

# 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

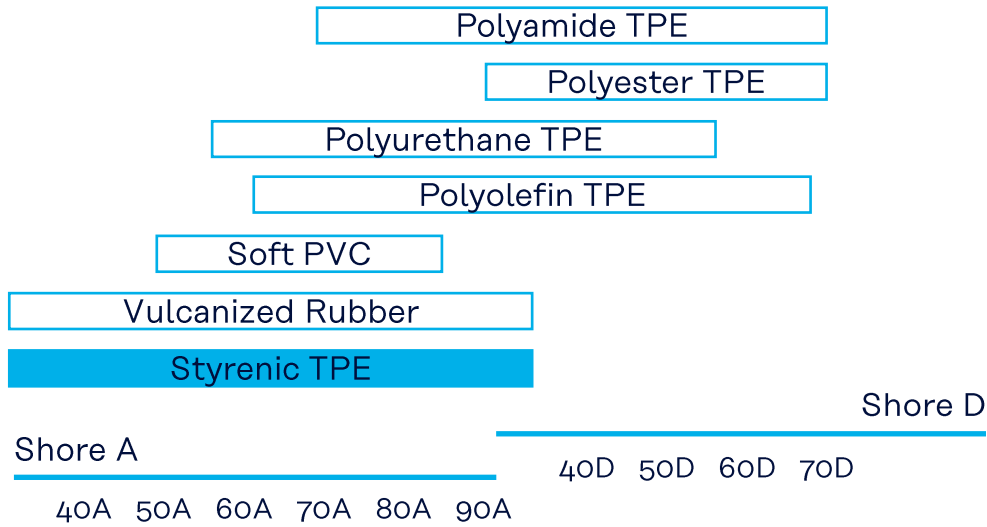
- Kashima, Japan
- Texas, U. S. A.
- Rayong, Thailand

### Global production capacity

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

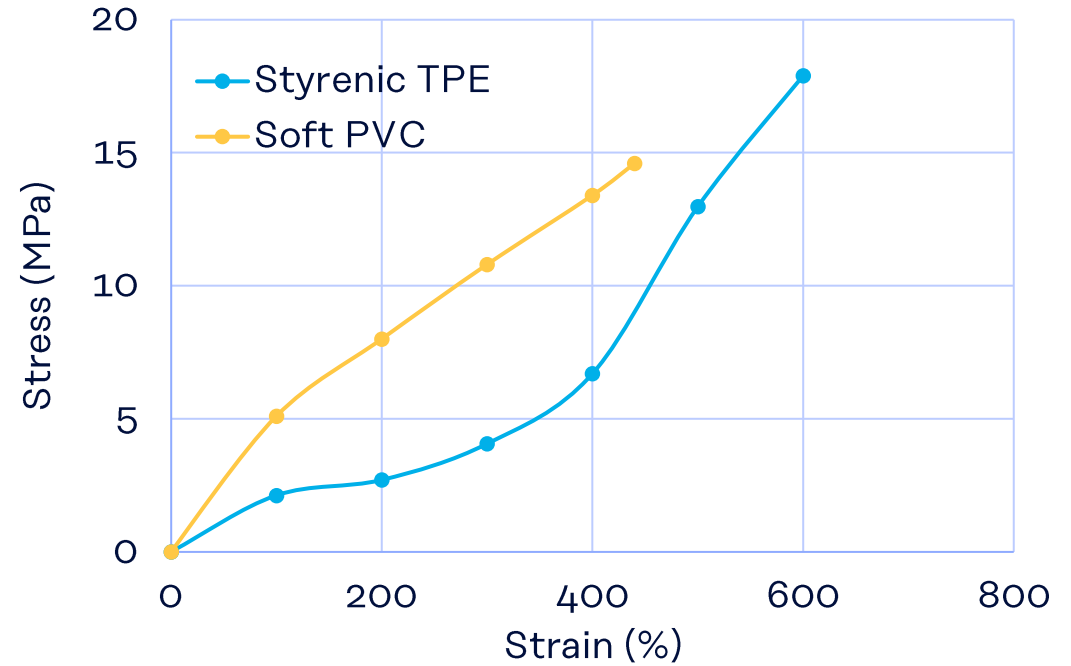


# Features of Styrenic TPE



Various TPE Hardness

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

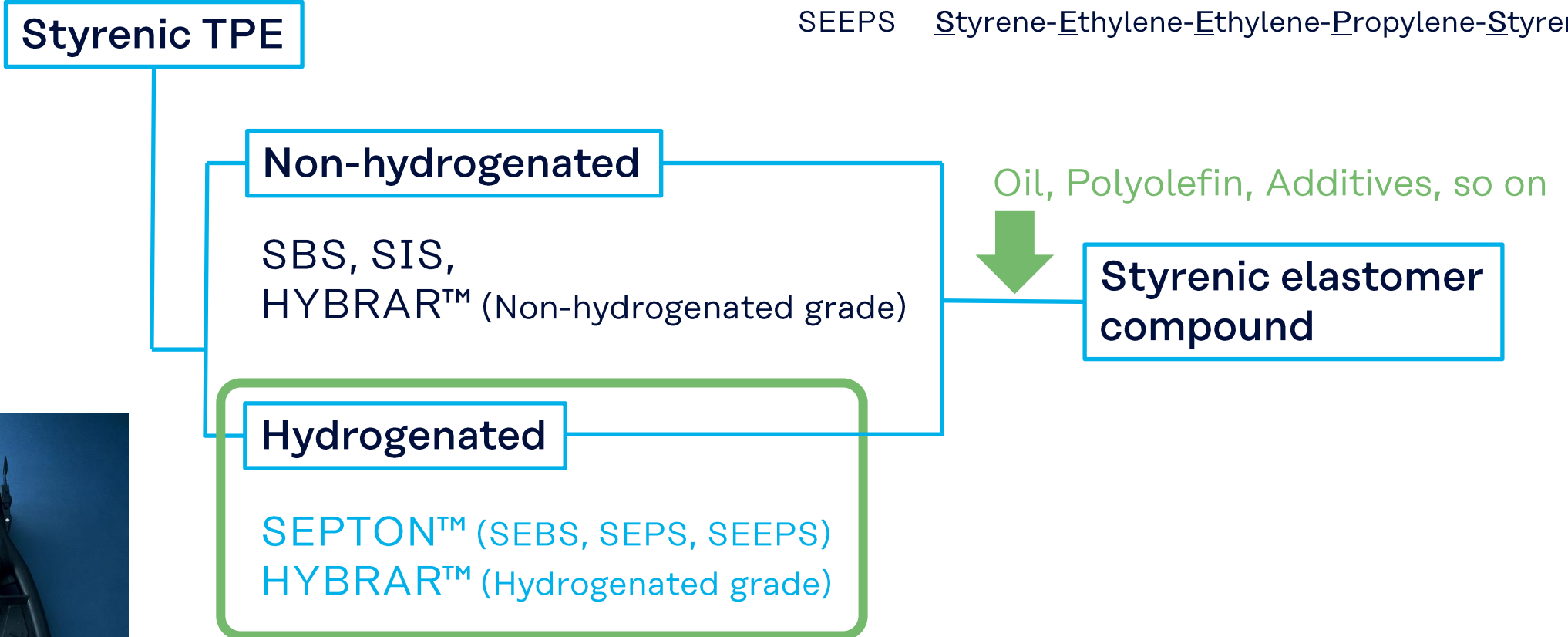


Stress-Strain curve of Styrenic TPE & Soft PVC

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

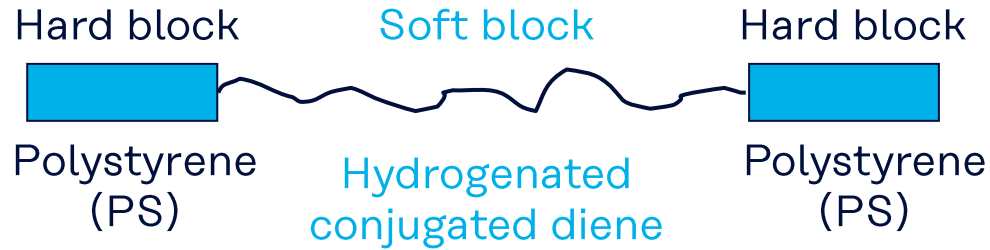
# Type of Styrenic TPE

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

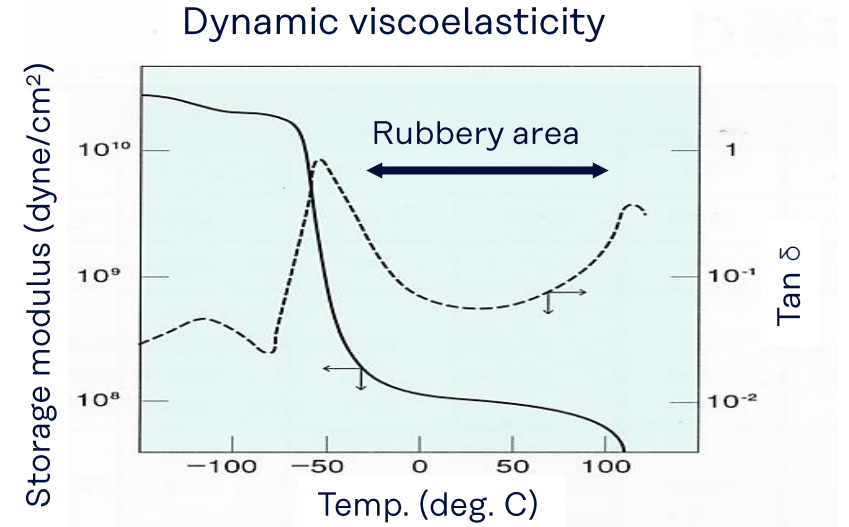
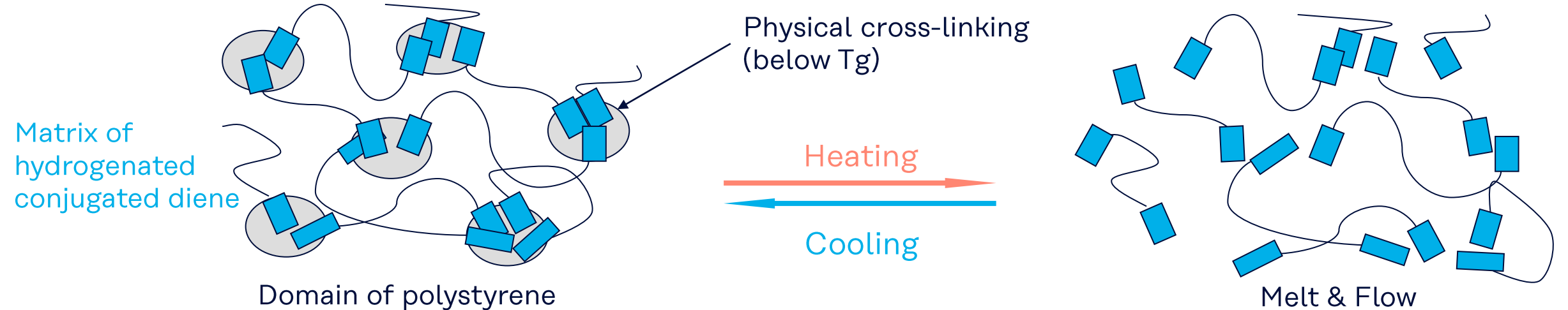


# Hydrogenated Styrenic Block Copolymer (HSBC)

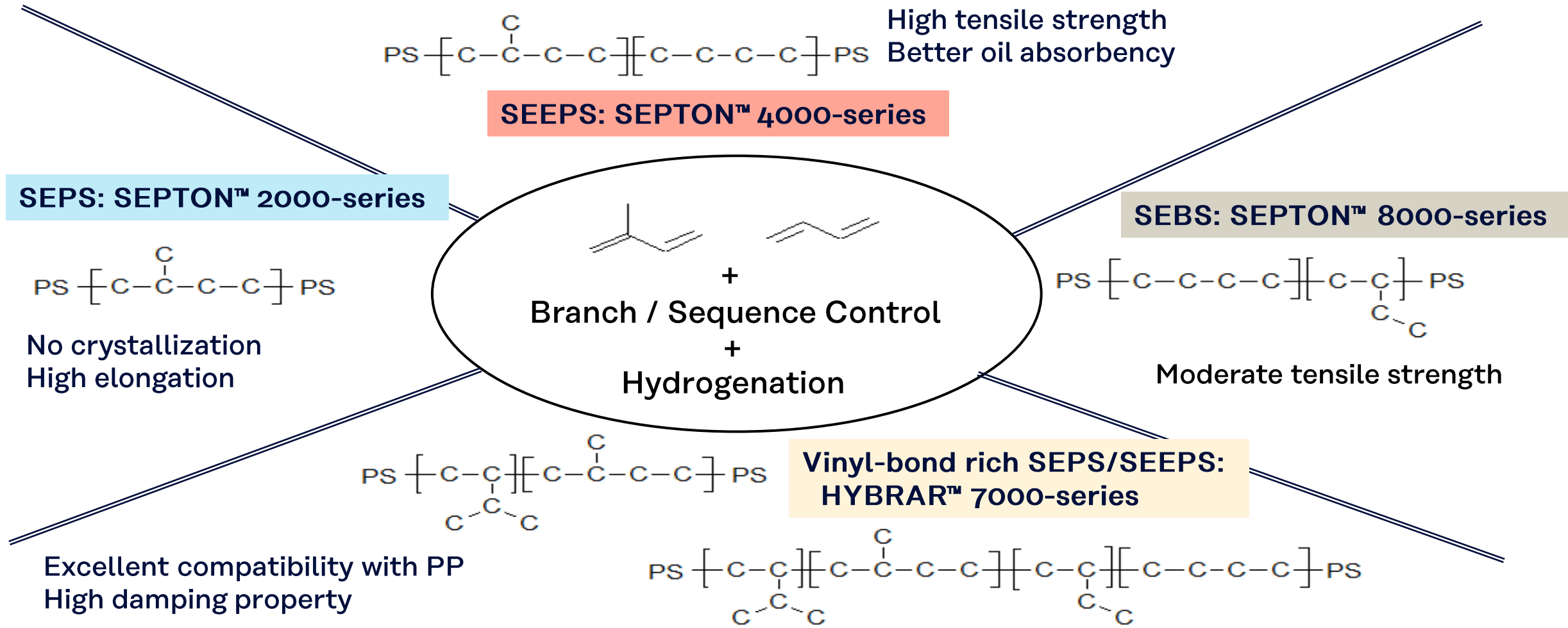
## Primary structure of HSBC



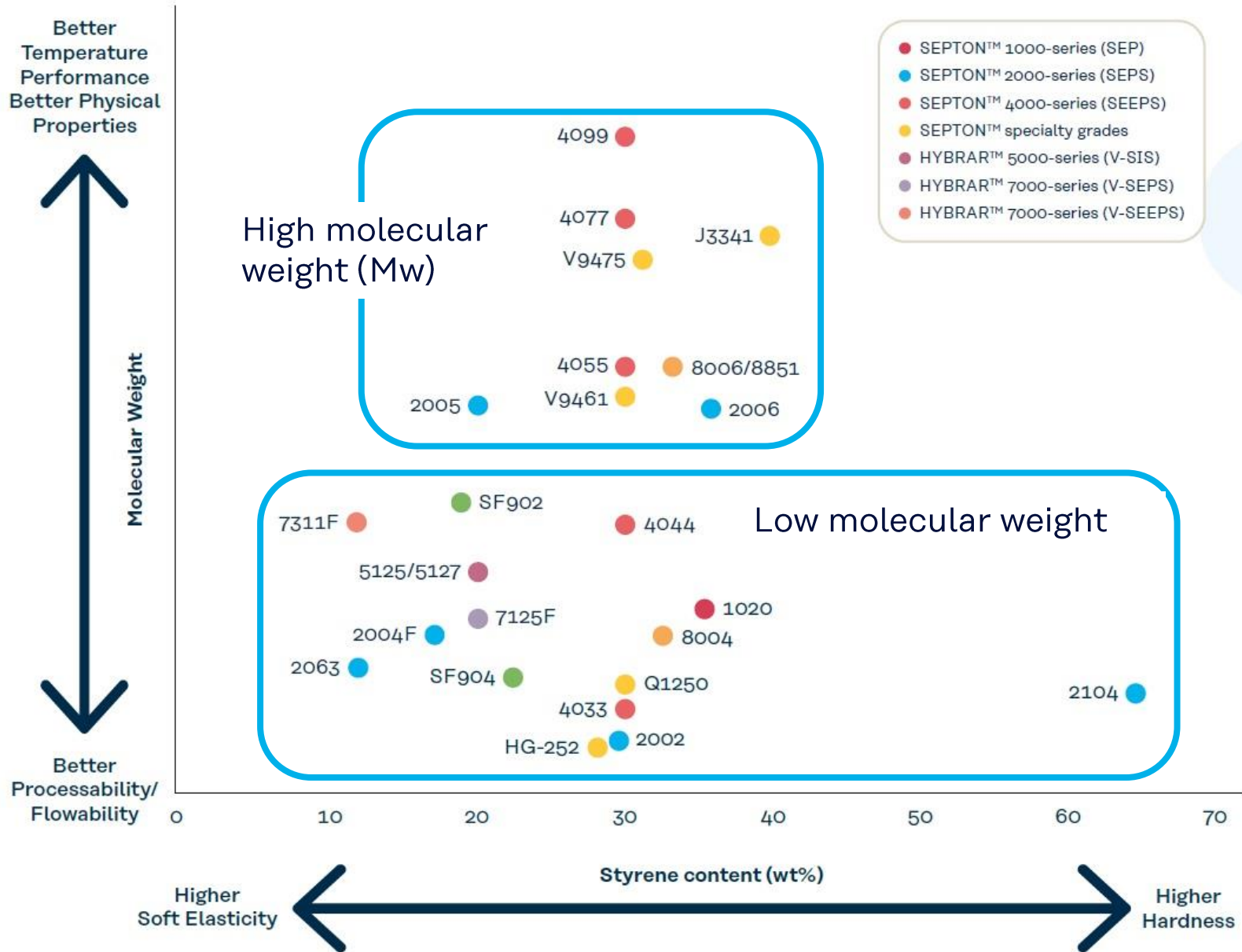
## Micro phase separation of HSBC



# Polymer Structure of SEPTON™ and HYBRAR™



# Grade Map



# 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	-	Crumbs
2006	SEPS	35	0.92	27	1,220	-	Crumbs
4055	SEEPS	30	0.91	90	5,800	-	Crumbs
4077	SEEPS	30	0.91	300	-	-	Crumbs
4099	SEEPS	30	0.91	670	-	-	Crumbs
8006	SEBS	33	0.92	42	-	-	Crumbs
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	-	40	-	Crumbs
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	18	-	29	140	Pellet
2104	SEPS	65	0.98	98	-	4.3	< 100	0.4	22	-	-	22	Pellet
4030S	SEEPS	20	0.89	67	2.5	34.0	490	1.0	1.5	-	81	-	Crumbs
4033	SEEPS	30	0.91	76	2.2	35.3	500	< 0.1	< 0.1	-	50	390	Crumbs
4044	SEEPS	32	0.91	-	-	-	-	No Flow	No Flow	22	460	-	Crumbs
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	-	Crumbs
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 $\delta$ (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)	15 wt% (mPa·s)	20 wt% (mPa·s)	30 wt% (mPa·s)	
5127	Vinyl-bond rich SIS	20	20	8	0.94	84	2.8	12.4	730	3	-	-	85	540	Pellet
5125	Vinyl-bond rich SIS	20	-3	-13	0.94	60	1.6	8.8	730	3	-	-	100	650	Pellet
7125F	Vinyl-bond rich SEPS	20	-5	-15	0.90	64	1.7	7.1	680	0.7	4	-	60	350	Pellet
7311F	Vinyl-bond rich SEEPS	12	-17	-32	0.89	41	0.6	6.3	1050	0.5	2	95	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

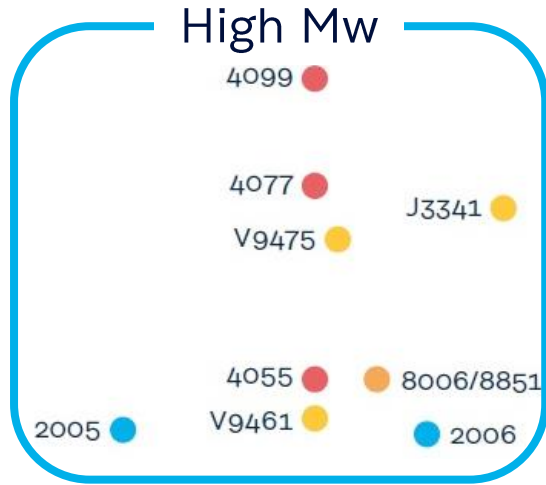
# Tensile Properties of SEPTON™

		SEPTON™ 4033	SEPTON™ 8004
Type		SEEPS	SEBS
Styrene Content	(wt%)	30	31
at 23 deg. C			
100% Modulus	(MPa)	2.2	2.3
Tensile Strength	(MPa)	35.3	31.6
Elongation	(%)	500	560
at 40 deg. C			
Tensile Strength	(MPa)	31.1	26.8
Elongation	(%)	530	570
at 60 deg. C			
Tensile Strength	(MPa)	11.7	9.7
Elongation	(%)	570	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

Crumbs

## Main Usage

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



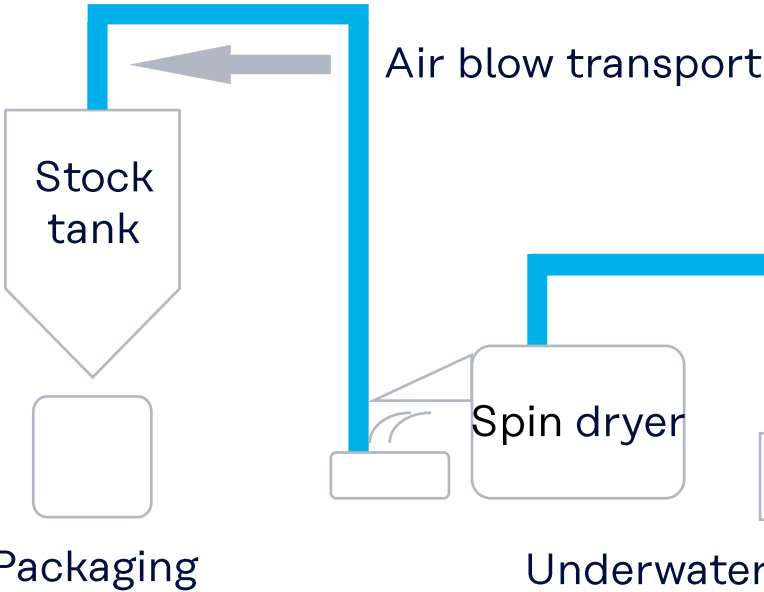
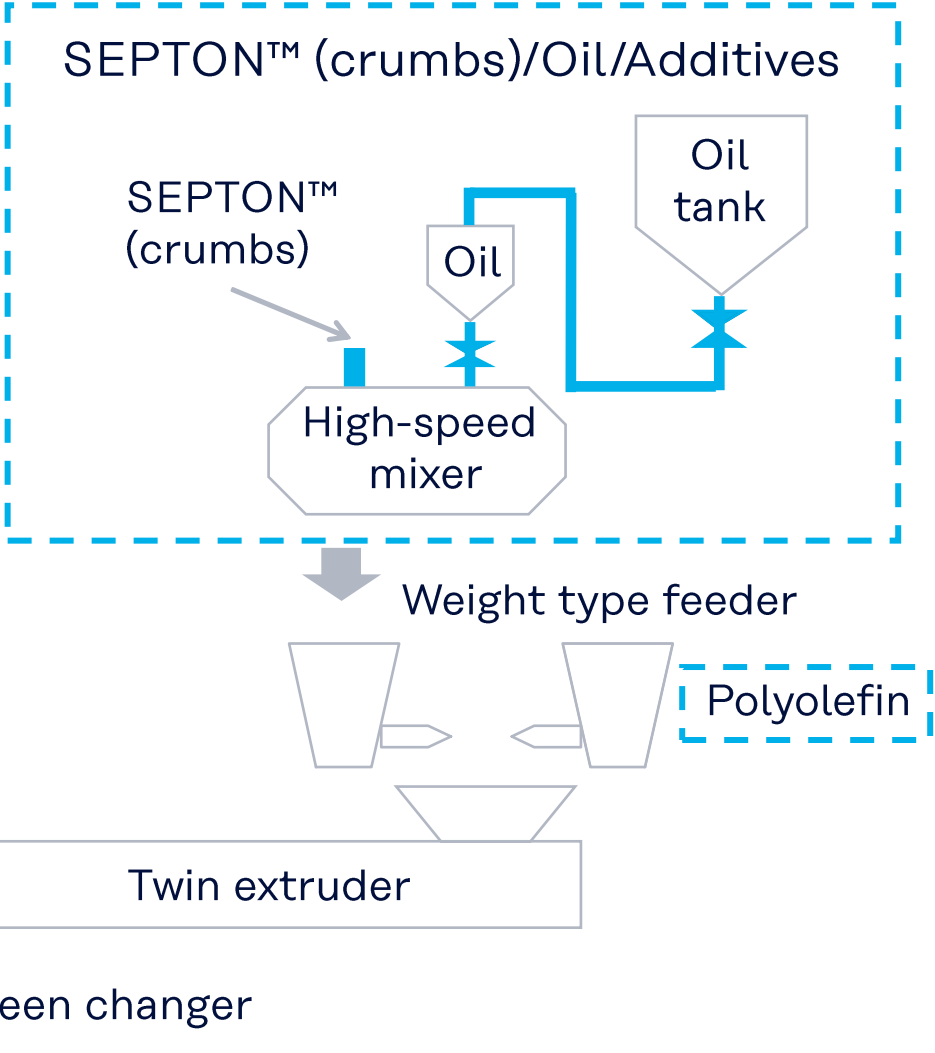
## Market

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

## Keyword

Soft touch, cushioning, heat resistance

# HSBC Compounding Process Flow



# 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
<b>Properties</b>						
Hardness (Type A)		21	50	72	89	92
<b>Tensile Properties</b>						
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



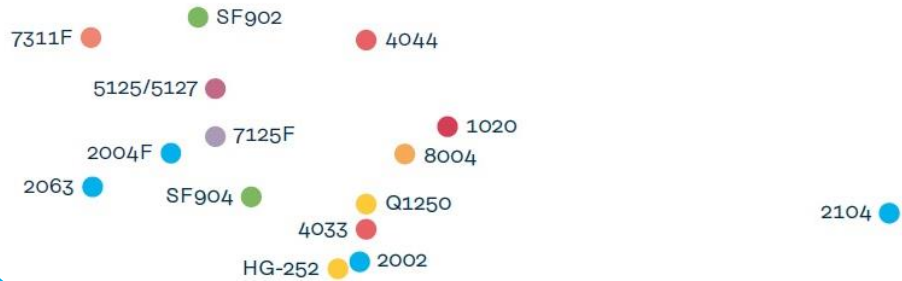
		SEPTON™		
		4055	4077	4099
Hardness (Type A)		70	70	70
100% Modulus	MPa	1.9	1.8	1.9
Tensile Strength	MPa	12.8	13.5	12.2
Elongation	%	820	860	800
Compression Set (70 deg. C)	%	38	36	36
	(100 deg. C)	50	44	41
	(120 deg. C)	55	50	45
MFR (230 deg. C, 5 kg)	g/10 min	29	28	16

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



# Low Mw Grades of SEPTON™/HYBRAR™

Low Mw



## Physical Form

Crumbs, 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		
SEBS					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™



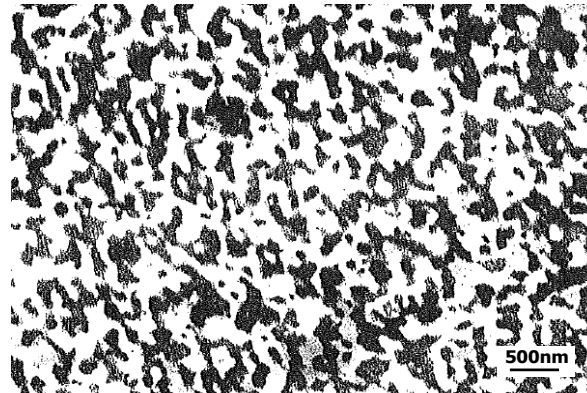
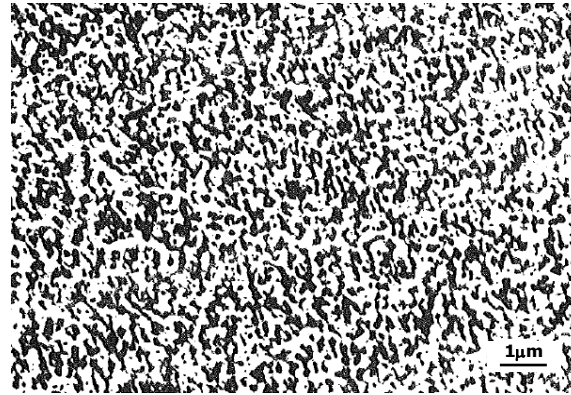
		1	2	3	4	5	6	7
Formulations	phr							
Random-PP (MFR=7)		100	90	70	60	90	70	60
HYBRAR™ 7125F			10	30	40			
HYBRAR™ 7311F						10	30	40
Properties								
Hardness	Shore D	63	55	46	42	54	44	35
Young's modulus	MPa	490	480	250	140	380	140	90
Tensile strength	MPa	37	35	30	30	34	30	28
Izod impact strength (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.

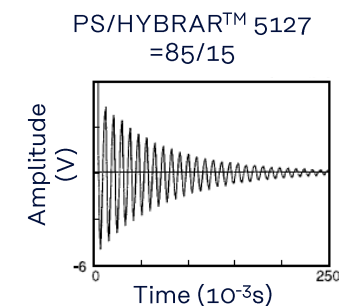
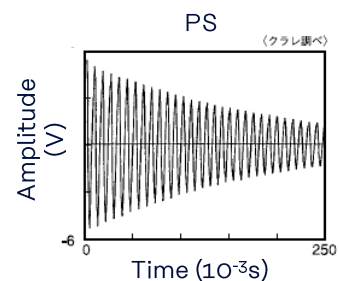
# Adhesives using Low Mw Grades of SEPTON™

		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™

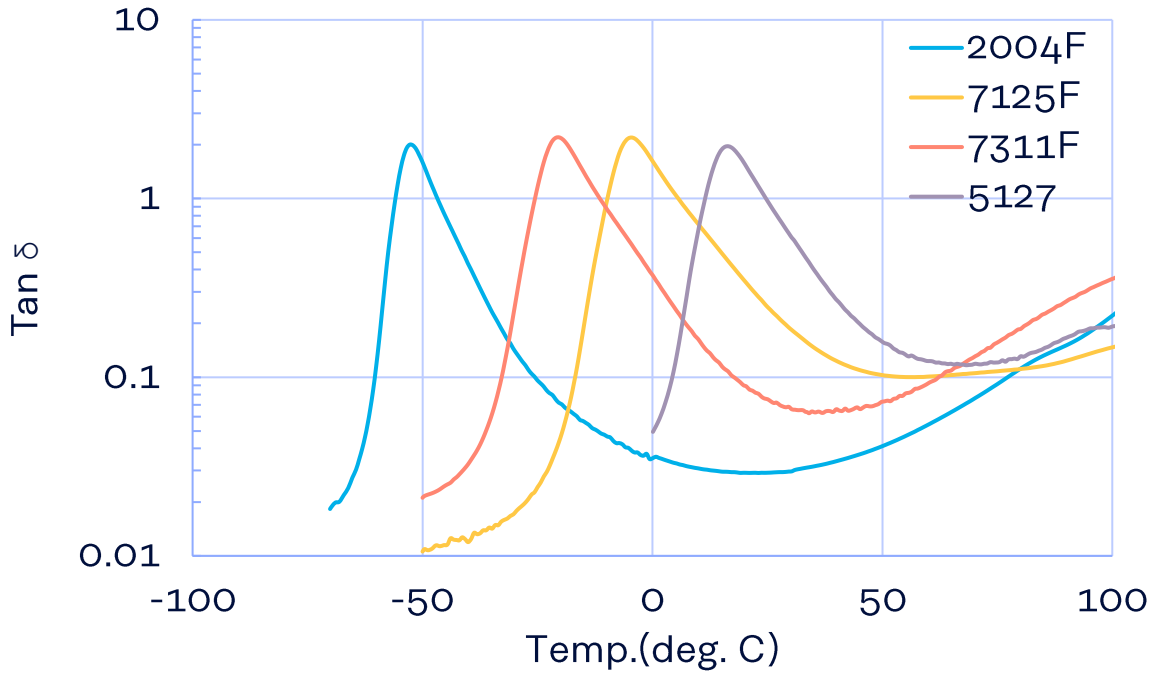
		1	2	3	4
Formulations	phr				
Polystyrene		100	90	85	80
HYBRAR™ 5127			10	15	20
Properties					
Tanδ	0 deg. C	0.033	0.044	0.047	0.049
	25 deg. C	0.035	0.051	0.075	0.115
	40 deg. C	0.037	0.045	0.063	0.094
Loss factor	-	0.016	0.023	0.040	0.068
Hardness	Shore D	83	80	76	74
Tensile modulus	MPa	2,600	2,300	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



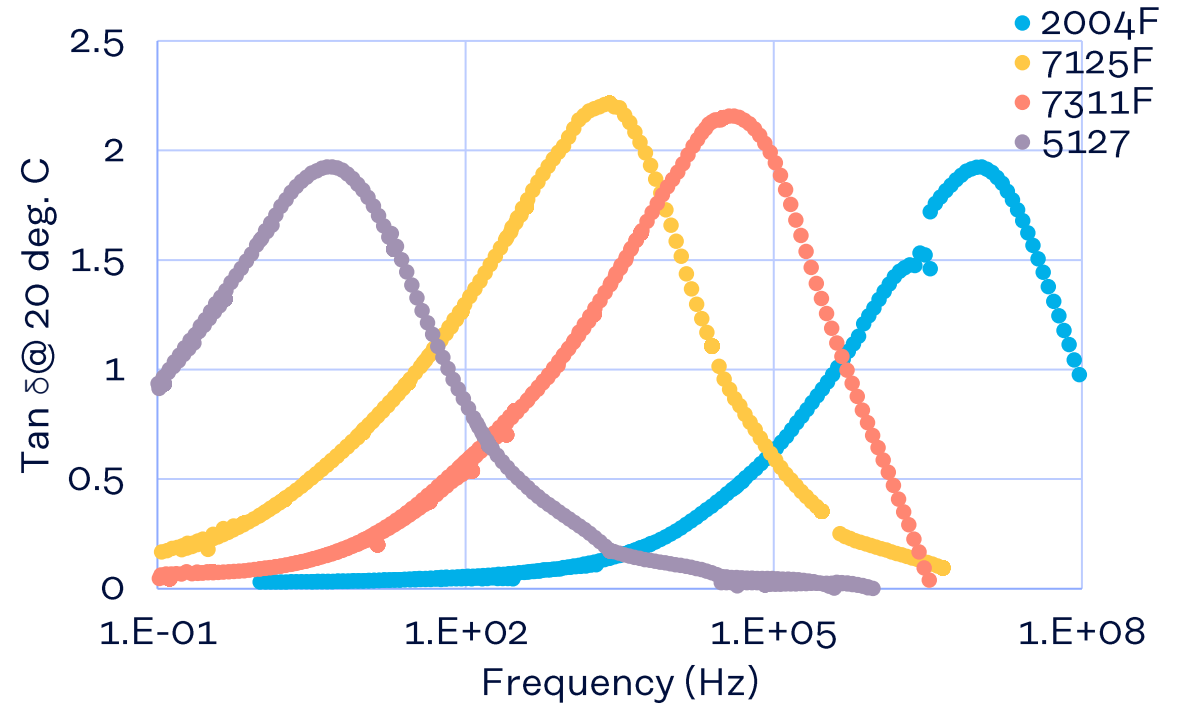
Cross-linked foam		1	2
Formulations	phr		
EVA(VA cont.=19 wt%)		100	50
HYBRAR™ 5127			50
Cross-linking agent		0.8	0.175
Forming agent		3	3
ZnO		2	2
Stearic acid		1	1
Zinc stearate		4	4
Properties			
Compression set	%	65	48
Rebound resilience	%	40	19

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

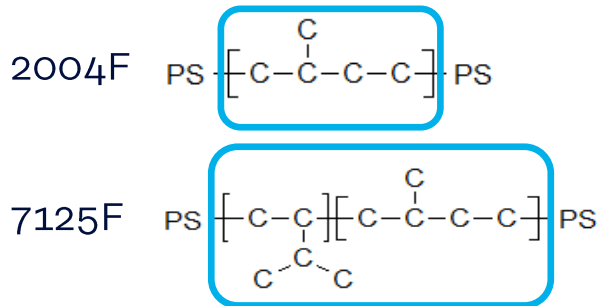
# Damping Properties of Low Mw Grades of SEPTON™/HYBRAR™



Tan  $\delta$  of SEPTON™ & HYBRAR™



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



Tg 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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