

# Introduction of SEPTON™ and HYBRAR™

Elastomer R&D Dept.  
Elastomer Division

***kuraray***

**Septon™**

**Hybrar™**

# SEPTON™ / HYBRAR™

## ~Styrenic Thermoplastic Elastomer (TPE)~

### Main application

- Alternative to rubber products
- Modifier for plastics
- Masterbatch

### Production base

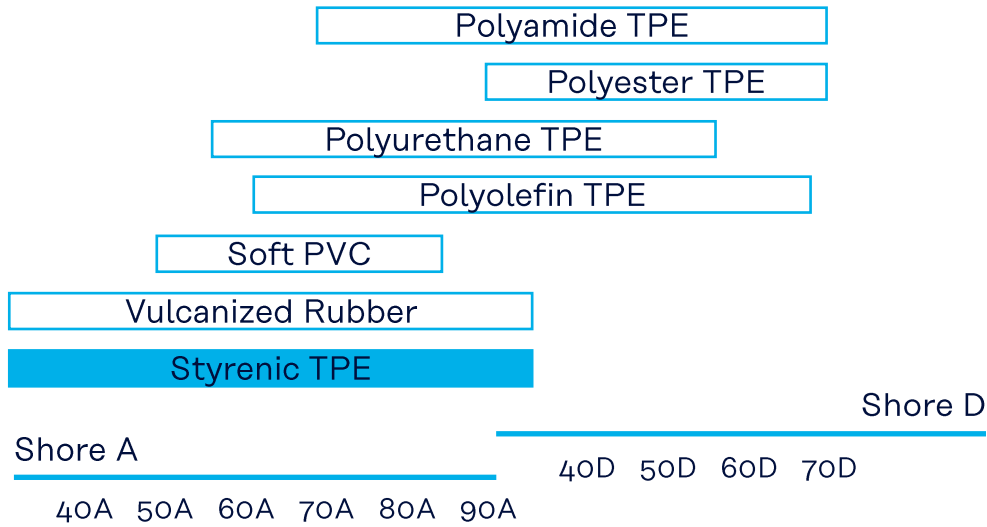
- Kashima, Japan
- Texas, U. S. A.
- Rayong, Thailand

### Global production capacity

- 64,000 MT/y (Japan + U. S. A. + Thailand)

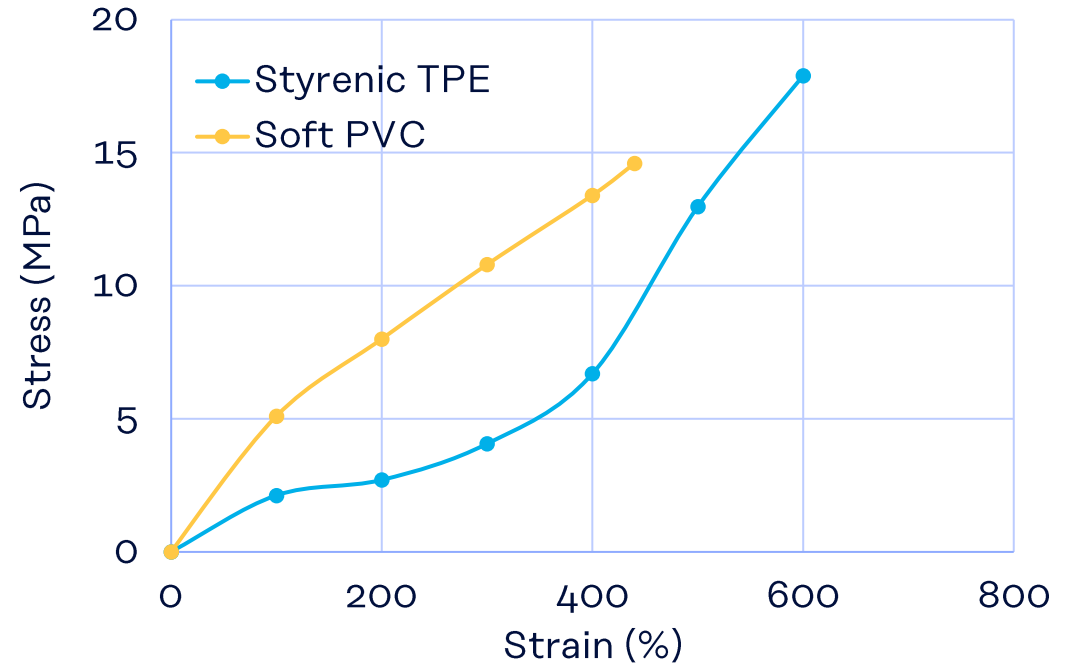


# Features of Styrenic TPE



Various TPE Hardness

Styrenic TPE: Hardness = 69A  
Soft PVC: Hardness = 75A

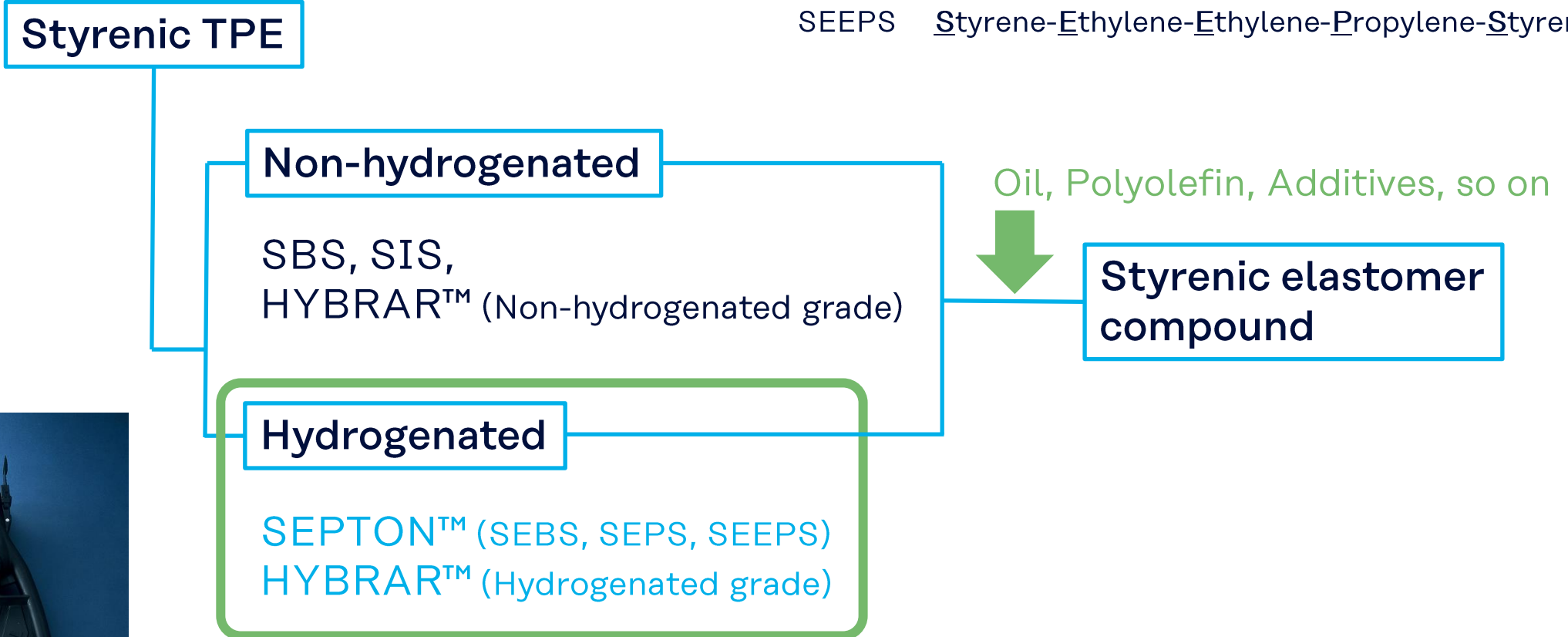


Stress-Strain curve of Styrenic TPE & Soft PVC

- Most flexible among TPEs.
- Designable from low to high hardness
- Natural rubber-like Stress-Strain curve
- Excellent compatibility with polyolefins (especially hydrogenated grades)
- Recyclable

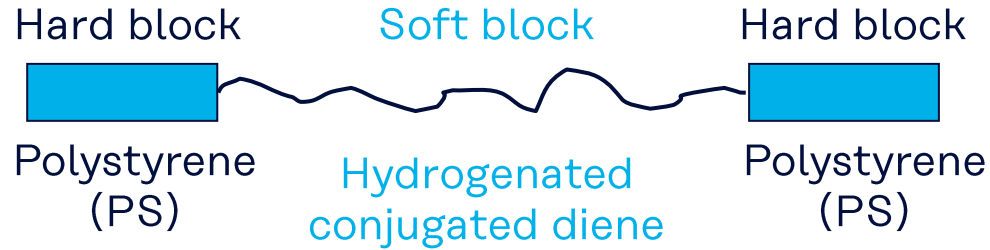
# Type of Styrenic TPE

- SBS Styrene-Butadiene-Styrene
- SIS Styrene-Isoprene-Styrene
- SEBS Styrene-Ethylene-Butylene-Styrene
- SEPS Styrene-Ethylene-Propylene-Styrene
- SEEPS Styrene-Ethylene-Ethylene-Propylene-Styrene

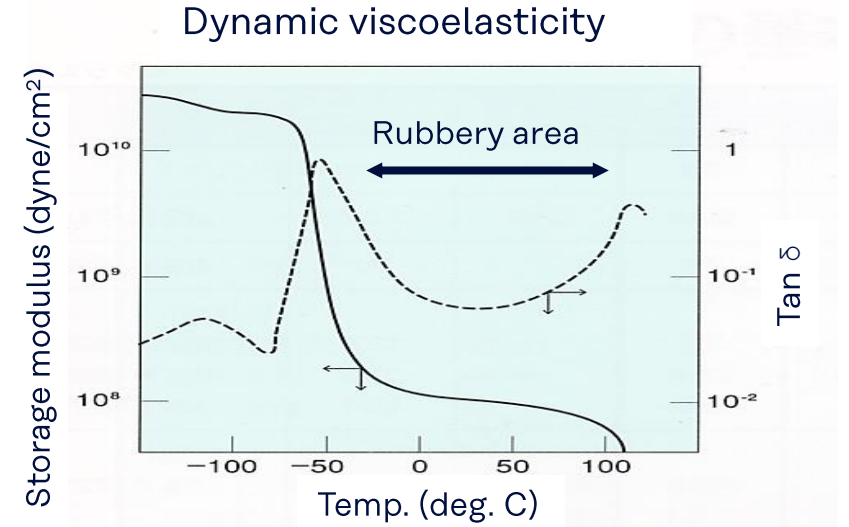
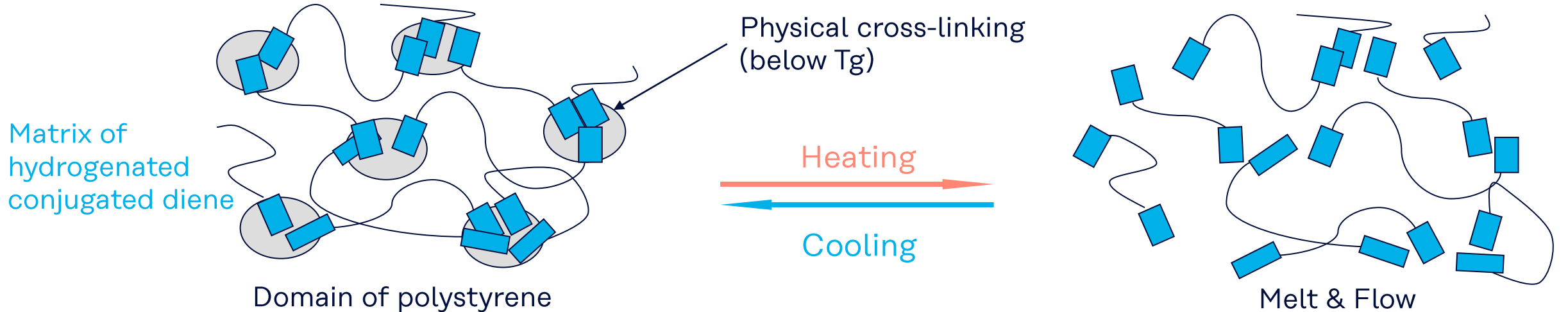


# Hydrogenated Styrenic Block Copolymer (HSBC)

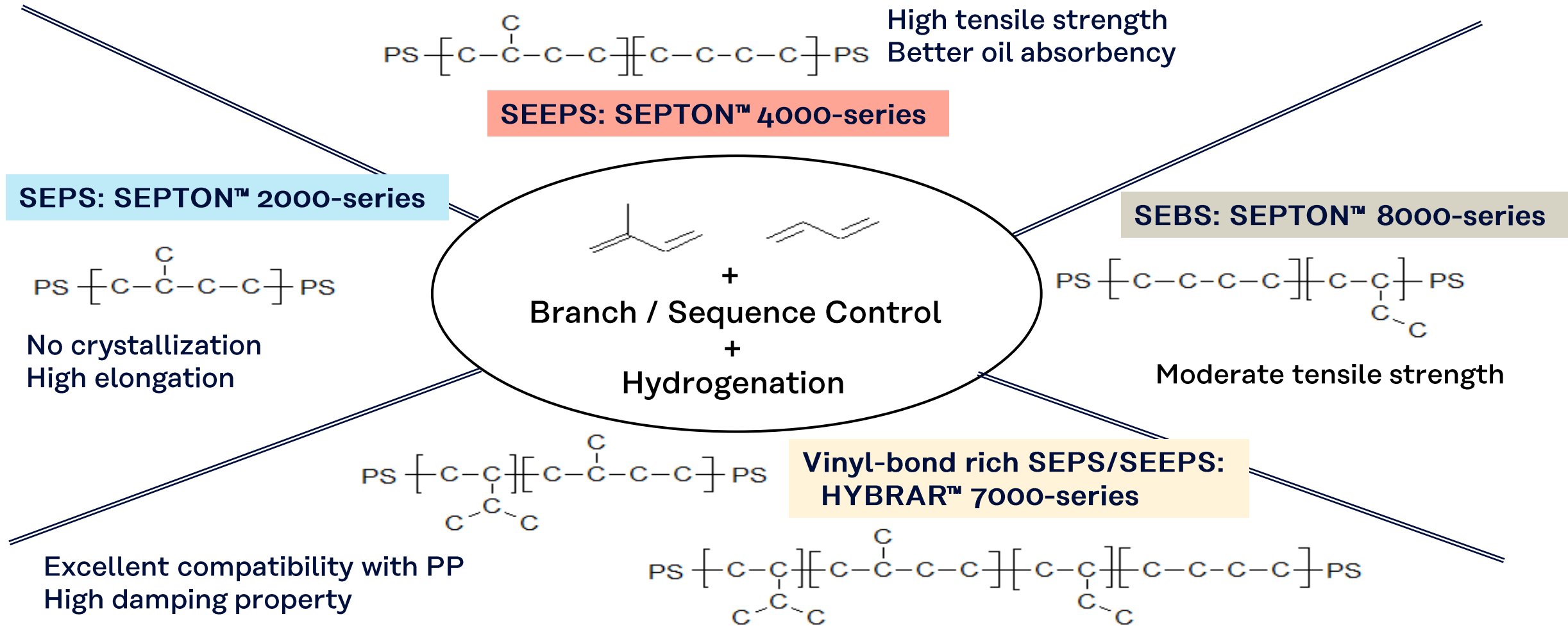
## Primary structure of HSBC



## Micro phase separation of HSBC



# Polymer Structure of SEPTON™ and HYBRAR™



# Grade Map

Better physical properties /  
High temp. performance

Molecular Weight

High molecular weight (Mw)

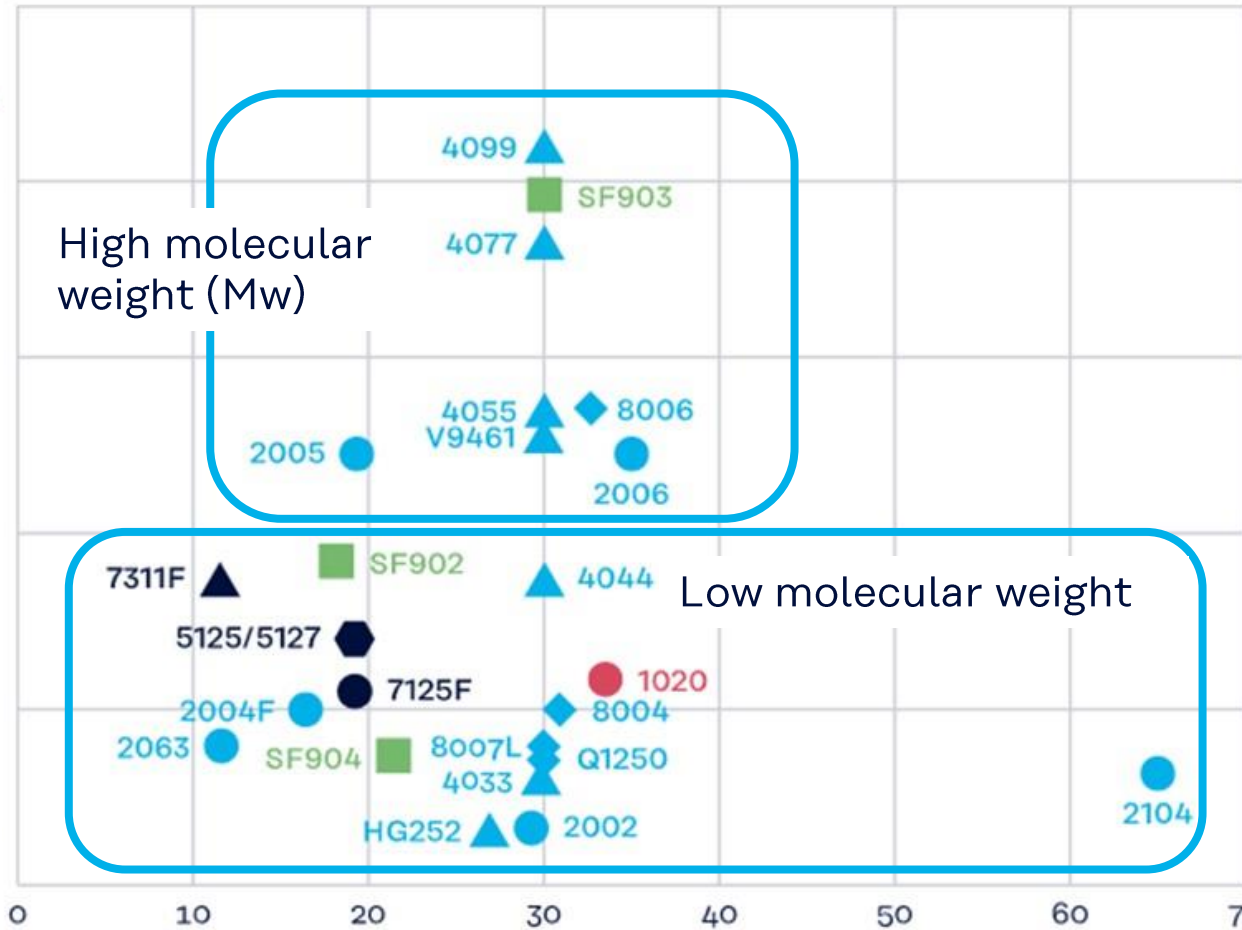
Low molecular weight

High flowability/processability

Soft elasticity

Styrene Content (wt %)

High hardness



- SEPTON™ 1000-series (SEP)
- SEPTON™ 2000-series (SEPS)
- ▲ SEPTON™ 4000-series (SEEPS)
- ◆ SEPTON™ 8000-series (SEBS)
- SEPTON™ BIO-series (HSFC)
- ▲ ◆ SEPTON™ specialty grades
- HYBRAR™ 5000-series (Vinyl-bond rich SIS)
- HYBRAR™ 7000-series (Vinyl-bond rich SEPS)
- ▲ HYBRAR™ 7000-series (Vinyl-bond rich SEEPS)



# Typical Properties of SEPTON™ (High Mw Grades)

| Grade       | Type  | Styrene Content (wt%) | Specific Gravity | Solution Viscosity         |                |                | Physical Form |
|-------------|-------|-----------------------|------------------|----------------------------|----------------|----------------|---------------|
|             |       |                       |                  | 5 wt% (mPa·s)              | 10 wt% (mPa·s) | 15 wt% (mPa·s) |               |
| 2005        | SEPS  | 20                    | 0.89             | 40                         | 1,700          | -              | Powder        |
| 2006        | SEPS  | 35                    | 0.92             | 27                         | 1,220          | -              | Powder        |
| 4055        | SEEPS | 30                    | 0.91             | 90                         | 5,800          | -              | Powder        |
| 4077        | SEEPS | 30                    | 0.91             | 300                        | -              | -              | Powder        |
| 4099        | SEEPS | 30                    | 0.91             | 670                        | -              | -              | Powder        |
| 8006        | SEBS  | 33                    | 0.92             | 42                         | -              | -              | Powder        |
| Test method |       |                       | ISO 1183         | Toluene solution 30 deg. C |                |                |               |



# Typical Properties of SEPTON™ (Low Mw Grades)

| Grade       | Type     | Styrene Content (wt%) | Specific Gravity | Hardness (Type A)     | Tensile Properties  |                        |                | MFR                            |                              | Solution Viscosity         |                |                | Physical Form |
|-------------|----------|-----------------------|------------------|-----------------------|---------------------|------------------------|----------------|--------------------------------|------------------------------|----------------------------|----------------|----------------|---------------|
|             |          |                       |                  |                       | 100% Modulus (MPa)  | Tensile Strength (MPa) | Elongation (%) | 230 deg. C, 2.16 kg (g/10 min) | 200 deg. C, 10 kg (g/10 min) | 5 wt% (mPa·s)              | 10 wt% (mPa·s) | 15 wt% (mPa·s) |               |
| 1020        | SEP      | 36                    | 0.92             | 70                    | -                   | 1.2                    | < 100          | -                              | 1.8                          | -                          | 42             | -              | Powder        |
| 2002        | SEPS     | 30                    | 0.91             | 80                    | 3.2                 | 11.2                   | 480            | 70                             | 100                          | -                          | -              | 25             | Pellet        |
| 2004F       | SEPS     | 18                    | 0.89             | 67                    | 2.2                 | 16.0                   | 690            | 5                              | -                            | -                          | -              | 145            | Pellet        |
| 2063        | SEPS     | 13                    | 0.88             | 36                    | 0.4                 | 10.8                   | 1,200          | 7                              | 22                           | -                          | 29             | 140            | Pellet        |
| 2104        | SEPS     | 65                    | 0.98             | 98                    | -                   | 4.3                    | < 100          | 0.4                            | 22                           | -                          | -              | 23             | Pellet        |
| 4033        | SEEPS    | 30                    | 0.91             | 76                    | 2.2                 | 35.3                   | 500            | < 0.1                          | < 0.1                        | -                          | 50             | 390            | Powder        |
| 4044        | SEEPS    | 32                    | 0.91             | -                     | -                   | -                      | -              | No Flow                        | No Flow                      | 22                         | 460            | -              | Powder        |
| HG-252      | SEEPS-OH | 28                    | 0.90             | 80                    | 3.0                 | 23.0                   | 500            | 26                             | -                            | -                          | -              | 70             | Pellet        |
| 8004        | SEBS     | 31                    | 0.91             | 80                    | 2.3                 | 31.6                   | 560            | < 0.1                          | < 0.1                        | -                          | 40             | -              | Powder        |
| 8007L       | SEBS     | 30                    | 0.91             | 77                    | 3.5                 | 29.0                   | 550            | 2.0                            | -                            | -                          | 20             | -              | Pellet        |
| Test method |          |                       | ISO 1183         | ISO 7619 as reference | ISO 37 as reference |                        |                | ISO 1133 as reference          |                              | Toluene solution 30 deg. C |                |                |               |

# Typical Properties of HYBRAR™ (Low Mw Grades)

| Grade       | Type                  | Styrene Content (wt%) | Peak Temp. of Tan δ (deg. C) | Glass Transition Temp. (deg. C) | Specific Gravity | Hardness (Type A)     | Tensile Properties  |                        |                | MFR                            |                                | Solution Viscosity |                |                | Physical Form |
|-------------|-----------------------|-----------------------|------------------------------|---------------------------------|------------------|-----------------------|---------------------|------------------------|----------------|--------------------------------|--------------------------------|--------------------|----------------|----------------|---------------|
|             |                       |                       |                              |                                 |                  |                       | 100% Modulus (MPa)  | Tensile Strength (MPa) | Elongation (%) | 190 deg. C, 2.16 kg (g/10 min) | 230 deg. C, 2.16 kg (g/10 min) | 5 wt% (mPa·s)      | 10 wt% (mPa·s) | 15 wt% (mPa·s) |               |
| 5127        | Vinyl-bond rich SIS   | 20                    | 20                           | 8                               | 0.94             | 84                    | 2.8                 | 12.4                   | 730            | 5                              | -                              | -                  | -              | 540            | Pellet        |
| 5125        | Vinyl-bond rich SIS   | 20                    | -3                           | -13                             | 0.94             | 60                    | 1.6                 | 8.8                    | 730            | 4                              | -                              | -                  | 100            | 650            | Pellet        |
| 7125F       | Vinyl-bond rich SEPS  | 20                    | -5                           | -15                             | 0.90             | 64                    | 1.7                 | 7.1                    | 680            | 0.7                            | 4                              | -                  | 55             | 350            | Pellet        |
| 7311F       | Vinyl-bond rich SEEPS | 12                    | -17                          | -32                             | 0.89             | 41                    | 0.6                 | 6.3                    | 1050           | 0.5                            | 2                              | 90                 | 240            | -              | Pellet        |
| Test method |                       |                       |                              | DSC*                            | ISO 1183         | ISO 7619 ss reference | ISO 37 as reference |                        |                | ISO 1133 as reference          | Toluene solution 30 deg. C     |                    |                | -              |               |

\*Temperature elevation rate = 10 deg. C/min

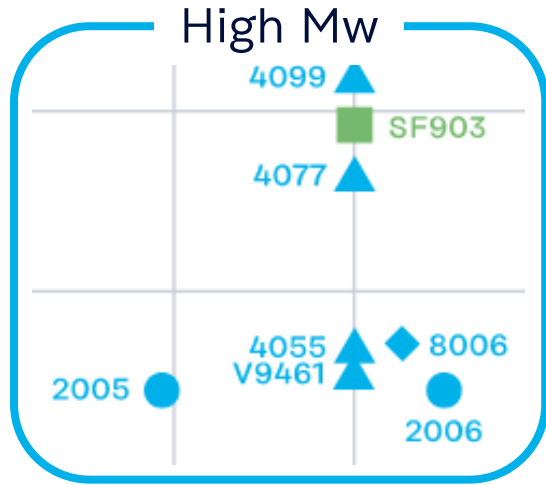
# Tensile Properties of SEPTON™

|                  |       | SEPTON™ |       |      |
|------------------|-------|---------|-------|------|
|                  |       | 4033    | 8007L | 8004 |
| Type             |       | SEEPS   | SEBS  | SEBS |
| Styrene Content  | (wt%) | 30      | 30    | 31   |
| at 23 deg. C     |       |         |       |      |
| 100% Modulus     | (MPa) | 2.2     | 3.5   | 2.3  |
| Tensile Strength | (MPa) | 35.3    | 29.0  | 31.6 |
| Elongation       | (%)   | 500     | 550   | 560  |
| at 40 deg. C     |       |         |       |      |
| Tensile Strength | (MPa) | 31.1    | 10.4  | 26.8 |
| Elongation       | (%)   | 530     | 610   | 570  |
| at 60 deg. C     |       |         |       |      |
| Tensile Strength | (MPa) | 11.7    | 5.6   | 9.7  |
| Elongation       | (%)   | 570     | 490   | 560  |

Test condition ISO-37, Compression molding, Tensile speed 500 mm/min

**SEEPS shows higher tensile strength.**

# High Molecular Weight (Mw) grades of SEPTON™



## Physical Form

Powder

## Main Usage

- ✓ Base polymer for compounds (alternative to vulcanized rubber, PVC)
- ✓ Base polymer for exceptionally soft compounds



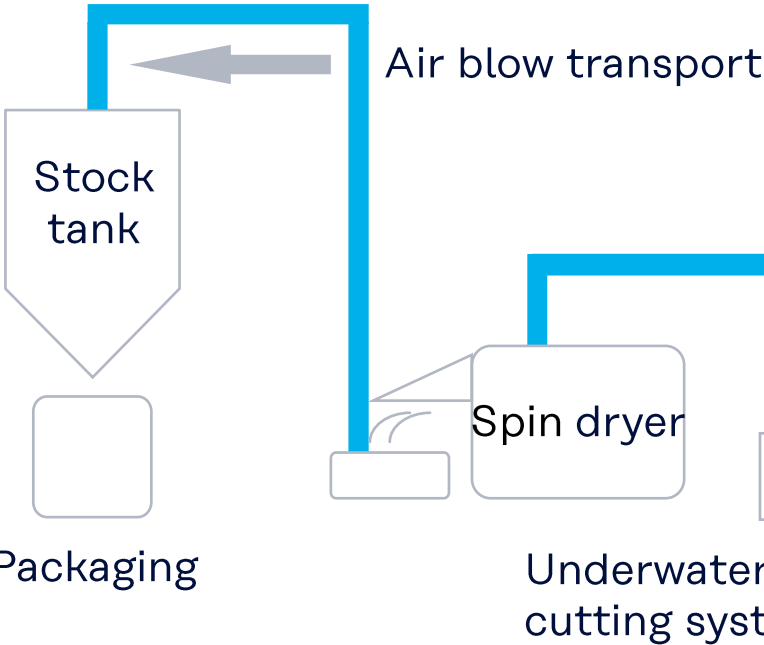
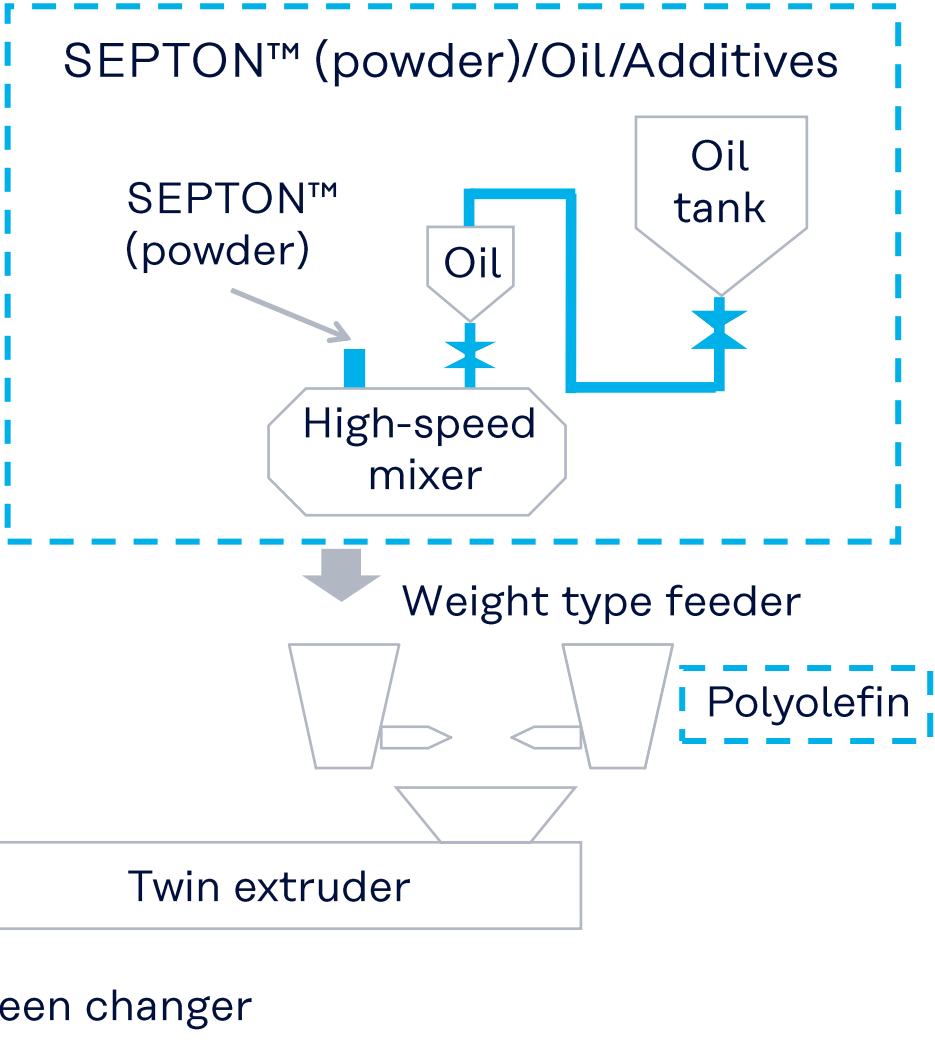
## Market

Automotive materials, consumer goods, medical materials, food packaging, materials, sporting goods, etc.

## Keyword

Soft touch, cushioning, heat resistance

# HSBC Compounding Process Flow



Packaging

# Compounds with High Mw grades of SEPTON™

\*Kinematic viscosity



| Formulations   | phr      | 1     | 2    | 3    | 4   | 5   |
|--|----------|-------|------|------|-----|-----|
| SEPTON™ 4055   |          | 100   | 100  | 100  | 100 | 100 |
| Paraffin oil (KV* at 40 deg. C = 382 mm <sup>2</sup> /s) |          | 100   | 100  | 100  | 100 | 100 |
| Homo-PP (MFR=10 g/10 min)                                |          | 0     | 20   | 40   | 80  | 100 |
| Antioxidant  |          | 0.1   | 0.1  | 0.1  | 0.1 | 0.1 |
| Properties   |          |       |      |      |     |     |
| Hardness (Type A)  |          | 21    | 50   | 72   | 89  | 92  |
| Tensile Properties                                       |          |       |      |      |     |     |
| 100% Modulus   | MPa      | 0.3   | 0.9  | 2.1  | 4.0 | 5.1 |
| 300% Modulus   | MPa      | 0.4   | 1.5  | 2.8  | 5.0 | 6.1 |
| Tensile Strength   | MPa      | 8.4   | 8.7  | 15   | 20  | 20  |
| Elongation   | %        | 1,030 | 900  | 870  | 840 | 800 |
| Permanent Set (100%, 10 min)                             | %        | 6     | 9    | 12   | 19  | 25  |
| Compression Set (70 deg. C, 22 h)                        | %        | -     | 25   | 35   | 47  | -   |
| MFR (230 deg. C, 2.16 kg)                                | g/10 min | <0.01 | 0.02 | 0.16 | 5.2 | 7.8 |

Designable from low to high hardness with good compression set

# Exceptionally soft Compounds using High Mw grades of SEPTON™



|                  |          | 1     | 2      |
|------------------|----------|-------|--------|
| Formulations     | phr      |       |        |
| SEPTON™ 4055     |          | 100   | 100    |
| Paraffin oil     |          | 200   | 400    |
| PP               |          | 15    | -      |
| Properties       |          |       |        |
| Hardness         | Type A   | 21    | 0      |
|                  | Shore 00 | 74    | 28     |
| Tensile Strength | MPa      | 5.3   | >1.7   |
| Elongation       | %        | 1,100 | >1,500 |

Designable exceptionally soft compounds with a large amount of oil



# Effect of Molecular Weight of SEPTON™ on Compound Properties

## Compound formulation

HSBC/Paraffin oil<sup>1)</sup>/Homo-PP<sup>2)</sup> (100/120/45 by wt)

1) Viscosity@40 deg. C = 96 mm<sup>2</sup>/s

2) MFR = 15 g/10 min



|                             |              | SEPTON™ |      |      |
|-----------------------------|--------------|---------|------|------|
|                             |              | 4055    | 4077 | 4099 |
| Hardness (Type A)           |              | 70      | 70   | 70   |
| 100% Modulus                | MPa          | 1.9     | 1.8  | 1.9  |
| Tensile Strength            | MPa          | 12.8    | 13.5 | 12.2 |
| Elongation                  | %            | 820     | 860  | 800  |
| Compression Set (70 deg. C) | %            | 38      | 36   | 36   |
|                             | (100 deg. C) | 50      | 44   | 41   |
|                             | (120 deg. C) | 55      | 50   | 45   |
| MFR (230 deg. C, 5 kg)      | g/10 min     | 29      | 28   | 16   |

Higher Mw grades of SEPTON™ improves compression set at high temperatures.

# Low Mw Grades of SEPTON™/HYBRAR™



## Physical Form

Powder, pellet

## Main Usage

- ✓Resin modifier  
(improves impact resistance, softness (alternative to PVC))
- ✓Soft film
- ✓Base polymer for adhesives
- ✓Damping material
- ✓Base polymer for compounds
- ✓Compatibilizer

## Market

Sanitary materials, medical materials, food packaging materials, sporting goods, electronic parts, etc.

## Keyword

Soft & transparent film/tube, adhesive, damping, high flow



# Improvement of Impact Resistance using Low Mw Grades of SEPTON™

|   |     | 1   | 2   | 3   | 4   | 5   |
|---|-----|-----|-----|-----|-----|-----|
| Formulations                                | phr |     |     |     |     |     |
| Block-PP (MFR=30)                           |     | 100 | 80  | 73  | 80  | 80  |
| SEPTON™ 2004F                               |     |     | 20  | 18  |     |     |
| SEPTON™ 8007L                               |     |     |     |     | 20  |     |
| Ethylene-Propylene-Rubber                   |     |     |     |     |     | 20  |
| Talc  |     |     |     | 9   |     |     |
| Properties                                  |     |     |     |     |     |     |
| Flexural modulus                            | MPa | 750 | 572 | 811 | 611 | 656 |
| Flexural strength                           | MPa | 23  | 18  | -   | 18  | 18  |
| Izod impact strength (Notched) at 25 deg. C | J/m | 117 | 614 | 298 | 509 | 164 |
| at -20 deg. C                               | J/m | 39  | 141 | 123 | 96  | 90  |

Addition of SEPTON™ to PP improves impact resistance.

# PP Softening using Low Mw HYBRAR™



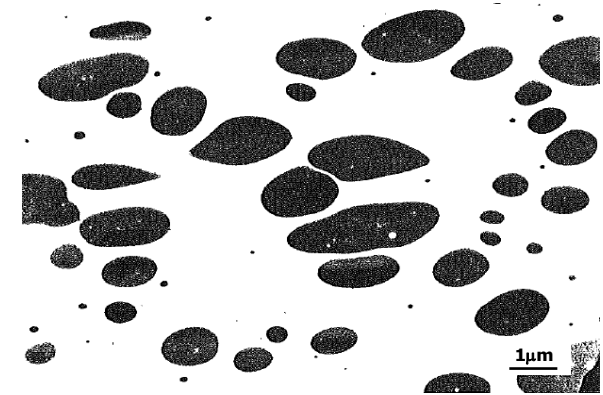
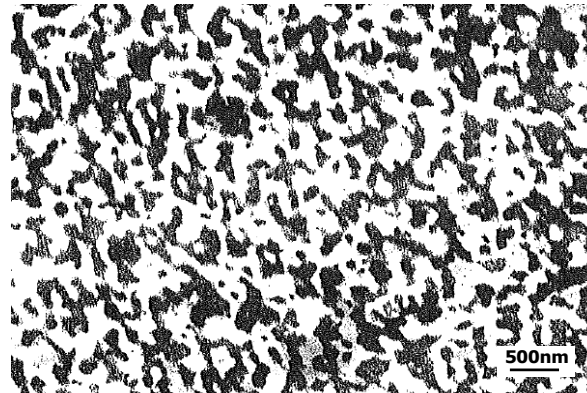
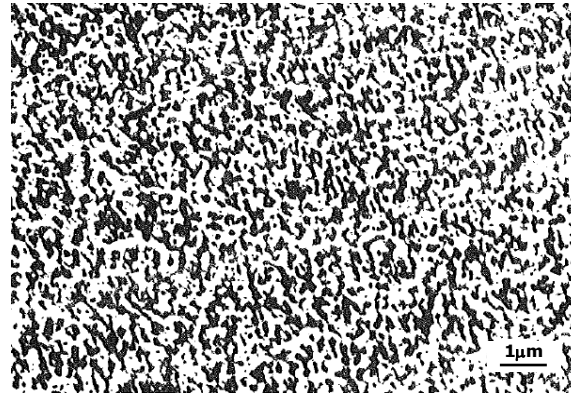
|   |         | 1   | 2   | 3   | 4   | 5   | 6   | 7   |
|---|---------|-----|-----|-----|-----|-----|-----|-----|
| Formulations                                  | phr     |     |     |     |     |     |     |     |
| Random-PP (MFR=7)                             |         | 100 | 90  | 70  | 60  | 90  | 70  | 60  |
| HYBRAR™ 7125F                                 |         |     | 10  | 30  | 40  |     |     |     |
| HYBRAR™ 7311F                                 |         |     |     |     |     | 10  | 30  | 40  |
| Properties                                    |         |     |     |     |     |     |     |     |
| Hardness                                      | Shore D | 63  | 55  | 46  | 42  | 54  | 44  | 35  |
| Young's modulus                               | MPa     | 490 | 480 | 250 | 140 | 380 | 140 | 90  |
| Tensile strength                              | MPa     | 37  | 35  | 30  | 30  | 34  | 30  | 28  |
| Izod impact strength<br>(Notched, -20 deg. C) | J/m     | 30  | 32  | 36  | 38  | 45  | 320 | 860 |
| HAZE  | %       | 52  | 49  | 30  | 19  | 52  | 33  | 27  |

- ✓ Compounds of PP and HYBRAR™ 7311F provides softness & low temp. impact resistance.
  - ✓ Compounds of PP and HYBRAR™ are transparent & have a PVC-like texture (without undesirable plasticizers).
- => Applications - soft films & tubing

# Compatibility of Low Mw Grades of HYBRAR™ with PP

HYBRAR™/r-PP (30/70 by wt)

General SEBS/r-PP (30/70 by wt)



Hydrogenated grade of HYBRAR™ shows good compatibility with PP.

# Adhesives using Low Mw Grades of SEPTON™

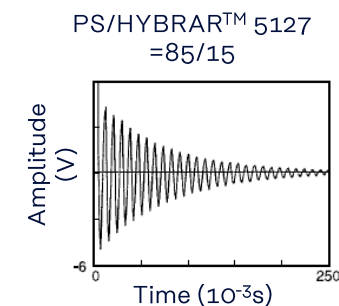
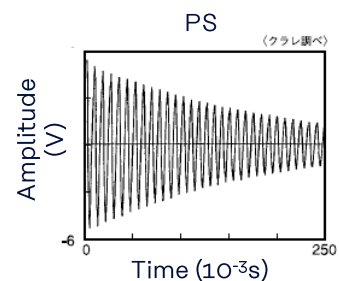
|  |          | 1    | 2    | 3    |
|--|----------|------|------|------|
| Formulations   | phr      |      |      |      |
| SEPTON™ 2063   |          | 100  | 100  | 100  |
| Aliphatic saturated hydrocarbon resin (softening point = 100 deg. C) |          | 100  | 150  | 200  |
| Paraffin oil (90 mm <sup>2</sup> /s at 40 deg. C)                    |          | 50   | 50   | 50   |
| Antioxidant  |          | 0.1  | 0.1  | 0.1  |
| Properties   |          |      |      |      |
| Ball tack *Higher No. means higher tack                              | Ball No. | 12   | 7    | <2   |
| Cohesion (creep test at 60 deg. C, 1 kg load)...Holding power        | min      | 99   | 51   | 22   |
| Adhesion to SUS (180° peel test, 300 mm/min)                         | N/10 mm  | 4.1  | 7.0  | 12.0 |
| Melt viscosity at 160 deg. C   | Pa·s     | 44.2 | 21.7 | 13.4 |
| at 180 deg. C  | Pa·s     | 16.6 | 10.4 | 6.5  |
| Softening point  | deg. C   | 118  | 109  | 100  |

SEPTON™ 2063 - base polymer for adhesives



# Damping Compounds using Low Mw Grades of HYBRAR™

|                   |           | 1     | 2     | 3     | 4     |
|-------------------|-----------|-------|-------|-------|-------|
| Formulations      | phr       |       |       |       |       |
| Polystyrene       |           | 100   | 90    | 85    | 80    |
| HYBRAR™ 5127      |           |       | 10    | 15    | 20    |
| Properties        |           |       |       |       |       |
| Tanδ              | 0 deg. C  | 0.033 | 0.044 | 0.047 | 0.049 |
|                   | 25 deg. C | 0.035 | 0.051 | 0.075 | 0.115 |
|                   | 40 deg. C | 0.037 | 0.045 | 0.063 | 0.094 |
| Loss factor       | -         | 0.016 | 0.023 | 0.040 | 0.068 |
| Hardness          | Shore D   | 83    | 80    | 76    | 74    |
| Tensile modulus   | MPa       | 2,600 | 2,300 | 2,200 | 1,900 |
| Tensile strength  | MPa       | 49    | 51    | 47    | 43    |
| Elongation        | %         | 13    | 18    | 21    | 17    |
| Flexural modulus  | MPa       | 2,600 | 2,300 | 2,100 | 1,700 |
| Flexural strength | MPa       | 74    | 34    | 28    | 23    |

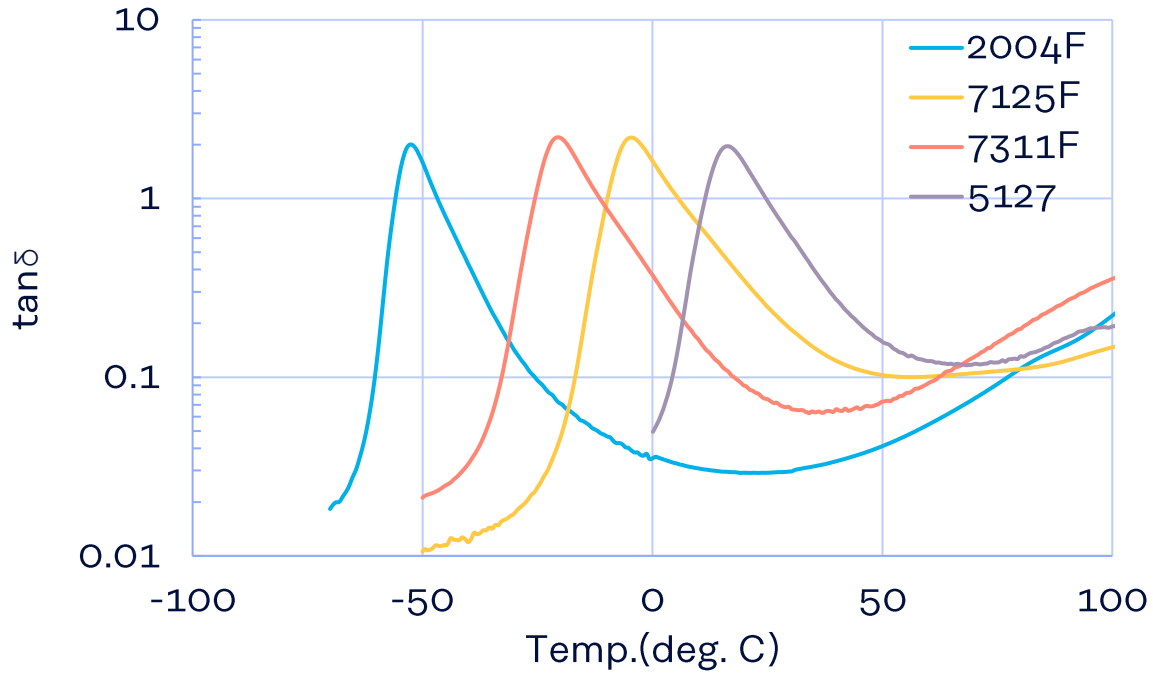


| Cross-linked foam    |     | 1   | 2     |
|----------------------|-----|-----|-------|
| Formulations         | phr |     |       |
| EVA(VA cont.=19 wt%) |     | 100 | 50    |
| HYBRAR™ 5127         |     |     | 50    |
| Cross-linking agent  |     | 0.8 | 0.175 |
| Forming agent        |     | 3   | 3     |
| ZnO                  |     | 2   | 2     |
| Stearic acid         |     | 1   | 1     |
| Zinc stearate        |     | 4   | 4     |
| Properties           |     |     |       |
| Compression set      | %   | 65  | 48    |
| Rebound resilience   | %   | 40  | 19    |

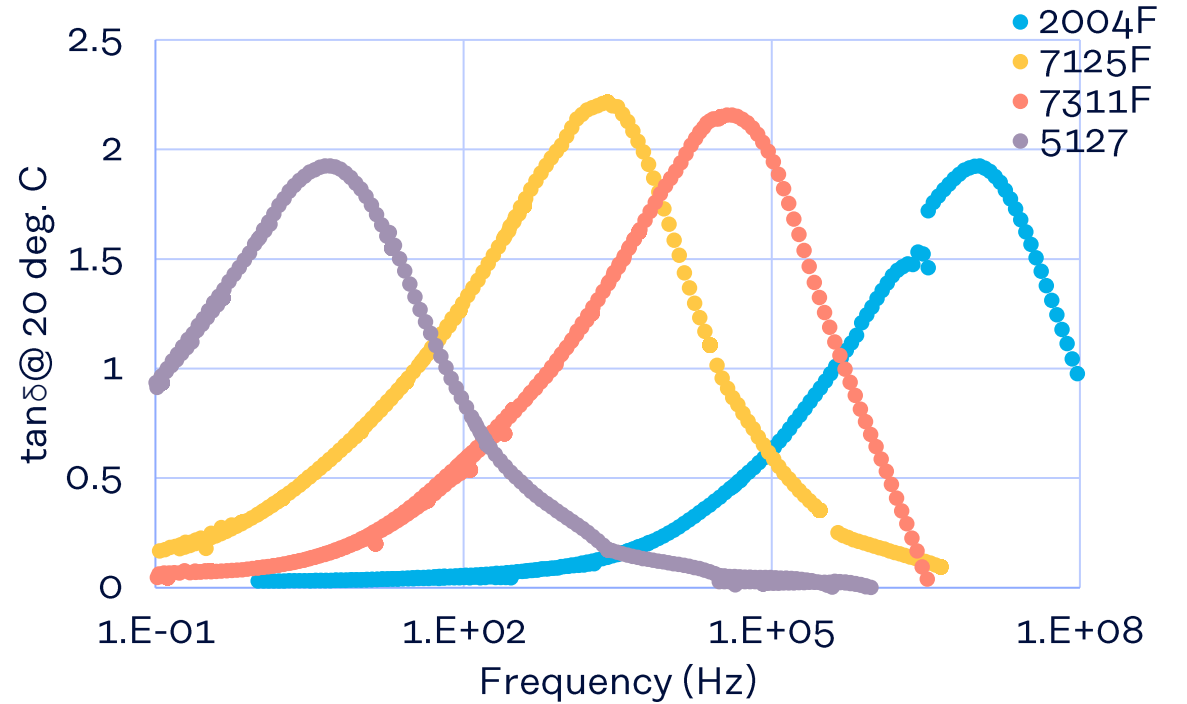
- ✓ HYBRAR™ improves damping properties.
- ✓ HYBRAR™ reduces rebound resilience while maintaining good compression set.



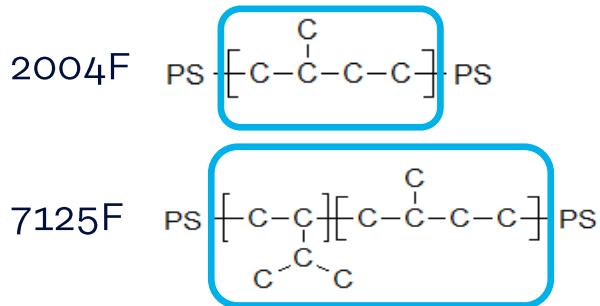
# Damping Properties of Low Mw Grades of SEPTON™/HYBRAR™



$\tan \delta$  of SEPTON™ & HYBRAR™



Frequency dependence of  $\tan \delta$  of SEPTON™ & HYBRAR™ (Master curve)



T<sub>g</sub> of HYBRAR™ is higher than that of SEPTON™ because of the difference in soft block structure.

# Summary

SEPTON™/Polyolefin/Process oil compounds are soft and alternatives to vulcanized rubbers.

⇒ **Recyclable**

HYBRAR™/PP compounds are soft, transparent and alternatives to PVC.

⇒ **Halogen & plasticizer free (safe material)**

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Precautions should be taken in handling and storage. Please refer to the appropriate Safety Data Sheet for further safety information. In using SEPTON™ and HYBRAR™, please confirm related laws and regulations, and examine its safety and suitability for the application.

For medical, health care and food contact applications, please contact your Kuraray representative for specific recommendations. Even so, users must conduct their own assessment, revisions, registrations as well rely in their own technical and legal judgment to establish the safety and efficacy of their compound and/or end product with SEPTON™ and HYBRAR™ for any application. SEPTON™ and HYBRAR™ should not be used in any devices or materials intended for implantation in the human body. Nothing contained herein constitutes a license to practice under any patent and it should not be construed as an inducement to infringe any patent and the user is advised to take appropriate steps to be sure that any proposed use of the product will not result in patent infringement.

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