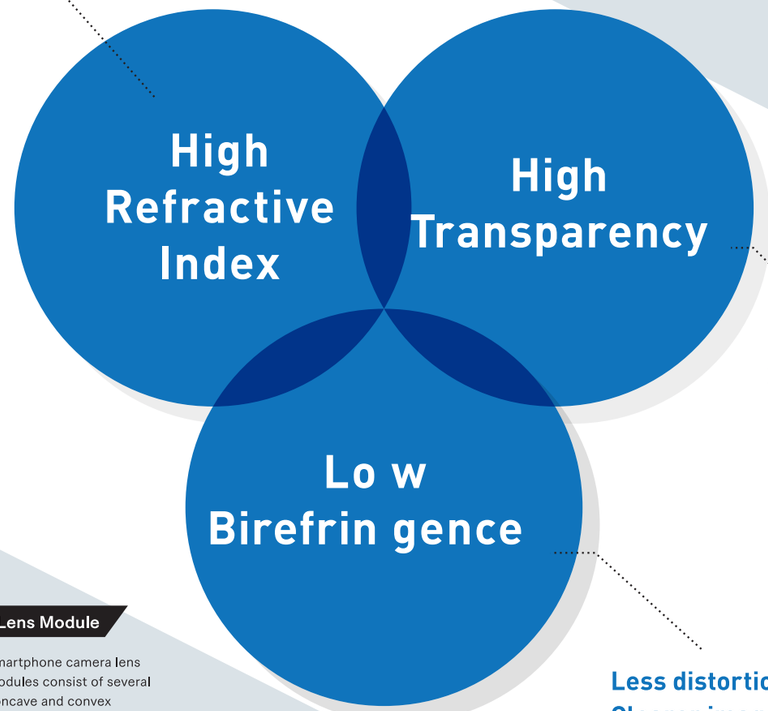
Birefringence and Adhesiveness of AR Coating



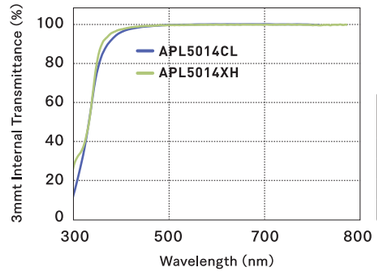
Excellent balance of low birefringence and good adhesiveness of AR Coating.

High refractive index, superior aberration correction. Flexible lens design.



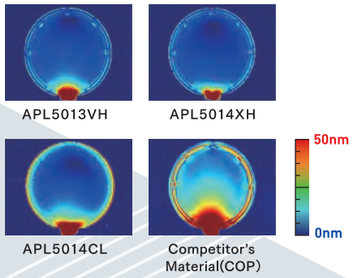


Excellent Transparency.



Wavelength (nm)	Internal Transmittance [3mmt](%)	
	APL5014CL	APL5014XH
800	>99	>99
600	>99	>99
400	98	98
350	83	88

Less distortion, Clearer image.

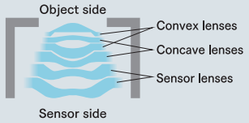


Application Sample **Smartphone**

Forms a clear image from small lenses.

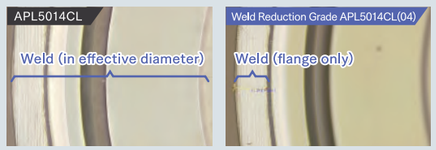
- Improves image quality.
- Controls lens curvature, Enhances design freedom.
- Contributes to thinner lens units.
- Excellent dimensional stability with little moisture adsorption.

Example of Smartphone Camera Lens Module



Smartphone camera lens modules consist of several concave and convex lenses. APEL™ is mainly used for convex and sensor-side lenses.

Weld reduction

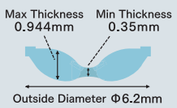


APEL™ has weld reduction grades for lens shape which is easy to find weld.

Molding Conditions

Mold Temperature	:Tg-5℃
Injection Speed	:50mm/s
Cylinder Temperature	:285℃

Lens Shape



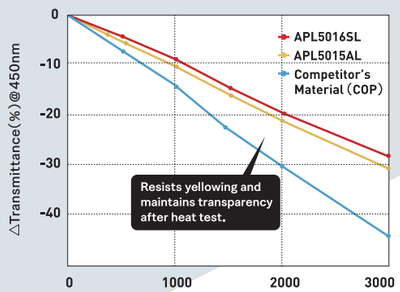
Uneven Thickness Rate
2.7

High Heat Resistance

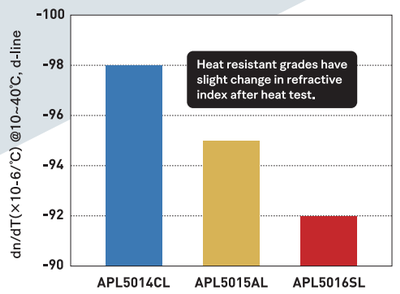
Resists yellowing, and deformation even at high temperature. Achieve highly sensitive, and precise lenses.

Heat Resistance 125℃ Test Results

(Change in Transmittance)



Change in Refractive Index



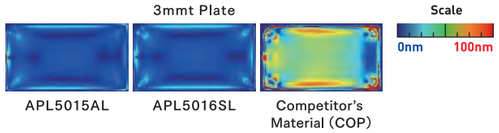
Application Sample **Automotive Camera Lenses**

(Sensing camera, view camera, drive recorder, back view monitor, head-up display, etc.)

Reliable lenses perform well on autonomous camera.

- Retains transparency with little yellowing under actual environment.
- Resists lens distortion even at high temperature.

Test Results of Automotive grades



Achieves clear images with little distortion.

Application Sample **PTP Packaging Sheets, Prefilled Syringes, Pill Bottles, Inspection Containers**

Medical packages that is not allowed to degrade under long-term storage condition.

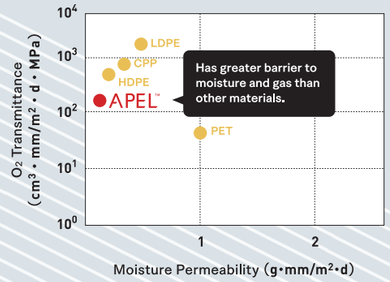
- Little effect on drugs due to low elution.
- Has low moisture permeability coefficient.
- Provides good barrier performance.

Type of Test	Parameter	Standard ※1	APL6509T (Low Tg grade)	APL6015T (High Tg grade)
Materials Test (JP compliant)	Residue on Ignition	0.10% or less※1	○ +	○ +
	Heavy Metals	Lower concentration than control solution※1	○ +	○ +
	Pb	Below absorbance of standard solution※1	○ +	○ +
	Cd	Below absorbance of standard solution※1	○ +	○ +
Dissolution Test (JP compliant)	Foaming test	Disappears within 3 min.※1	○ +	○ +
	pH	Difference of 1.5 or less to blank solution※1	○ +	○ +
	$KMnO_4$ reducing substance※1	Difference of 1.0 ml or less to blank solution※1	○ +	○ +
	UV absorption spectrum	220～241nm:0.08 or less※1	○ +	○ +
		241～350nm:0.05 or less※1	○ +	○ +
	Residue on evaporation	1.0mg or less※1	○ +	○ +

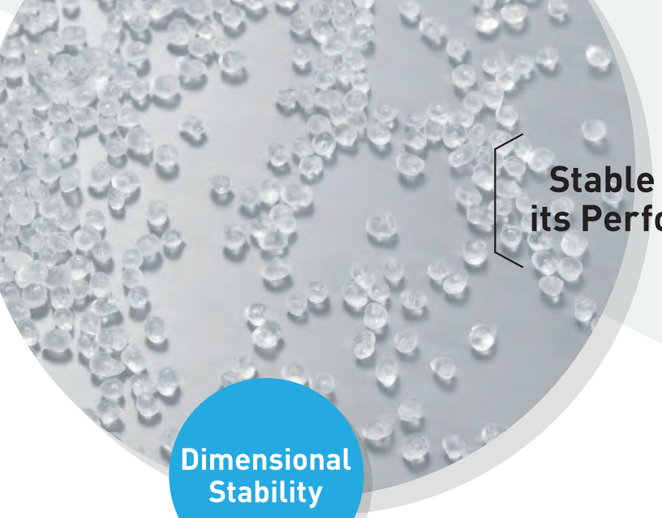
○=Compliant or negative results obtained in the performed tests.
※1 Standards: polyethylene or polypropylene containers for aqueous injections (Japan pharmacopeia 13th edition)

High Moisture Resistance

Transparent Resin with Lowest Transparency Coefficient. Prevents Transmittance of Moisture.

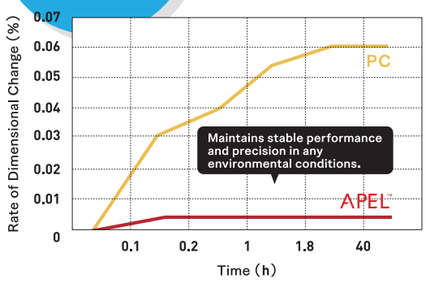


The lowest moisture permeability of APEL™ among transparent resins is perfectly fit for moisture-proof containers and PTP films, and provides better barrier performance than PE, PP.



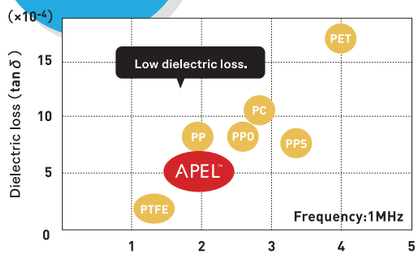
Stable Material that Demonstrates its Performance in Any Environment.

Dimensional Stability



APEL™ has lower water absorption and better dimensional stability than PC.

Electrical Characteristics



APEL™ has characteristics of low dielectric loss and low dielectric constant.

Chemical Resistance

Resistant to acid and alkaline polar solvents.

Type of Chemical	APEL™	PP	PC	PET	PVC	PMMA	PEN
Acid	○	○	○	△	○	△	△
Alkali	○	○	×	×	△	△	×
Inorganic salt	○	○	○	○	○	○	○
Alcohol	○	○	×	△	○	×	△
Ketone	○	○	×	○	×	×	○
Ester	○	○	×	○	×	×	○
Chlorinated solvent	×	×	×	○	×	×	○
Aromatic solvent	×	△	×	○	×	×	○
Gasoline	×	△	×	○	×	○	○
Grease	×	△	×	○	△	△	○
Salad oil	×	○	○	○	○	△	○

△ : Caution × : Not good

APEL™ is highly resistant to acids, alkalis, and polar solvents, which is necessary for bioanalysis cell and medical packaging.

Solvent		Immersion Time 2hr	Immersion Time 24hr
Halogen hydrocarbon	1,2-Dichloroethylene	○	×
	Chloroform	××	–
	Trichlorethylene	××	–
	Carbon tetrachloride	××	–
	Perchloroethylene	×	–
Aliphatic hydrocarbon	Cyclohexene	×	–
	Cyclohexane	×	–
	n-Hexane	△	△
	Methylcyclohexane	×	–
	n-Heptane	△	△
	Mineral spirits	○	△
	Kerosene	○	△
Alcohol	Methanol	○	○
	Isopropanol	○	○
	Propylene glycol	○	○
	Benzyl alcohol	○	○
Ether	Methyl cellosolve	○	○
	Ethyl cellosolve	○	○
	Isopropyl ether	○	○
	1-Methoxy-2-butanol	○	○
	3-Methoxy-1-butanol	○	○
	Carbitol	○	○
Ketone	Methyl ethyl ketone	○	○
	Cyclohexanone	○	○
	Diacetone alcohol	○	○
	Isophorone	○	○
	Diisobutyl ketone	○	○
Ester	Methyl acetate	○	○
	Ethyl acetate	○	○
	Isobutyl acetate	○	○
	n-Butyl acetate	○	○
	sec-Butyl acetate	○	○
Aromatic	Benzene	×	–
	Toluene	×	–
	Xylene	×	–

(Code) ×× : Dissolves × : Dissolves partially △ : Swells ○ : No change

Test method: Cut out a 10mm square test piece from a 2mm thick square plate and immerse.

APEL™ Molding technical information for optical grades

*Describes points to consider concerning injection molding for optical grades.
As regards technical information of non-optical information is separately available upon a request.

1. Injection molding machine

1-1 Selection criteria for molding machines

○ The molding machine size should be adequate to the product volume. A bigger machine tends to lengthen the retention time of molten resin, often resulting in carbonation and/or yellow discoloration of the resin.

1-2 Screw design

○ A lower compression ratio around 2 is preferable, but molding is possible with about 2.5.
○ A full flight screw is recommended to use. It is preferable that the screw head incorporates a backflow prevention mechanism (a check valve).
○ High shear stress at plasticization may cause discoloration and/or black spots on APEL™.

1-3 Material of screw and cylinder

○ Coating of non-attachment properties to molten resin is recommended to use.
○ Effective coating include Cr plating as well as TiN, TiCN, TiC or W2C.

1-4 Nozzle

○ Open type or shut-off type is useable.

2. Mold Design

2-1 Basic Structure

○ Mold should be designed with APEL™ mold shrinkage of 0.6%, followed by a fine adjustment. A drift angle 2˚ or greater should be applied, taking the mold shrinkage into consideration.
○ APEL™ is a resin that has a high rigidity and is low in extensibility, thus is not suitable for an undercut shape which may cause cracks on mold goods.

2-2 Material of mold

○ Choose a material that is suitable for thorough mirror polishing and on the mold surface of which gases resulting from molding processes are unlikely to produce tarnish.

2-3 Gates, Runners and Sprue

○ Shapes similar to those used for conventional resins are applicable.
○ A pinpoint gate is effective for reducing internal stress in the gate of mold goods and also for eliminating the need of finishing process on the gate of mold goods.
○ A cold runner is more recommendable than a hot runner as a hot runner may cause black spots, yellowing and/or discoloration due to retention of resin.
○ Round type is the most suitable for runner.

2-4 Degassing

○ Degassing can be done through the parting lines, but when tarnish that is likely on account of gases is recognized it will be necessary to make an approximately 0.02 mm deep ditch for degassing.

2-5 Stringiness prevention

○ A high nozzle temperature can cause stringiness. A sprue having a stringiness preventing function will be effective.

3. Method of molding

3-1 Pre-drying

○ Pre-drying of the pellets is recommended.
○ APEL™, being a low hygroscopic resin, can be molded without pre-drying. However, a slight amount of water on the surface of a pellet may affect the appearance of molded goods. Moreover, dissolved air in such a pellet may cause yellow discoloration and when gasified it can cause poor transcription. Accordingly, pre-drying is effective whenever a high standard appearance is required.
○ Pre-drying a pellet is also effective in making smooth plasticization at molding.

Pre-drying conditions

Grade	Temperature (℃)	Time (hrs)
APL5014CL	110~120	6~12
APL5015AL	120	6~12
APL5016SL	120	6~12
APL5013VH	100	6~12
APL5014XH	120	6~12

3-2 Material Purging

○ When another material has been used, it is necessary to perform a purge with a commercially available cleaning pellet that is suitable for the molding temperature or polypropylene (homo-type) for 3 to 5 kgs or so before replacing to APEL™. This should be followed by a purge with APEL™ for 2 to 3 kgs. Check for muddy or tarnished surface on the molded goods.
○ If purging is still insufficient, it will be effective to use glass-fiber reinforced polypropylene as a purging material or to perform a cleaning with the screw removed.

3-3 Molding Conditions

[Cylinder Temperature]

○ The heat resistance of APEL™ differs according to grade, thus a cylinder temperature should be set in line with the following formula:
Cylinder temp. = APEL™ softening temp. + 100 to 130˚C
○ Except for the space under the hopper, the temperature of each cylinder block should be set practically flat.
○ When temperature setting is too low and noise is heard in the cylinder, increase the cylinder temperature. Increasing the temperature in the hopper side (before screw compression section) will be especially effective.

[Mold Temperature]

○ Mold transfer performance of APEL™ tends to be affected by mold temperature. The closer the mold temperature (measured value) is to the glass transition temperature (Tg) of the resin, the better the mold transfer is. Adjust it to the Tg of the resin. (Recommended Temperature: Tg-15 ~ Tg-3˚C (Measured value)

[Back Pressure]

○ 3~5 Mpa(30~50kgf/cm²), maximum 10 MPa(100kgf/cm²)
○ Too much backpressure may lead to yellowing, discoloration and/or gel generation.

[Injection Pressure]

○ Holding pressure (secondary pressure) should be set as low as possible in the range of 50 to 150 MPa.
○ Because of high solidification speed of amorphous materials such as APEL™, too high holding pressure will cause cracks and/or leave deformation around the gate.

[Injection Speed]

○ Increasing injection speed is effective in improving mold transcription, thus improving the appearance of goods.

[Suck Back]

○ Suck-back should be avoided as much as possible.
○ Although suck-back is effective in preventing stringiness, by dragging air in from the nozzle it may cause bubbles and/or yellowing. If suck-back is unavoidable, make the suck-back volume minimal.

[Screw Speed]

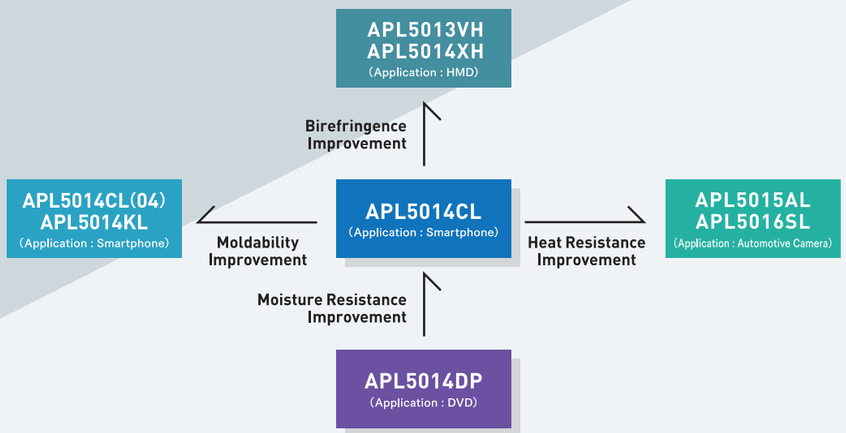
○ If the screw speed is too high, it may drag air in and cause bubbles.

3-4 Pausing or termination of molding

○ Stop the molding machine to interrupt the operation for a short time.
○ If an interruption extends over 1 hour, lower the cylinder temperature to 170˚C to avoid burning the resin inside the cylinder.
○ To terminate the operation, switch off the heater after the cylinder internal area is replaced with polypropylene.

DATA 〔 Product Data 〕

Optical Grade Line-Up



Product Line-Up

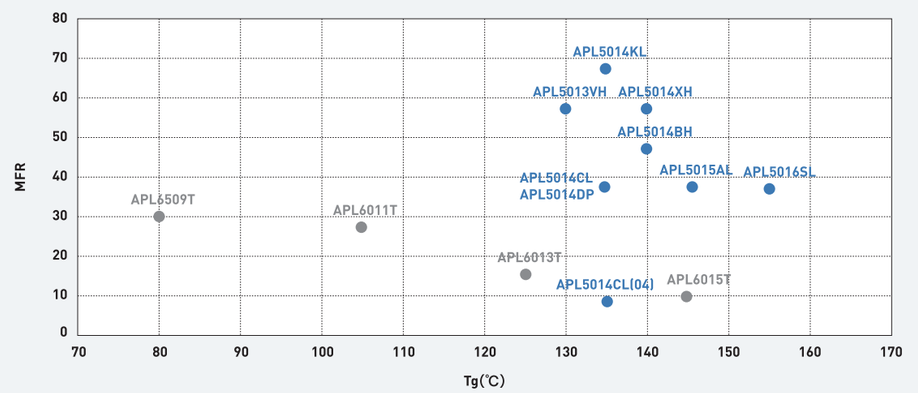


Table of Product Properties

Test Item		Measurement method	Unit	Optical grade									Non-optical grade				Competitor's Material		
				APL5014CL	APL5014CL(04)	APL5014KL	APL5015AL	APL5016SL	APL5013VH	APL5014XH	APL5014BH	APL5014DP	APL6509T	APL6011T	APL6013T	APL6015T	PC	PMMA	PS
TMA		Mitsui Chemicals method	℃	147	147	147	155	165	140	150	146	147	90	115	135	155	-	-	-
Tg		Mitsui Chemicals method	℃	135	135	135	145	155	130	140	140	135	80	105	125	145	-	-	-
Specific gravity		ASTM D792	-	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.05	1.04	1.02	1.03	1.04	1.04	1.20	1.18	1.05
MFR(260℃、2.16kg)		Mitsui Chemicals method	g/10min	37	9	67	37	37	56	56	46	36	30	26	15	10	-	-	-
HDT(1.82MPa)		ASTM D648	℃	119	123	122	132	139	119	125	126	125	70	95	115	135	125	75	80
Tensile modulus of elasticity		ASTM D638	MPa	2500	2800	2500	2500	2700	2500	2500	-	-	-	-	-	-	-	-	-
Tensile strength at yield		ASTM D638	MPa	57	63	60	56	49	56	51	50	60	60	60	60	60	65	65	45
Tensile strength at break		ASTM D638	%	3	3	3	2	2	3	3	3	3	60	3	3	3	110	2	3
Flexural modulus		ASTM D790	MPa	3300	3000	3100	3300	3400	3200	3400	3500	3200	2500	2700	3000	3200	2400	3000	3100
Flexural strength		ASTM D790	MPa	85	76	78	87	68	84	77	120	100	100	110	110	110	90	110	80
IZOD impact test	Notched	ASTM D256	J/m	16	24	12	12	11	12	14	14	25	35	25	25	25	650	20	20
	Without notched		kJ/m²	10	12	11	10	7	11	9	7	10	20	15	15	10	-	-	-
Rockwell hardness		Mitsui Chemicals method	-	-	-	-	-	-	-	-	-	-	120	-	-	125	70	80	80
Moisture permeability		ASTM F1249	g·mm/m²·d	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.12	0.09	0.09	0.09	0.09	0.09	-	-	-
Total light transmittance(3mmt)		JIS K7361	%	91	91	91	91	91	91	91	91	91	91	90	90	90	-	-	-
Haze		JIS K7136	%	≦0.5	≦0.5	≦0.5	≦0.5	≦0.5	≦0.5	≦0.5	≦0.5	2	2	3	3	4	-	-	-
Refractive index		Mitsui Chemicals method	n_d	1.544	1.544	1.544	1.544	1.544	1.544	1.544	1.544	1.544	1.54	1.54	1.54	1.54	-	-	-
Abbe's number		-	-	56	56	56	56	56	56	56	56	56	56	56	56	56	-	-	-
Partial dispersion (θgF)		-	-	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	-	-	-	-	-	-	-
Birefringence		Central part at Φ25 of a square plate 65×35×3t(mm)	Scale 0nm 100nm	<20nm	<20nm	<20nm	<20nm	<20nm	<20nm	<20nm	<20nm	-	-	-	-	-	-	-	-
Mold shrinkage (MD/TD)		Mitsui Chemicals method	%	0.5/0.5	0.5/0.5	0.5/0.5	0.5/0.5	0.6/0.6	0.5/0.5	0.5/0.5	0.5/0.5	0.6/0.5	0.6/0.5	0.6/0.5	0.6/0.5	0.6/0.5	-	-	-
Coefficient of linear expansion		Mitsui Chemicals method	-	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	6.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	7.0/6.0	-	-	-
Water absorption		ASTM D570	%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.2	0.3	0.03
Application Sample		-	-	Smartphone	Smartphone	Smartphone	Smartphone, Automotive Camera	Automotive Camera	HMD HUD	HMD	BD, Projector	DVD	Film, Sheet	Industrial parts	Industrial parts	Medical packages	-	-	-

[Note]
The data indicated in this material are representative values obtained by our own testing methods.
The written contents in this material are based on currently available information and data etc.
Please be mentioned that we do not provide any warranty about the listed data and evaluation.