No. RRS00-001-E1

Introduction of SEPTON™ and HYBRAR™

Elastomer R&D Dept.
Elastomer Division

kuraray Septon™ Hybrar™

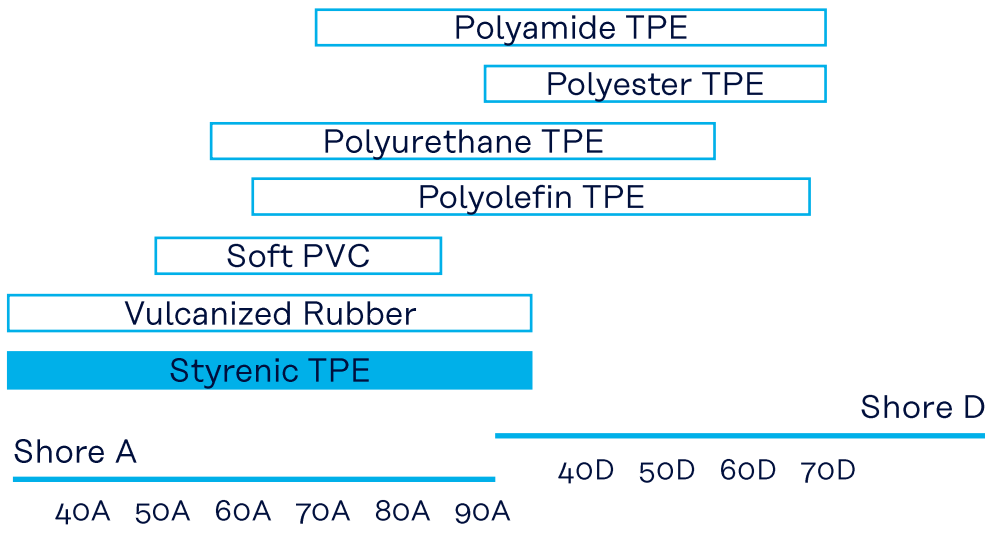
SEPTON™ / HYBRAR™
~Styrenic Thermoplastic Elastomer (TPE)~

Main application
- Alternative to rubber products
- Modifier for plastics
- Masterbatch

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

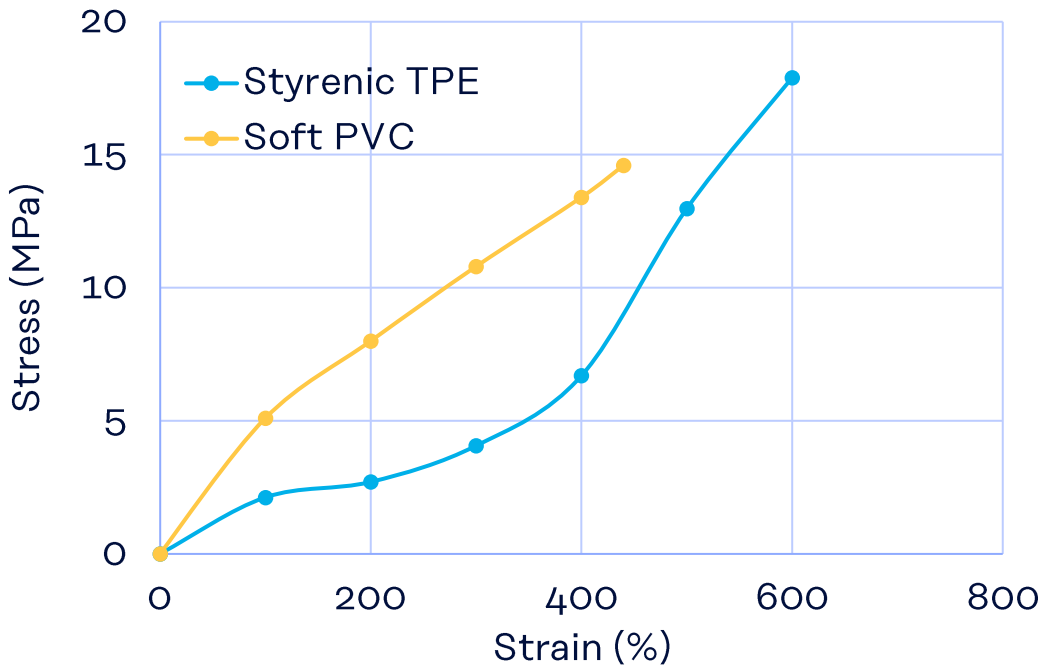
Global production capacity
- 64,000 MT/y (Japan + U. S. A. + Thailand)

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

Styrenic TPE

Non-hydrogenated

SBS, SIS,
HYBRAR™ (Non-hydrogenated grade)

Hydrogenated

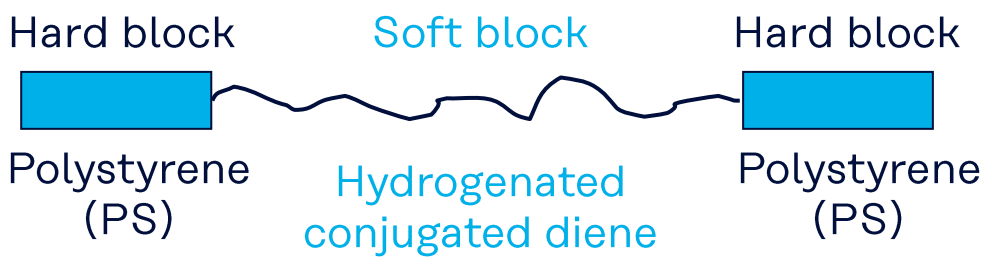
SEPTON™ (SEBS, SEPS, SEEPS)
HYBRAR™ (Hydrogenated grade)

Oil, Polyolefin, Additives, so on

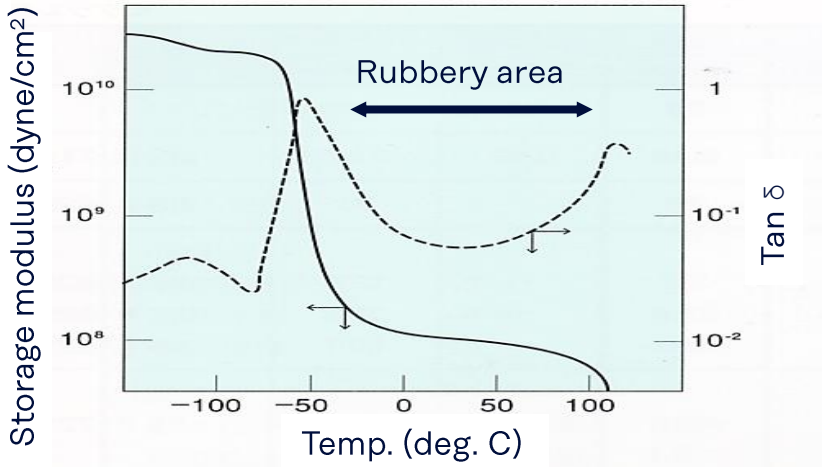
Styrenic elastomer compound

Hydrogenated Styrenic Block Copolymer (HSBC)

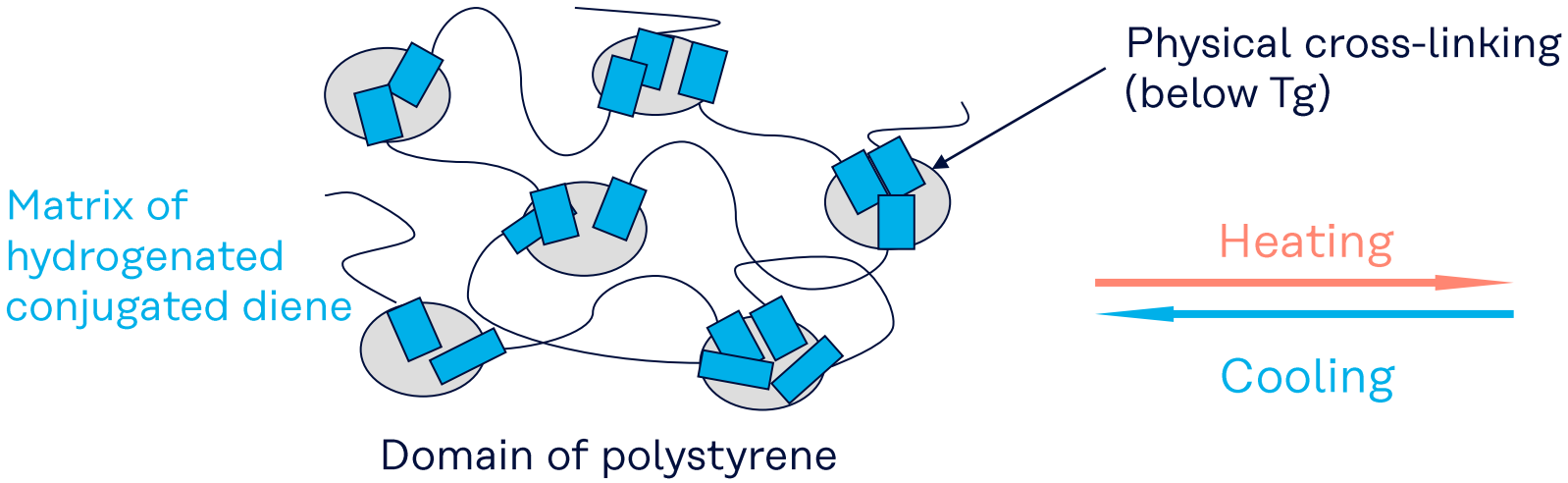
Primary structure of HSBC



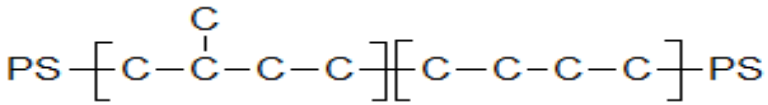
Dynamic viscoelasticity



Micro phase separation of HSBC



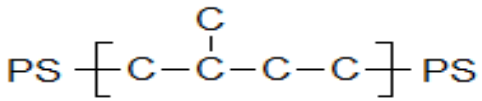
Polymer Structure of SEPTON™ and HYBRAR™



High tensile strength
Better oil absorbency

SEEPS: SEPTON™ 4000-series

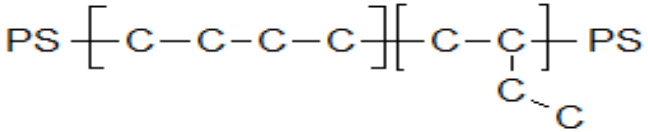
SEPS: SEPTON™ 2000-series



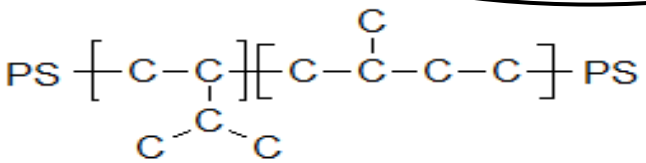
No crystallization
High elongation

+
Branch / Sequence Control
+
Hydrogenation

SEBS: SEPTON™ 8000-series

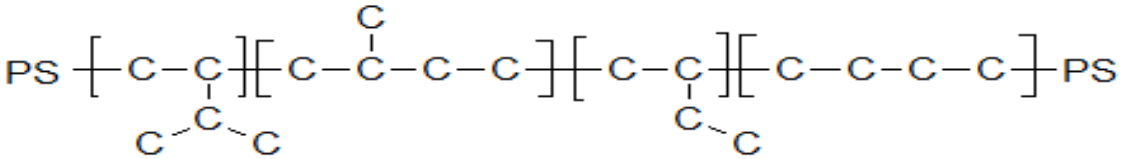


Moderate tensile strength

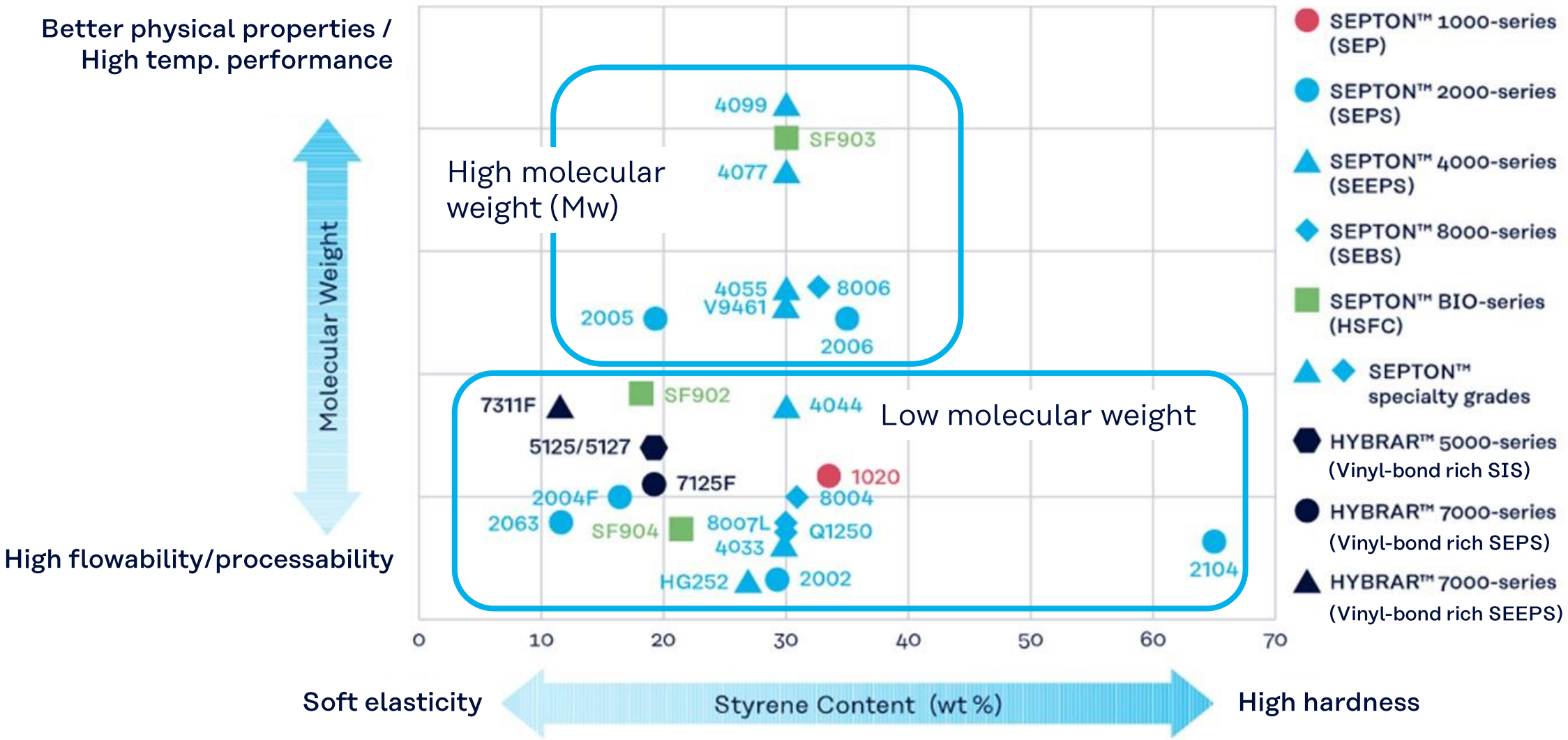


Excellent compatibility with PP
High damping property

Vinyl-bond rich SEPS/SEEPS: HYBRAR™ 7000-series



Grade Map


Better physical properties /
High temp. performance
High flowability/processability
Molecular Weight
High molecular weight (Mw)
Low molecular weight
4099
SF903
4077
4055
V9461
8006
2005
2006
7311F
SF902
4044
5125/5127
7125F
1020
2004F
8004
2063
SF904
8007L
4033
Q1250
HG252
2002
2104
0
10
20
30
40
50
60
70
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	-	40	-	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	18	-	29	140	Pellet
2104	SEPS	65	0.98	98	-	4.3	< 100	0.4	22	-	-	22	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	-	-	25	-	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)	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

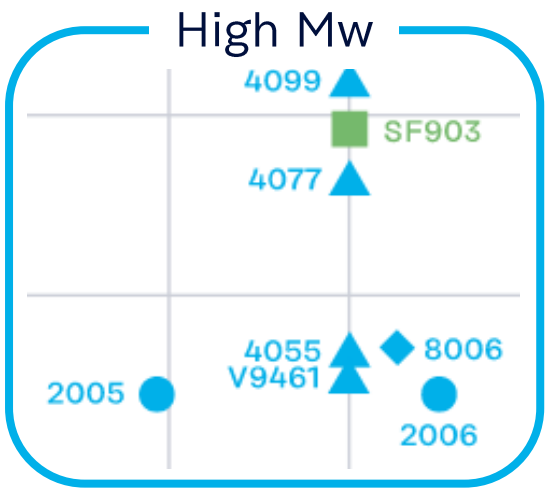
Tensile Properties of SEPTON™

		SEPTON™		
		4033	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™



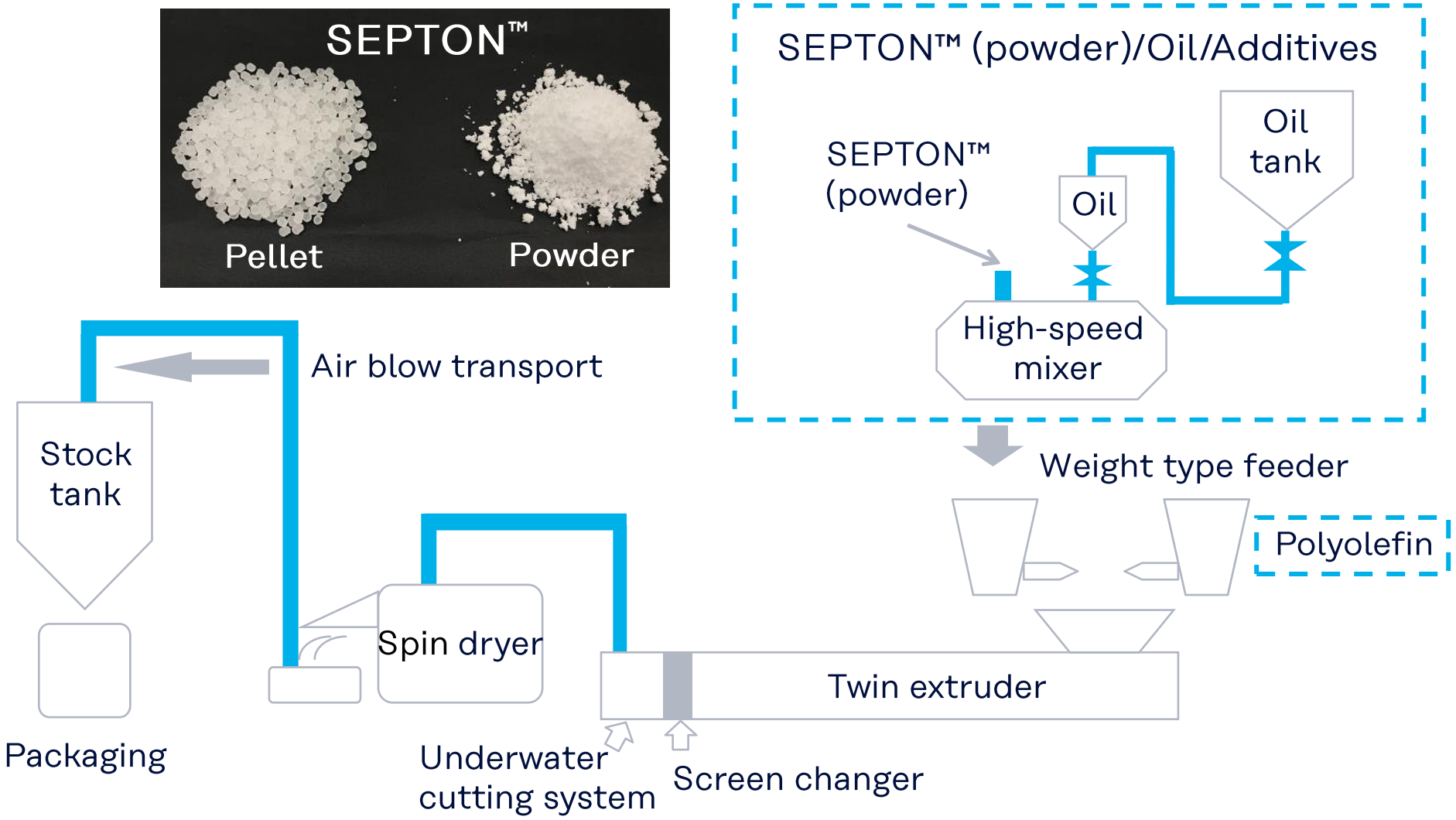
Physical Form
Powder

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



Compounds with High Mw grades of SEPTON™

*Kinematic viscosity

		1	2	3	4	5
Formulations	phr					
SEPTON™ 4055		100	100	100	100	100
Paraffin oil (KV* at 40 deg. C = 382 mm^2/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[1)]/Homo-PP[2)] (100/120/45 by wt)
1) Viscosity@40 deg. C = 96 mm^2/s
2) MFR = 15 g/10 min

High Mw

		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™

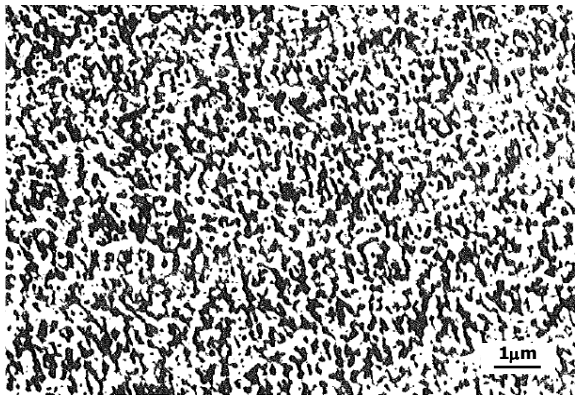
		1	2	3	4	5	6	7
Formulations	phr							
Random-PP (MFR=7)		100	90	70	60	90	70	60
HYBRAR™ 7125F			10	30	40			
HYBRAR™ 7311F						10	30	40
Properties								
Hardness	Shore D	63	55	46	42	54	44	35
Young's modulus	MPa	490	480	250	140	380	140	90
Tensile strength	MPa	37	35	30	30	34	30	28
Izod impact strength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

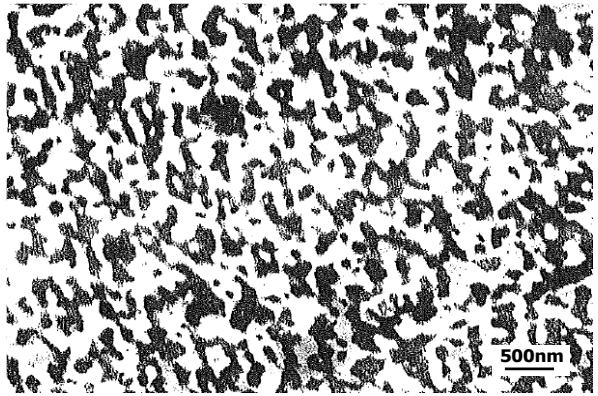
- ✓ Compounds of PP and HYBRAR™ 7311F provides softness & low temp. impact resistance.
- ✓ Compounds of PP and HYBRAR™ are transparent & have a PVC-like texture (without undesirable plasticizers).

=> Applications - soft films & tubing

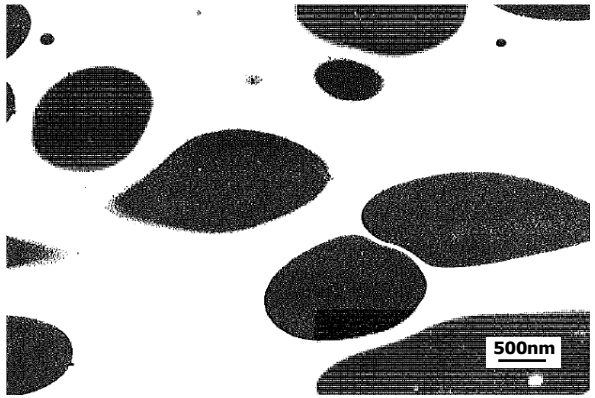
Compatibility of Low Mw Grades of HYBRAR™ with PP

HYBRAR™/r-PP (30/70 by wt)





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



Hydrogenated grade of HYBRAR™ shows good compatibility with PP.

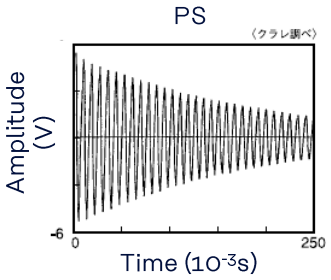
Adhesives using Low Mw Grades of SEPTON™

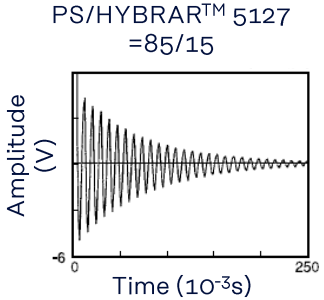
		1	2	3
Formulations	phr			
SEPTON™ 2063		100	100	100
Aliphatic saturated hydrocarbon resin (softening point = 100 deg. C)		100	150	200
Paraffin oil (90 mm^2/s at 40 deg. C)		50	50	50
Antioxidant		0.1	0.1	0.1
Properties				
Ball tack *Higher No. means higher tack	Ball No.	12	7	<2
Cohesion (creep test at 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

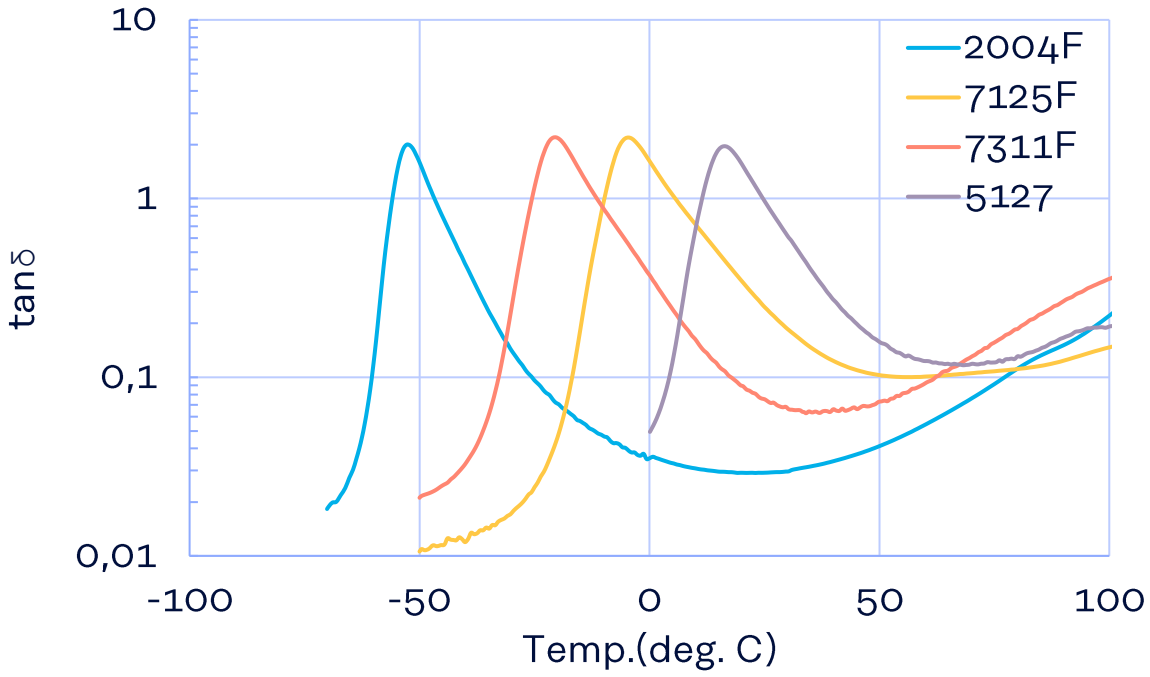




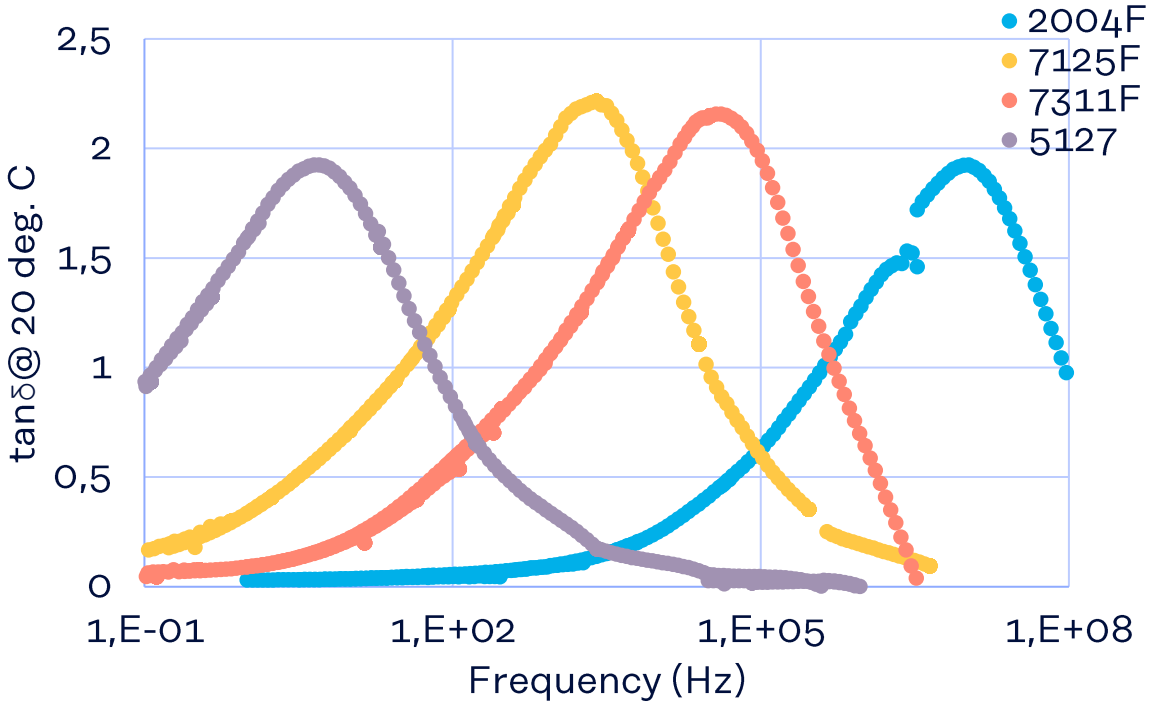
Cross-linked foam		1	2
Formulations	phr		
EVA(VA cont.=19 wt%)		100	50
HYBRAR™ 5127			50
Cross-linking agent		0.8	0.175
Forming agent		3	3
ZnO		2	2
Stearic acid		1	1
Zinc stearate		4	4
Properties			
Compression set	%	65	48
Rebound resilience	%	40	19

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

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

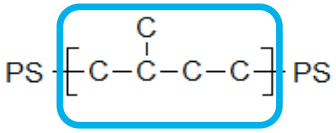


tanδ of SEPTON™ & HYBRAR™

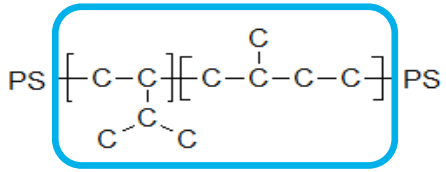


Frequency dependence of tanδ of SEPTON™ & HYBRAR™
(Master curve)

2004F



7125F



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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