# TUFTEC™

**H Series**

**P Series** Selective Hydrogenated Type

**M Series** Acid or Amine Modified Type

**Hydrogenated Styrenic Thermoplastic Elastomer (SEBS)**

AsahiKASEI

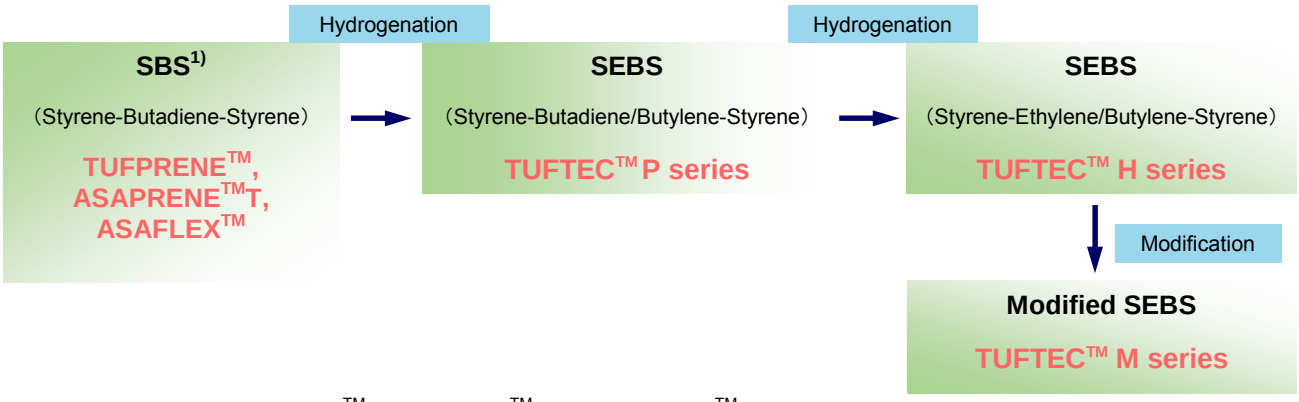
# Table of Contents

# 1. Fundamentals

TUFTEC™ is a hydrogenated thermoplastic styrenic elastomer with excellent weatherability and heat resistance that is produced by hydrogenation of styrene and butadiene block copolymers.

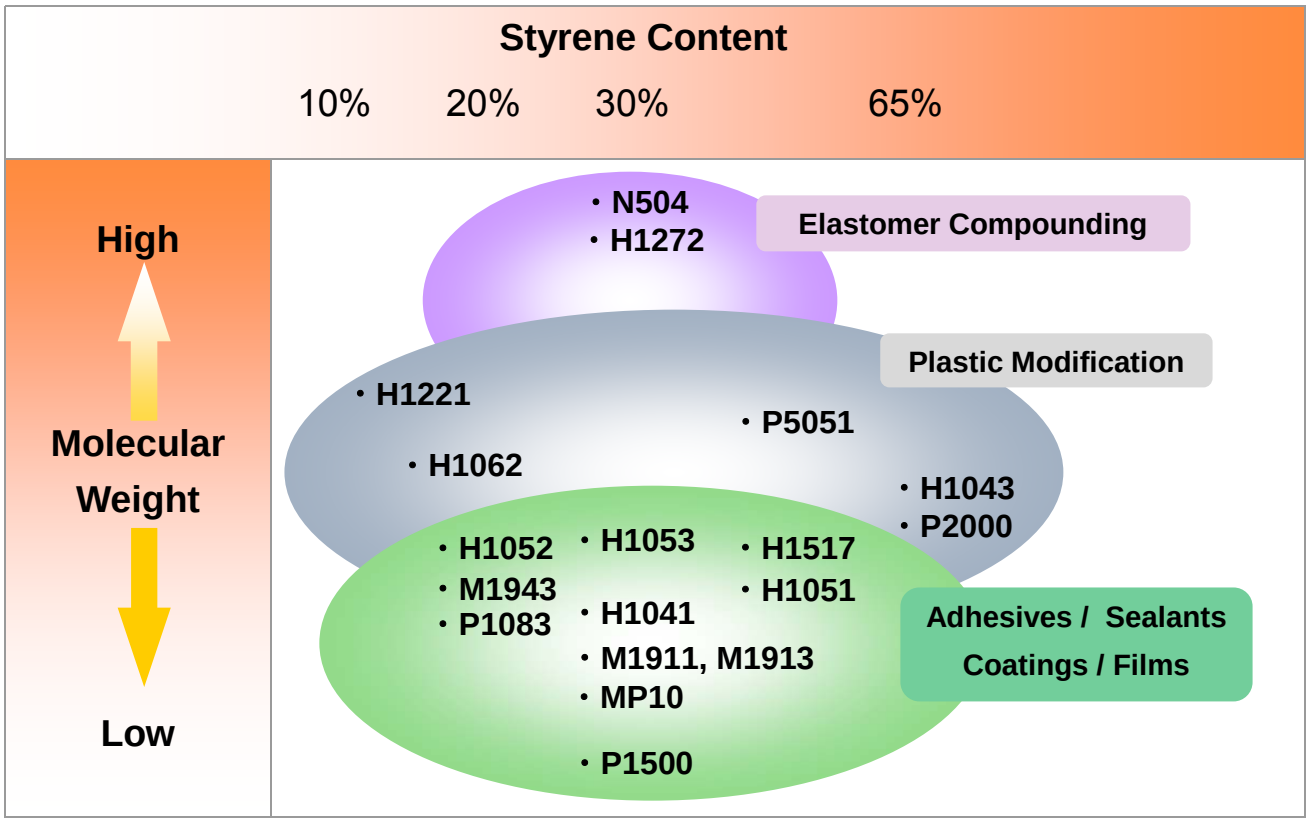
TUFTEC™ is the product of longstanding leadership in elastomers development and process technology at Asahi Kasei Corporation, beginning with its SBS elastomers and extending through the world-leading H-series SEBS elastomers, which were introduced in 1987 and then followed by the functional group-bearing M-series as the world's first modified SEBS elastomers.

TUFTEC™ P-series matches the rapidly diversifying market needs. It is produced by highly selective partial-hydrogenation of the SBS polymer, resulting in higher heat resistance than SBS elastomers and greater processability and low-temperature properties than fully-hydrogenated SEBS elastomers, in addition to the inherent polymer characteristics and properties.




*1) Information on TUFPRENE™, ASAPRENE™T, and ASAFLEX™ is given in separate brochures.

## TUFTEC™ Polymer Grades / Application Map



## 2. Salient Features of TUFTEC™ H Series

- ◆ Thermoplastic elastomers with the high elasticity and strength comparable to vulcanized rubber
- ◆ Excellent weatherability and resistance to heat aging
- ◆ Rubber elasticity retention over broad temperature range
- ◆ Excellent flex resistance
- ◆ Excellent chemical (acid, alkali, and alcohol) resistance
- ◆ Low density - 0.89 to 0.97 g/cm$^3$
- ◆ Excellent compatibility with styrenic and olefinic resins, imparting high impact strength

## 3. TUFTEC™ H Series Grades and Properties

| Grade | | | | | H1221 | H1062 | H1052 | H1053 | H1041 |
|---|---|---|---|---|---|---|---|---|---|
| Property | | Test Method | Test Condition | Units | Non Oil-extended | | | | |
| Density | | ISO 1183 | - | g/cm$^3$ | 0.89 | 0.89 | 0.89 | 0.91 | 0.91 |
| S/EB Weight Ratio | | Asahi Kasei Method | - | % | 12/88 | 18/82 | 20/80 | 29/71 | 30/70 |
| MFR | | ISO 1133 | 230°C 2.16kgf | g/10min | 4.5 | 4.5 | 13.0 | 1.8 | 5.0 |
| | | | 200°C 5kgf | g/10min | - | - | 10.0 | - | 3.5 |
| | | | 190°C 2.16kgf | g/10min | - | - | - | - | 0.3 |
| Hardness | | ISO 7619 | Durometer Type A | - | 42 | 67 | 67 | 79 | 84 |
| Tensile Strength | | ISO 37 | Dumbbell, Type 1A 500mm/min | MPa | 9.5 | 15.0 | 11.8 | 25.0 | 21.6 |
| Elongation | | | | % | 980 | 670 | 700 | 550 | 650 |
| 300% Tensile Stress | | | | MPa | 1.0 | 4.3 | 2.5 | 4.8 | 3.4 |
| Heat Resistance | Maintained Ratio of Tensile Strength | ISO 188 | Type 2 Oven 120°C 168 hrs | % | - | 97 | 99 | 98 | 97 |
| | Maintained Ratio of Elongation | | | % | - | 100 | 98 | 98 | 101 |
| Physical Form | | | | | Pellets | | | | |
| Applications | | PP Modifier | | | • | • | • | | • |
| | | PPE, PS Modifier | | | | | | • | • |
| | | Compatibilizer | | | | | | • | • |
| | | Multilayer Films | | | • | • | • | | |
| | | Adhesives & Sealants | | | • | • | • | • | • |
| | | TPE Compounds | | | • | • | • | | |

| Grade | | | | N504 | H1051 | H1517 | H1043 | H1272 |
|---|---|---|---|---|---|---|---|---|
| Property | Test Method | Test Condition | Units | Non Oil-Extended | | | | Oil Extended |
| Density | ISO 1183 | - | g/cm$^3$ | 0.91 | 0.93 | 0.93 | 0.97 | 0.90 |
| S/EB Weight Ratio | Asahi Kasei Method | - | % | 32/68 | 42/58 | 43/57 | 67/33 | 35/65 |
| MFR | ISO 1133 | 230°C 2.16kgf | g/10min | - | 0.8 | 3.0 | 2.0 | - |
| | | 200°C 5kgf | g/10min | - | 0.5 | - | 5.0 | - |
| | | 190°C 2.16kgf | g/10min | - | - | - | - | - |
| Hardness | ISO 7619 | Durometer Type A | - | - | 96 | 92 | 72 *1) | 35 |
| Tensile Strength | ISO 37 | Dumbbell, Type 1A 500mm/min | MPa | - | 32.3 | 16.0 | 10.3 | 18.6 |
| Elongation | | | % | - | 600 | 780 | 20 *2) | 950 |
| 300% Tensile Stress | | | MPa | - | 8.3 | 7.6 | - | 1.0 |
| Heat Resistance | Maintained Ratio of Tensile Strength | ISO 188 | Type 2 Oven 120°C 168 hrs | % | - | - | - | 99 | 98 |
| | Maintained Ratio of Elongation | | | % | - | - | - | 96 | 99 |
| Physical Form | | | | Crumb | Pellet | | | |
| Applications | PP Modifier | | | | | | | |
| | PPE, PS Modifier | | | • | • | • | • | • |
| | Compatibilizer | | | | | • | • | |
| | Multilayer Films | | | | | | | |
| | Adhesives & Sealants | | | | | | | |
| | TPE Compounds | | | • | | | | • |

*[1]Durometer type D *[2]10mm/min

## 4. TUFTEC™ P series—Salient Features

- **Good heat resistance compared with SBS**
- **Good processability compared with SEBS**
- **Low-temperature properties compared with SEBS**
- **Good compatibility to polyolefin**
- **Good compatibility to several type of tackfier**
- **Cross-linkable**

## 5. TUFTEC™ P series—Grades and Properties

| Grade | | | | P1083 | P1500 | P5051 | P2000 |
|---|---|---|---|---|---|---|---|
| Properties | Test Method | Test Condition | Units | Non Oil-Extended | | | |
| Density | ISO 1183 | - | g/cm$^3$ | 0.89 | 0.94 | 0.94 | 0.98 |
| S/BB ratio | Asahi Kasei Method | - | wt% | 20/80 | 30/70 | 47/53 | 67/33 |
| MFR | ISO 1133 | 190°C 2.16kgf | g/10min | 3.0 | 4.0 | 3.0 | 3.0 |
| | | 200°C 5kgf | | - | - | - | 45 |
| Solution Viscosity | | 15% Toluene | mPa·s | - | 35 | - | - |
| Hardness | ISO 7619 | Durometer Type A | - | 56 | 69 | 93 | - |
| | | Durometer Type D | - | - | - | - | 74 |
| Tensile Strength | ISO 37 | Dumbbell, Type 1A 500mm/min | MPa | 9.0 | 3.0 | 31.0 | 24.5 |
| Elongation | | | % | 700 | 780 | 700 | 42 |
| 300% Tensile Stress | | | MPa | 3.0 | 2.1 | 7.0 | — |
| Physical Form | | | | Pellet | | | |
| Application | | PP Modifier | | • | | | • |
| | | PS Modifier | | | | • | • |
| | | Compatibilizer | | | | • | • |
| | | Multi Layer Films | | | | | • |
| | | Adhesives & Sealants | | • | • | • | |
| | | Foam Shoe Soles | | • | | • | |
| | | TPE Compounds | | • | | | |

## 6. TUFTEC™ M series—Salient features

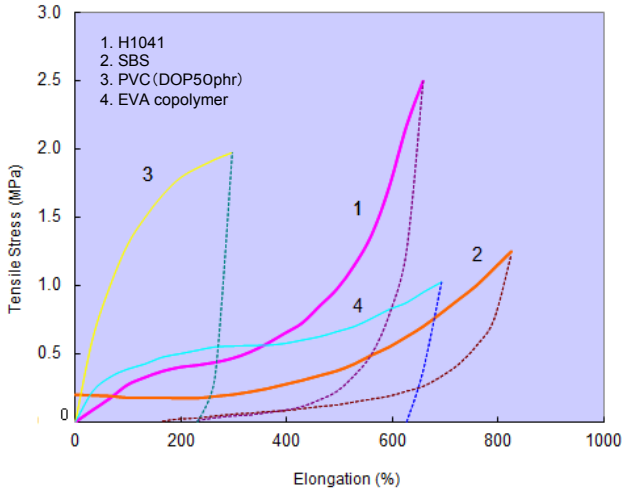
- ◆ Reactive elastomers with the same basic properties as H-series
- ◆ Functional groups impart:
  - ・Excellent compatibility with engineering plastics
  - ・Excellent adhesion to metals and plastic substrates

## 7. TUFTEC™ M series—Grades and properties

| Grade | | | | | M1943 | M1913 | M1911 | MP10 |
|---|---|---|---|---|---|---|---|---|
| Property | | Test Method | Test Condition | Units | Acid Modified | | | Amine-modified |
| Acid Number | | Titration Method | — | mgCH3ONa/g | 10 | 10 | 2 | - |
| Density | | ISO 1183 | - | g/cm$^3$ | 0.90 | 0.92 | 0.91 | 0.91 |
| S/EB Weight Ratio | | Asahi Kasei Method | - | % | 20/80 | 30/70 | 30/70 | 30/70 |
| MFR | | ISO 1133 | 230°C 2.16kgf | g/10min | 8.0 | 5.0 | 4.5 | 4.0 |
| | | | 200°C 5kgf | g/10min | 6.0 | 4.0 | 3.5 | - |
| Hardness | | ISO 7619 | Durometer Type A | - | 67 | 84 | 84 | 89 |
| Tensile Strength | | ISO 37 | Dumbbell, Type 1A 500mm/min | MPa | 11.0 | 22.0 | 22.0 | 28.0 |
| Elongation | | | | % | 650 | 600 | 650 | 600 |
| 300% Tensile Stress | | | | MPa | 2.9 | 4.4 | 4.1 | 5.6 |
| Tensile Modulus | | ISO 527 | 1mm/min | MPa | 6.9 | 25 | 20 | - |
| Heat Resistance | Maintained Ratio of Tensile Strength | ISO 188 | Type 2 Oven 120℃ 168hrs | % | 99 | 98 | 99 | - |
| | Maintained Ratio of Elongation | | | % | 96 | 95 | 96 | - |
| Physical Form | | | | | Pellet | | | |
| Application | PA Modifier | | | | • | • | | |
| | PET Modifier | | | | • | • | | |
| | TPU Modifier | | | | • | • | | • |
| | PC Modifier | | | | • | • | | |
| | Compaitbilizer | | | | • | • | | |
| | Adhesives & Sealants | | | | • | • | • | • |
| | Tie Layer Films | | | | • | • | • | • |

# 8. Basic Properties of TUFTEC™

## 1. Stress-strain Curves




Test sample: 2 mm thickness compression molded
Test method: ISO 37, No. 3 dumbbell, 500 mm/min

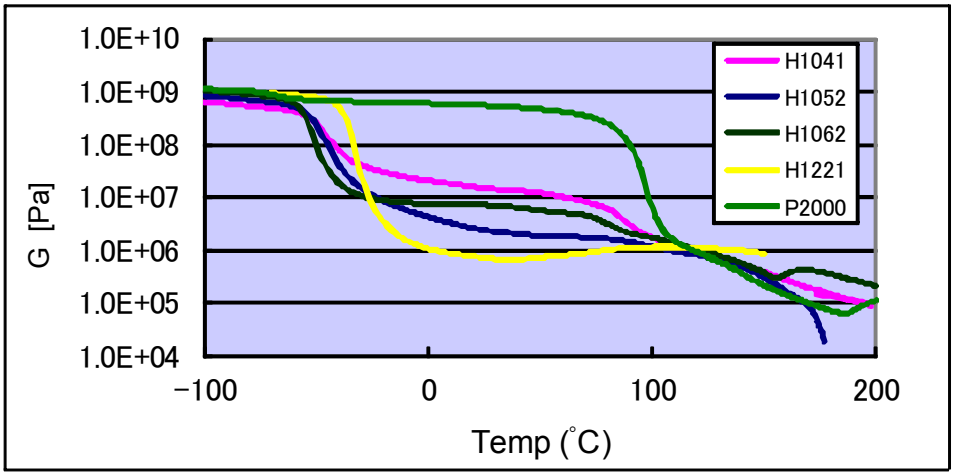
## 2. Solubility in Specific Solvents

| Soluble | Low or non-soluble |
|---|---|
| Cyclohexane | Ethanol |
| Toluene | Isopropanol |
| Xylene | n-pentane |
| THF | n-hexane |
| Chloroform | Acetone |
| | Methanol |

Note: TUFTEC™ swells strongly in gasoline, kerosene, and lubricating oils.

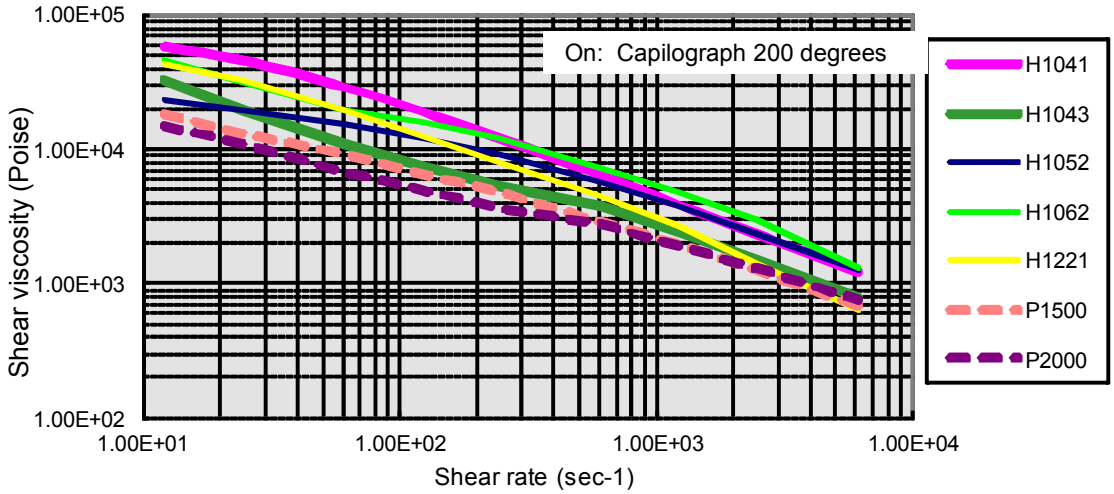
## 3. Elasticity vs. Temperature

On : ARES2 mechanical spectrometer
Plate : ≤12.7 mm (W) x ≤5 cm (L) x 0.8~3.2 mm (T)
Mode: Dynamic temperature ramp



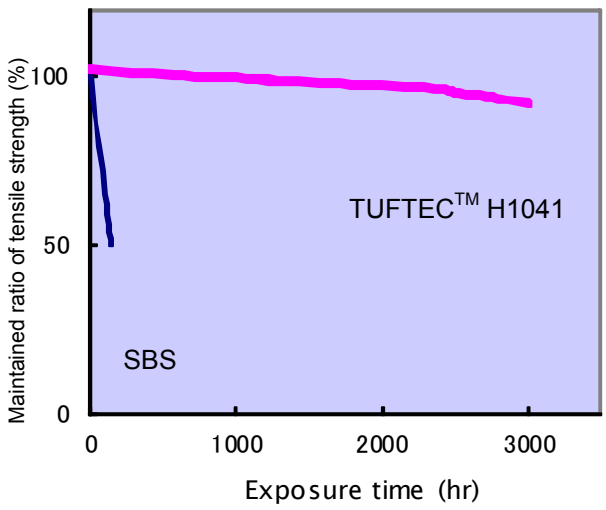

## 4. Viscosity vs. Shear Rate

**Low ← P1500、P2000<H1043<H1221、H1272、H1052<H1062、H1041<H1053<H1051 → High**



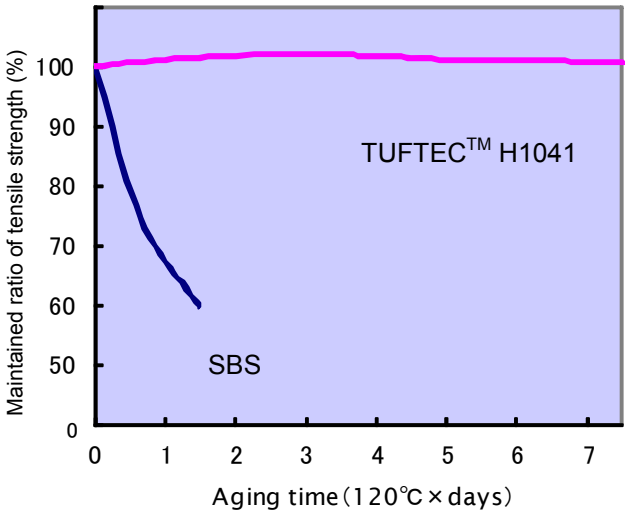
## 5. Weatherability

On Sunshine Weatherometer




## 6. Heat-aging Resistance

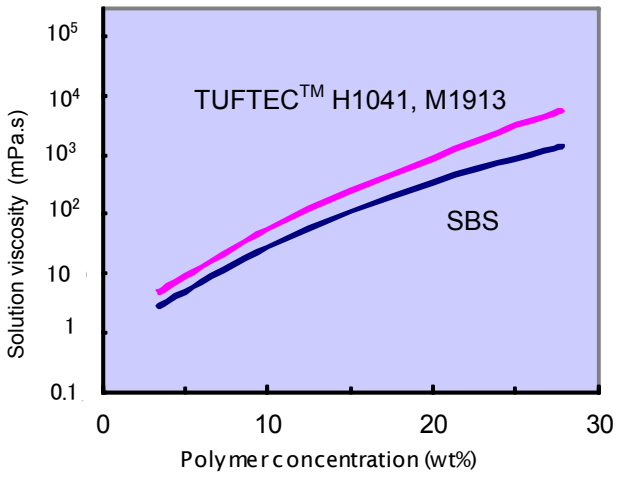
Gear Aging Test




Test conditions:

Weather-resistant formulations
Black panel temperature, 63℃
Spray cycle, 18 min/120 min

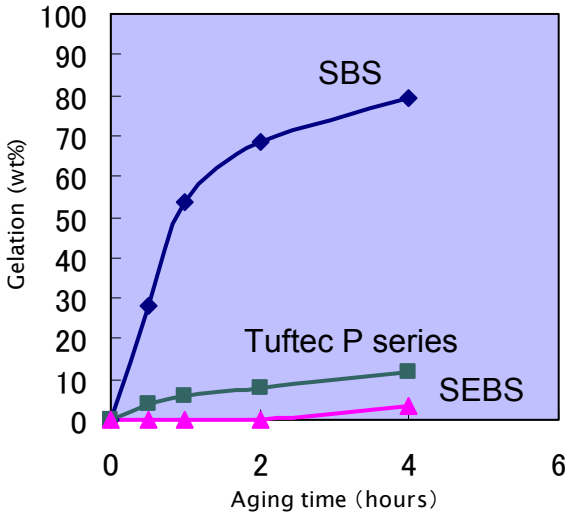
## 7. Toluene Solution Viscosity




Test conditions:

B-type viscosity meter @ 25℃

## 8. Heat Resistance




Gelation ratio after aging at 200℃,

with equal styrene contents

# 9. TUFTEC™—Applications and Recommended Grades

| | Object Material | Effect | End Products | Recommended Grades | | |
|---|---|---|---|---|---|---|
| | | | | H series | P series | M series |
| **Resin Modifier** | PP | Enhancing impact strength | - Car bumpers<br>- Car interior (Instrumental panels, door trim)<br>- Food & medical packaging | H1062<br>H1052 | P1083 | |
| | | Softening the material | - Cable jacket & sheathing<br>- Stretch film<br>- Hoses, Tubes<br>- Food & medical packaging | H1221<br>H1062<br>H1052 | | M1913<br>M1943 |
| | PPE | Enhancing impact strength and toughness | - IC trays<br>- Electronic parts | H1051<br>H1053<br>H1272 | | |
| | PA | Enhancing impact strength and toughness | - Electric connectors | | | M1913<br>M1943 |
| | PET | Enhancing impact strength and toughness | - Toughening agent for recycled PET | H1051<br>H1053 | | M1913 |
| **Compatibilizer** | PP/PS<br>PP/PPO | Enhancing ductility, Toughening recycled material | - Microwavable food containers<br>- Cable jacket & sheathing<br>- Strengthening agent for recycling | H1041<br>H1043<br>H1051 | P2000<br>H1517 | M1913<br>M1943 |
| **Asphalt Modifier** | | Good impact re-sistance with thermal stability | - Hot mopping asphalt roofing | H1053 | P1500 | |
| **Adhesives and Sealants** | | | - Adhesives for protective films<br>- Adhesives for buildings and constructions<br>- Hot melt adhesives for hygiene products<br>- Sealants for automotive<br>- Laminating materials for PS sheets<br>- Adhesives for aluminum and PP | H1221<br>H1052<br>H1041 | P1500<br>P5051<br>P1083 | M1913 |
| **Cross-linked Foam** | | | - Foamed shoe soles | | P5051<br>P1083 | |
| **Raw Material for TPE Compounds** | | | - Grips<br>- ABS over-molded products<br>- Airbag covers | H1272<br>H1062<br>N504 | | M1913<br>M1943<br>MP10 |

# 10. Use and Effect of TUFTEC™ as Resin Modifier

TUFTEC™ H series and M series, with their outstanding compatibility characteristics, are widely used to modify and to compatibilize both thermoplastic and thermoset resins and plastics.

◊ In blends with engineering and commodity plastics, for high impact strength or flexibility.

◊ As reactive binders, to produce new alloys with special characteristeics, through compatibilization of previously unattainable polymer combinations.

## 1. Basic Guideline on Effectiveness for Different Resin Types

| Engineering plastics | H series | M series |
|---|---|---|
| Polyamide (PA) | P | E |
| Polyesters (PEs) | P | G |
| Polyphenylene ether（PPE) | E | E |
| Polyoxymethylene (POM) | G | P |
| Polycarbonate (PC) | P | G |
| Polyphenylene sulfide (PPS) | G | G |

| Commodity plastics | H series | M series |
|---|---|---|
| Polyethylene (PE) | G | G |
| Polypropylene (PP) | E | G |
| Polystyrene (PS) | E | E |

Rating index

E:Excellent G:Good P:Poor

## 2. Polypropylene Modification

TUFTEC™ H-series is effective for polypropylene modification. The optimum grade vary depending on the targeted characteristics of the end product, as illustrated below.

**(1) Block PP modification with TUFTEC™ H1041**

**(2) Improving low-temperature properties of talc-filled PP with TUFTEC™ H1062**

**(3) Clear, flexible PP with TUFTEC™ H1221**

### (1) Block PP Modification with TUFTEC™ H1041

As shown in this table, modification of block PP with TUFTEC™ H1041 can effectively increase softness and low-temperature impact strength. Adding the optimum amount of TUFTEC™ is the key to achieve the desired combination of stiffness and impact strength.

| | | | | Block-PP / TUFTEC™ H1041 | | | |
|---|---|---|---|---|---|---|---|
| Property | | Test Method | | 100/0 | 85/15 | 70/30 | 55/45 |
| MFR | g/10min | ASTM D 1238 | | 1.9 | 2.3 | 2.9 | 3.9 |
| Tensile Strength | MPa | ASTM D 638 | | 23 | 22 | 17 | 14 |
| Elongation at Break | % | | | 700 | 600 | 570 | 540 |
| Flexural Strength | MPa | ASTM D 790 | 23°C | 34 | 26 | 19 | 15 |
| | | | 50°C | 20 | 15 | 11 | 8 |
| | | | 80°C | 12 | 9 | 6 | 4 |
| Flexural Modulus | MPa | ASTM D 790 | 23°C | 1,200 | 850 | 640 | 450 |
| | | | 50°C | 640 | 490 | 350 | 240 |
| | | | 80°C | 390 | 280 | 200 | 130 |
| Izod Impact Strength*1 | J/m | ASTM D 256 | 23°C | 150 | NB | NB | NB |
| | | | 0°C | 61 | NB | NB | NB |
| | | | -10°C | 52 | NB | NB | NB |
| | | | -30°C | 45 | 82 | NB | NB |
| | | | -40°C | 43 | 69 | NB | NB |
| Hardness | Shore D | ASTM D 1706 | | 72 | 68 | 63 | 56 |

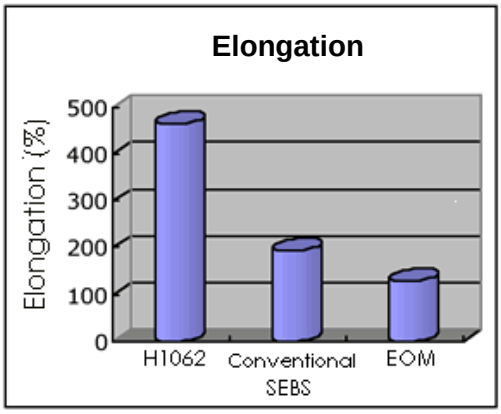
*1 Izod impact test, NB:Non-breaking

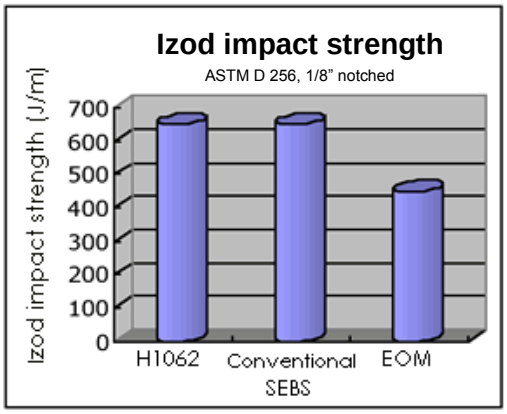
## (2) Improvement of Low-temperature Properties of Talc-filled PP with TUFTEC™ H1062

Block polypropylene with TUFTEC™ is superior in impact resistance, elongation, low-temperature brittleness, and their performance characteristics, as indicated by this comparison of TUFTEC™ H1062 with a conventional styrene-ethylene/butylene-styrene (conventional SEBS) and an ethylene/octene copolymer (EOM).

| | H1062 | Conventional SEBS | EOM |
|---|---|---|---|
| Brittleness Temperature (°C) | -32.3 | -27.8 | -17.4 |

Typical application of TUFTEC™ modified talc-filled PP compounds




Formulation and compounding conditions

Formulation: PP, block copolymer (MFR 30) / TUFTEC™ H1062/talc=65/15/20

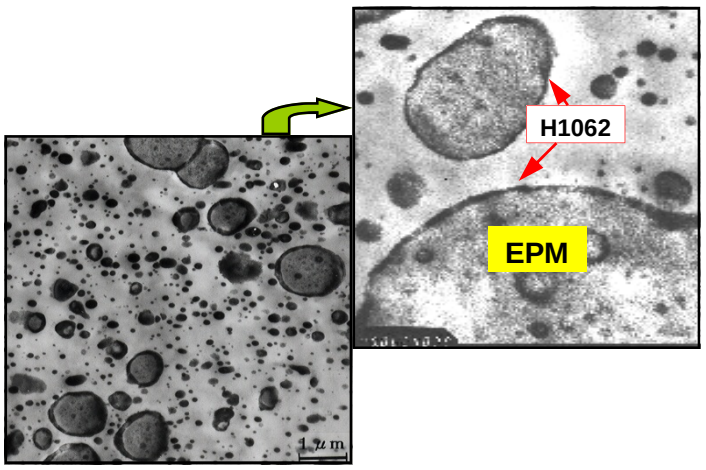
Compounding cylinder temp.: 210°C

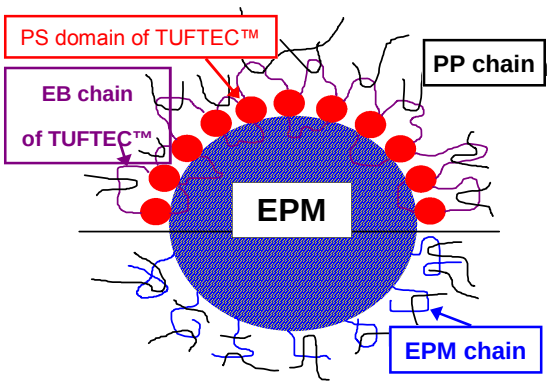
Injection molding: Cylinder temp:230°C, Mold temp:40°C

Injection time: 10 sec, Cooling time: 30 sec

### Homo PP/EPM/H1062 (80/15/5) morphology and mechanism

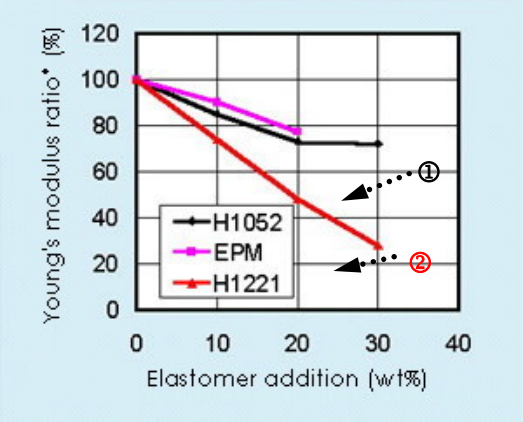
TUFTEC™H1062 encapsules the EPM rubber particles and enhances the interfacial adhesion between the polypropylene and EPM, stabilizing the blend morphology.

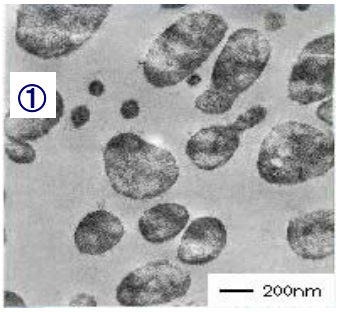


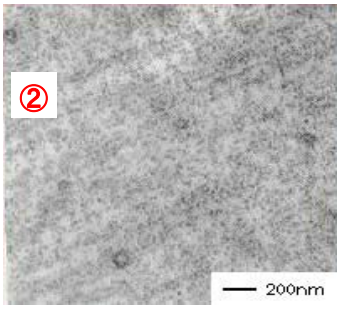
## (3) Clear, Flexible PP with TUFTEC™ H1221

As shown below, clear and flexible polypropylene can be obtained by adding TUFTEC™ H1221, due to its nanometer-order dispersibility in polypropylene.




PP/H1052 (80/20)
Young's modulus **700 MPa**




PP/H1221 (80/20)
Young's modulus **340 MPa**

### Properties of TUFTEC™ H1221 and H1052 Blends with PP

**Homo PP (MFR 7.0 film grade with slipping agent)/ TUFTEC™ = 80/20**

| | Property | Units | TUFTEC™ H1052 | TUFTEC™ H1221 |
|---|---|---|---|---|
| | MFR (230 °C, 2.16 kgf) | g/10 min | 13 | 3 |
| | Bound Styrene | % | 20 | 13 |
| **Sheet or Film** | Young's Modulus (MD/TD) | MPa | 700/550 | **340/380** |
| | Tensile Yield Strength (MD/TD) | MPa | 7/6 | 5/5 |
| | Tensile Rupture Strength (MD/TD) | MPa | 18/18 | 13/13 |
| | Elongation (MD/TD) | % | 72/66 | 70/71 |
| | Light Transmission | % | 91.5 | 92.4 |
| | Haze | % | 17.8 | **4.2** |
| | Blanching, ΔT | % | 33.3 | **3.2** |
| **Injection Molding** | Flexural Modulus | MPa | 1,100 | **710** |
| | Tensile Yield Strength | MPa | 29 | 23 |
| | Tensile STrength at Break | MPa | 21 | 28 |
| | Elongation | % | 730 | 530 |
| | Brittle Temperature | °C | <-30 | -21.4 |

**Sheet or Film**

Young's modulus: 20 mm X 100 mm X 70 μm, 2 mm/min
Light transmission and Haze: 70 μm thickness
Blanching: Light transmission loss under DuPont impact test
(0.4 mm thickness sheet, 1/2" missile, 1 kg load, 50 cm height)

**Injection Molding**

Flexural modulus: JIS K6758, bending speed 2 mm/min
Tensile properties: JIS K6758, tensile speed 50 mm/min
Brittleness temperature: JIS K7216

**Blending Condition**

30 mmΦ twin screw extruder, 210 °C, 200 rpm

### Applications

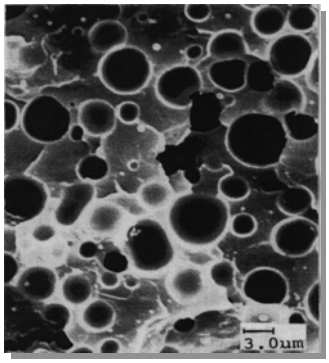
Truck covers


Carry bags

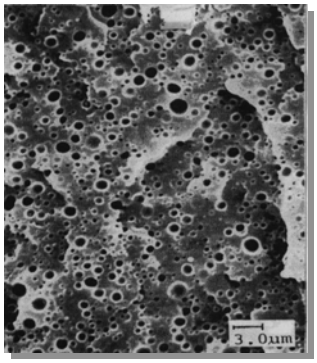
Logo mark line

## 3. Polyamide Modification

As shown by these two micrographs of modified nylon 6 (PA6) obtained under the same blending and extruding conditions, the TUFTEC™ M series enables the formation of significantly smaller dispersed particles than the TUFTEC™ H series, and far higher impact strength, due to the formation of a graft structure by the reaction of the TUFTEC™ M acid anhydride groups with the PA6 functional end groups.

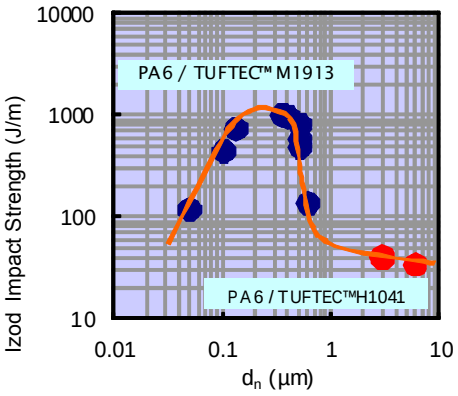



PA6 / TUFTEC™H1041
Izod impact strength 50 J/m




PA6 / TUFTEC™M1913
Izod impact strength 850 J/m

As shown on the right, maximum impact strength can be obtained by optimizing the size of dispersed particles, which is dependent on the PA6 end-group, the functional-group content of TUFTEC™ M, and the blending and extruding conditions.




## 4. Polycarbonate Modification

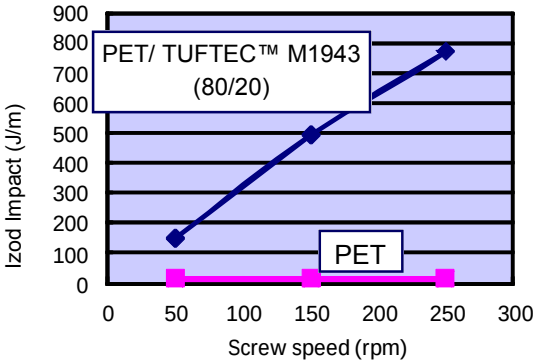
Because of their modified polymeric structure, and the polarity of polycarbonate (PC), TUFTEC™ M series polymers exhibit a large effect on PC even when added in small quantities, as shown here in comparison with the non-modified TUFTEC™ H1041.

| Material (Composition, wt%) | Izod Impact Strength 1/4" (J/m) | Tensile Strength (MPa) | Flexural Strength (MPa) | Flexural Modulus (MPa) |
|---|---|---|---|---|
| PC | 180 | 64 | 98 | 2,500 |
| PC / TUFTEC™H1041 (97.5 / 2.5) | 270 | 59 | 91 | 2,400 |
| PC / TUFTEC™M1913 (97.5 / 2.5) | 720 | 58 | 89 | 2,400 |
| PC / TUFTEC™M1943 (97.5 / 2.5) | 750 | 58 | 90 | 2,400 |

## 5. PET Modification

The impact strength of PET can be increased substantially by TUFTEC™ M, as shown here for TUFTEC™ M1943, and the increase can be controlled by screw speed and other conditions.

| Property | Units | PET | PET/TUFTEC™ M1943 | | |
|---|---|---|---|---|---|
| Screw speed | rpm | 250 | 50 | 150 | 250 |
| Izod impact strength @ 23 °C | J/m | 16 | 150 | 492 | 769 |
| Flexural modulus @ 23 °C | MPa | 2380 | 1500 | 1520 | 1550 |




# *11. Use and Effects of TUFTEC™ as Compatibilizer*

## 1. Compatibilization of Styrenic and Oefinic Resins

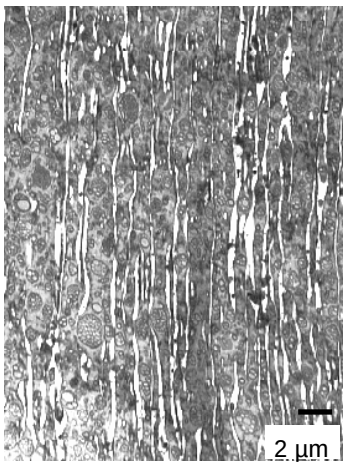
TUFTEC™H1043 and P2000 are high-performance compatibilizers for styrenic and olefinic resins. They enable,

1. co-continuous morphology in the compatibilized styrenic-olefinic alloy at styrenic rich compositions.
2. compatibility with polystyrene and polyphenylene ether.
3. outstanding compatibility with polypropylene and polyethylene.

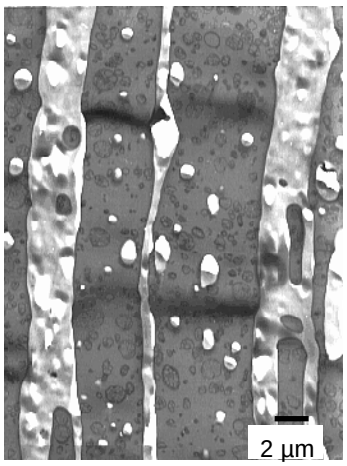
**HIPS/PP/TUFTEC™ P2000 typical TEM micrographs**

The TUFTEC™P2000 molecular structure is highly compatible with both HIPS and PP, enabling this extremely fine dispersion of PP into HIPS.

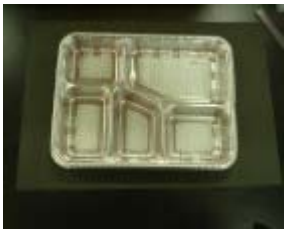
Matrix: HIPS (dark areas)
Dispersed particles: PP (white areas)
Samples: Sheets (0.7 mm), Ruthenium-stained ultra-thin sections




HIPS / PP / P2000
70 / 30 / 6




HIPS / PP
70 / 30



HIPS/PP/TUFTEC™ film laminated food tray

Thermoformed food container

## 2. TUFTEC™ H compatibilization of HIPS and PP

| Property | Units | Test Method | Test Condition | HIPS | PP | HIPS/PP without TUFTEC™ | HIPS/PP with H1041 70/30/6 | HIPS/PP with H1043 70/30/6 |
|---|---|---|---|---|---|---|---|---|
| Density | g/cm³ | ISO 1183 | - | 1.05 | 0.90 | 0.99 | 0.99 | 0.99 |
| MFR | g/10 min. | ISO 1133 | 200°C 5 kgf | 6.6 | 8.5 * | 25 | 13 | 13 |
| Tensile Strength | MPa | ASTM D638 | 5 mm/min. | 30.4 | 26.5 | 26.5 | 23.5 | 28.4 |
| Elongation | % | ASTM D638 | 5 mm/min. | 19 | >200 | 3 | 16 | 170 |
| Flexural Srength | MPa | ASTM D790 | 3 mm/min. | 52 | 31 | 46 | 40 | 46 |
| Flexural Modulus | MPa | ASTM D790 | 3 mm/min. | 2260 | 1080 | 1860 | 1570 | 1770 |
| Izod Impact Strength | J/m | ASTM D256 | | 7.5 | 12.0 | 4.4 | 11.2 | 7.2 |
| HDT | °C | ASTM D648 | 4.6 kg | 87 | 105 | 91 | 89 | 89 |
| Vicat Softening Point | °C | ASTM D1525 | | 106 | 150 | 110 | 108 | 108 |

## 3. TUFTEC™ P2000 compatibilization of styrenics and PP

| Styrenic Resin / PP Relative Proportions | | | | PP / HIPS, GPPS or ABS / TUFTEC™P2000 30 / 70 / 0 or 10 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | PP | | | | | |
| | | | | HIPS | | GPPS | | ABS | |
| Property | Units | Test Method | Test Condition | No TUFTEC™ | TUFTEC™ P2000 | No TUFTEC™ | TUFTEC™ P2000 | No TUFTEC™ | TUFTEC™ P2000 |
| Density | g/cm³ | ISO 1183 | - | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| MFR | g/10 min. | ISO 1133 | 200°C, 5 kg | 9.2 | 9 | 12.8 | 6.5 | 81 *1 | 57 *1 |
| Tensile Strength | MPa | ASTM D 638 | 5 mm/min. | 26.0 | 31.6 | 31.0 | 46.0 | 29.7 | 38.0 |
| Elongation | % | ASTM D 638 | 5 mm/min. | 3 | 170 | 2 | 100 | 3 | 145 |
| Flexural Strength | MPa | ASTM D 790 | 2 min. | 47 | 50 | 54 *2 | 75 | 50 | 66 |
| Flexural Modulus | MPa | ASTM D 790 | 2 min. | 1,790 | 1,870 | 2,570 | 2,520 | 2,190 | 2,050 |
| Izod Impact Strength | J/m | ASTM D256 | notched | 2.7 | 52 | 17 | 18 | 52 | 60 |

*1: 220 °C, 10 kg. *2: Rupture

PP: homopolymer, MFR=3.3 (230 °C, 2.16 kg).

HIPS: PSJ-Polystyrene 475D, MFR=2.0 (200 °C, 5 Kg). GPPS: PSJ-Polystyrene™ 685 by PS Japan, MFR=1.5 (200 °C, 5 kg)

ABS: STYLAC™ ABS 121B by Asahi Kasei Corp., MFR=17 (220 °C, 10 kg).

# 12. Use and Effect of TUFTEC™ in Adhesive Applications

As indicated below, TUFTEC™ H, M, and P series all provide excellent performance as the base polymer for a broad range of regular and pressure-sensitive adhesives.

## 1. Compatibility with Tackifier Resins

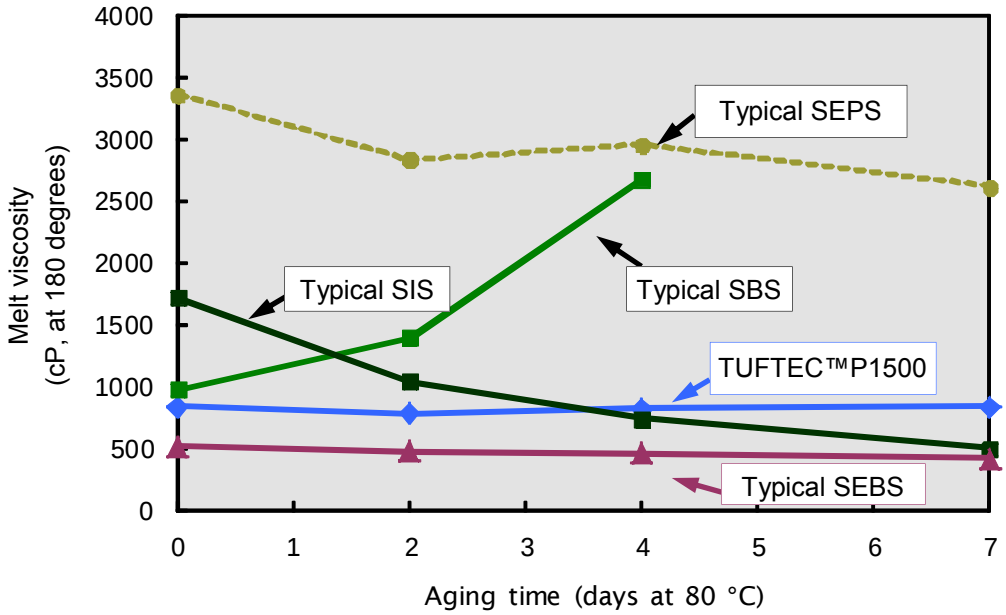
Compatibility of TUFTEC™ and other styrenic thermoplastics with typical tackifiers

| Polymer | SEBS | TUFTEC™ P1500 | SBS | SIS | SEPS |
|---|---|---|---|---|---|
| Alicyclic saturated hydrocarbon | F | G | N | G | G |
| Alicyclic Hydrocarbon | N to F | G | G | G | F to G |
| Aliphatic Hydrocarbon | G | G | N | G | G |
| Hydrogenated Polyterpene | G | G | N | G | G |

**Compatibility rating: G: Good, F: Fair, N: Non-compatible**

## 2. Thermal Stability of Pressure-sensitive Adhesives

Thermal stability of typical pressure-sensitive adhesive formulations based on TUFTEC™ P1500 and other styrenic block copolymers, with an alicyclic hydrocarbon tackifier.



## 3. Adhesive Peel Strength of Neat Polymers

| Adherend | Press Temp. (°C) | Adhesive Strength* (N /10 mm) | | |
|---|---|---|---|---|
| | | TUFTEC™ M1913 | TUFTEC™ H1041 | TUFPRENE™ A |
| | | Modified SEBS | SEBS | SBS |
| Aluminum Foil, 100 μm | 200 | 53 | 4 | 11 |
| PET Film, 50 μm | 180 | 10 | 1 | 0.4 |
| Nylon 66 Plate, 3 mm | 180 | 24 | 1 | 8 |
| Stainless Steel Plate, 2mm | 200 | 39 | 8 | 16 |
| Steel Plate, 2 mm | 200 | >60 | 11 | 47 |
| EVOH Plate, 2 mm | 140 | 43 | 3 | 0.4 |
| Glass Plate | 200 | 23 | 0.4 | 3 |

Adhesion process: Place neat polymer on adherend, 5 min pre-heating, 5 min press under 1 kgf/cm² load, 3 min cooling.

Peeling procedure: T-shape peeling for film or foil adherend, 180-degree peeling for plates
Peeling speed 200 mm/min, at room temperature.

*Adhesive layer: 200 μm

## 4. Tackifier Selection

Formulation (411 parts in total)
Polymer :100 phr
Tackifier :250 phr
Paraffin Oil (PW380) : 60 phr
Stabilizer :1 phr

Adhesion characteristics with typical tackifiers

| Tackifier | | Melt Viscosity @180°C (mPa.s) | Softening Point (°C) | Adhesive properties | | |
|---|---|---|---|---|---|---|
| | | | | Loop Tack (N /15 mm) | Adhesive Strength (N /10 mm) | Holding Power @65°C (hours) |
| Alicyclic Hydrocarbon | SEBS | 600 | 91 | 0.8 | 16.1 | 1.9 |
| | P1500 | 830 | 107 | 4.4 | 15.9 | 6 |
| Alicyclic Saturated Hydrocarbon | SEBS | 520 | 92 | 3.1 | 16.3 | 6 |
| | P1500 | 840 | 103 | 14.1 | 17.3 | 20 |
| Aliphatic Hydrocarbon | SEBS | 480 | 92 | 15.8 | 14.5 | 10 |
| | P1500 | 860 | 106 | 17.7 | 18.6 | 25 |
| Hydrogenated Polyterpene | SEBS | 850 | 101 | 0.1 | 17.2 | 7 |
| | P1500 | 1,830 | 119 | 0.1 | 17.6 | 15 |

How to make adhesive composites: Blending in toluene solution

Tape formation: Coating adhesive composites on PET film with 50 μm thickness

# 13. 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 "AK"), 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 TUFTEC™ for the intended use, purpose, and application.

## 1. Safe handling and use

Always observe the following general precautions and consult the Material Safety Data Sheets (MSDS) issued by AK, before handling or using TUFTEC™, and investigate and determine by advance test-ing 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 TUFTEC™ for the intended use, purpose and application.

### *1) Hot and molten polymer*

Avoid inhalation and eye or skin contact with any gases generated in heating or melting TUFTEC™ 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*

TUFTEC™ 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 TUFTEC™ 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 TUFTEC™ 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 TUFTEC™ vary with the resin grade and type of use. Consult AK or its representatives for related information.

## 2. Medical and food applications

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

## 3. Patent infringement

AK warrants only that the sale or use of TUFTEC™ 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 April 2016

**Asahi Kasei Corporation**

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