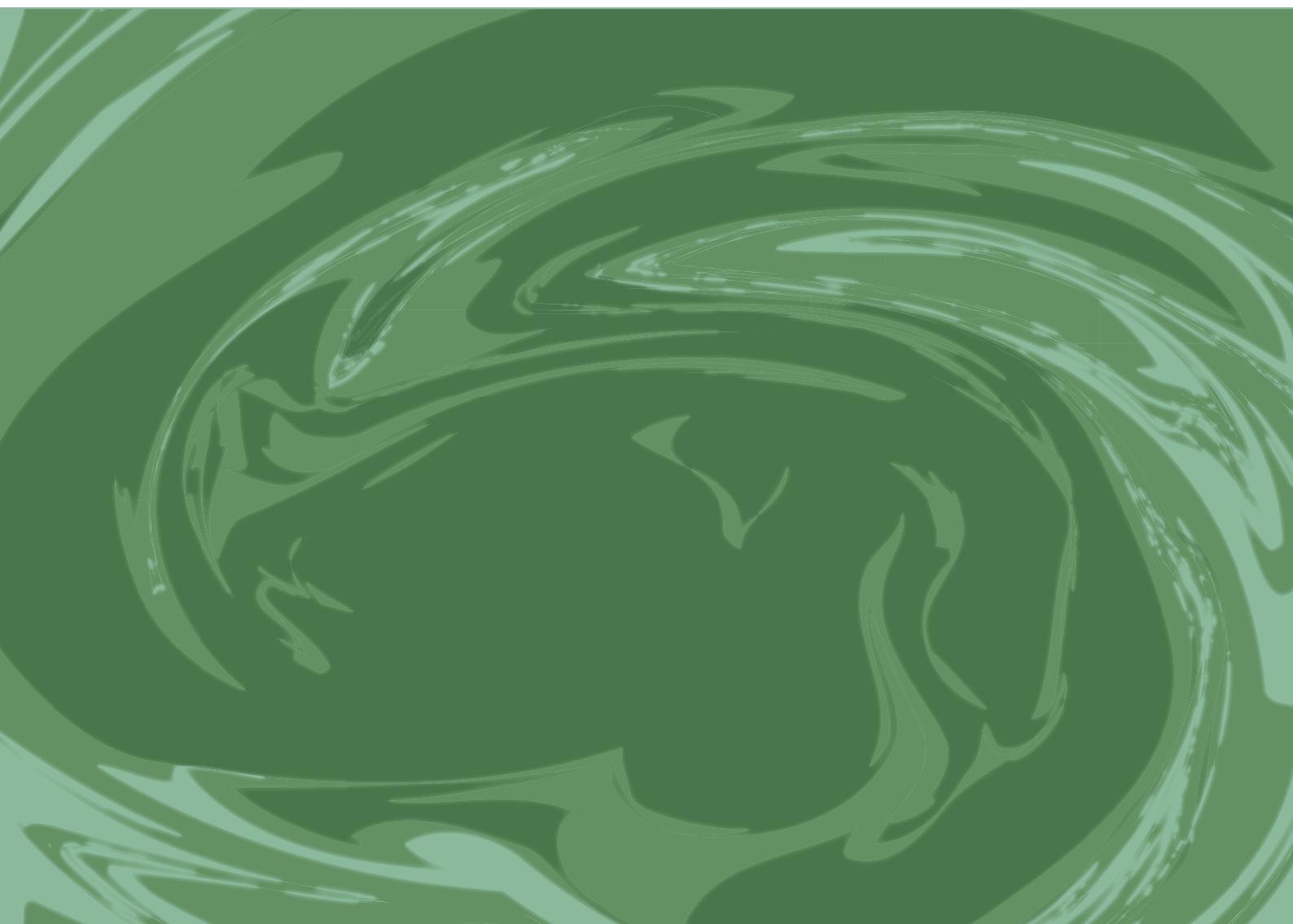


Asahi**KASEI**

TUFPRENE™ **ASAPRENET™**

Styrene-Butadiene Thermoplastic Elastomers
The SBS elastomers from Asahi KASEI

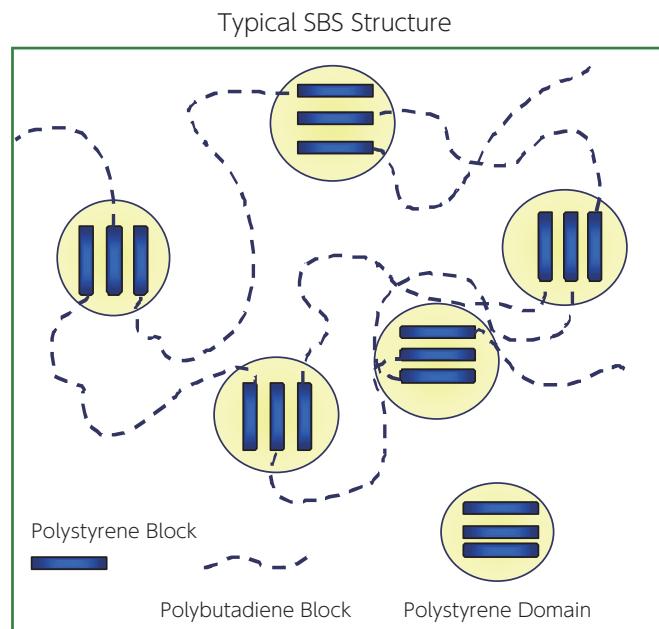


1 Fundamentals

TUFPRENE™ and ASAPRENE™-T are styrene-butadiene-styrene (SBS) thermoplastic elastomers.

Their block-copolymer structure combines the properties of the hardsegment polystyrene blocks and the soft-segment polybutadiene blocks, resulting in ease of processing and excellent performance characteristics.

While exhibiting the flow properties of plastics at processing temperature, they also exhibit elasticity of rubber at ordinary temperature.



2 Salient features

TUFPRENE™ and ASAPRENE™-T provide elastic performance comparable to that of vulcanized rubber at room temperatures, yet they can be readily extruded and molded in the same manner as other thermoplastics. They also feature other characteristics that provide superior performance and broad-ranging applications.

- Stable rubber elasticity in a wide temperature range (approx. -50°C to 50°C).
- Superior low-temperature characteristics.
- High adhesive strength, for a broad range of materials.
- Superior compatibility with polystyrene and other resins, and with asphalt.
- Low solution viscosity, ready solubility in a broad range of industrial solvents.
- High slip resistance.
- Crosslinking capability.
- Low specific gravity, for lightweight products.

1 Fundamentals

2 Salient features

3 Basic properties

4 Processability

5 Grades and properties

6 Typical applications – Resin modification

7 Typical applications – Adhesives

8 Typical applications – Asphalt modification

9 Typical applications – Compounds

10 Important Notes and Precautions

3 Basic properties

1 Fundamentals

2 Salient features

3 Basic properties

4 Processability

5 Grades and properties

6 Typical applications
– Resin modification

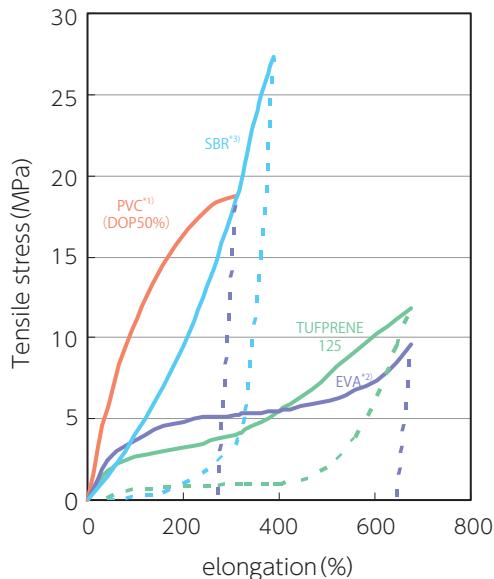
7 Typical applications
– Adhesives

8 Typical applications
– Asphalt modification

9 Typical applications
– Compounds

10 Important Notes and Precautions

Tensile stress vs. elongation



¹Polyvinyl chloride, 1030 °C of polymerization.

²Styrene-butadiene rubber, SBR1502, ASTM A.

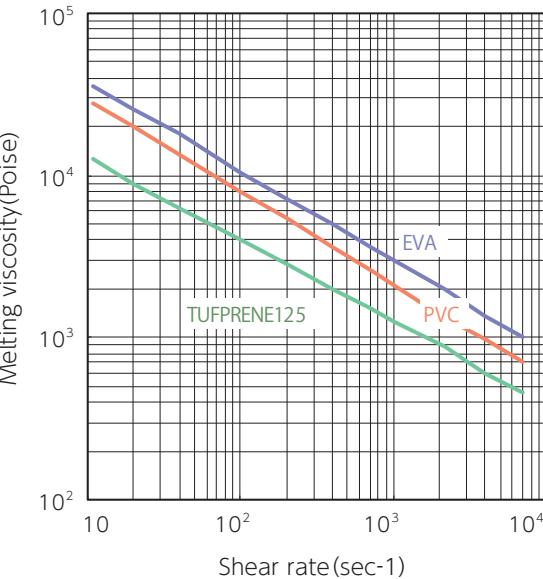
³Ethylene-vinyl acetate, 19% vinyl acetate, 2.5 MFR.

Test piece : Compression-molded sheet,
2-mm, dumbbell #3 JIS.

Test temp. : 23°C.

Hysteresis : Through elongation to 80% of
elongation at break.

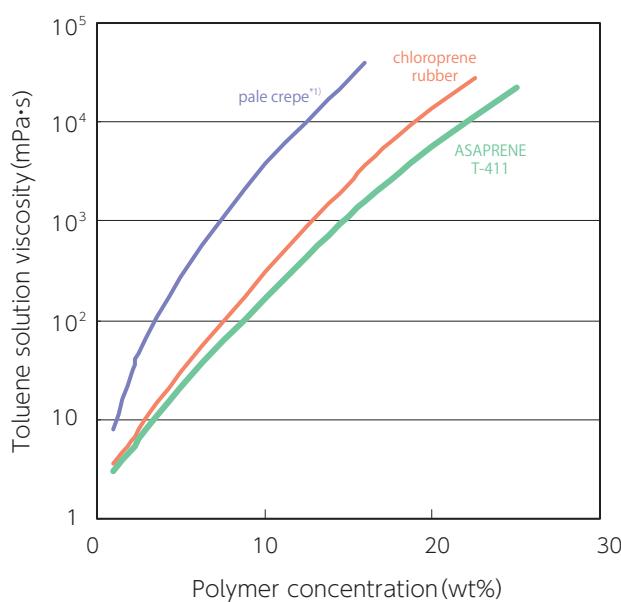
Flowability



Capilograph nozzle : 1 mmφ x 10 mL.

Temp.: 200°C

Solution viscosity

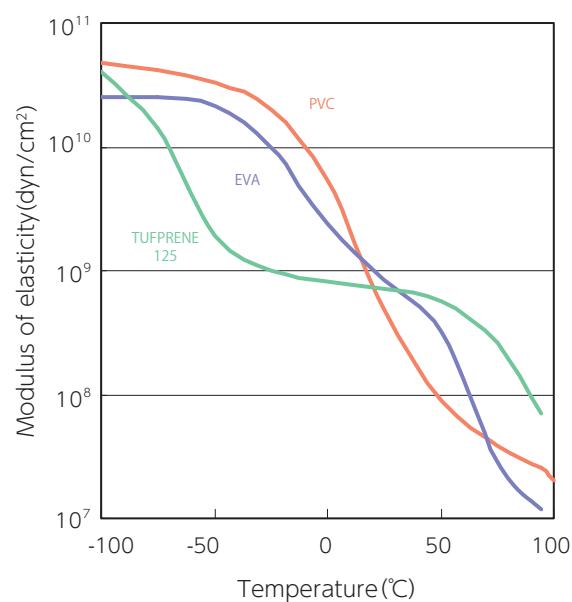


¹ML₁₊₄₅₀

Viscosity meter: B-type.

Temp.: 25°C

Elasticity vs. temperature



By viscoelasticity spectrometer.

Test piece: Compression-molded sheet,

2mm thick, 3mm wide.

Chuck interval, 30mm: Frequency, 35Hz.

Solvent selection

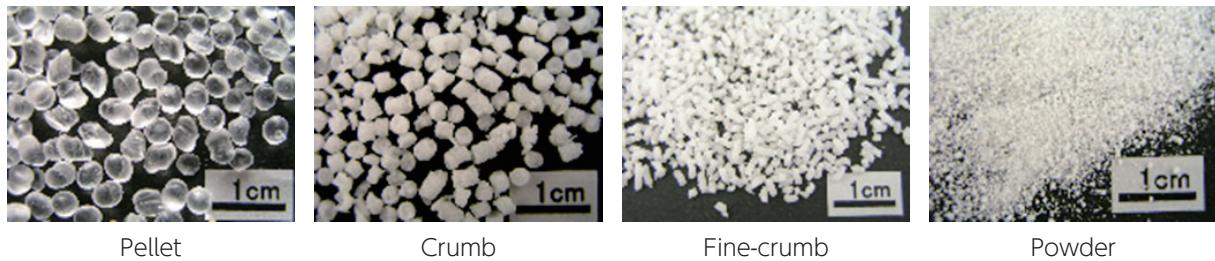
TUFPRENE™ and ASAPRENE™-T can be used with a fairly broad variety of solvents. Their level of dissolution in a number of typical solvents is shown here.

High solubility	Low solubility or insolubility
Cyclohexane Xylene Toluene THF Chloroform	n-Pentane n-Hexane Acetone Methanol Ethanol Isopropanol

Available forms

TUFPRENE™ and ASAPRENE™-T are supplied in pellet, crumb, or powder form, depending on the type and grade.

Certain grades can be provided in fine-crumb form.



4 Processability

The appropriate molding temperature for TUFPRENE™ and ASAPRENE™-T will depend on the product configuration, mold structure, molding machine type, and other process conditions. A resin temperature between 160°C and 220°C is generally optimal. Lower resin temperatures may cause molding failures and product anisotropy due to poor flowability, and higher resin temperatures may cause melt degradation. For vacuum forming, temperatures of 110°C to 160°C are generally suitable.

Molding process Typical applications	Molding temperature (°C)							
	100	120	140	160	180	200	220	240
Injection molding Shoe soles, using oil-extended SBS/filler/resin/oil							↔	↔
T-die extrusion Food containers, using SBS/PS resins						↔	↔	
Vacuum forming Food containers, using SBS/PS resin/SBS sheet	↔	↔						

5 Grades and Properties of TUFPRENE™ and ASAPRENE™T

1
Fundamentals

2
Salient
features

3
Basic
properties

4
Processability

5
Grades and
properties

6
Typical
applications
– Resin
modification

7
Typical
applications
– Adhesives

8
Typical
applications
– Asphalt
modification

9
Typical
applications
– Compounds

10
Important
Notes and
Precautions

Properties	Units	Method	TUFPRENE™			ASAPRENE™ T					
			A	125	126S	T-411	T-432	T-437	T-438	T-439	
Density	g/cm³	ISO1183	0.95	0.95	0.95	0.94	0.94	0.94	0.94	0.95	
Melt Flow Rate 190°C, 2.16kg	g/10min	ISO1133	2.6	4.5	4.5	0	0	-	-	-	
Melt Flow Rate 200°C, 5kg	g/10min	ISO1133	13	20	20	0	0.2	2	25	-	
Hardness Durometer Type A	-	ISO7619	85	88	91	75	75	75	80	83	
300%Tensile Stress	MPa	ISO37	2.5	4.3	4.5	2.3	2.0	2.3	3.0	4.0	
Tensile Strength	MPa	ISO37	14	20	25	20	30	31	5	6	
Elongation	%	ISO37	1100	800	790	750	750	890	1150	880	
Viscosity as 25% solution in toluene	mPa·s		650	570	440	20200	3100	1700	470	170	
Viscosity as 15% solution in toluene	mPa·s		-	-	-	-	330 ^{a)}	-	47.5 ^{a)}	25 ^{a)}	
Viscosity as 10% solution in toluene	mPa·s		-	-	-	270 ^{a)}	-	-	-	-	
Styrene/Butadiene Weight Ratio	%		40/60	40/60	40/60	30/70	30/70	30/70	35/65	45/55	
Weight(kg/bag)	paper bag	Pellet	25	25	25				25	25	
		Crumb				15	15	20			
		Powder ^{b)}				20	20				
FDA			○	○	○				○		
Typical Applications ^{c)}			Adhesives PS mod. Asp. mod.	PS mod.	PS mod.	Adhesives Asp. mod. Shoe MC	Adhesives Asp. Mod.	Asp. Mod.	Adhesives	Adhesives	

a) Specification b) G.#20 mesh pass.

c) Abbreviations: PS = polystyrene, Asp.= asphalt, mod.= modification, Shoe MC = footwear molding compounds.

Test pieces: Compression-molded sheet, 2-mm thick, type1A dumbbell shape. Measurement temp.: 23°C.

Roll kneading temp.: 120°C~130°C. Compression molding: Preheating, 160°C 5 min.

Compression: 80 kg/cm² 160°C 5 min. Cooling: 3 min.

6 Applications – Resin modification

Polystyrenes

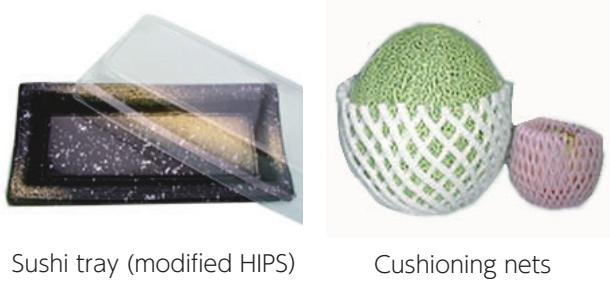
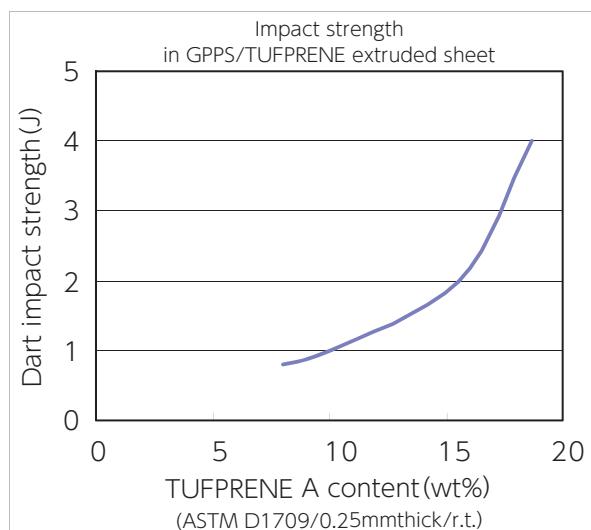
Recommended grades: TUFPRENE™A, 125, and 126S

1 Fundamentals

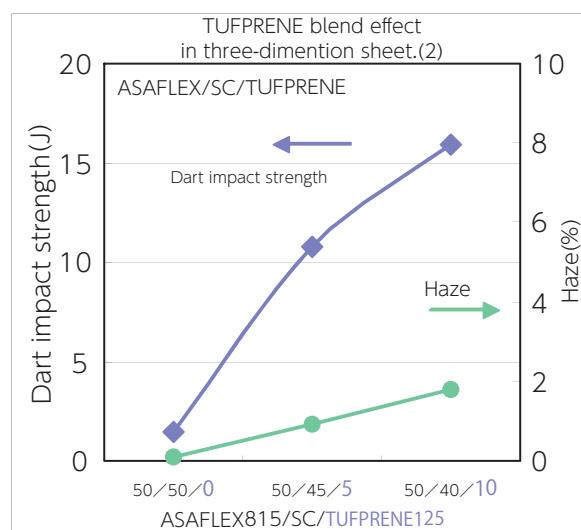
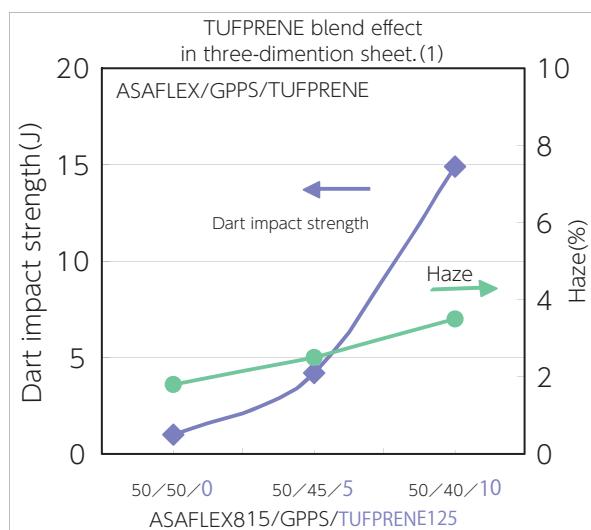
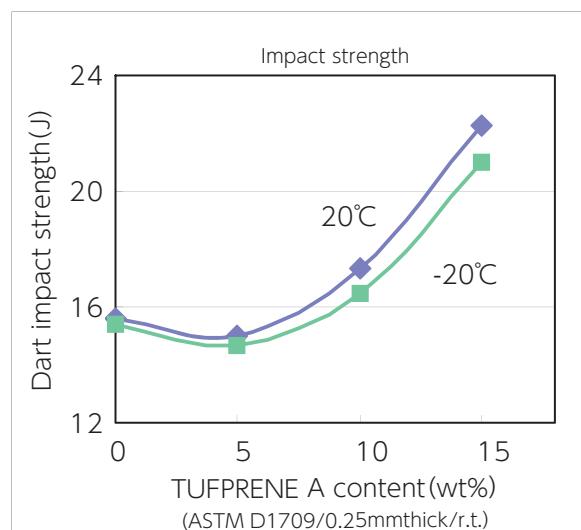
TUFPRENE™ and ASAPRENE™-T blend readily with a broad range of poly-styrenic and other resins, for significant improvements in their processing and performance characteristics.

Properties improved by modification

- Impact strength
- Low-temperature characteristics
- Coatability, printability, and adhesion
- Deep-drawing characteristics
- Skid resistance



Sushi tray (modified HIPS) Cushioning nets



*ASAFLX™ is clear styrenic copolymer from Asahi Kasei Corp. SC polymer is a styrenic copolymer from PS Japan Corp. As it is designed to be similar to ASAFLEXTM in refraction index, sheet with significantly high transparency which is unattainable with any GPPS can be obtained by blending them.

2 Salient features

3 Basic properties

4 Processability

5 Grades and properties

6 Typical applications – Resin modification

7 Typical applications – Adhesives

8 Typical applications – Asphalt modification

9 Typical applications – Compounds

10 Important Notes and Precautions

Thermosetting resins

TUFPRENE™ and ASAPRENE™-T improve the sink formation, warping, and cracking problems by effectively reducing thermosetting shrinkage of unsaturated polyester for FRP. They dissolve readily in styrene monomer, the widely-used FRP solvent, for fine, stable dispersion.

7 Applications – Adhesives

1
Fundamentals

TUFPRENE™ and ASAPRENE™-T exhibit excellent characteristics as the base polymer of hot-melt, solution, and film adhesives and sealants. Their elastic properties make them highly effective as flexible adhesives for sanitary products.

2
Salient
features

Salient characteristics of adhesives made with TUFPRENE™ and ASAPRENE™-T

- High elasticity and adhesion without curing agent
- Adhesion to polyolefins, metals, and many other materials
- Excellent transparency
- Excellent low-temperature properties and flexibility
- Low solution viscosity, ready solubility in variety of solvents
- Effective as base polymer for disposable-diaper, sanitary-product, and many other adhesives

3
Basic
properties

4
Processability

5
Grades and
properties

6
Typical
applications
– Resin
modification

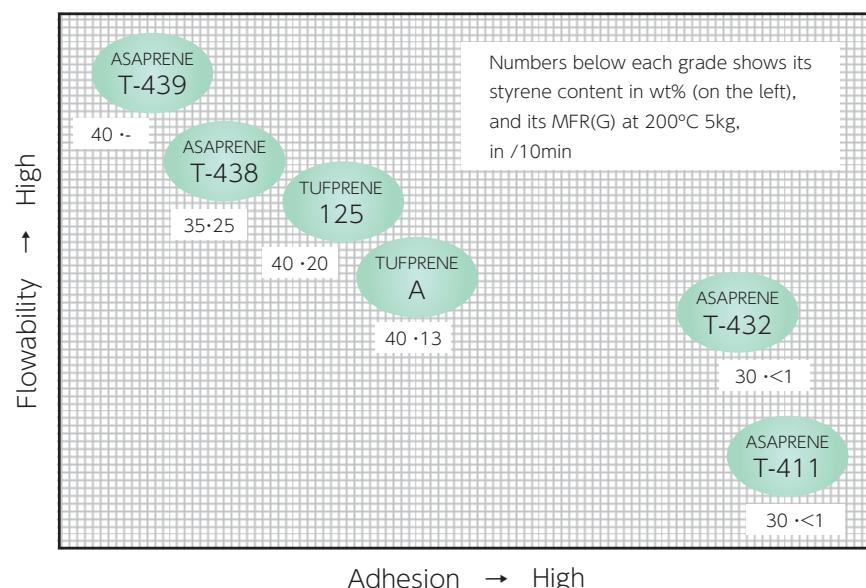
7
Typical
applications
– Adhesives

8
Typical
applications
– Asphalt
modification

9
Typical
applications
– Compounds

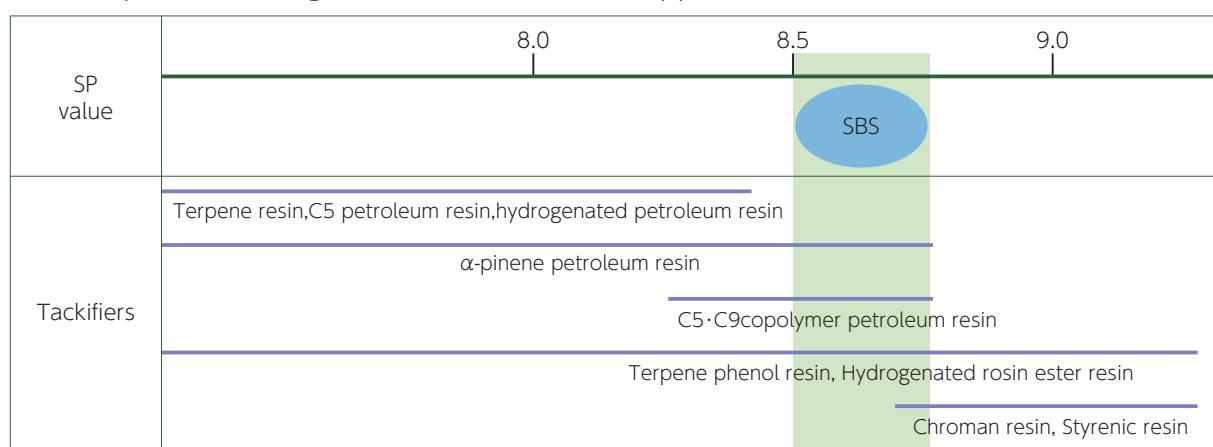
10
Important
Notes and
Precautions

Grade selection for adhesive flowability and adhesive strength



Selection of compatible tackifiers is essential. Tackifiers for TUFPRENE™ and ASAPRENE™-T must be similar to SBS in solubility parameter (SP), as shown below.

SBS-compatible SP range of common tackifiers (approx. 8.5~8.75)



8 Applications – Asphalt modification

TUFPRENE™ and ASAPRENE™-T impart superior characteristics to asphalt in applications ranging from road paving to waterproof sheeting, seams and joints, and steel-pipe coatings.

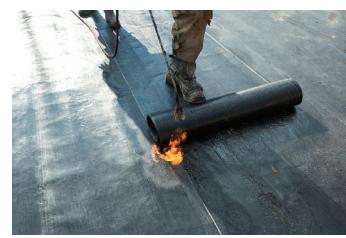
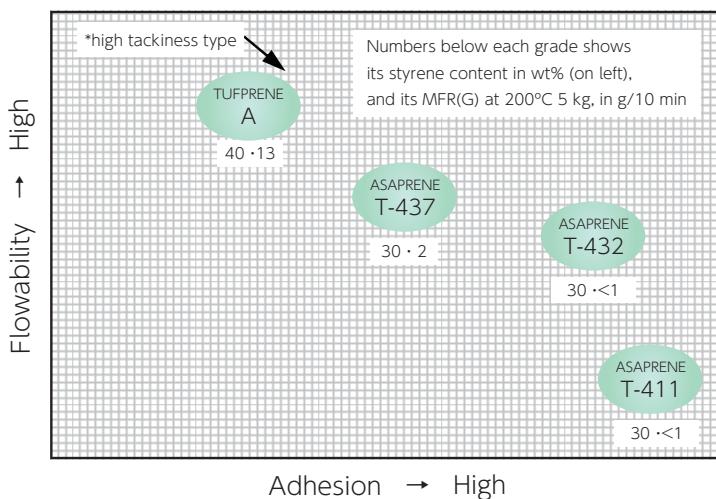
Characteristics of modified asphalt with TUFPRENE™ and ASAPRENE™-T:

- Higher softening temperature
- Reduced temperature sensitivity
- Broader service-temperature range
- Increased cohesive and adhesive strength
- Superior low-temperature characteristics
- Increased elasticity and impact strength.



Asphalt Paving

Grade selection for asphalt flowability and softening temp.



Modified-asphalt sheeting



Modified-asphalt for bridge-floor waterproofing

Typical properties of asphalt blends with TUFPRENE™ and ASAPRENE™-T

- Reduced temperature sensitivity, greater strength and durability -

Grade		TUFPRENE™ A	ASAPRENE™ T-411	ASAPRENE™ T-432	ASAPRENE™ T-437	Straight asphalt 60-80
Elastomer	Styrene content(wt%)	40	30	30	30	-
	MFR, 200°C,5kg load (g/10min)	13	0	0.2	2	
	Melt Viscosity (200°C) (mPa·s)	650	3,150	1,850	1,560	
	Softning point(°C)	96	119.5	110	108	
Formulation	Penetration(1/10mm)	69	47	49	43	77
	Tensile properties	Yield strength (MPa)	1.4	1.4	1.5	1.4
		Max. stress (MPa)	-	5.1	4.2	3.7
		Elongation (%)	1500	1,800	2,050	>3,000
	Low temperature bending test(°C)	30	-5	-5	-5	10

Blend composition: TUFPRENE™ or ASAPRENE™ - T /straight asphalt 60-80 = 10/90

Test conditions: Solution viscosity: Brookfield viscometer, 200°C. Softening point: R&B method.

Penetrability: 5 sec, 100g, 25°C

9 Applications – Compounds

1
Fundamentals

Compounds with TUFPRENE™ and ASAPRENE™-T as base or secondary polymer together with appropriate oils and fillers can be processed on ordinary injection molding machines and extruders, for optimal characteristics and properties in a broad range of household and industrial products – particularly those requiring the right degree of flexibility.

2
Salient
features

3
Basic
properties

4
Processability

5
Grades and
properties

6
Typical
applications
– Resin
modification

7
Typical
applications
– Adhesives

8
Typical
applications
– Asphalt
modification

9
Typical
applications
– Compounds

10
Important
Notes and
Precautions

Recommended
Grade



ASAPRENE™
T-411

10 Important Notes and Precautions

All information, data, and values contained herein are given as a representation in good faith of results obtained by the indicated test methods and of data, information, and documents currently available to Asahi Kasei Corporation (hereinafter "AKC"), for use only as a basic guide to grade selection for various applications and not as any explicit or implied warranty or guarantee of any nature, and are subject to change in accordance with changes in product properties and new findings or knowledge. It is the responsibility of the user to determine the safety and suitability of TUFPRENE™ and ASAPRENE™-T(hereinafter collectively "SBS") for the intended use, purpose, and application.

(1) Safe handling and use

Always observe the following general precautions and consult the Safety Data Sheets (SDS) issued by AKC, before handling or using SBS, and investigate and determine by advance testing the safety and suitability of any addition or mixing of any other resin, additive, or other material. It is the responsibility of the user to determine the safety and suitability of any additive or other material with SBS.

① Hot and molten polymer

Avoid inhalation and eye or skin contact with any gases generated in heating or melting SBS and with the hot or molten polymer. Employ local ventilation and protective gear, including chemical goggles and protective gloves, during any heating or melting operation.

② Combustibility

SBS is flammable and must be kept strictly away from heat, sparks, and flame during handling and storage. In the event of its combustion, carbon monoxide and other toxic combustion gases may be generated; extinguish with water or with foam or dry chemical extinguisher.

③ Disposal

Dispose of SBS in accordance with local and national law and regulations, by burning in a properly equipped incinerator or by burial in a properly designed landfill site. Note that carbon monoxide and other toxic gases may be generated during incineration. Do not release to sewers, ground, or any body of water.

④ Storage

Store SBS in a cool dark area away from direct sunlight, humidity, and moisture.

⑤ Molding conditions

Appropriate temperatures and other conditions for the molding and extruding of SBS vary with the resin grade and type of use. Consult AKC or its representatives for related information.

(2) Medical and food applications

Certain SBS grades comply with hygienic standards. For any application involving extended bodily contact, medical devices and containers, or food packaging, contact AKC. AKC will not be responsible for any problem in connection with or arising out of any use performed without its consent.

(3) Patent infringement

AKC warrants only that the sale or use of SBS does not in itself infringe any patent or other industrial property right relating thereto, but does not warrant against infringement by reason of its use in combination with other materials or in any process.

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Revised on June 2019

1 Fundamentals

2 Salient features

3 Basic properties

4 Processability

5 Grades and properties

6 Typical applications
– Resin modification

7 Typical applications
– Adhesives

8 Typical applications
– Asphalt modification

9 Typical applications
– Compounds

10 Important Notes and Precautions

10