UBE NYLON

EXTRUSION APPLICATION

UBE INDUSTRIES,LTD.

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Introduction

Responsible for a long line of accomplishments in outstanding engineering plastics,
UBE NYLON products have won the trust and respect of users the world over.
UBE NYLON – NYLON 6, NYLON COPOLYMERS –
is in wide use throughout industry with their unique properties utilized to their fullest potential.

UBE NYLON 6 has a number of excellent properties as follows:

- ◆ **Excellent in impact strength and rigidity**
- ◆ **Having a smaller friction coefficient, thus excellent in abrasion resistance**
- ◆ **Excellent in resistance to oils, solvents and chemicals**
- ◆ **Superior in heat resistance**
- ◆ **Appropriate to mass production, contributing to cost reduction**

Summary

1. Introduction
2. Nomenclature
3. Monofilament Applications
4. Film Applications
5. TERPALEX
   Polyamide 6/66/12 Copolymer

Nomenclature

The first 2 digits in the code indicate the type of Polyamide.

10: Polyamide 6 homopolymer
50: Polyamide 6/66 copolymer
70: Polyamide 6/12 copolymer

The third and fourth digits indicate the molecular weight level for 1000 series. In case of copolymer, the third digit shows the viscosity level. The co-polymerization ratio can be roughly calculated from the fourth digit multiplying by 5.

Ex. **1022FDX04**: Polyamide 6 homopolymer
→ **MW**: c.a. 22 x 1,000 = 22,000

Ex. **5034MTX1**: Polyamide 6/66 copolymer
→ **MW**: level = 3 (high viscosity)
→ **PA6/66**: c.a. 80/20 (4 x 5 = 20et%)
→ **M**: monomer-contain type

"T" means the basic grade for monofilament application and the grade contain some additives for maintain good process stability and high transparency. In case of "MT", means monomer containing grade offering good flexibility and softness.

Grade list

Grade	Specialties	Applications
1022T	Medium viscosity Polyamide 6 homopolymer	Fishing net, small size monofilament General application
1022MT2	Monomer containing type of 1022T	Fishing net, small size monofilament requiring softness applications
5021T	Medium viscosity, Polyamide 6/66 copolymer High knot strength (for Knot improvement) Softness is similar to 1022MT2 (At the heat setting of the net, higher shrink ratio than PA6 may be expected)	Fishing net, small - medium size monofilament General application
5033TX7	High viscosity, Polyamide 6/66 copolymer High transparency and tenacity Higher drawing ratio can be achieved for superior line strength	Small – medium size sports fishing line
5034TX18	High viscosity, Polyamide 6/66 copolymer Higher transparency and softness than 5033TX7 High tenacity	Small size sports fishing line and long line (main line)
5034MTX1	Monomer containing type of 5034TX18 High softness	All size of sports fishing line, trimmer line and long line (main line) requiring softness applications
5034MTAX1	Excellent transparency and softness Specially developed for very big size diameter (over 2mm in diameter)	Applications requiring large diameter and high transparency Suitable for over 2mm diamater (main line of long line)
7034T	High viscosity, Polyamide 6/12 copolymer High stretch-ability result higher line strength than 50 series Lower moisture absorption keeps superior physical property even in water	All size of sports fishing line and long line (branch line) Appearance of filament shows a “brilliant crystal tone” and highly reputed for branch line application

Basic property

Item	Type	Melting point (℃)	Relative Viscosity	
			98% H_2SO_4	96% H_2SO_4
1022T	PA6	220	3.60	3.37
1022MT2		216	3.52	3.30
5021T	PA6/66	204	3.25	3.06
5033TX7		196	4.40	4.05
5034TX18		191	4.40	4.05
5034MTX1		190	4.25	3.92
5034MTAX1		190	4.25	3.92
7034T	PA6/12	201	4.10	3.87

Flow property at 260℃

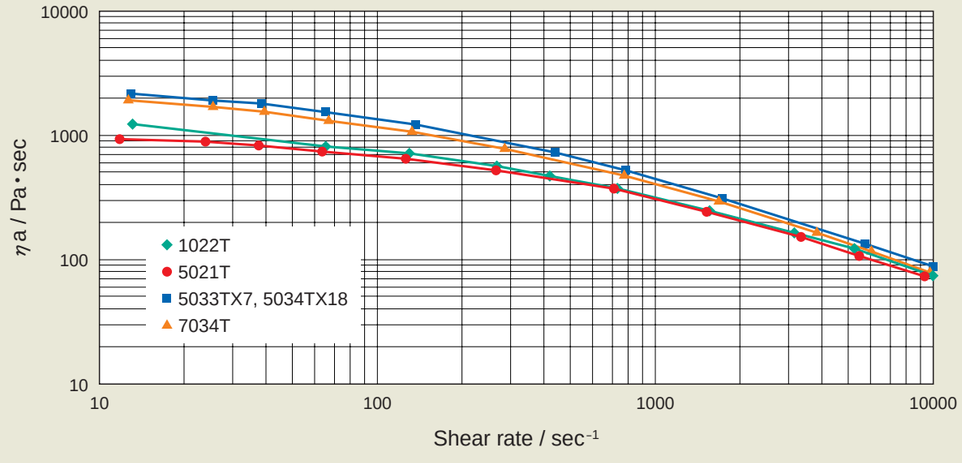


*Diagram just for reference. Please refer to technical brochure of products for detailed data.

Processing condition

Typical processing condition of 1022, 5021, 5033 and 5034 series. (Small diameter)

Item	Grade		1022T	5021, 5033, 5034
	Monofilament diameter (mm)		0.4	0.4
Extruder	Nozzle diameter (mm)		2.0	2.0
	Temperature (℃)	C1	210 – 240	210 – 240
		C2	240 – 260	240 – 260
		C3	250 – 270	250 – 270
		AD	260 – 280	250 – 270
		D	250 – 270	240 – 260
Quenching bath temperature (℃)			5 – 10	5 – 10
Drawing	Drawing Ratio	1st (G2/G1)	3.0 – 4.0	3.0 – 4.0
		2nd (G3/G2)	1.1 – 1.7	1.1 – 1.7
		Total (G3/G1)	4.5 – 5.5	4.5 – 5.5
	Temperature (℃)	1st (Hot water / Steam)	95/100	95/100
		2nd (Hot air)	200	200
Heat setting	Relaxation ratio		0.90 – 0.98	0.90 – 0.98
	Temperature (℃)		200 – 220 Hot air	200 – 220 Hot air
Line speed (m / min.)		G3	100	100

Typical processing condition of 5033, 5034 and 7034 series. (Large diameter)

Item	Grade		5033, 5034	7034
	Monofilament diameter (mm)		2.0	2.0
Extruder	Nozzle diameter (mm)		6.0	6.0
	Temperature (℃)	C1	210 – 240	210 – 240
		C2	240 – 260	240 – 260
		C3	250 – 280	250 – 280
		AD	250 – 280	250 – 280
		D	230 – 270	230 – 270
Quenching bath temperature (℃)			5 – 10	5 – 10
Drawing	Drawing Ratio	1st (G2/G1)	3.0 – 4.0	3.0 – 4.0
		2nd (G3/G2)	1.1 – 1.7	1.1 – 1.7
		Total (G3/G1)	4.5 – 6.0	4.5 – 6.5
	Temperature (℃)	1st (Hot water / Steam)	85 – 95/105	85 – 95/105
		2nd (Hot air)	200	200
Heat setting	Relaxation ratio		0.90 – 0.98	0.90 – 0.98
	Temperature (℃)		200 – 220 Hot air	200 – 220 Hot air
Line speed (m / min.)		G3	40	40

Properties

Application type			Small size diameter					Large size diameter				
Polymer type			Polyamide 6		Polyamide 6/66			Polyamide 6/66				Polyamide 6/12
Grade		Unit	1022T	1022MT2	5021T	5033TX7	5034TX18	5033TX7	5034TX18	5034MTX1	5034MTAX1	7034T
Physical properties												
Monofilament diameter (mm)			0.4					2.0				
Drawing Ratio (G3/G1)			5.5					5.5				6.0
Denier		d	1,355	1,340	1,337	1,342	1,328	34,800	34,800	34,800	34,900	34,200
Line	Strength	g/d	9.2	8.5	8.4	8.2	8.1	6.5	6.2	5.8	5.9	6.8
	Tenacity	Kg	12.5	11.3	11.2	11.0	10.8	225	215	201	205	232
	Elongation	%	26	25	29	31	32	34	36	36	37	35
Tensile modulus		g/d	30	23	27	18	18	14	14	8	8	13
Knot	Strength	g/d	4.5	4.1	6.9	7.4	7.4	3.6	3.6	3.7	3.9	4.0
	Tenacity	Kg	6.1	5.5	9.3	10.0	9.8	125	124	128	136	136
	Elongation	%	15	13	23	30	29	31	31	33	36	30

Grade list

UBE NYLON 1000 Series

Grade	Specialties	Processing	Applications
1022B	Standard Polyamide 6 Medium viscosity	Best for T-die	General applications
1030B	Standard Polyamide 6 High viscosity	Best for T-die	General applications
1022FDX99	Nucleated (Medium viscosity)	Best for T-die Suitable for air cooled blown	General applications
1022FD14	Low COF Excellent processing stability	Best for BOPA	BOPA film
1022FD12	Low COF	Best for water cooled blown	General applications
1022C2	Excellent gas barrier property Superior heat resistance	Best for T-die	Heavy duty bagss Thermoforming

UBE NYLON 5000 Series

Grade	Specialties	Processing	Applications
5033B **5034B**	Standard Polyamide 6/66 Medium shrink, low slip	Best for middle layer usage in T-die, air cooled blown	Top web Thermoforming
5034FDX17	Special grade for Air blown Low curl, High shrink High transparency Good thermoform ability	Best for air cooled blown	Pouch Thermoforming
5034FDX40	High transparency Low neck-in Nucleated type	Best for air cooled blown Suitable for T-die	Shrink bags Pouch
5033FDX27	High slip type Medium shrink	Suitable for T-die and air cooled blown	Sausage casings Big bag
5033FDX57	High transparency High gloss, softness/shrink	Best for water cooled blown	Sausage casings Shrink package
5023FDX21	Low COF Good Transparency	Best for water cooled blown	General application
5034C2	Excellent gas barrier property	Best for air cooled blown and T-die	Thermoforming, Vacuum package

UBE Nylon 7000 Series

Grade	Specialties	Processing	Applications
7024B **7034B**	High transparency Good thermoform ability Low W.V.T.R.* High shrink-ability Low extrusion temperature	Best match for co-extrusion with EVOH resins in air cooled blown Flavor barrier (compared with HDPE)	Form-fill-seal (Air blown) Cereal packages

UBE NYLON Special Grade

Grade	Specialties	Processing	Applications
3030XA	Standard Polyamide 12 High viscosity Low W.V.T.R.	Best for T-die and water cooled blown	General applications
NRR102	High retort treatment	Best for T-die and water cooled blown	Retort packaging

*W.V.T.R: Water Vapor Transmission Rate

Basic property

Grade	Type	Tm (℃)	Relative Viscosity	
			98% H_2SO_4	96% H_2SO_4
1022B	PA6	220	3.60	3.37
1030B		220	4.40	4.08
1022FDX99		220	3.60	3.37
1022FD14		220	3.60	3.37
1022FD12		220	3.60	3.37
1022C2		220	3.80	3.54
5033B	PA6/66	196	4.40	4.08
5034B		192	4.40	4.08
5034FDX17		192(*)	4.40(*)	4.08(*)
5034FDX40		192	4.40	4.08
5033FDX27		196	4.30	3.93
5033FDX57		196	4.40	4.08
5023FDX21		196	3.83	3.55
5034C2		192	3.60	3.36
7024B	PA6/12	200	2.80	2.63
7034B		200	4.10	3.80
3030XA	Special Grade	178	2.85	2.27
NRR102		220	3.60	3.37

(*) : Value of base polymer

Flow property at 260℃

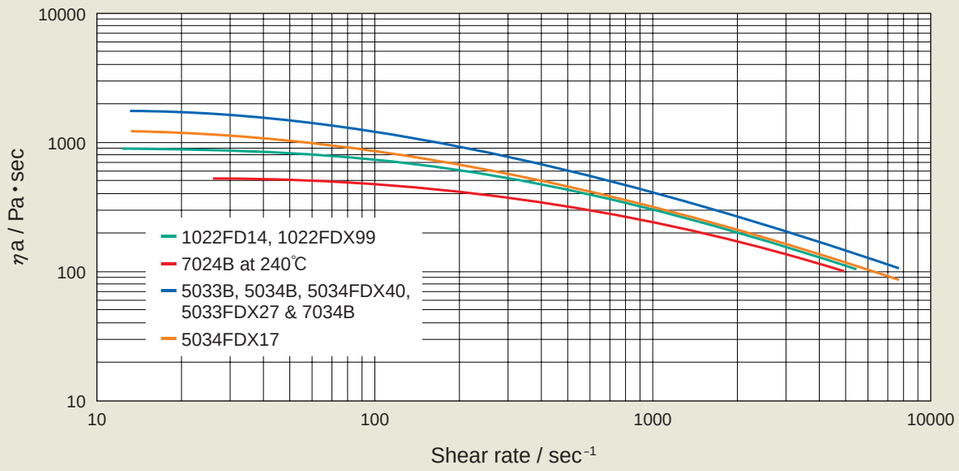


*Diagram just for reference. If more information is needed, please refer to the technical brochure of each grade.

Processing condition

Typical processing conditions for film application.

	1000 series	5000 series	7000 series
C_1	200 – 220	190 – 210	190 – 200
C_2	210 – 230	220 – 230	200 – 210
C_3	230 – 240	230 – 240	210 – 220
C_4	240 – 250	230 –240	220 – 240
AD	250 – 260	240 – 250	230 – 250
CF	250 – 260	240 – 250	230 – 250
D1 – D4	250 – 260	240 – 250	230 – 250

Manufacturing process

Nylon films can be distinguished between oriented and unoriented film in terms of the film shape.
Besides, the manufacturing process of the films can be divided into casting process (T-die casting method)and blown process (Ring die method), furthermore, the latter one into water-cooling and air-cooling method.
In manufacturing of the Nylon film, it is very important to select the grade most suitable for the processing method.
The table below shows the correlation between UBE NYLON film grades and the different processes.

Manufacturing process

Manufacturing process			UBE NYLON film grades		
			PA6	PA6/66	PA6/12
Casting process		Unoriented	1022B 1030B 1022FDX99 1022C2	5033B 5034B 5033FDX27 5034FDX40 5034C2	
		Oriented	1022FD14		
Blown process	Air cooled		1022FDX99	5033B 5034B 5033FDX27 5034FDX17 5034FDX40 5034C2	7024B 7034B
	Water cooled	Unoriented	1022FD14 1022C2	5033FDX27 5033FDX57	
		Oriented	1022FD14	5033FDX57	

Properties of T-die cast film

Polymer type				**Polyamide 6**				**Polyamide 6/66**					
Property		Unit	Specification	Natural		Nucleated	Barrier	Natural			Nucleated	Slip	Special
				Medium viscosity	High viscosity			High Viscosity					Low curl
				1022B	**1030B**	**1022FDX99**	**1022C2**	**5033B**	**5034B**	**5033FDX57**	**5034FDX40**	**5033FDX27**	**5034FDX17**
Mechanical property	Data of T-die cast film (Chillroll 50℃)												
Tensile strength at yield		MPa	ASTM D-882	30 – 32	30 – 32	30 – 32	36 – 38	22 – 24	22 – 24	22 – 24	22 – 24	22 – 24	25 – 27
Tensile strength at break		MPa		105 – 110	105 – 110	100 – 105	95 – 100	105 – 115	105 – 115	105 – 115	105 – 115	105 – 115	105 – 115
Tensile elongation at break		%		550 – 600	550 – 600	500 – 550	400 – 450	550 – 650	550 – 650	550 – 650	550 – 650	550 – 650	550 – 650
Tensile modulus		GPa		0.60 – 0.65	0.55 – 0.65	0.60 – 0.65	1.00 – 1.05	0.35 – 0.40	0.35 – 0.40	0.35 – 0.40	0.35 – 0.40	0.35 – 0.40	0.50 – 0.55
Piercing strength		N/mm	JAS P-1019	850 – 950	1,000 – 1,100	850 – 950	950 – 1,050	900 – 1,000	900 – 1,000	900 – 1,000	850 – 950	850 – 950	850 – 950
Piercing elongation		mm		13 – 14	14 – 15	13 – 14	11 – 12	14 – 15	14 – 15	14 – 15	14 – 15	14 – 15	14 – 15
Flex crack resistance (Gelbo test)	23℃, 1000cycle	holes/0.04m^2	Mil B-131C	< 15	< 15	< 15	< 30	< 5	< 5	< 5	< 10	< 5	< 10
	5℃, 100cycle			< 5	< 5	< 5	< 15	< 5	< 5	< 5	< 10	< 5	< 10
Optical properties													
Haze		%	ASTM D-1003	0.5	0.5	0.5	1.5	< 0.5	< 0.5	< 0.5	< 0.5	3.5	3.0
Gloss		%	ASTM D-523	155	155	155	140	155	155	155	155	130	135
Gas permeability													
Oxygen		ml/m^2 day	ASTM D-3985	40 – 42	40 – 42	40 – 42	24 – 26	40 – 43	40 – 43	40 – 43	40 – 43	40 – 43	37 – 39
Water Vapor Transmission Rate		g/m^2 day	JIS Z-0208	120 – 130	120 – 130	120 – 130	60 – 70	125 – 135	125 – 135	125 – 135	125 – 135	115 – 125	90 – 100
Electrical properties													
Surface resistivity		ohm	UBE method	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}	> 1.0 x 10^{15}
Other properties													
Coefficient of friction (Static)		—	ASTM D-1894	> 1.0	> 1.0	> 1.0	0.3 – 0.4	> 1.0	> 1.0	> 1.0	> 1.0	0.3 – 0.4	0.3 – 0.4
Coefficient of friction (Dynamic)		—		> 1.0	> 1.0	> 1.0	0.3 – 0.4	> 1.0	> 1.0	> 1.0	> 1.0	0.3 – 0.4	0.3 – 0.4
Regulation	# ; Approval for direct contact with food $; Approval for indirect contact with food O ; Contact us												
FDA			—	#	#	#	O	$	$	$	$	$	$
EU-Directive			—	#	#	#	#	#	#	#	#	#	#

Properties of T-die cast film

Polymer type				Polyamide 6/12	
Property		Unit	Specification	Natural	
				Medium viscosity	High viscosity
				7024B	**7034B**
Mechanical property Data of T-die cast film (Chillroll 50℃)					
Tensile strength at yield		MPa	ASTM D-882	22 – 24	22 – 24
Tensile strength at break		MPa		95 – 105	95 – 105
Tensile elongation at break		%		550 – 650	550 – 650
Tensile modulus		GPa		0.40 – 0.45	0.40 – 0.45
Piercing strength		N/mm	JAS P-1019	800 – 900	800 – 900
Piercing elongation		mm		14 – 15	14 – 15
Flex crack resistance (Gelbo test)	23℃, 1000cycle	holes/0.04m^2	Mil B-131C	< 20	< 20
	5℃, 100cycle			< 10	< 10
Optical properties					
Haze		%	ASTM D-1003	1.0	1.0
Gloss		%	ASTM D-523	155	155
Gas permeability					
Oxygen		ml/m^2 day	ASTM D-3985	90 – 100	90 – 100
Water Vapor Transmission Rate		g/m^2 day	JIS Z-0208	80 – 90	80 – 90
Electrical properties					
Surface resistivity		ohm	UBE method	> 1.0 x 10^{15}	> 1.0 x 10^{15}
Other properties					
Coefficient of friction (Static)		—	ASTM D-1894	> 1.0	> 1.0
Coefficient of friction (Dynamic)		—		> 1.0	> 1.0
Regulation # ; Approval for direct contact with food $; Approval for indirect contact with food O ; Contact us					
FDA			—	$	$
EU-Directive			—	#	#

Polymer type				Polyamide 12
Property		Unit	Specification	Natural
				3030XA
Mechanical property Data of T-die cast film (Chillroll 50℃)				
Tensile strength at yield		MPa	ASTM D-882	33 – 35
Tensile strength at break		MPa		85 – 95
Tensile elongation at break		%		400 – 450
Tensile modulus		GPa		0.75 – 0.80
Piercing strength		N/mm	JAS P-1019	800 – 900
Piercing elongation		mm		11 – 12
Flex crack resistance (Gelbo test)	23℃, 1000cycle	holes/0.04m^2	Mil B-131C	< 15
	5℃, 100cycle			< 1
Optical properties				
Haze		%	ASTM D-1003	0.5
Gloss		%	ASTM D-523	155
Gas permeability				
Oxygen		ml/m^2 day	ASTM D-3985	1,000 – 1,100
Water Vapor Transmission Rate		g/m^2 day	JIS Z-0208	45 – 55
Electrical properties				
Surface resistivity		ohm	UBE method	> 1.0 x 10^{15}
Other properties				
Coefficient of friction (Static)		—	ASTM D-1894	> 1.0
Coefficient of friction (Dynamic)		—		> 1.0
Regulation # ; Approval for direct contact with food $; Approval for indirect contact with food O ; Contact us				
FDA			—	#
EU-Directive			—	#

Approval:
UBE's film grades were originally developed for food packaging film. Please consult your sales representative as to whether each grade conforms to a country's food hygiene regulation.

TERPALEX is a newly developed special copolymer which is composed of three polyamides monomer ingredients, PA 6, PA 66 and PA 12.
By ternary copolymerization, TERPALEX has lower crystalinity (lower MP) in comparison with current copolymers.

General features (for monofilament applications)

- ◆ Excellent transparency
- ◆ Softness
- ◆ Good stretching performance
- ◆ High mechanical property
- ◆ Suitable for big size (diameter) applications
- ◆ Wider processing range

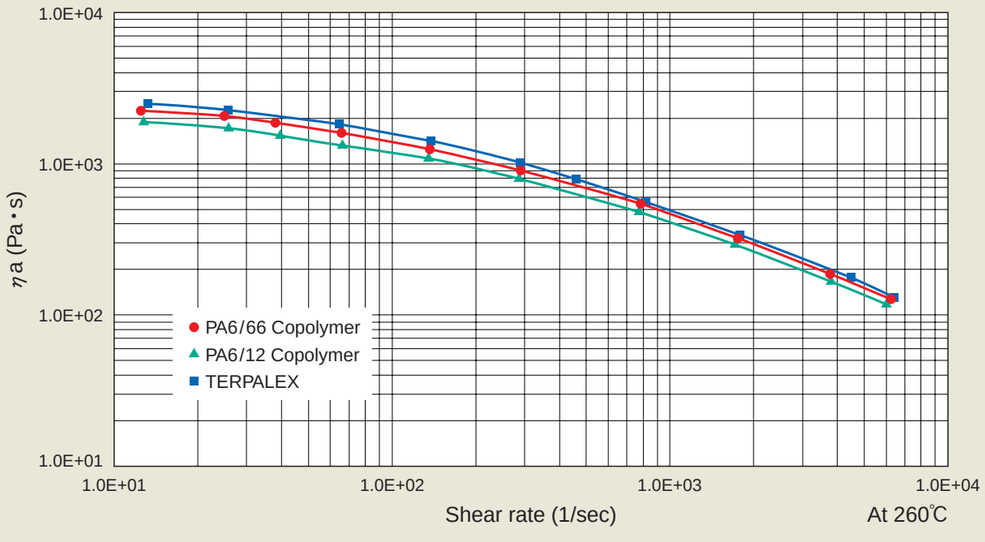
General features (for film applications)

- ◆ Excellent transparency
- ◆ Higher shrinkage ratio
- ◆ Improved deep draw ability
- ◆ Good pin-hole resistance
- ◆ Most suitable for co-extrusion with EVOH

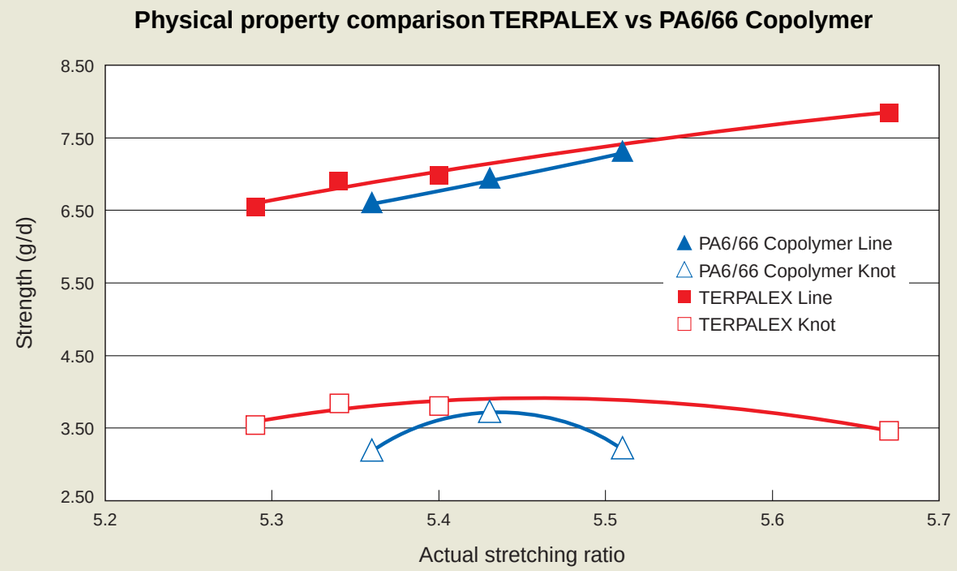
Basic property

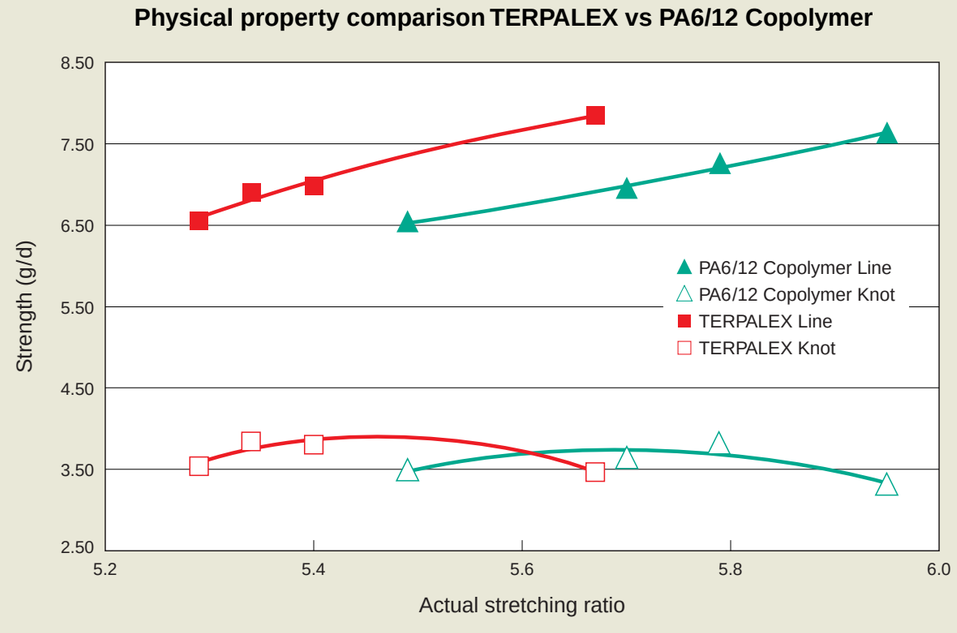
Item	Unit	TERPALEX	PA6/66 Copolymer	PA6/12 Copolymer
Relative Viscosity 96% H_2SO_4	—	4.05	4.05	3.87
Moisture content	%	< 0.1	< 0.1	< 0.1
Melting Point	℃	190	191	199
Extractable	%	< 1.0	< 1.0	< 1.0

Flow property



Monofilament data





Film data

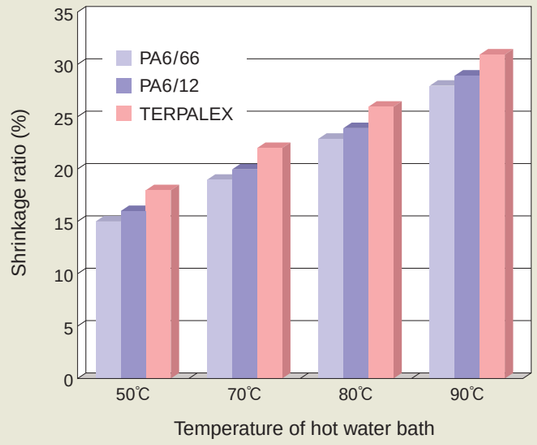
Physical property & Pin-hole resistance

T-die Cast mono-layer film / 30 microns

Item	Unit	Method ASTM	TERPALEX	PA6/66 Copolymer	PA6/12 Copolymer
Tensile strength	Mpa	D882	100	105	95
Tensile modulus			560	600	700
Flex crack resistance @23℃/1000 cycle	Holes/0.04m^2	MIL B-131C	< 10	< 10	< 20
@0℃/200 cycle			< 15	< 15	< 20
@0℃/200 cycle After heat treatment*			60	70	80

* Film samples were exposed at 80 deg. C for 48hrs

Shrinkage property



● **Test conditions**
Film: T-die cast film / 100 microns
Stretching ratio: 3.0 x 3.0
Stretching temp: 80℃
Test procedures: Biaxialliy oriented film soaked in hot water for 1 min. and then conditioned at room temperature for 24 hrs.

Thermoforming property

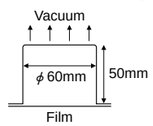
Depth at thermoforming test (unit: mm)

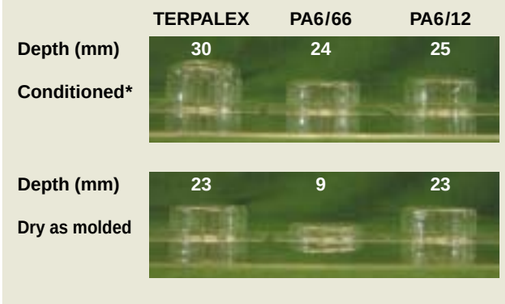
Item	Conditioned*	Dry as molded
PA6/12	25	23
PA6/66	24	9
TERPALEX	30	23

* Before thermoforming, sample was conditioned at 23℃ 50%RH

● **Test conditions**
【Deep-drawing condition】
Film: T-die cast
Film thickness: 100μ
Heating temp.: 80℃
Heating time: 2 min.
Vacuum: 20 mmHg

【Dimension of mold】





* Before thermoforming, sample was conditioned at 23℃ 50%RH

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