

KRATON™ Polymers

Grade Range

KRATON™
Polymers

What are KRATON™ polymers?

Strong, Flexible, Elastic, Versatile.

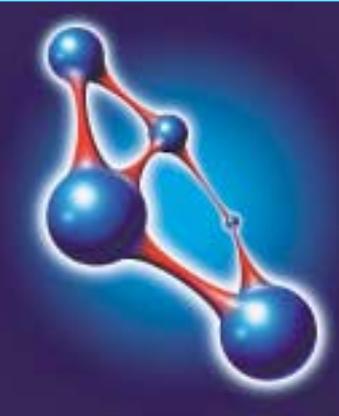
KRATON™ polymers are high performance elastomers engineered for a wide spectrum of end uses. The versatility of KRATON polymers is due to their distinctive molecular structure, which can be precisely controlled and tailored to perform in specific applications.

There are three different families of KRATON polymers (KRATON D, KRATON G and KRATON IR), each of which has its own distinct performance characteristics, which make them particularly well-suited for specific applications. KRATON D and KRATON G are both styrenic block copolymers while KRATON IR constitutes a family of polyisoprene rubbers.

KRATON D and KRATON G polymers are special elastomers that have a combination of high strength and low viscosity for easy thermoplastic processing at elevated temperatures or in solution. Their strength can be equal to that of vulcanized rubber, yet they do not require vulcanisation. They have a Shore A Hardness range of 11-91 and tensile strengths from 1 to 38 MPa.

KRATON IR polymers are special polyisoprene elastomers that can be processed in the same way as Natural Rubber (NR), including vulcanisation. They combine the key qualities of NR such as good mechanical properties, hysteresis and temperature resistance with additional features such as high purity, light colour, good flow or low gel content.

All KRATON polymers are readily dissolved in certain solvents, and remain flexible at temperatures as low as -80°C. Many grades can be used in FDA-regulated products that have contact with food. KRATON D, G and IR polymers are also adaptable to electrical applications, as they can provide good insulation. They are also highly extendible with fillers, resins, and oils which can allow them to be formulated into a wide variety of hardnesses for pressure-sensitive adhesives, sealants, polymer-modified bitumen, or even flexible oil gels. The neat polymer is clear and colourless, and in certain cases remains clear when compounded. It is also highly colourable.



As an additive, KRATON D and KRATON G polymers can help to improve the impact toughness of plastics, the high and low temperature viscosities of motor oils, or the shrink characteristics of polyester thermosets. At higher concentrations, KRATON D, G and IR polymers can also help to improve the flexibility, softness, elasticity, and feel of certain plastics and rubbers.

The versatility of KRATON polymers can be seen in the numerous processing techniques in which they are used: injection moulding, blow moulding, compression moulding, extrusion, calendaring, hot melt, and solution-applied coatings. In all these processes, KRATON D and KRATON G polymers scrap can be reprocessed without losing their physical properties.

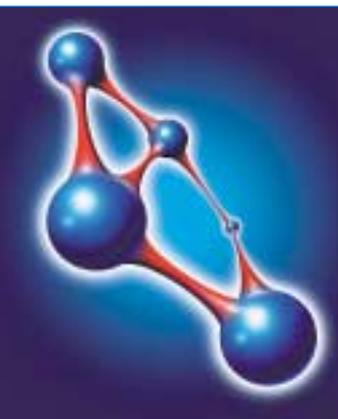
KRATON™ polymers are versatile performers.

KRATON styrenic block copolymers are classified into three categories. Those with an unsaturated rubber mid-block constitute KRATON D polymers, while those with a saturated mid-block make up KRATON G polymers. KRATON IR polymers are polyisoprene elastomers.

Both the D and G series polymers are elastic and flexible. They have a wide range of properties, can be easy to process using thermoplastic processing methods, have good electrical resistance properties, and can be reprocessible.

KRATON G polymers can give the added advantages of increased oxidation and weather resistance, higher service temperatures, and increased processing stability.

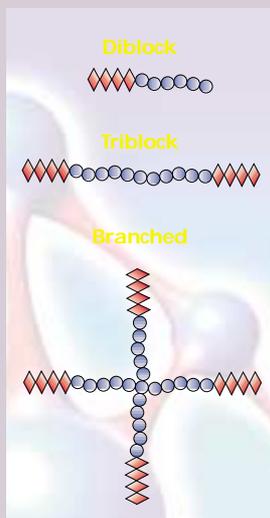
KRATON IR polymers can be used in virtually all segments where NR is traditionally present, while adding value through their unique features. They can also be utilised in applications where NR has never been used, e.g. when high purity and/or well-defined molecular structures are required.



Their unique structure is the essence of KRATON™ polymers' versatility.

The versatility of KRATON polymers stems from the unique molecular structure of the linear homopolymers, linear diblock, triblock, and branched polymers. KRATON IR polymers are linear polyisoprene homopolymers while each molecule of KRATON D and G polymers consists of block segments of styrene monomer units and rubber monomer units. Each block segment in KRATON D and G polymers may consist of 100 monomer units or more. The most common structures are the linear A-B-A block types: styrene-butadiene-styrene (SBS), styrene-isoprene-styrene (SIS), which are KRATON D polymers, and a second generation of the styrene-ethylene/butylene-styrene type (SEBS) or styrene-ethylene/propylene-styrene (SEPS), which are the KRATON G polymers. In addition to the A-B-A type polymers, there are specialized polymers of the branched (A-B)_n type: (styrene-butadiene)_n or (styrene-isoprene)_n, and di-block (A-B) type: styrene-butadiene (SB), styrene-ethylene/propylene (SEP) and styrene-ethylene/butylene (SEB). See Diagram 1.

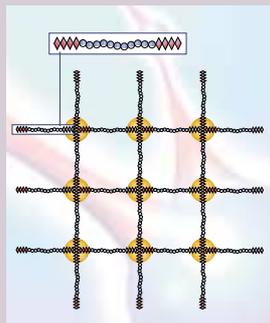
Diagram 1:
Backbone Structures



The A-B-A molecular structure of KRATON polymers has polystyrene end-blocks and an elastomeric mid-block. Prior to processing, the polystyrene end-blocks are associated in rigid domains. "Physical crosslinking" via these domains yields a continuous three-dimensional network. During processing, in the presence of heat and shear or solvent, the polystyrene domains soften and permit flow. After cooling or solvent evaporation, the polystyrene domains reform and harden, locking the rubber network in place. See Diagram 2. This "physical crosslinking" and the reinforcing effect of the styrene domains give KRATON D and KRATON G polymers their high tensile strength. The rubber mid-block gives them their elasticity. Since the "physical crosslinking" is reversible, KRATON D and KRATON G polymers scrap can be reprocessed.

The KRATON D and G polymers diblock is an A-B structure, or di-block of styrene and rubber. This structure can provide unique rheology characteristics in solvents, bitumen, or oils over a broad range of temperatures, balanced adhesive and cohesive strengths, and generally lower viscosity and improved mixability.

Diagram 2: 3D Network

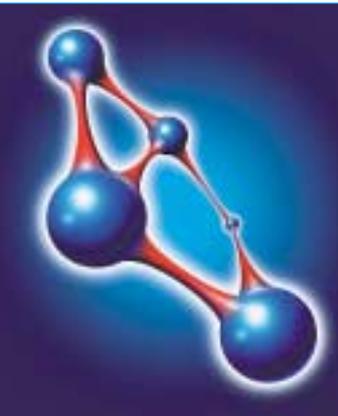


KRATON™ polymers' typical properties

Hardness — In most cases, the degree of “rubberiness” of KRATON D and G polymers is reflected by the Shore Hardness data shown in the charts on pages 5-9. The Shore A can range from 11 to 91 in the various KRATON D polymer and KRATON G polymer grades. The hardness of KRATON IR will also vary to a great extent, as a function of the compound recipe. KRATON IR is usually slightly softer than NR.

Weatherability — KRATON G polymers exhibit good resistance to ozone attack and can typically withstand prolonged outdoor exposure applications.

Chemical Resistance — All KRATON D and KRATON G polymers products have good resistance to water, acids, and bases. Soaking in hydrocarbon solvents and oils will deteriorate both grades; however, short exposures can be tolerated.



KRATON™ polymers selector guide

KRATON D polymer and KRATON G polymer grades are either pure polymer (1000 series) or oil-modified block copolymers (4000 series). These grades are most suitable as performance modifiers in blends with thermoplastics, thermosets and bitumen, for use in general compounding applications, or as the base polymer for adhesive, sealant, or coating formulations.

KRATON IR polymers are also available as either pure polymer or oil-extended polymer. For the pre-selection of KRATON IR polymers, please use the following table. Additional information can be found in the KRATON IR Elastomers Fact Sheet and the four individual Data Sheets.

KRATON IR Polymer Grades

	305	307	309	310
Oil-extended	•		•	
Clear		•		•
High performance	•	•		
Easy processing*			•	•

* lower viscosity

To simplify the selection of either a KRATON D polymer or KRATON G polymer grade, please refer to the series that contains the physical properties best suited for a particular application (as shown on pages 5-9). End-use applications by grade are shown in the table on the right.

End-Use Applications

Series	KRATON™ D Polymer Grades		KRATON™ G Polymer Grades		
	1100	4000 ¹	1600	1700	1900 ²
Pure Polymer For use as a major compounding ingredient or additive					
Modified Bitumen	•	•	•	•	•
Polymer Modification	•	•	•	•	•
Adhesives/Sealants Coatings	•	•	•	•	•
Thermoset Modification	•			•	•
Oil Gels			•	•	
General Elastomer Compounding (including footwear)	•	•	•	•	•

1. Oiled polymer.

2. Functionalized KRATON G polymers, e.g., KRATON FG 1901 polymer.

KRATON™ D – SBS

Grade ¹	D-1101	D-1102	D-1184	D-1186	D-1192	D-4113	D-4153	D-4270	D-4271	D-4272	D-4274
Berre, France ²			•	•	•			•	•	•	•
Pernis, The Netherlands ²			◦	◦							
Wesseling, Germany ²	•	•	•	•		•		◦	◦	◦	◦
Belpre, USA ²	•	•	•	◦		◦					
Kashima, Japan ²	•	•	•	◦		◦		◦	◦	◦	◦
Paulinia, Brazil ²				•			◦	•	◦	◦	•
Type ³	Linear SBS/SB	Linear SBS/SB	Branched (SB) _n /SB	Branched (SB) _n /SB	Linear SBS 40% vinyl	Linear SBS/SB + oil	Linear SBS/SB + oil	Branched (SB) _n /SB + oil			
Polystyrene Content (%)	31	29	30	30	30	35	35	32	45	53	49
Total Extractables (%)	<1	<1	<1	<1	<1	32.0	30.5	31.5	34.0	28.5	31.0
Diblock Content (%)	17	17	14.5	9.0	<5	17	11	6.0	4.0	7.0	4.0
Solution Viscosity (Pa.s) ⁴	4.0	1.2	21	21	-	-	-	-	-	-	-
Melt Flow Rate (g/10 min) ⁵	<1	6	<1	<1	<1	22	30	15	10	11	20
Tensile Strength (MPa) ⁶	33	33	27	24	-	20	15	12	16	14	14
300% Modulus (MPa) ⁶	2.9	2.9	2.5	3.0	-	2.3	2.3	1.9	2.0	3.9	4.1
Elongation at Break (%) ⁶	880	880	820	800	-	1300	1300	1100	1000	830	890
Hardness, Shore A, 30s	72	70	75	74	-	49	47	46	72	89	82
Physical Form ⁷	Porous Pellet, Milled Powder, Fluffy	Dense Pellet, Porous Pellet	Porous Pellet, Milled Powder, Fluffy	Porous Pellet, Milled Powder, Fluffy	Porous Pellet, Milled Powder	Porous Pellet, Milled Powder	Porous Pellet	Porous Pellet	Porous Pellet	Porous Pellet	Porous Pellet

- In the grade nomenclature 'D' indicates KRATON D (unhydrogenated Styrenic Block Copolymers).
- The full dot '•' and open dot '◦' indicate actual and possible manufacturing location, respectively. No indication means either manufacturing of the grade at the location has not been assessed or requires additional hardware or is not possible. The actual manufacturing location is indicated by a suffix in the grade name, e.g. D-1101C. For grades commercialised before mid-1996, a 'C' indicates locations outside the USA, for grades commercialised after mid-1996 an 'A' indicates Germany (Wesseling), 'E' France (Berre), 'J' Japan (Kashima), 'B' Brazil (Paulinia) and 'N' indicates The Netherlands (Pernis). No suffix indicates the USA (Belpre).
- SBS: Styrene-Butadiene-Styrene block copolymer, SB: Styrene-Butadiene diblock, (SB)_n: Styrene-Butadiene multi-arm copolymer.
- At 25% mass in toluene at 25°C.
- Under 5 kg at 200°C. The '**' indicates 2.16 kg at 190°C.
- Typical properties determined on film cast from toluene solution according to ASTM D-412, '**' indicates 10 inch/min.
- Not all physical forms are available from all manufacturing locations. For KRATON D grades the physical form is indicated by a suffix in the grade name, e.g. D-1101CS. 'P' indicates dusted dense pellet, 'M' indicates dusted milled powder, 'U' indicates undusted porous pellet, 'S' and no suffix indicate dusted porous pellet and 'F' indicates fluffy crumb. Crumb is in use as an alternative description for porous pellet.

KRATON™ D – SIS

Grade ¹	D-1107	D-1111	D-1112	D-1113	D-1117	D-1119	D-1124	D-1160	D-1161	D-1193x	D-1163	D-1165
Berre, France ²	○	○						•	○			
Pernis, The Netherlands ²								•	•		•	•
Wesseling, Germany ²	•	○						○	○		○	○
Belpre, USA ²	•	•	•	•	•	•	•	○	○	•	○	○
Kashima, Japan ²	•		•					○	○		○	○
Paulinia, Brazil ²								•	•		○	○
Type ³	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Branched (SI) _n /SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI	Linear SIS/SI
Polystyrene Content (%)	15	22	15	16	17	22	30	19	15	24	15	30
Diblock Content (%)	17	15	38	56	33	66	29	0	19	20	38	17
Solution Viscosity (Pa.s) ⁴	1.60	1.20	0.90	0.69	0.47	0.34	0.34	1.00	1.20	0.40	0.90	0.34
Melt Flow Rate (g/10 min) ⁵	9	2	23	16	33	25	4	9	12	13	16	8
Tensile Strength (MPa) ⁶	28	28	10*	4*	8*	-	-	32	28	-	17	21
300% Modulus (MPa) ⁶	0.9	1.8	0.5*	0.3*	0.4*	-	-	1.9	0.9	-	0.7	2.7
Elongation at Break (%) ⁶	1300	1200	1400*	1500*	1300*	-	-	1300	1300	-	1400	1200
Hardness, Shore A	37	52	34	-	32	-	-	52	37	-	34	65
Physical Form ⁷	Dense Pellet, Porous Pellet, Milled Powder	Porous Pellet	Dense Pellet	Dense Pellet	Dense Pellet	Dense Pellet	Dense Pellet	Porous Pellet	Porous Pellet, Milled Powder	Dense Pellet	Porous Pellet	Porous Pellet

- In the grade nomenclature 'D' indicates KRATON D (unhydrogenated Styrenic Block Copolymers), 'X' denotes Plant Development Product.
- The full dot '•' and open dot '○' indicate actual and possible manufacturing location, respectively. No indication means either manufacturing of the grade at the location has not been assessed or requires additional hardware or is not possible. The actual manufacturing location is indicated by a suffix in the grade name, e.g. D-1107C. For grades commercialised before mid-1996, a 'C' indicates locations outside the USA, for grades commercialised after mid-1996 an 'A' indicates Germany (Wesseling), 'E' France (Berre), 'J' Japan (Kashima), 'B' Brazil (Paulinia) and 'N' indicates The Netherlands (Pernis). No suffix indicates the USA (Belpre).
- SIS: Styrene-Isoprene-Styrene block copolymer, SI: Styrene-Isoprene diblock, (SI)_n: Styrene-Isoprene multi-arm copolymer.
- At 25% mass in toluene at 25°C.
- Under 5 kg at 200°C. The '**' indicates 2.16 kg at 190°C.
- Typical properties determined on film cast from toluene solution according to ASTM D-412, '**' indicates 10 inch/min.
- Not all physical forms are available from all manufacturing locations. For KRATON D grades the physical form is indicated by a suffix in the grade name, e.g. D-1107CS. 'P' indicates dusted dense pellet, 'M' indicates dusted milled powder, 'U' indicates undusted porous pellet and 'S' and no suffix indicate dusted porous pellet. Crumb is in use as an alternative description for porous pellet.

KRATON™ G – SEBS & SEP

Grade ¹	G-1650E	G-1651E	G-1652	G-1654E	G-1657	G-1701E	G-1702	G-1726	FG-1901X	FG-1924X
Belpre, USA ²	•	•	•	•	•	•	•	•	•	•
Berre, France ²	•	•	◦	•		•	◦			
Type ³	Linear SEBS	Linear SEBS	Linear SEBS	Linear SEBS	Linear SEBS/SEB	Linear SEP	Linear SEP	Linear SEBS/SEB	Linear SEBS + 1.7% bound succinic anhydride	Linear SEBS + 1% bound succinic anhydride
Polystyrene Content (%)	30	33	30	31	13	37	28	30	30	13
Diblock Content (%)	0	0	0	0	30	100	100	70	0	30
Solution Viscosity (Pa.s) ⁴	8.0	-	1.35	-	4.2	>50	>50	0.18	-	-
Melt Flow Rate (g/10 min) ⁵	-	-	10	-	8	-	-	65	-	-
Tensile Strength (MPa) ⁶	34	38	31	24	23	2.1	2.1	2.4	34	23
300% Modulus (MPa) ⁶	5.5	6.2	4.8	6.2	2.4	-	-	-	-	-
Elongation at Break (%) ⁶	500	-	500	700	750	<100	<100	200	500	750
Hardness, Shore A, 30s	75	76	75	75	52	72	75	60	75	65
Physical Form ⁷	Powder	Powder	Powder	Powder	Pellet	Powder	Powder	Pellet	Pellet	Pellet

- In the grade nomenclature 'G' indicates KRATON G (hydrogenated Styrenic Block Copolymers), 'FG' denotes functionalised KRATON G, 'X' denotes Plant Development Product.
- The full dot '•' and open dot '◦' indicate actual and possible manufacturing location, respectively. No indication means either manufacturing of the grade at the location has not been assessed or requires additional hardware or is not possible. The actual manufacturing location is indicated by a suffix in the grade name, e.g. G-1650E. An 'E' indicates France (Berre), while no suffix indicates the USA (Belpre).
- SEBS: Styrene-Ethylene/Butylene-Styrene block copolymer, SEB: Styrene-Ethylene/Butylene diblock.
SEP: Styrene-Ethylene-Propylene diblock.
- At 25% mass in toluene at 25°C.
- Under 5 kg at 200°C.
- Typical properties determined on film cast from toluene solution according to ASTM D-412, 10 inch/min. 6a: obtained from melt-pressed film, micro-tensile specimen.
- Pellets are dusted.



End Use Requirements

If the finished article is intended for use in contact with food or in pharmaceutical applications, toys, and other human contact areas, the relevant regulations should be observed. Detailed information is available from the supplier.

For food packaging, manufacturers of the final product should ensure that all ingredients used comply with the regulations. It should be noted that some of these regulations require tests to be carried out on the final product, e.g. migration. These are the responsibility of the final product manufacturer.

Restriction on Medical/Healthcare Applications

DO NOT USE KRATON™ POLYMERS PRODUCTS IN ANY DEVICES OR MATERIALS INTENDED FOR TEMPORARY OR PERMANENT IMPLANTATION IN THE HUMAN BODY. THE KRATON POLYMERS BUSINESS ALSO RESTRICTS THE USE OF ITS PRODUCTS IN OTHER MEDICAL/HEALTHCARE APPLICATIONS.

Please contact your KRATON Polymers Sales Representative for more details.

THE KRATON POLYMERS BUSINESS HAS NO SPECIFIC EXPERTISE IN THE MEDICAL/HEALTHCARE MARKET OR APPLICATIONS and does not intend to perform testing, clinical studies or other investigations of the suitability of its products for specific medical/healthcare applications. KRATON Polymers products are generally manufactured for use in a variety of commercial applications.

DO NOT USE THE TRADENAMES, TRADEMARKS, LOGOS OR OTHER SIMILAR IDENTIFYING CHARACTERISTICS OF THE KRATON POLYMERS BUSINESS IN THE MANUFACTURE, SALE OR PROMOTION OF MEDICAL DEVICES OR MATERIALS.

THE KRATON POLYMERS BUSINESS MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSES (INCLUDING MEDICAL APPLICATIONS) FOR ITS PRODUCTS.

Each customer or user of KRATON Polymers products is solely responsible for determining the suitability of the materials they select for the intended purpose. With regards to medical/healthcare applications, each customer or user must conduct their own studies, registrations, and other related activities to establish the safety and efficacy of their products.

Safety and Handling Precautions

Read the Material Safety Data Sheet for KRATON Polymer products carefully and thoroughly before beginning any work with this product. Additional information relating to Health, Safety, Storage, Handling and Processing can be found in the KRATON Polymer HSE Fact Sheet (ref. K0155), available from your local KRATON Polymers representative. It is also recommended to consult other sources of safety information, for example, the current edition of Toxicity and Safe Handling of Rubber Chemicals - Code of Practice 4th Edition 2000, British Rubber Manufacturers Association Limited (BRMA), London, EC2A 3JE, UK, Tel: +44 (0)20 7457 5040.

KRATON polymers and compounds can accumulate electrostatic charges when rubbed, chafed or abraded. Equipment should provide a means of dissipating any charges that may develop. Processing of KRATON polymers and compounds in high shear equipment can cause the temperature to rise. Do not allow the temperature to exceed 225-230°C (437-446°F) for KRATON D polymers and compounds and 280-285°C (536-545°F) for KRATON G polymers and compounds. Maintain a fire watch if these temperatures are reached. KRATON Polymer products (the neat resin or the base product) are high molecular weight polymers which by all accounts are non-toxic and biologically inactive.

Warranty

The information contained in this publication is, to the best of our knowledge, true and accurate, but any recommendations or suggestions which may be made are without guarantee, since the conditions of use are beyond our control. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or its use.

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For further information:

In the USA

call toll free 1-800-4-KRATON
(1-800-457-2866)
or fax +1 713-241-6502

In South America

fax +55 (0)19 3874-7275

or contact your local KRATON polymers
representative

Contact us:

Marketing Communications Manager
E-mail: Brian.Moffett@KRATON.com

In Europe/Africa

fax +44-(0)18-2977-0961

In Asia-Pacific

fax +81-3-5500-3259

E-mail: info@KRATON.com

Visit us at: www.KRATON.com



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