'TORAY'
Innovation by Chemistry

Polyphenylene Sulfide(PPS) Film

Torelina. Catalogue

TORELINA CATALOGUE

Torelina. Polyphenylene Sulfide(PPS) Film

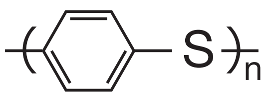
Torelina* is the world's first PPS film that was commercialized by Toray.
Torelina* excels in electrical properties and dimensional stability. Its UL-certified high temperature durability exceeds that of Lumirror*. Therefore, this material is extensively used in various applications such as mold releaser and for electronic components.

1 Features

1. Resistant to higih and low temperatures
2. Nonflammability
3. Chemical resistance
4. Hydrolysis resistance
5. Electrical Properities
6. Creep Characteristics

Polyphenylene Sulfide (PPS)

As shown below, PPS is a polymer simply composed of a series of alternating aromatic rings and sulfur atoms.
This material was first discovered in the late 19th century, as is evidenced in studies by Friedel and Crafts.



However, the history of PPS as an industrial material is relatively short. In the 1940's and 1950's, many engineers failed in their attempts to produce PPS for industrial use. In 1967, however, Edmonds and Hill of Phillips Petroleum Company devise a method for producing PPS through the synthesis of para-dichlorobenzene and sodium sulfide.
This marked the beginning of industrial-scale commercialization of PPS.

In 1972, Phillips Petroleum used its original manufacturing technology to begin commercial-scale production of PPS. They called the product Ryton* and it was soon noted for having effectively balanced thermal and chemical resistances, nonflammability and electrical properties. Ryton* is highly renowned today in the field of injection molding as a rapidly growing heat-resistant polymer.

Torelina. Polyphenylene Sulfide(PPS) Film

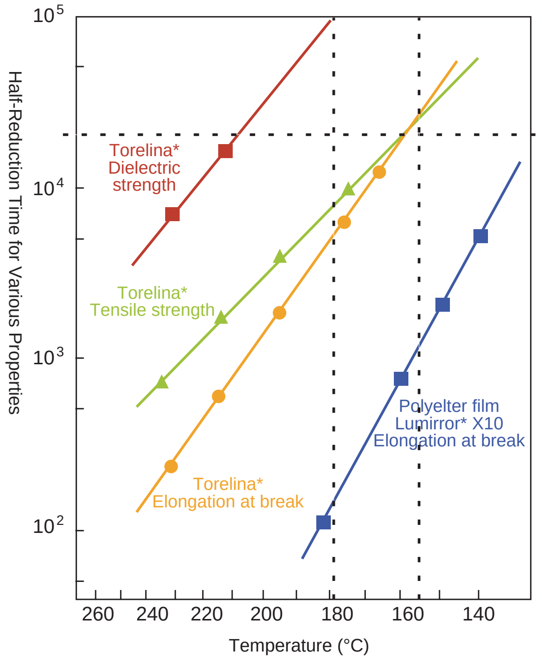
2 Resistant to high and low temperatures

Long-Term Thermal Resistance

Fig. 1 is an Arrhenius plot showing the relationship between the temperature and the time taken to reduce Torelina*'s tensile strength, elongation at break and dielectric strength by half of their initial values, when forced aging is applied at various temperatures. Fig. P1 estimates Torelina*'s durability when it is used over extended periods of time at high temperatures .

Torelina*, having a thickness of 25μm or thicker, has received approval for long-term thermal resistance indices of 160°C for mechanical properties including tensile strength and elongation at break, and 180°C for dielectric strength. This approval is based on the U.S. UL-746B Standard and Japanese Electrical Appliances Regulations. Regarding dielectric strength, Torelina* is to receive approval for a long-term thermal resistance index of almost 200°C.

Fig.1 Half-Reduction Time for Various Properties vs. Temperature



Long-Term Thermal Resistance	Standards	Minimum Thickness(μm)	Upper limit of usable temperature (°C)		
			Elongation	Strength	Electrical properties
US	UL746B	9	(160)	160	200
JAPAN	Material registration according to the Electrical Appliance and Material Control Law	25	155	170	180

Torelina. Polyphenylene Sulfide(PPS) Film

2 Resistant to higih and low temperatures

Short-Term Thermal Resistance

For short periods of time, such as several seconds to hours, Torelina* can withstand even higher temperatures than the aforementioned long-term thermal resistance. Table 1 shows the variation of mechanical properties after Torelina* has been heated for one hour at 230°C and 260°C.

Virtually no deterioration is found in mechanical properties of Torelina* under these testing conditions.

Table 1. Short-Term Thermal Resistance at High Temperatures

Film Thickness(μm)	Property	Heating conditions		
		No heat treatment	230 °C X 1hr.	230 °C X 1hr.
12	Tensile Strength(MPa)	250	220	200
	Elongation at Break(%)	67	71	87
	Dielectric Strength(kV/mm, AC)	213	213	228
25	Tensile Strength(MPa)	250	220	170
	Elongation at Break(%)	73	68	72
	Dielectric Strength(kV/mm, AC)	247	239	264
75	Tensile Strength(MPa)	250	220	210
	Elongation at Break(%)	72	63	79
	Dielectric Strength(kV/mm, AC)	165	166	163

Tensile Strength, Elongation : measured lengthwise according to the ASTM D882-64T method.
Dielectric Strength : measured according to the JIS C-2151 method.

3 Nonflammability

Torelina* is a self-extinguishing film. Film thicker than 25μm is approved by UL 94 as VTM-0 grade.

Torelina. Polyphenylene Sulfide(PPS) Film

4 Chemical resistance

Chemical Resistance

Torelina* features exceptionally outstanding resistance to chemicals. Table 2 indicates the variation of tensile strength in Torelina* and polyester film when they are immersed in different chemicals. Torelina*'s tensile strength remains stable in virtually all chemicals excluding concentrated sulfuric acid and nitric acid. Torelina* does not have very weak points of chemical resistance as found in polyimide and polyester films against strong base and aramid paper against acid.

Table 2. Tensile Strength of Different Films When Immersed in Chemicals (Testing conditions: 30°C, 10 days)

Chemicals	Concentration(%)	Torelina*		Polyester film	
		25μm		25μm	
		Percent tensile strength retained(%)	Remarks*	Percent tensile strength retained(%)	Remarks*
Acid, sulfuric	-	11	P	0	P
Acid, sulfuric	30	96	E	92	E
Acid hydrochloric	-	100	E	85	G
Acid, nitric	-	0	P	0	P
Acid, nitric	10	97	E	92	E
Acid, glacial acetic	-	100	E	90	G
Sodium hydroxide	10	94	E	47	P
Ammonium hydroxide	-	100	E	0	P
Sodium carbonate	2	98	E	-	-
Iron(II) chloride	45	94	E	-	-
Hydrogen peroxide	30	80	G	-	-
Methanol	-	98	E	-	-
Ethanol	-	100	E	-	-
Acetone	-	99	E	94	E
Carbon tetrachloride	-	94	E	91	E
Benzene	-	100	E	90	G
Toluene	-	98	E	-	-
Methyl-ethylketone	-	90	G	-	-
n-hexane	-	98	E	-	-
Methylene chloride	-	96	E	-	

* E : Excellent
G : Good
P : Poor

Torelina. Polyphenylene Sulfide(PPS) Film

4 Chemical resistance

Gasohol Resistance

In addition to gasoline and other fuel oils, Torelina* also features a superb durability against gasohol, the gasoline-alcohol mixture which is now receiving attention as a substitute for gasoline.(See Table 3.)

Table 3. Gasohol Resistance of Torelina*

Gasohol	Torelina*		Polyester film Lumirror* S10	
	100μm		100μm	
	Tensile Strength Retained (%)	Elongation at Break Retained (%)	Tensile Strength Retained (%)	Elongation at Break Retained (%)
FUEL-C Isooctane (50%) / Toluene(50%)	87	80	95	90
FUEL-C85% / Methanol 15%	80	78	85	78
FUEL-C80% / Ethanol 20%	82	75	75	85
FUEL-C / Lauryl peroxide 2.5%	81	70	70	85
FUEL-C / Triethanolamine 0.5% / Dioctylphthalate 0.2%	81	75	65	35

Testing conditions: 60°C, 500 hours

Freon Resistance

As shown in Table 4, Torelina* has a high resistance to Freon, the substance used as a refrigerant in air conditioners, etc., and the amount of extract is very small.

1.Testing conditions

(1)Torelina*: 250μm

(2)Freon: R134a

(3)Temperature:170°C (vapor phase)

(4)Pressure: 3.4-3.5MPa

2.Test results

Table 4. Freon Resistance of Torelina*

Film	Properties	After 500 hr.
Torelina* (250μm)	Strength Retained (%)	100
	Elongation at break Retained (%)	80
PET film (250μm)	Strength Retained (%)	60
	Elongation at break Retained (%)	5 or lower
PEN film (250μm)	Strength Retained (%)	48
	Elongation at break Retained (%)	2

Note: Percentage of tensile strength and elongation retained
Percentage retained (%) = Value after aging/initial value X 100

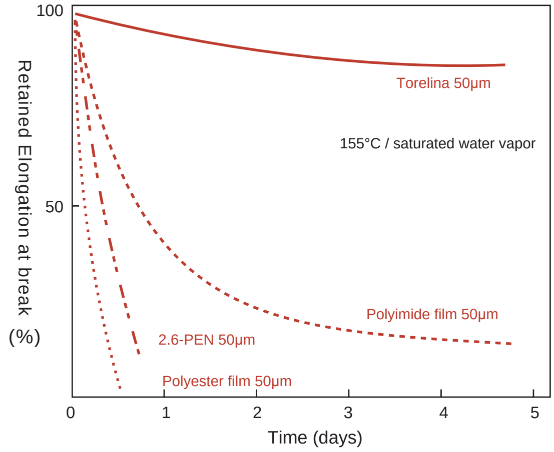
Torelina. Polyphenylene Sulfide(PPS) Film

5 Hydrolysis resistance

Hydrolysis Resistance

PPS is a polymer which shows virtually no hydrolysis. Accordingly, Torelina* features outstanding resistance to hydrolysis. Fig. 2 shows the decrease of elongation at break of various thin films when placed in saturated water vapor at 155°C. In absolutely dry conditions polyimide film boasts better thermal resistance than Torelina*. In water vapor, however, it deteriorates much more rapidly.

Fig. 2 Hydrolysis Resistance of Various Films
(Decrease of elongation at break in saturated water vapor at 155°C)

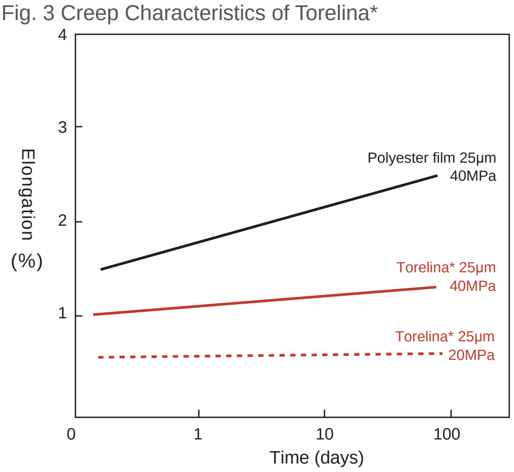


6 Creep Characteristics

Creep Characteristics

Figure 3 compares the creep characteristics of Torelina* with polyester films. In comparison with other films, Torelina* exhibits a lower dimensional change even after being subject to stress for long periods of time.

Fig. 3 Creep Characteristics of Torelina*



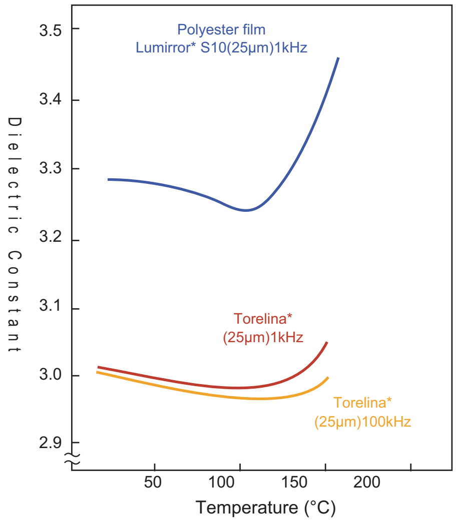
Torelina. Polyphenylene Sulfide(PPS) Film

7 Electrical Properities

(1) Dielectric Properties

The dielectric constant of Torelina* is 3.0, and it is exceptionally stable for a wide range of temperature and frequency variations.

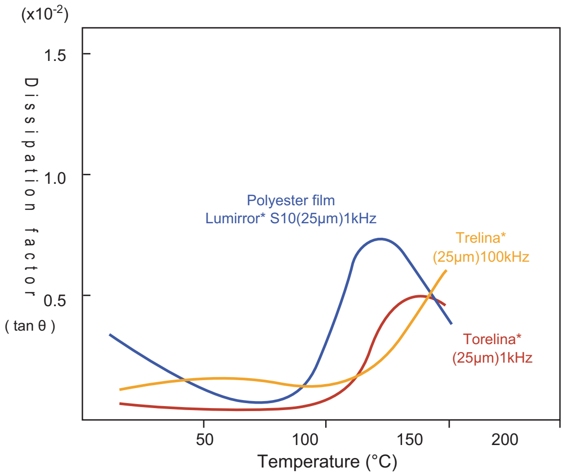
Dielectric Constant vs. Temperature



(2)Dissipation Factor

The dissipation factor(tan δ) of Torelina is exceptionally small, very close to that of polypropylene film, when its dielectric constant is taken into account. At temperatures below 120°C , the dissipation factor is very consistent over temperature or frequency variations.

Dissipation factor vs. Temperature



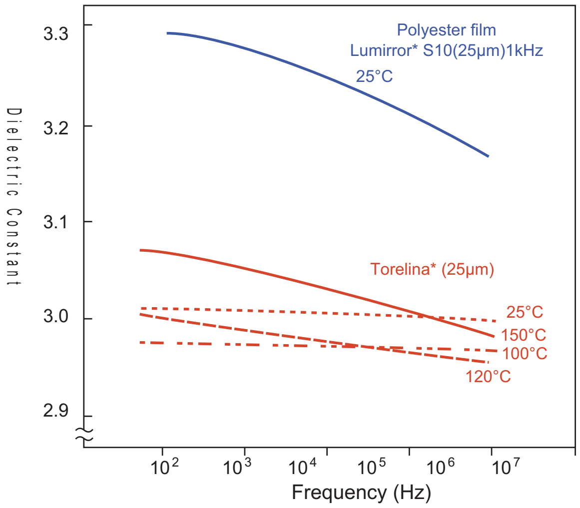
Torelina. Polyphenylene Sulfide(PPS) Film

7 Electrical Properities

Frequency Dependence

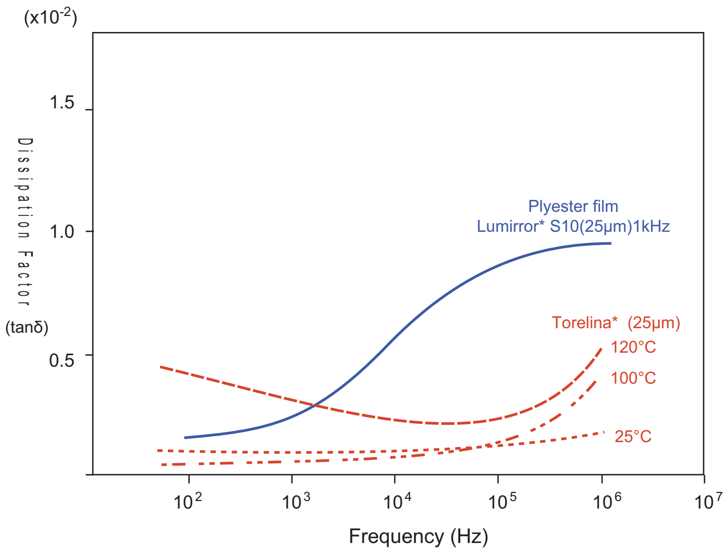
(1)Dielectric Constant

Dielectric Constant vs. Frequency



(2)Dissipation Factor

Dissipation Factor vs. Frequency



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8 Applications

- Capacitors
  (SMD chip, high-heat-resistant, high-frequency types, etc.)
- Variable capacitors
- Flexible printed circuit boards
  (nonflammable, heat-resistant, and high-frequency types)
- Motor/transformer insulation
- Wire wrapping
  (for heat-resistant and fire-retardant cables)
- Industrial tapes
  (for class F heat resistance, masking, electrolytic capacitor element bonding, etc.)
- Mold release
- Acoustic membranes and diaphragms

9 List of Grade

Type	Applicable thicness (μm)	Standard thicness (μm)	Remarks
1X00	6 or thinner	1.2,1.5,2,2.5,3.5,4,6	-
1X30	6 or thinner	1.2,1.5,2,2.5,3.5,4,6	Corona-treated type(inner side)
3X00	925	9,12,16,25	-
3000	9 - 100	9,12,16,25,38,50,75,100	-
3030	9 - 100	9,12,16,25,38,50,75,100	Corona-treated type(inner side)
5000	125 - 350	125,175,250,300,350	-

Types 3X00, 3000, 3030 and 5000 in the table above are UL-approved.
·Flammability(25μm or thicker film): UL94, VTM-0 (self-extinguishing)
·Relative temperature indiced: UL746B
160°C (mechanical)
200°C (electrical)

10 Processability

In a similar fashion as common plastic films, Torelina* can undergo various processes including printing, coating, lamination, metallization, matting, molding, slitting, corona treatment (for good adhesion) and annealing (for lower heat shrinkage)

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