TPX™

Precautions

1. General Precautions

- The data indicated in this brochure are representative values which obtained by our own testing methods. Furthermore, the written contents in this brochure are based on the current available information and data etc. Please be mentioned that we do not provide any warranty about the accuracy or suitability thereof for any particular applications.
- The detailed technical information will be given to you when you contact us.
- For the detailed safety information, please refer to Materials Safety Data Sheet of TPX™.
- Please pay attention to industrial property rights about applications listed in this brochure. Before using TPX™, please evaluate the practical applicability of TPX™ and make sure whether any problems will not be caused.
- Please avoid fire, direct sunshine, water wetting and any abrupt temperature change at the storage place of TPX™.
- Please avoid the outdoor usage of TPX™ for a long period of time as it may cause the color change or the quality deterioration.
- These precautions are given on the assumption that TPX™ would be used in a normal way. If TPX™ is used in any special way, please take additional safety measures.

2. Use of TPX™ for Medical-related applications and Food contact applications

- Please contact us when you intend to use TPX™ in such applications.

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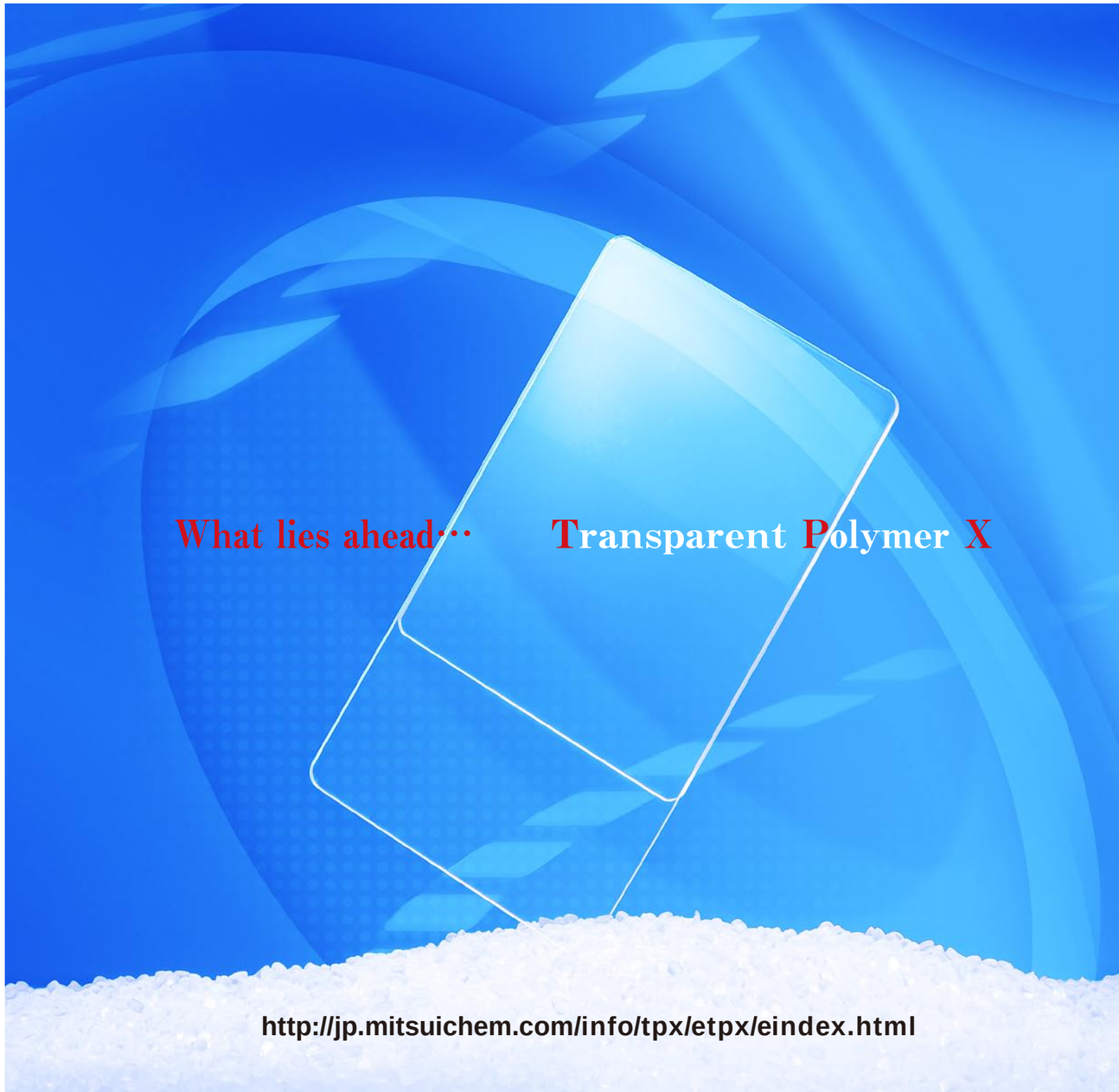
Mitsui Chemicals

Creation : Apr. 2010
Revision : Sept. 2011

Mitsui Chemicals

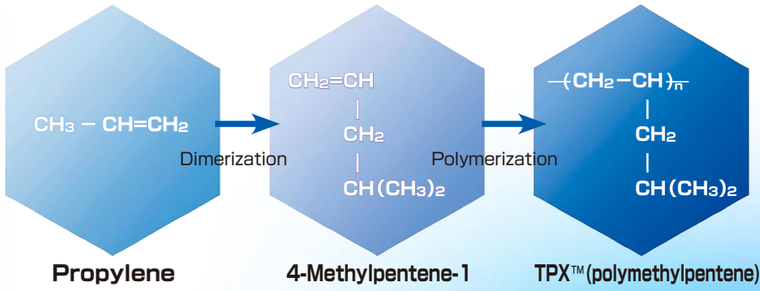
Polymethyl Pentene (PMP)

TPX™



http://jp.mitsuichem.com/info/tpx/etpx/eindex.html

TPX™ is...



A functional resin that creates high-value-added products.

What is TPX™?

TPX™ is a 4-methylpentene-1-based olefin copolymer.
TPX™ has a unique molecular structure. Although TPX™ is a crystalline olefin polymer, it shows transparency. Because of its excellent heat-resistance, release property and chemical resistance, TPX™ is used for industrial materials, including mandrels and sheaths in the manufacture of high-pressure rubber hose, mold cups to create LED light and other applications such as release film on FPC manufacturing process and release paper in the manufacture of synthetic leather.
Furthermore, TPX™ possesses a lowest density among thermoplastic polymers and then provides the molded articles with lower weight. This leads to reduce the environmental load for transportation. It is also noted that TPX™ is a halogen-free polymer denoted as environmentally-friendly material.
TPX™ is also used for food-related applications such as food wraps, food preservation packs, baking carton and microwave oven tableware.

TPX™ provides the high added value as functional polymer that the other conventional polymers cannot supply.

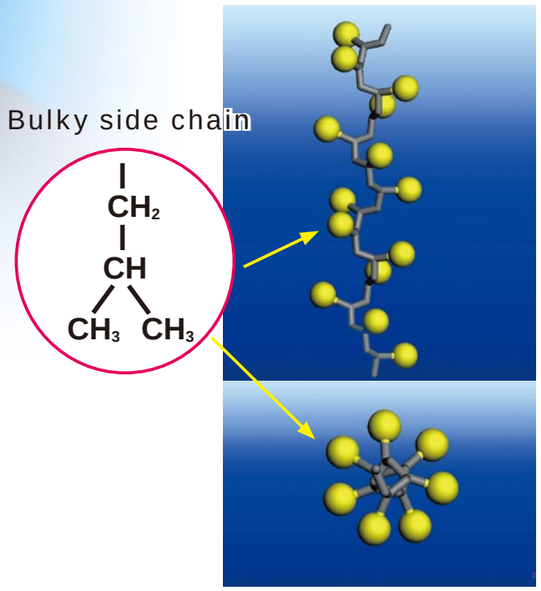
Bulky Side Chain

- *Limited Molecular Movement* → **Heat Resistance** Tm : 220 ～ 240 ℃
- *Very Small Density Difference between Crystal and Amorphous* → **Transparency** Haze < 5%
- *Low Packing Density of Molecules* → **Gas Permeability** 10 times larger than PE; **Low Density** Density : 830 kg/m^3; **Releaseability** Surface Tension : 24 mN/m

Polyolefin

- *Non-Polar Molecule* → **Excellent Low Dielectric Properties** ε =2.1, tan δ = 0.0008 (@10GHz)
- *Stable C-C Bond in a Main Chain* → **Chemical Resistance**
- **Halogen-free Good for the Environment**

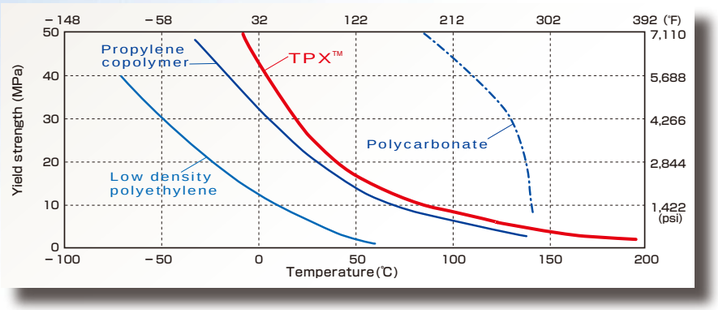
Crystal Structure of TPX™
7_2 Helical



TPX™ shows unique properties not available with any conventional resins.

Heat resistance

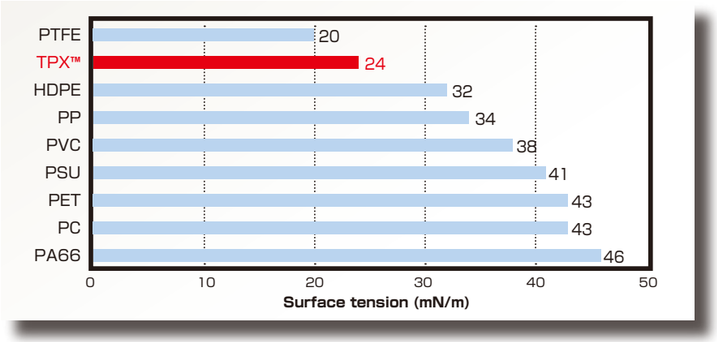
TPX™ has a high melting point in the range from 220℃ to 240℃ and a high vicat softening temperature. Hence, it can be used for high temperature application. However, as heat distortion temperature of TPX™ is almost same as that of polypropylene, the application under high-stress environment needs to be carefully considered.



Releasability and Non-compatibility

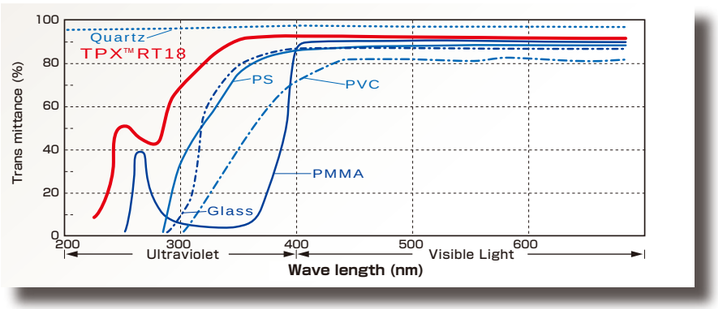
The surface tension of TPX™ (24mN/m) is very low and this value is the secondary lowest as compared to fluorine polymers. Hereby, TPX™ shows excellent releasability against various materials. TPX™ is used as release material in hardening process of thermosetting resins (urethane, epoxy etc.) Furthermore, since TPX™ shows incompatibility against thermoplastic resins (PET, PP etc.) it is used to create a porous structure in PET or PP membranes.

Comparison of Surface Tention



Transparency

Although TPX™ is a crystalline polymer, it exhibits excellent transparency (Haze : < 5 %) and light transmittance. Especially TPX™ is used for optical analysis cells because of the higher UV transmittance as compared to glass and other transparent polymers.



Chemical resistance

Because of its stable C-C bonds, TPX™ has better chemical resistance as compared to polycarbonate and acrylic polymer. TPX™ basically shows excellent chemical resistance particularly against acids, alkalis and alcohol. For this reason, TPX™ is used in various applications which require chemical resistance, such as cosmetic container caps and tubes, experimental apparatus and analytical cells.

Chemicals \ Resin	TPX™	PMMA	PC	PS	PA
Concentrated sulfuric acid (98%)	A	C	C	A	D
Ammonia water	A	A	C	A	A
Sodium hydroxide (40%)	A	A	C	A	A
Sodium oxalate	A	A	A	A	—
Acetone	A	C	C	C	B
Methyl ethyl ketone	A	C	C	C	C
Ethanol	A	C	A	A	A
Toluene	C	E	C	E	—
Trichloroethylene	C	E	E	E	—
Brake oil	A	D	C	B	—

[25℃] A:Not attacked; B:Practically not attacked; C:Atacked (swelling); D:Attacked (cracked); E : Attacked (dissolve)

Gas permeability

TPX™ has a characteristic of excellent gas permeability derived from its molecular structure. Hence, TPX™ is widely used for gas permeative applications such as gas separation membranes.

Unit : mol・m/(㎡・s・Pa)

Gas type	Measured Condition	Resin			
		TPX™ (MX002)	HDPE	PP	PET
Moisture permeability	40℃、90% RH	3.20×10^{-13}	4.85×10^{-14}	2.91×10^{-14}	5.83×10^{-14}
O_2 permeability	23℃	9.40×10^{-15}	5.88×10^{-16}	5.17×10^{-16}	3.76×10^{-18}
N_2 permeability	23℃	2.33×10^{-15}	2.12×10^{-16}	7.99×10^{-17}	—
CO_2 permeability	23℃	3.29×10^{-14}	1.18×10^{-15}	1.46×10^{-15}	—

Low dielectric property

Since TPX™ has a non-polar structure; its dielectric property is almost same as fluorine polymers. It should be noted that dielectric property of TPX™ is hardly affected by frequency and TPX™ can be injection-molded unlike PTFE. TPX™ shows stable dielectric property in the wide range of frequency.

Dielectric property \ Resin		TPX™	PTFE	ETFE	PE
Dielectric constant	10kHz	2.1	2.1	2.6	2.3
	1MHz	2.1	2.1	2.6	2.3
	10GHz	2.1	2.1	2.6	2.3
Dielectric dissipation factor (tan δ)	10kHz	< 0.0003	< 0.0003	0.0006	—
	1MHz	< 0.0003	< 0.0003	0.0015	—
	10GHz	0.0008	0.0005	0.0150	—

Low density

The density of TPX™ is the lowest (830 kg/m^3) among thermoplastic polymers, and its specific volume is larger than that of other transparent polymers. For this reason, it is possible to reduce the weight of injection-molded articles by using TPX™ or also TPX™ compounds.

Steam resistance

TPX™ shows a very low water absorbance and therefore the dimension of a TPX product is hardly affected by water absorbance. Furthermore, since TPX™ does not hydrolyze in boiling water, it can be used for experimental apparatus and animal cages which require the steam sterilization.

Food sanitation

Hygienic approved TPX™ grades (JPN standards, FDA regulations and EU regulations) are also available and they are used for food wraps and microwave oven tableware.

Low refractive index

The refractive index of TPX™ is 1.463n_0^{20}, lower than fluorine polymers.

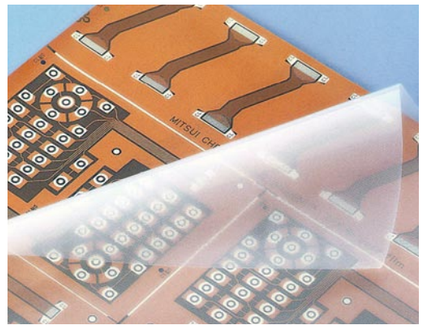
TPX™ expands the possibilities of advanced technologies.

As process material for hardening process

Releasability　Heat resistance　Chemical resistance

LED mold

Rubber hose mandrels and sheaths



Release film

Release paper for synthetic leather

As high-value-added product

RT18、MX004、MX002O、DX820、DX845

Transparency　Releasability
Heat resistance　Low density
Chemical resistance　Low dielectric properties
Gas permeability　Food sanitation
Steam resistance

Cosmetic container caps and tubes

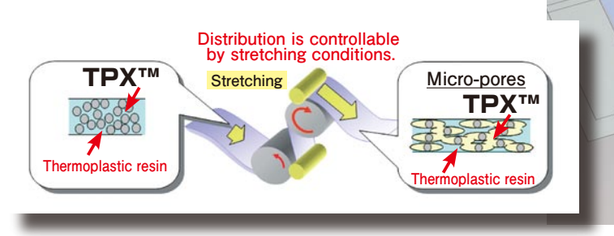
Hollow fiber

Animal cage

Experimental apparatus

As resin modifier

Non-compatibility
Heat resistance



Synthetic paper

As food container/packaging material

Heat resistance　Releasability　Gas permeability
Food sanitation

Heat-resistant tableware for microwave ovens

Food wraps and baking carton

TPX™ meets a broad range of needs with a full grade mix.

Physical Properties					Type	High-Modulus				Intermediate-Modulus	Low-Modulus			Opaque	
					Grade	RT18, RT31※1 (RT18XB, RT31XB※2)	DX845	DX231	DX820	MX004 (MX004XB※2)	MX002	MX002O	DX310	MBZ230(A)	DX560M
		List	Measured Condition	Unit	Methodology										
Basic Properties		Density	Density Gradient Method	kg/m³ lb/in³	MCI Method	833 0.030	833 0.030	832 0.030	832 0.030	833 0.030	834 0.030	834 0.030	834 0.030	1100 0.040	856 0.031
		MFR	Applied Force= 5kgf, 260℃	g/10min	MCI Method	26 (RT18) 21 (RT31)	9	100	180	25	21	21	100	57	33
		Melting Point	DSC Method	℃ F	ASTM D3418	232 449.6	232 449.6	232 449.6	232 449.6	228 442.4	224 435.2	224 435.2	226 438.8	233 451.4	221 429.8
		Water Absorption		%	ASTM-D570	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01
Thermal Properties		Vicat Softening Temperature	Injection Molded Specimen (2㎜ thick × 2pcs) Heat Speed: 50℃ /hour Applied Load: 10N	℃ F	ASTM-D1525	168 334.4	168 334.4	178 352.4	172 341.6	164 327.2	149 300.2	149 300.2	145 293.0	162 323.6	89 192.2
		Heat Distortion Temperature	Injection Molded Specimen (1/4 inch thick) Heat Speed: 120℃ /hour Applied Stress: 0.45MPa	℃ F	ASTM-D648	127 260.6	127 260.6	126 258.8	132 269.6	100 212.0	93 199.4	93 199.4	80 176.0	145 293.0	59 138.2
		Coefficient of Linear Expansion	TMA Method Measured Range: -10℃~ 160℃ Applied Force: 3g Nitrogen Flow: 100mL/min	cm/cm℃	MCI Method	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.17×10^{-4}	1.28×10^{-4}	3.53×10^{-4}
Mechanical Properties	23℃ 73°F	Yield Stress	Injection Molded Specimen (ASTM-4) Cross-Head-Speed: 50㎜/min Chuck Distance: 65㎜	MPa PSI	ASTM-D638	30 4350	30 4350	29 4205	32 4640	25 3625	21 3045	21 3045	20 2900	27 3915	8 1160
		Fractured Stress		MPa PSI	ASTM-D638	25 3625	25 3625	25 3625	25 3625	20 2900	10 1450	10 1450	10 1450	26 3770	9 1305
		Fractured Strain		%	ASTM-D638	22	19	19	7	27	87	87	52	20	100
		Tensile Modulus		MPa PSI	ASTM-D638	1900 275500	1900 275500	1860 269700	1950 282750	1300 188500	900 130500	900 130500	850 123250	2250 326250	280 40600
	23℃ 73°F	Flexural Modulus	Injection Molded Specimen (3.2㎜ thick) Cross-Head-Speed: 1.3㎜/min Span Length: 51㎜	MPa PSI	ASTM-D790	1450 210250	1500 217500	1450 210250	1600 232000	750 108750	480 69600	480 69600	490 71050	1820 263900	190 27550
		Flexural Strength		MPa PSI	ASTM-D790	36 5220	40 5800	37 5365	40 5800	25 3625	18 2610	18 2610	18 2610	40 5800	6 870
	23℃ 73°F	Izod Impact Strength	Injection Molded Specimen (Machined Notch)	J/m ft-lbs/in	ASTM-D256	24 0.45	25 0.47	13 0.24	10 0.19	27 0.51	30 0.56	30 0.56	19 0.36	99※3 1.85※3	495※3 9.27※3
			Injection Molded Specimen (w/o Notch)	kJ/m² ft-lbs/in²	ASTM-D4812	10 4.8	10 4.8	8 3.8	9 4.3	22 10.5	NB	NB	29 13.8	56※3 26.6※3	NB
	23℃ 73°F	Rockwell Hardness	Injection Molded Specimen R scale	—	ASTM-D785	83	86	88	90	66	<50※4	<50※4	<50※4	84	<50※4
Optical Properties		Haze	Injection Molded Specimen C illuminant	%	ASTM-D1003	0.7	0.7	1.7	2.1	0.7	1.3	0.7	1.7		
		Transmittance		%	ASTM-D1003	94	94	93	92	94	93	94	93		
		Refractive Index	Injection Molded Specimen (2㎜ thick) Wave Length: 589㎚	—	ASTM-D542	1.462	1.462	1.462	1.461	1.462	1.463	1.463	1.463		
Electrical Properties		Volume Resistivity	Injection Molded Specimen (2㎜ thick)	Ω・cm	ASTM-D257	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{16}$	$>10^{15}$
		Dielectric Breakdown	Injection Molded Specimen (2㎜ thick)	KV/mm V/mil	ASTM-D149	32 812	32 812	32 812	32 812	32 812	32 812	32 812	32 812	28 711	31 787
		Relative Dielectric Constant	Injection Molded Specimen (2㎜ thick), Frequence: 1MHz	—	ASTM-D150	2.11	2.11	2.11	2.14	2.14	2.15	2.15	2.15	2.38	2.15
Moldability		Spiral Flow	Injection Temperature: 310-320℃ Mold Temperature: 73℃	cm	MCI Method-1	51	50			53	56	56		48	
		Molding shrinkage	Injection Molded Specimen (2㎜ thick) MD	%	MCI Method-2	1.6	1.5			1.7	1.6	1.6		1.5	
			Injection Molded Specimen (2㎜ thick) TD	%	MCI Method-2	1.3	1.4			1.4	1.3	1.3		1.1	
Processing Method		Injection Molding		◎ : Recommended ○ : Applicable		◎	○	○	○	◎	◎	◎	○	◎	○
		Extrusion-Coating						◎	◎		○		◎		
		Extrusion-T-Die Casting				○	◎			◎	◎	◎		○	○
		Extrusion-Profile type, Mandrel, Pipe				○	○			◎	◎	○			◎
		Extrusion-Fiber Spinning				○	○	○	◎	○	○	○	○		
		Direct Blow Molding					○			○	○	○			○

MCI Method-1 Moulding Temp. : 310 ~ 330℃ (depending on the grade)
MCI Method-2 Moulding Temp. : 260 ~ 280℃ (depending on the grade)
Note: Figures shown here are representative values but not specified values.

As for the EU Directive, it is necessary to check the conformity of the application on the basis of the final product.
TPX™ contains chemical substances whose Specific Migration Limit (SML) is 0.05 mg/kg and 5 mg/kg.
For details about EU Directive as well as details about the conformity of TPX™ with the FDA regulations, please contact our responsible department.

※1 RT31, RT31XB : Low odor grade
※2 RT18XB, RT31XB, MX004XB : Blue tint grade
※3 Partially Break
※4 Not detective by ASTM-D785

We will provide full technical support to our customers based on the choice of a suitable grade.

Precautions in molding process

- Since TPX™ pellets does not absorb water, it is unnecessary to dry it before molding process.
- Temperature control of molding equipment needs to be in the vicinity of 300℃ due to high melting point of TPX™.
- Nitrogen purging is recommended at the hopper of molding equipment to reduce the heat decomposition of TPX™.
- Before TPX™ molding process, the previous polymer should be fully purged out by low-MFR polypropylene and then switched to TPX™ molding. It is noted that appearance of TPX™ products is seriously affected by small amount of contamination remained in molding equipment.

Injection molding process

The viscosity of TPX™ remarkably decreased at the over melting point. Therefore, the recommended gate shape is a pin gate to avoid residual strain around the gate. A pin gate at the off center position is especially recommended for shallow products.

Cylinder temperature

Injection temperature is in the range from 270 to 300℃ .

Injection pressure/injection speed

Injection pressure and injection speed should be set as low as possible to obtain the product with free residual strain.

Mold temperature

Mold temperature is in the range from 20 to 60℃

Basic mold structure

Although the mold structure for TPX™ injection is basically similar to a PP type, an ejecting method and a surface finish condition are slightly different due to the TPX™ inherent release property.

Mold materials

A mold material should be chosen from the viewpoints of surface hardness, corrosion resistance, machinability and total shot number. The recommended mold material for TPX™ should have the following features.

(1) Mirror-like polished surface
(2) Good resistance against cloud and rust generated by molded gas

Example of Injection Molding Condition

Injection Machine	Clamp Force Capacity: 70ton	
Screw Diameter	ϕ 32mm	
Mold shape	Casserole Dish	
	136 × 136 × 58 (max thickness 3mm)	
Gate	Pin Gate	
Pre-Drying	Not Required	
Cylinder Temperature (℃)	C1	270
	C2	280
	C3	300
	C4	300
	Nozzle	290
Injeciton Pressure (MPa)	P1	30
	P2	40
	Pressure keeping	30
injection speed (%)	V1	30
	V2	40
Injeciton time (s)	t1+t2	3
	Dwell Pressure	2
Cooling Time(s)		20
Cylinder Temperature (℃)		40

Surface finish

The surface finish of a mold determines the transparency of a TPX™ product as TPX™ easily catches up a mold surface topography. The mold should be polished as fine as possible. A proper thickness of the mold plating is in the range from 0.015 to 0.02㎜. Gas generation is occasionally a concern issue as TPX™ is usually injected at nearby 300℃. It is recommended that a mold is occasionally cleaned by cloth during injection molding and anti-corrosion agent is better to be sprayed on the surface of mold.

Extrusion molding process

Although TPX™ can be extruded by conventional extruders used for PP and PE, there are some precautions for the choice of an extruder due to high melting point of TPX™. An extruder for TPX™ preferably possesses the following specifications.

Extruder

(1) High heating capacity
Extrusion of TPX™ is generally conducted in the range from 250 to 320℃ cylinder temperature. Therefore, the extruder must have sufficient heat capacity.
(2) Temperature control in four or more zones
It is recommended that the temperature control of the cylinder is conducted in four or more zones so that an adequate amount of heat will be given to TPX™ pellets.
(3) L/D
L/D of an extruder is preferably 30 to completely plasticize TPX™ even with large resin extrusion amount.

Example of Extruding Condition (T-Die Cast)

Exturder	T-Die Cast Extruder (3-Layered)	
Die	Multi Manifold Die	
Pre-Drying	Not Required	
Die Rip Gap	0.5㎜	
Air Gap	30㎜	
Cylinder Temperature (℃)	C1	280
	C2	290
	C3	290
	C4	290
	Adaptor	290
	Die	290
Casting Roll Temperature (℃)		50
Pull-Up Speed (m/min)		20
Film Thickness (um)		50

Screw

We will propose a following screw design for extrusion of TPX™.
(1) Long feed
Feed zone of 8-12D is suitable for plasticization of TPX™.
(2) Semi-compression screw
A semi-compression screw is suitable for TPX™ extrusion. The proper compression ratio is in the range from 2.6 to 3.8. The desirable length of the compression zone is about 10D
(3) Long metering
A screw with a metering zone with more than 8D is suitable to homogenize and mix the molten resin sufficiently.
(4) Depth
If the screw has a large depth at the feed zone, TPX™ pellets hardly receive sufficient heat for plasticizing from the barrel. Therefore, the depth should be around 6mm for the case of < 60mm cylinder diameter.

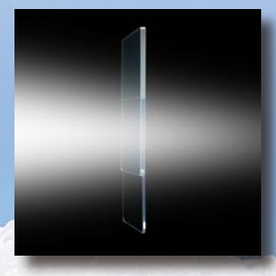
Blow molding

The blow molding of TPX™ is limited to the direct blow molding process. The injection blow molding process is not suitable due to the difficulty of uniform stretching. It should be noted that the transparency of a blow molded TPX™ product is inferior as compared to an injection molded product.

Post-Processing and Coloring

For the purposes of printing, painting and bonding, TPX™ needs to have frame, corona and plasma treatments to increase its surface tension. TPX™ is not suitable for cutting manufacturing due to low mechanical strength. The most suitable method to color TPX™ is dry blending with color mastarbatch. With respect to the choice of color masterbatch, it should have high heat resistance which can be sustained at processing temperature of TPX™.

The more detailed information about TPX™ processing is available as technical brochure.



TPX™