



HUNTSMAN

Enriching lives through innovation

Stretching the possibilities

**TPU elastomers
for Film & Sheet
applications**

Experts in elastomers

Our polyurethanes business division is a leading developer of polyurethane (PU) and thermoplastic polyurethane (TPU) materials. Combining global reach with decades of experience in material innovation, we are experts in urethane-based elastomers and have in-depth knowledge of their application across a vast range of industries.

A flexible partner for Film & Sheet producers

As a leading global producer of TPU elastomers for the film and sheet industry, we've developed a comprehensive range of TPU grades that can be customized for a variety of commercial, consumer and industrial film and sheet applications.

From textiles, construction and transport applications, to the manufacture of consumer goods, our TPU grades of film and sheet elastomers have broad functionality with flexible design capabilities.





Trusted brands to inspire innovation

We offer a portfolio of TPU elastomers for the film and sheet industry, which includes a variety of aromatic and aliphatic backbones, combined with polyester, polyether and polycaprolactone polyols.

TPUs with aromatic backbone

- Used in applications that require flexibility, strength and toughness
- Good processability.

TPUs with aliphatic backbone

- Intrinsically resistant to UV light
- No yellowing even in outdoor conditions
- Excellent optical clarity.



Ester-based TPUs

- Good resistance to oils and chemicals
- Excellent abrasion and wear resistance
- High mechanical properties including high tear resistance
- High thermal resistance
- Compatible with PVC and other polar polymers.

Ether-based TPUs

- Excellent hydrolysis resistance, particularly at elevated temperatures
- Excellent low temperature properties
- High dynamic flexibility
- Resistance to microbial attack
- Specific gravity slightly lower than polyester grades.

Benefits:

- Durability
- High abrasion resistance
- High elasticity across the entire hardness range
- Good flexibility over a wide temperature range
- Excellent impact strength at low temperatures
- Resistance to oils, grease and numerous chemicals
- Pleasant haptics
- Easy to color
- Intrinsically recyclable.

Barrier films

Our IROGRAN® E and PS (ester-based) and IROGRAN® P (ether-based) TPU grades are frequently used in barrier type structures for containment applications. An excellent choice for barrier and wear layer films or sheets, these TPU elastomers can offer high durability, and puncture, abrasion and tear resistance, alongside soft, elastic properties.

Typical applications:

- Breathable roofing membranes
- Breathable performance textiles
- Lumbar support for automotive seating
- Inflatables
- Cure-in-place pipe (CIPP) liners
- Coated textiles
- Protective clothing and life vests
- Waterproof apparel
- Containment liners and water tanks
- Bladders for sports and automotive applications
- Air mattresses and mattress covers.

Benefits:

- Tunable breathability
- Weathering, oil and chemical resistance
- Antimicrobial.



Adhesive films

Our IROGRAN® CA and PS, and IROSTIC® M ester-based TPUs for adhesive film applications provide a solvent-free, environmentally friendly, permanent thermo-bonding solution that enables new design and performance possibilities.

Typical applications:

- Adhesive applications in footwear
- Seam sealing tapes for waterproofing apparel
- Stitch-free and seamless lingerie
- Emblems and labels
- Laminated fabrics
- Composite wood panel to plastics lamination for furniture.

Benefits:

- A broad range of melting points to suit each application
- Fast crystallization rate
- Good resistance to washing agents
- Excellent adhesion to different substrates
- High elastic recovery combined with a soft touch.



Surface protection

Our aliphatic KRYSTALGRAN® TPU film and sheet grades are a reliable and robust surface protection solution for applications where excellent durability, abrasion and scratch resistance, and strict outdoor UV protection is required.

Suitable for use in a wide range of sectors, our KRYSTALGRAN® TPUs are commonly used in OEM and after-market automotive and aerospace paint protection projects.

Typical applications:

- Paint protection films for susceptible vehicle components such as wheel arches
- Laminated flooring topcoat
- Leading edge protection for helicopter and wind turbine blades
- Graphic films, signs and labels
- Textile coatings
- Electronic screen protection
- Synthetic leather.

Benefits:

- Transparency
- Intrinsic outdoor UV resistance
- Weathering and chemical resistance
- Abrasion and scratch resistance.



Specialty TPUs

Within our diverse portfolio of TPU products, we offer specialty elastomer grades for established and emerging applications that are tunable to achieve specific performance traits for your film and sheet application.

Our range of available TPU grades can be produced under good manufacturing practice (GMP) conditions to meet FDA / FCM requirements for food contact applications and NSF / KTW certification standards for potable water applications.

For the textile industry, we have a team of experts that can help choose OEKO-TEX® or blue sign® compatible grades, which can be used for direct skin contact applications.

We also provide products that offer:

- Flame retardancy (e.g. UL 94 V0)
- Antistatic properties
- A matt finish.

For safety glazing applications, we have also developed a range of finished KRYSTALFLEX® TPU films, which are available in a variety of thicknesses and roll widths. These films are used in complex laminated glazing projects for aerospace, rail, military and bulletproof applications.

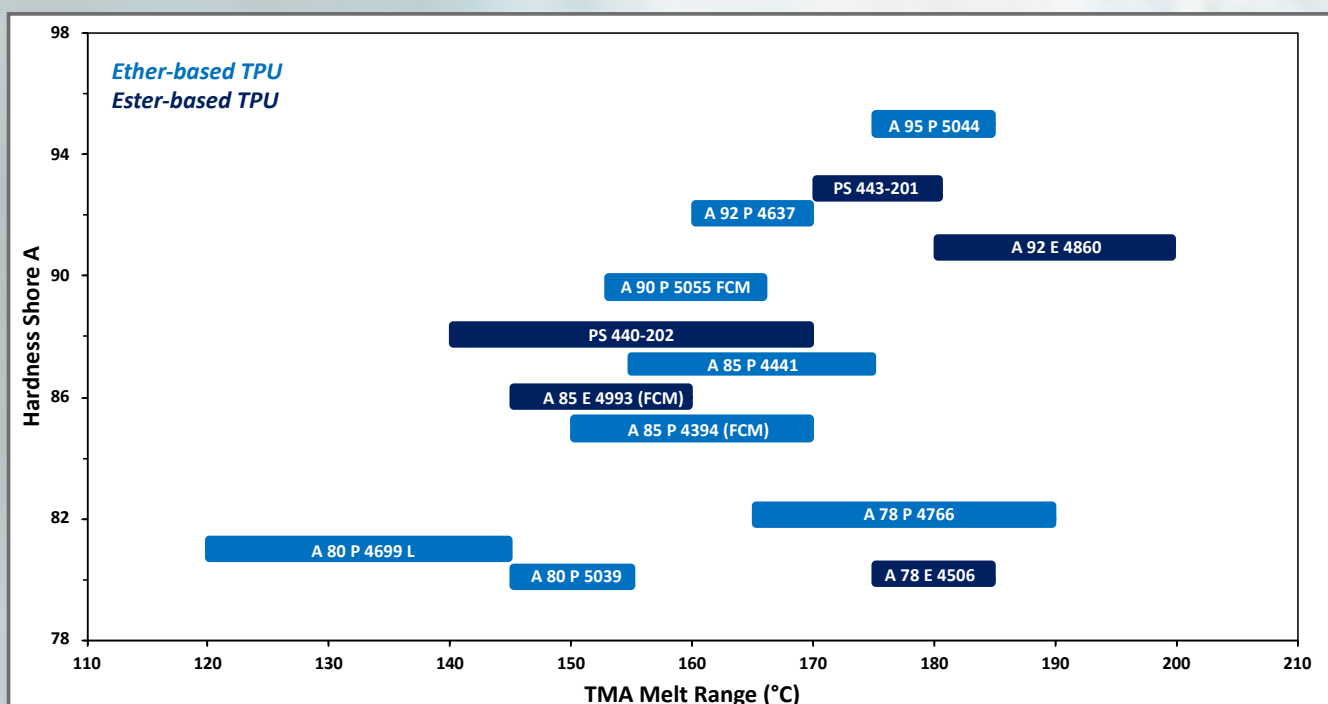


IROGRAN® TPUs:

Key products for barrier films



Physical properties	Norm	Unit	A 80 P 5039	A 80 P 4699L	A 78 P 4766	A 85 P 4394	A 85 P 4441	A 90 P 5055 FCM	A 92 P 4637	A 95 P 5044	A 78 E 4506	A 85 E 4993	PS 440-202	A 92 E 4860	PS 443-201
			IROGRAN® ether-based								IROGRAN® ester-based				
GENERAL															
Hardness	ISO 7619	Shore A	80	81	82	85	87	88	92	95	80	86	88	91	93
Hardness	ISO 7619	Shore D	29	31	30	36	38	34	39	48	30	36	38	42	48
Density	ISO 1183-1	g/cm³	1,1	1,09	1,16	1,12	1,11	1,12	1,13	1,14	1,17	1,21	1,21	1,20	1,22
MECHANICAL															
Tensile strength	DIN 53504	MPa	32	30	30	45	40	30	45	55	50	35	48	49	52
Elongation @ break	DIN 53504	%	720	750	700	640	650	600	600	500	700	600	650	600	430
Tensile stress @ 100% elongation	DIN 53504	MPa	4,6	5,7	5,2	7	7,3	7	9,1	12,3	4,4	5,9	5,6	7,5	12
Tensile stress @ 300% elongation	DIN 53504	MPa	8,7	8,4	8	12	11	11	15,9	30,7	8,5	11,2	10	16	34
Tear strength	ISO 34-1	N/mm	45	45	40	60	60	60	74	90	60	65	62	85	130
Compression set 70h @ 23°C	ISO 815	%	23	24	20	20	24	25	25	-	21	25	30	25	-
Compression set 24h @ 70°C	ISO 815	%	43	46	36	40	42	45	41	-	36	50	80	39	-
Abrasion	ISO 4649	mm³	30	50	40	25	35	35	30	30	25	25	30	30	36
THERMAL															
TMA low melt range	Huntsman	°C	145	125	165	150	155	150	160	175	175	145	142	180	169
TMA high melt range	Huntsman	°C	155	150	190	170	175	170	170	187	185	160	170	200	181
OTHER FEATURES															
Transparency			x			x			x	x		x			
High crystallinity					x						x		x	x	
Matt finish				x			x								
Available as food contact grade			x			x	x	x				x			
Processable by blown-film extrusion				x		x	x		x		x		x		

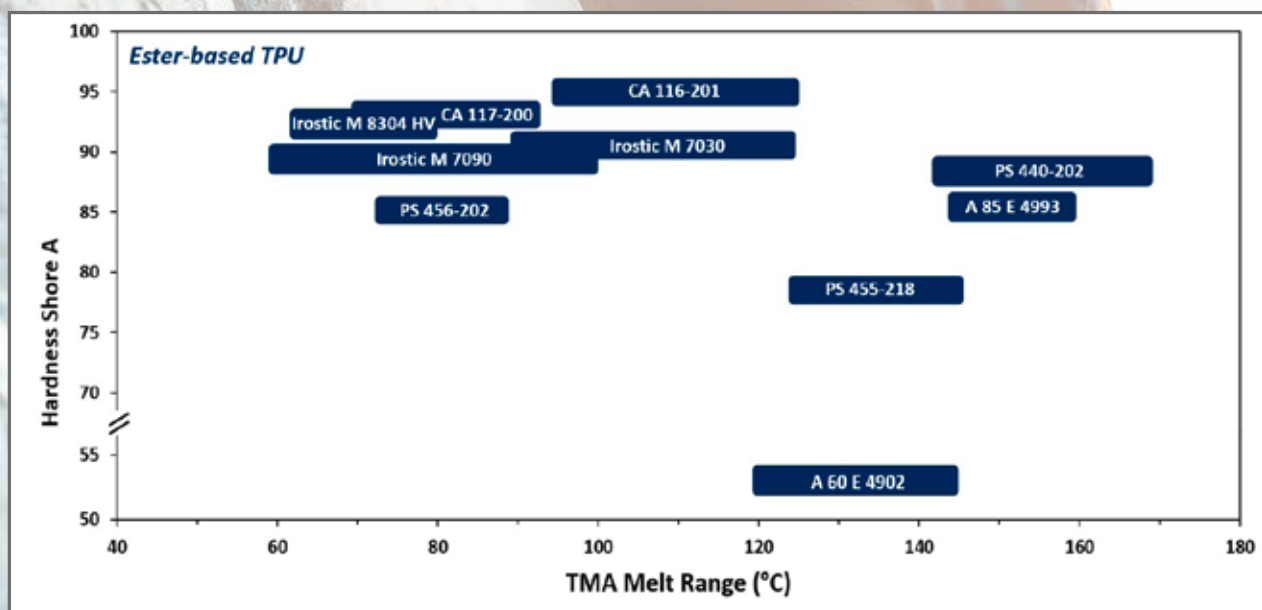


IROGRAN® and IROSTIC® TPU: Key products for adhesive films



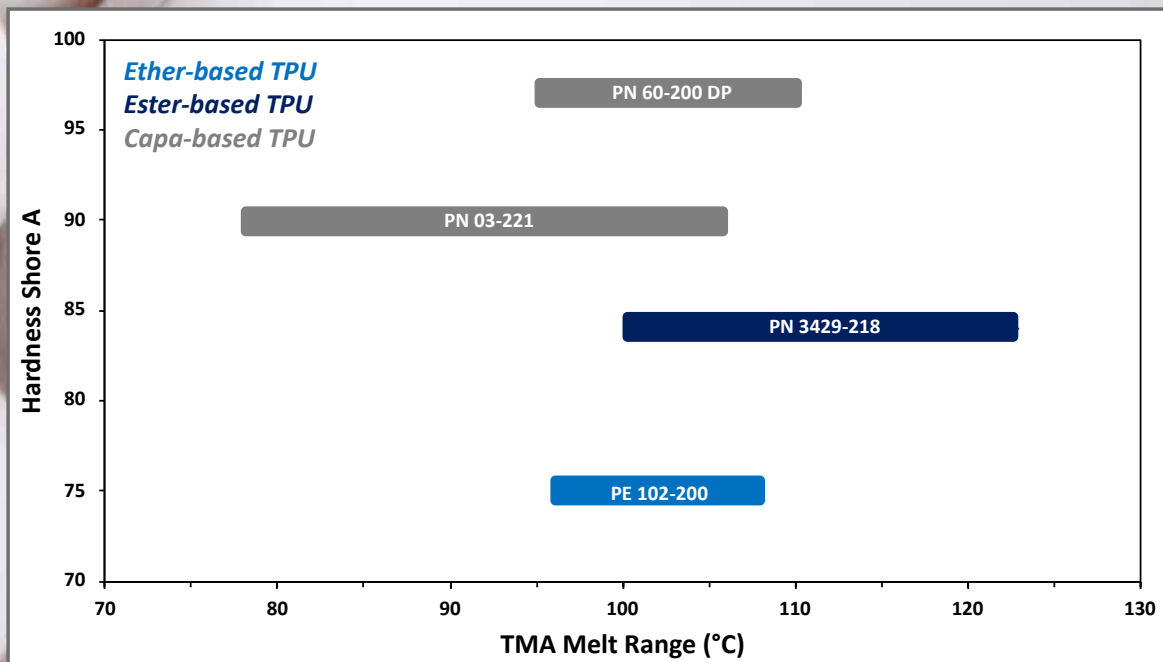
Physical properties	Norm	Unit	A 60 E 4902*	PS 455-218	PS 456-202	A 85 E 4993	PS 440-202	CA 117-200	CA 116-201	M 7030	M 7090	M 8304 HV
			IROGRAN® ester-based						IROSTIC® ester-based			
GENERAL												
Hardness	ISO 7619	Shore A	55	75	85	86	88	93	95	90	93	95
Hardness	ISO 7619	Shore D	15	29	36	36	-	50	49	45	46	46
Density	ISO 1183-1	g/cm ³	1,14	1,18	1,19	1,21	1,21	1,15	1,16	1,16	1,16	1,12
MECHANICAL												
Tensile strength	DIN 53504	MPa	10	39	19	35	48	20	33	23	19	18
Elongation @ break	DIN 53504	%	860	580	710	600	650	660	400	410	461	550
Tensile stress @ 100% elongation	DIN 53504	MPa	1,4	3,8	2	5,9	5,6	6,2	9	-	-	-
Tensile stress @ 300% elongation	DIN 53504	MPa	2,4	9,2	4	11,2	10	6,8	6,5	-	-	-
Tear strength	ISO 34-1	N/mm	23	73	46	65	62	87	75	-	-	-
Compression set 70h @ 23°C	ISO 815	%	40	-	-	25	30	-	-	-	-	-
Compression set 24h @ 70°C	ISO 815	%	80	-	-	50	80	-	-	-	-	-
Abrasion	ISO 4649	mm ³	75	74	-	25	30	-	-	50	223	61
THERMAL												
TMA low melt range	Huntsman	°C	120	125	73	145	142	71	95	90	75	62
TMA high melt range	Huntsman	°C	145	144	89	160	170	93	124	125	115	80
OTHER FEATURES												
Excellent multi-layer bonding					x			x	x			
Transparency				x		x						
High crystallinity							x					
Available as food contact grade						x						
Processable by blown-film extrusion							x					

* IROGRAN® A 60 E 4902 displays very high elasticity and excellent recovery



KRYSTALGRAN® TPUs: Key products for surface protection films (aliphatic)

Physical properties	Norm	Unit	PE 102-200	PN 3429-218	PN 03-221	PN 60-200 DP
			KRYSTALGRAN®			
			Ether-based	Ester-based	Caprolactone-based	
GENERAL						
Hardness	ISO 7619	Shore A	75	84	90	97
Hardness	ISO 7619	Shore D	32	38	48	56
Density	ISO 1183-1	g/cm ³	1,07	1,17	1,15	1,14
MECHANICAL						
Tensile strength	DIN 53504	MPa	15	58	47	58
Elongation @ break	DIN 53504	%	620	450	390	370
Tensile stress @ 100% elongation	DIN 53504	MPa	5,1	6,8	4,8	15
Tensile stress @ 300% elongation	DIN 53504	MPa	8,6	23	28	43
Tear strength	ISO 34-1	N/mm	58	74	58	114
Compression set 70h @ 23°C	ISO 815	%	19	24	40	75
Compression set 24h @ 70°C	ISO 815	%	90	90	99	97
Abrasion	ISO 4649	mm ³	40	42	-	105
THERMAL						
TMA low melt range	Huntsman	°C	90	100	78	95
TMA high melt range	Huntsman	°C	111	123	106	120
OTHER FEATURES						
Transparency			x	x	x	x



Further technical data about individual products plus best practice advice for handling and processing our elastomers is available by contacting your local sales representative or by visiting our online product finder tool: <http://www.huntsman-tpu.com/>

Handling recommendations

Storage

- Our TPU grades should be stored in cool and dry conditions, if possible at room temperature.
- TPUs are hygroscopic, meaning that dry pellets can absorb up to 1,5 wt. % of moisture relatively quickly if packaging is left open. After use, seal any packaging promptly to protect any remaining material.
- Keep material dry during processing by covering the feed hopper whenever possible.

Drying

- To ensure optimal processing performance, materials must be dried before processing. Water content of the granulate should not exceed 0,02 wt. %.
- Desiccant air dryers, circulating air dryers and vacuum drying ovens can be used to reduce the moisture content of the granulates before processing.
- Drying recommendations depend on the hardness of the resin, chemical structure and drying process. For TPUs with a Shore A above 90, a higher drying temperature is typically required. For drying conditions for specific TPU grades, please refer to the respective technical datasheet.

Coloring & additives

- Our TPU elastomers can be opaque or transparent, depending on their processing route and microstructure. They can be colored using a masterbatch with typical amounts ranging from 1 to 4 wt. %, depending on the thickness of the final product and the pigment concentration in the masterbatch.
- Using an incompatible masterbatch may cause poor pigment dispersion as well as a poor surface finish with surface defects.
- Different types of additives (UV stabilizers, anti-blocking agents, release aids, etc.) can be added to our TPU grades to enhance material properties.
- It is important to ensure that color or additive masterbatches do not contain any moisture. For that reason, masterbatches used during the processing of our TPU grades should be pre-dried appropriately.

Processing advice

We have developed TPU film and sheet materials for special processes including:

- Flat-die or T-die extrusion
- Cast-film extrusion
- Blown-film extrusion
- Laminating and embossing.

Our TPU grades can be extruded either by flat-die extrusion or blown-film extrusion (annular die). Although blown film extrusion is more suitable for the production of very thin films (<20µm), and flat-die extrusion is more suited to sheets (>250µm), both processes can be used to achieve a very broad range of film or sheet thicknesses. With blown films, the addition of anti-blocking agents as well as the use of a carrier (i.e. supporting foil) makes the entire process easier.



Flat-die
extrusion line
(Courtesy of
Breyer)



Blown-film
extrusion line

Global elastomers experts

Committed to customers: We build partnerships with our customers and work across an international network of R&D and manufacturing locations to help solve complex challenges and deliver the highest levels of technical support and customer care.

Committed to quality: Wherever we are, whatever we are doing, we prioritize environmental, health and safety protection, and we are always rigorous about quality control and assurance.

Committed to innovation: We keep pace with the most innovative trends in plastics processing by using the latest equipment and making regular investments in our formulation, manufacturing and R&D capabilities.

Committed to sustainability: We create solutions that contribute to a more sustainable society by helping to conserve energy, preserve natural resources and reduce our overall carbon footprint.



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About Huntsman:

Huntsman Corporation is a publicly traded global manufacturer and marketer of differentiated and specialty chemicals with 2018 revenues of more than \$9 billion. Our chemical products number in the thousands and are sold worldwide to manufacturers serving a broad and diverse range of consumer and industrial end markets. We operate more than 75 manufacturing, R&D and operations facilities in approximately 30 countries and employ approximately 10,000 associates within our four distinct business divisions.

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