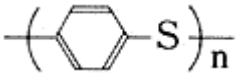
Torelina. Polyphenylene Sulfide (PPS) Film

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.

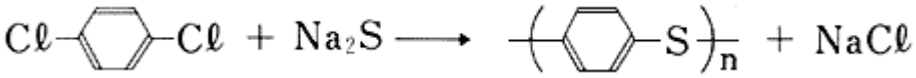
About PPS

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 devised 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.

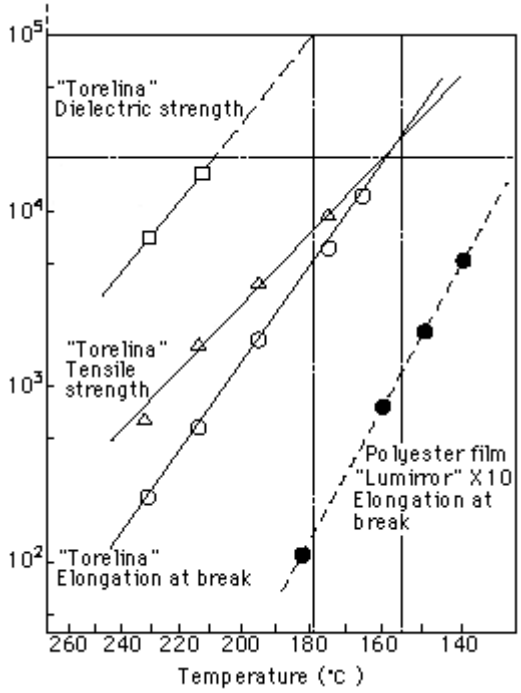
'TORAY' Torelina Polyphenylene Sulfide (PPS)Film

Resistant to higih 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



•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 P1 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.	260°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.

Nonflammability

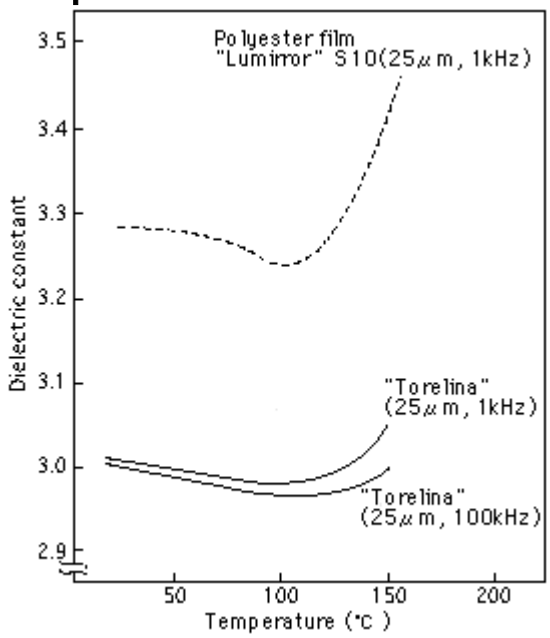
http://www.ul.com/

Electrical Properities

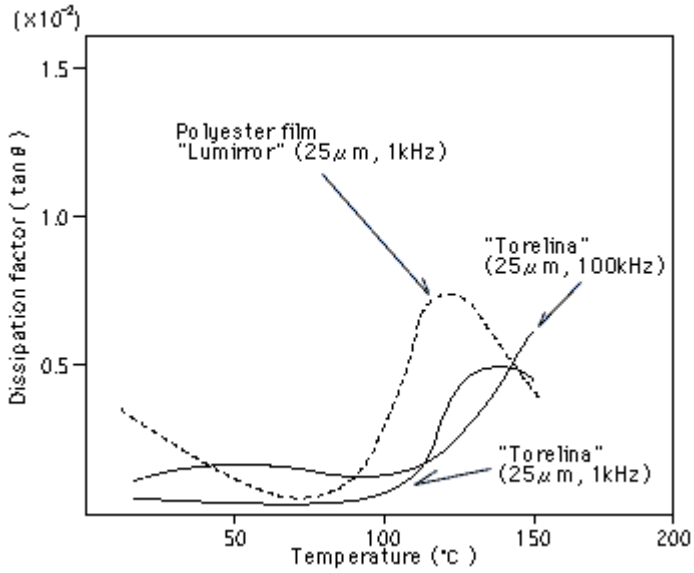
・Dielectric Properties

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

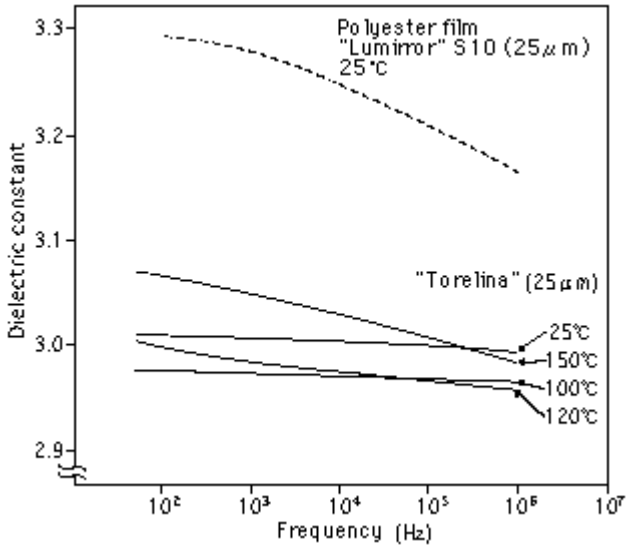
Dielectric Constant vs. Temperature



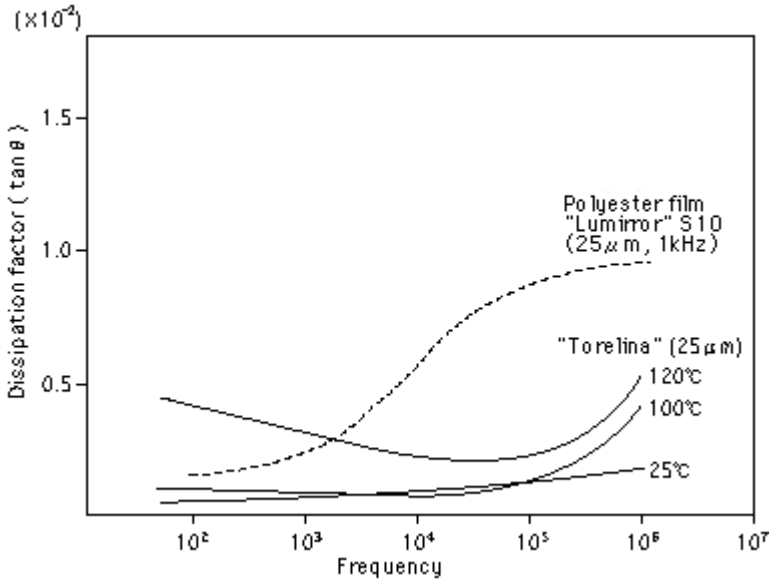
Dissipation factor vs. Temperature



Dielectric constant vs. Frequency



Dissipation factor vs. Frequency



Chemical resistance

·Chemical Resistance

Torelina* features exceptionally outstanding resistance to chemicals. Table 1 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 1 Tensile Strength of Different Films When Immersed in Chemicals (Testing conditions: 30°C, 10 days)

Chemicals	Concentration (%)	Torelina* 25μm		Polyester film 25μm	
		Percent tensile strength retained (%)	Remarks*	Percent tensile strength retained (%)	Remarks*
Acid, sulfuric	conc.	11	P	0	P
Acid, sulfuric	30	96	E	92	E
Acid, hydrochloric	conc.	100	E	85	G
Acid, nitric	conc.	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	conc.	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-ethyl-ketone	-	90	G	-	-
n-hexane	-	98	E	-	-
Methylene chloride	-	96	E	-	-

* E: Excellent
G: Good
P: Poor

·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 2.)

Table 2 Gasohol Resistance of Torelina*

Gasohol	Torelina* 100μm		Polyester film Lumirror* S10 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-C (85%) / Methanol (15%)	80	78	85	78
FUEL-C (80%) / Ethanol (20%)	82	75	92	85
FUEL-C / Lauryl peroxide (2.5%)	81	70	91	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 3, 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.

Table 3 Freon Resistance of Torelina*

1. Testing conditions

(1) Torelina*: 250μm
(2) Freon: R134a
(3) Temperature:170°C (vapor phase)
(4) Pressure: 3.4～3.5MPa

2. Test results

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

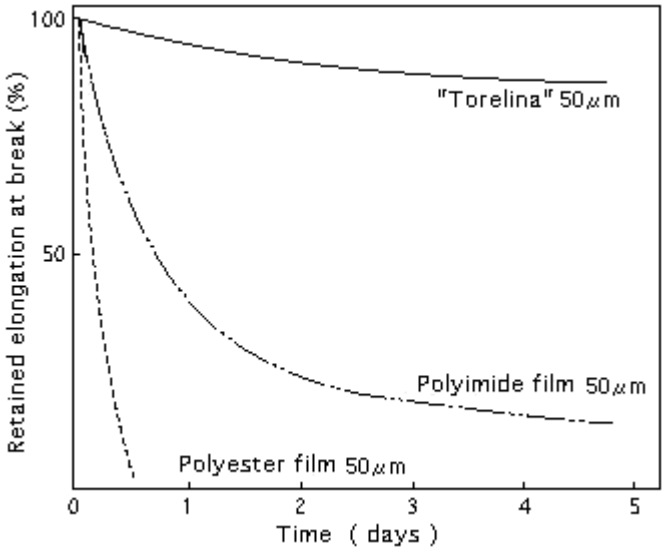
Note: Percentage of tensile strength and elongation retained
Percentage retained (%) = Value after aging/initial value X 100

Hydrolysis resistance

•Hydrolysis Resistance

PPS is a polymer which shows virtually no hydrolysis. Accordingly, Torelina* features outstanding resistance to hydrolysis. Fig. 1 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. 1 Hydrolysis Resistance of Various Films
(Decrease of elongation at break in saturated water vapor at 155°C)

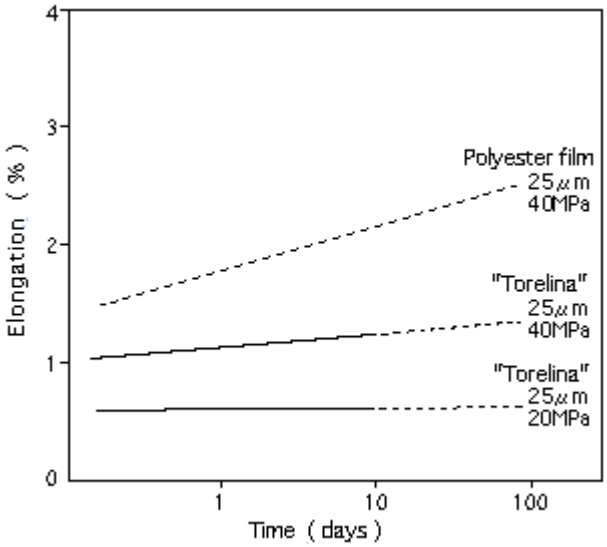


Creep Characteristics

•Creep Characteristics

Figure below 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.

Creep Characteristics of Torelina*



'TORAY' Torelina Polyphenylene Sulfide (PPS)Film

Applications

- Capacitors (SMT, high-temperature, high-frequency, high-reliability)
- Variable capacitors
- Flexible printed circuit boards, keyboard membranes
- Motor/transformer insulation, flat motors
- Cable wrapping
- Industrial tapes, interior coverage materials
- Acoustic membranes, diaphragms
- Microwave oven-ready food packing, etc.

List of Torelina* Types

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

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

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)

'TORAY' Torelina. Polyphenylene Sulfide (PPS)Film

Laminated Film "TLT"

TLT* is a thermal-resistant, insulating material having a three layer configuration as shown on the right. Combining outstanding electrical and mechanical properties as well as high thermal resistance with superior flexibility, TLT* is ideal for use as a thin electrical insulating material, and meets wide use in class F insulation systems. This material also enables customers to achieve greater working efficiency through its automated insertion ability and excellent processability.
(Available grades: #75-380, actual thickness: 88 - 388㎛)

Normal thickness (㎛)	Type	Thickness of each layer (㎛)			Total actual thickness including adhesive layers (㎛)
		PPS	PET	PPS	
# 50	U	16	12	16	58
# 75	U	12	50	12	88
#100	U	12	75	12	113
#130	U	16	100	16	146
#150	U	16	125	16	171
#220	U	16	188	16	234
#240	U	16	210	16	256
#280	U	16	250	16	296
#330	U	16	300	16	346
#380	U	16	350	16	388