

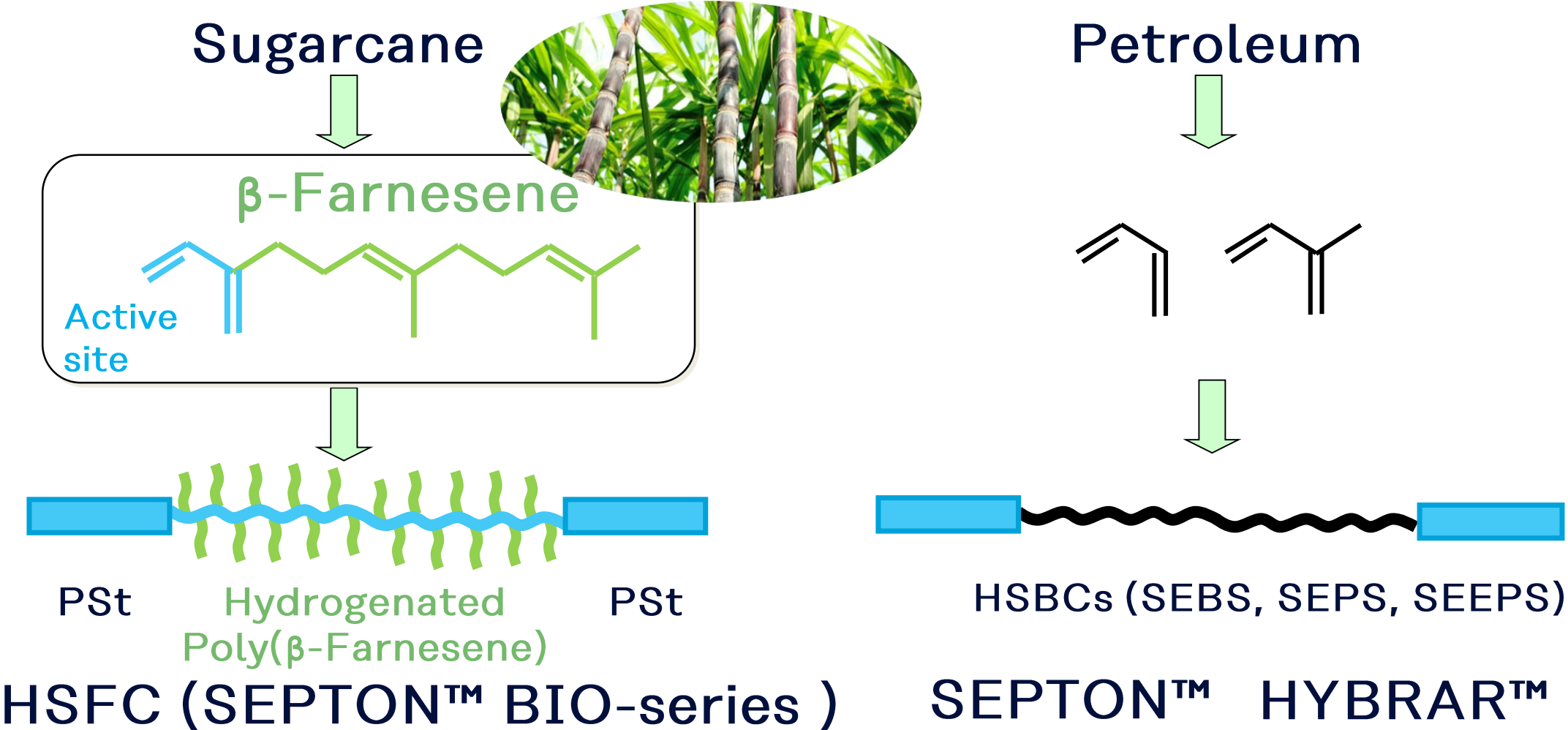
New Thermoplastic Rubber

Introduction of SEPTON™ BIO-series

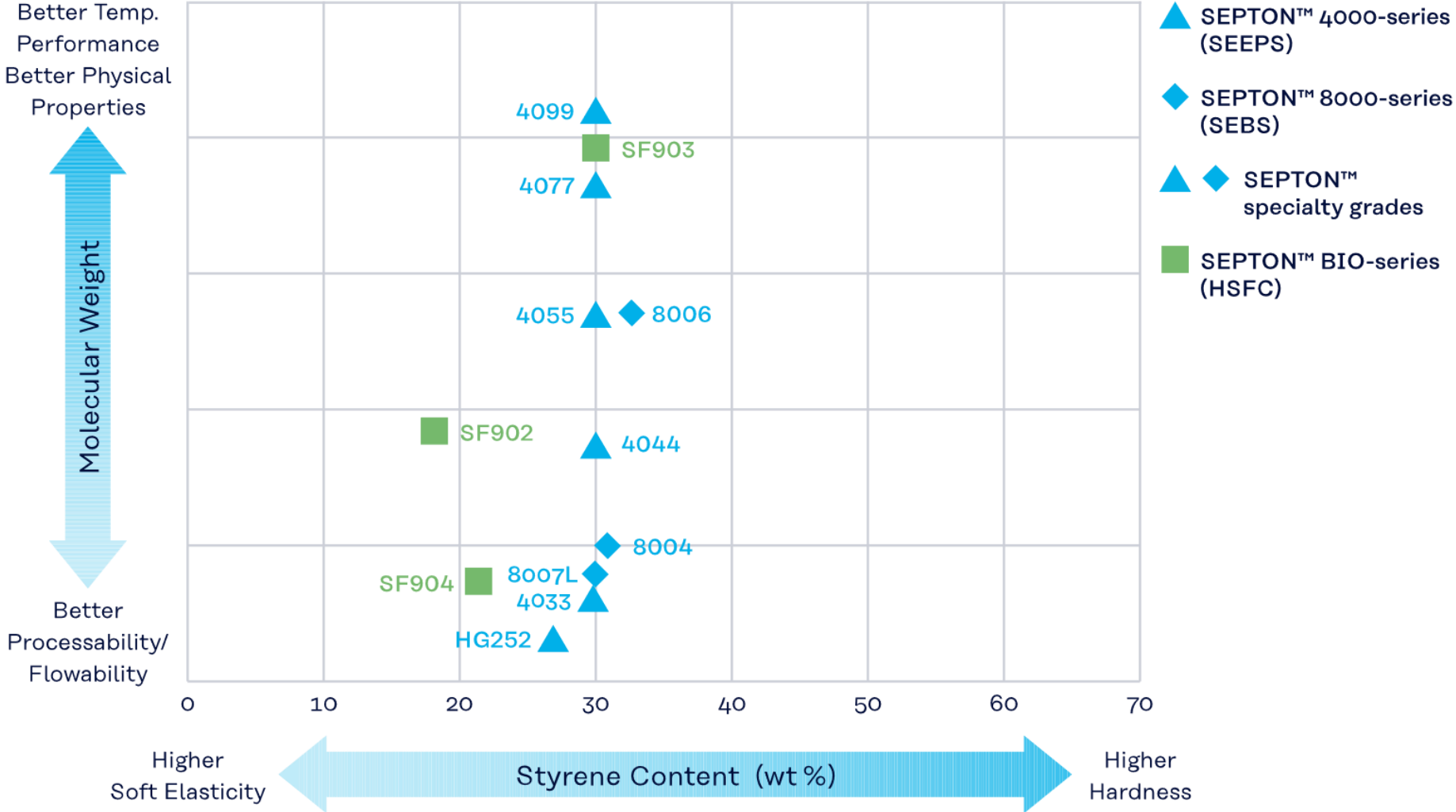
Elastomer R&D department
Elastomer division

kuraray

What is SEPTON™ BIO-series (HSFC) ?



Grade Map



Typical Properties

Grade	Styrene Content (wt%)	Peak Temp. of tanδ (deg.C)	Glass Transition Temp. (deg.C)	Specific Gravity	Hardness (Type A)	Tensile Property			MFR			Solution Viscosity					Physical Form
						100% Modulus (MPa)	Tensile Strength (MPa)	Elongation (%)	190deg.C, 2.16kg (g/10min)	230deg.C, 2.16kg (g/10min)	230deg.C, 10kg (g/10min)	5wt% (mPa.s)	10wt% (mPa.s)	15wt% (mPa.s)	20wt% (mPa.s)	30wt% (mPa.s)	
SEPTON™ BIO-series SF902	18	-50	-59	0.88	8	0.2	4.8	820	No Flow	No Flow	55	-	11	20	-	-	Pellet
SEPTON™ BIO-series SF903	30	-50	-59	0.90	21	0.2	4.6	550	No Flow	No Flow	2.1	8.6	28	102	-	-	Pellet
SEPTON™ BIO-series SF904	21	-49	-57	0.89	25	0.3	5.8	900	15	48	>700	-	-	32	-	-	Pellet
HYBRAR™ 5127	20	15	8	0.94	84	2.8	12.4	730	5	-	-	-	-	-	-	540	Pellet
HYBRAR™ 5125	20	-8	-13	0.94	60	1.6	8.8	730	4	-	-	-	-	-	100	650	Pellet
HYBRAR™ 7125	20	-7	-15	0.90	64	1.7	7.1	680	0.7	4	-	-	-	-	55	350	Pellet
HYBRAR™ 7311	12	-22	-32	0.89	41	0.6	6.3	1050	0.5	2	-	-	-	90	240	-	Pellet
SEPTON™ 4055	30	(-54)	-56	0.91	-	-	-	-	No Flow	No Flow	No Flow	90	5800	-	-	-	Powder
Measurement Method	-	Tested by ARES	DSC, (Temp. increase by 10deg.C/min)	ISO 1183	ISO 7619			ISO 37			ISO 1133			Toluene solution, 30deg.C			-

1. Precautions should be taken in handling and storing. Refer to the appropriate Material Safety Data Sheet for further safety information.
 2. In using SEPTON™ BIO-series, please confirm related law and regulations, and examine its safety and suitability for the application.
 3. SEPTON™ BIO-series should not be used in any devices or materials intended for implantation in the human body, for medical, health care and food contact applications.
- * The figures, graphs, and charts in this technical information are representative ones measured by Kuraray, and those are without guarantee because each conditions of use are beyond Kuraray's control.

Typical Properties

		SEPTON™ BIO-series		
		SF902	SF903	SF904
		Middle	High	Low
MW				
Styrene cont.		18	30	21
Properties				
Hardness	Type A	8	21	25
MFR [190deg.C, 2.16kg]	g/10min	No flow	No flow	15
MFR [230deg.C, 10kg]	g/10min	55	2.1	>700
100% Modulus * ¹	Mpa	0.2	0.2	0.3
Tensile Strength * ¹	Mpa	4.8	4.6	5.8
Elongation * ¹	%	820	550	900
C.S [25deg.C]	%	6	Broken	28
C.S [70deg.C]	%	35	21	100
ODT * ²	deg.C	330	> 350	210
Bio-based content* ³	%	80	68	48

*¹ Compression molded sheet of 1mm thickness

*² Order-Disorder transition Temperature

*³ Calculation by Kuraray method developed from ASTM6866 / Feeding ratio of farnesene

Features

Strengths

- Softness
- High flowability
- Low C-set, Low permanent set
- High damping property
- High $\tan\delta$ in wide temp. range
- High adhesiveness
- Isotropy
- Plasticizer Less
- High grip
- Eco-friendly

Weakness

- Low Tensile strength
- Tackiness

Analysis of Bio-based Content

Bio-based Content Analysis using ASTM 6866 (Accelerator Mass Spectrometry)

1) Sample Preparation

- a) The sample was oxidized by heating to produce CO₂ gas, without chemical pretreatment.
- b) The produced CO₂ gas was purified in a vacuum line.
- c) The purified CO₂ gas sample was reduced to graphite by hydrogen using iron as a catalyst.
- d) The produced graphite was pressed into a target holder with a hole of 1mm diameter for the AMS ¹⁴C dating, using a hand-press machine.

2) Measurement

- The graphite sample was measured against a standard of Oxalic acid (HOxII).
- ¹⁴C-AMS (accelerator mass spectrometry) system based on the tandem accelerator.

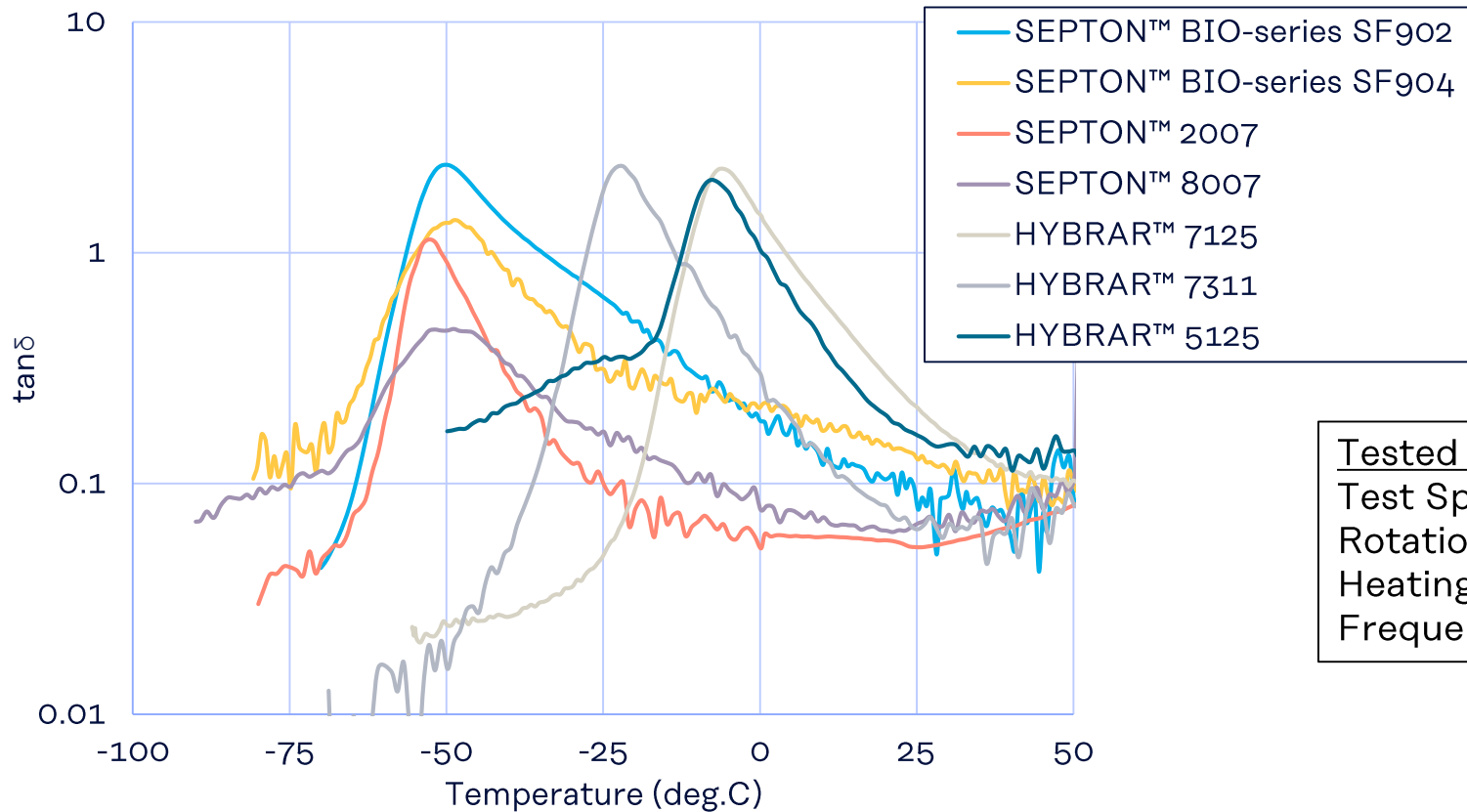
3) Result

Sample Name	Sample State	Mean Bio-based Result by using ASTM 6866 *
SEPTON™ BIO-series SF902	Solid	80%
SEPTON™ BIO-series SF903	Solid	68%
SEPTON™ BIO-series SF904	Solid	50%
β-Farnesene	Liquid	99%

* Ratio of bio-based component in the material, assuming that all the materials are of present day or fossil origins.

Damping Property

- SEPTON™ BIO-series show high $\tan\delta$ value in wide temperature range.

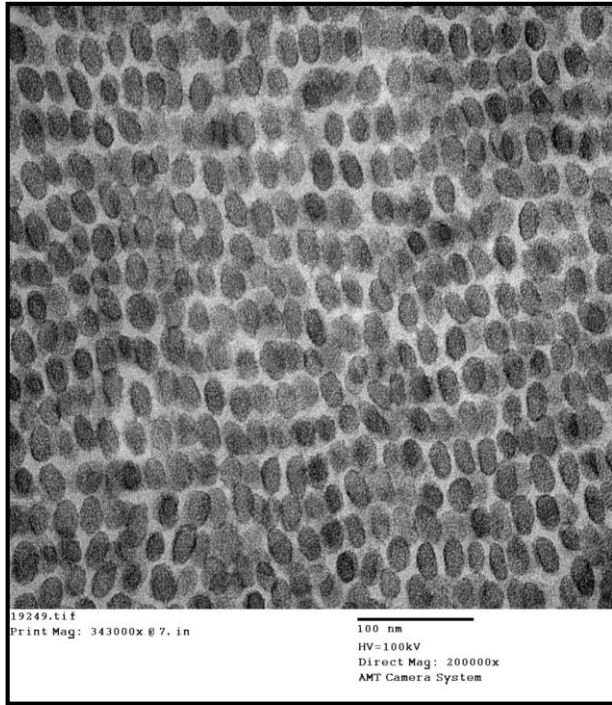


Tested by ARES
Test Specimen; Cylinder, diameter = 8mm, height = 2mm
Rotation mode
Heating rate; 2 deg. C/min
Frequency; 1 Hz

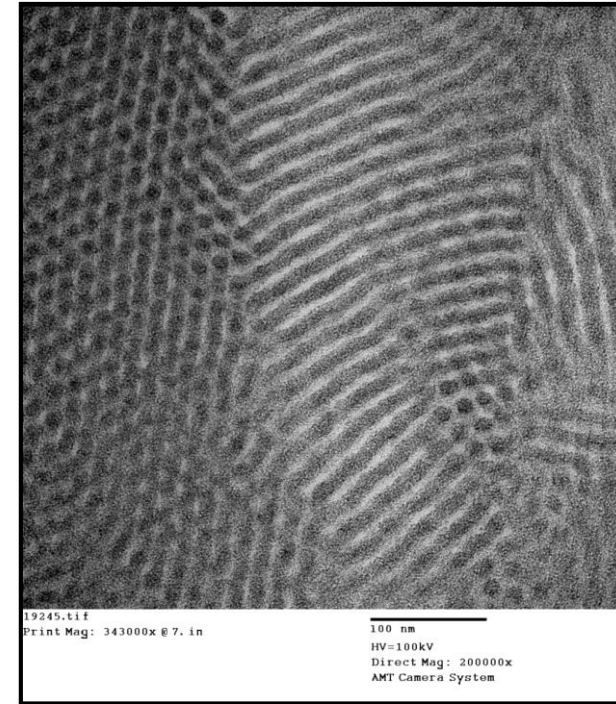
TEM Image

- SEPTON™ BIO-series has sphere polystyrene domain, although SEBS with same styrene content has cylinder type St domain.

HSFC (SEPTON™ BIO-series: St=30wt%)



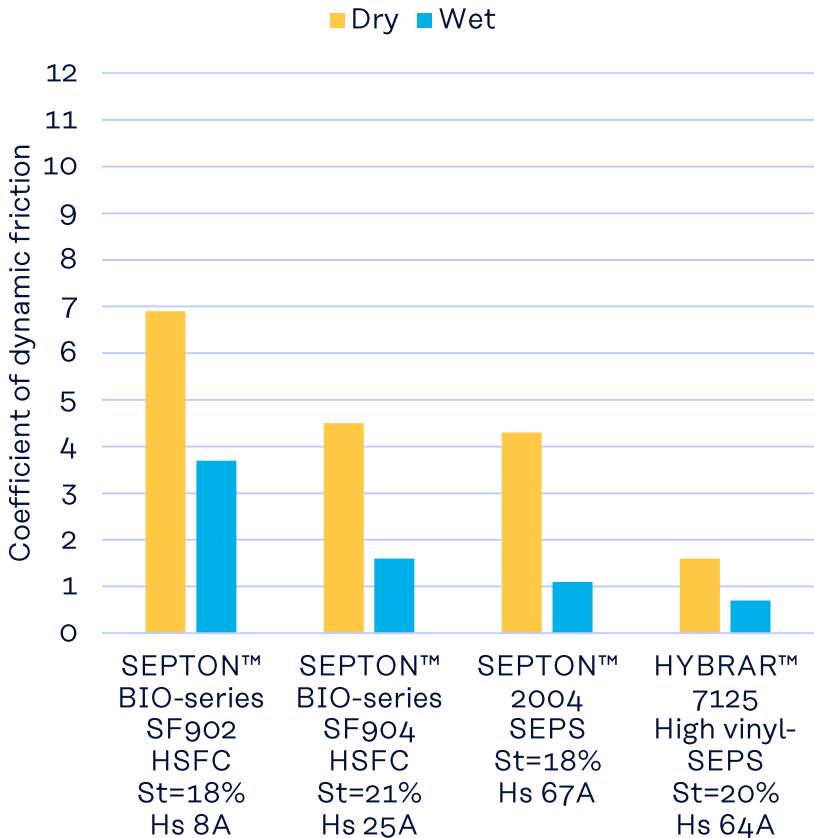
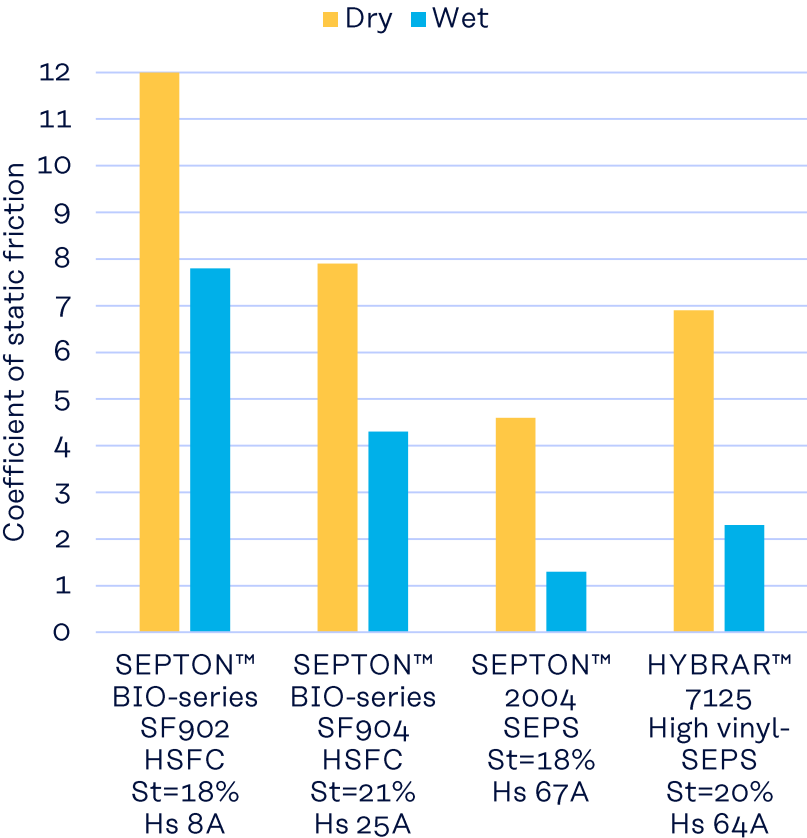
SEBS (SEPTON™ 8007 : St=30wt%)



* cast sheet (from 10wt% CHx solution)

Grip performance

- SEPTON™ BIO-series have high grip performance compared with general HSBC.

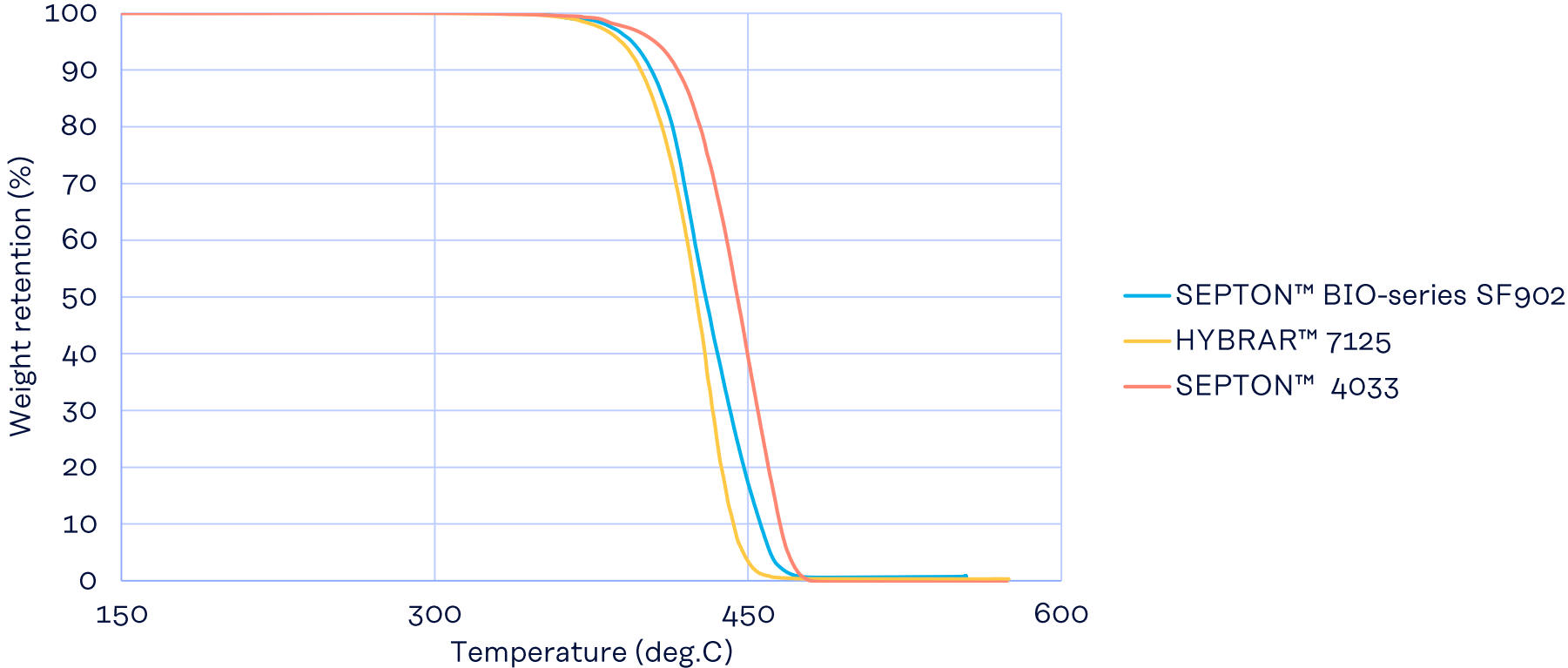


Aluminum



Specimen;
Compression molded sheet (0.5mmt)

Heat Resistance



Test conditions : Thermo-balance Heat Degradation, Heat rate 10deg. C/min., Nitrogen Atmosphere

Line-up

	Adhesive	Protective Film	Sealant	Resin Modifier	Compound	Jelly	Nonwoven
<u>SEPTON™ BIO-series SF902</u> Middle MW Low St cont.	✓	✓ Solvent coating	✓	✓			
<u>SEPTON™ BIO-series SF903</u> High MW Middle St cont.				✓	✓	✓	
<u>SEPTON™ BIO-series SF904</u> Low MW Low St cont.	✓	✓ Co-extrusion & Solvent coating	✓	✓	✓		✓

Adhesive

Features

- High adhesiveness and tackiness without tackifier
- Low bleeding
- High adhesiveness to PE, Glass with tackifier
- Good heat resistance (SEPTON™ BIO-series SF902)
- Good film extrusion mold-ability (SEPTON™ BIO-series SF904)

Adhesive Properties of Solvent Coated Film

		Units	SEPTON™ BIO-series SF904	SEPTON™ BIO-series SF902	HSBC-1	SEPTON™ BIO-series SF904 + TF*3	SEPTON™ BIO-series SF902 + TF*3	HSBC-2 + TF*3	Test Method
SAFT*1	to SST*2	(deg. C)	145	202	188	132	190	159	
Ball tack		(Ball No.)	5	6	2	6	8	5	JIS Z0237
Rolling ball tack		(cm)	> 37.5	11	> 37.5	36.7	17	> 37.5	ASTM D3121
180° Peel strength	to Glass	(N/25mm)	0.1	0.3	0.03	4.9	8.9	10	
	to SST*2	(N/25mm)	8.1	5.7	12	13	15	11	
	to PE	(N/25mm)	0.5	0.7	0.05	2.8	2.7	0.2	
	to PMMA	(N/25mm)	11	9.8	18	15	14	14	

*1: 0.5kgf, sample size 25 mm x 25mm, temperature increment 0.5 deg. C/min

*2: Stainless steel

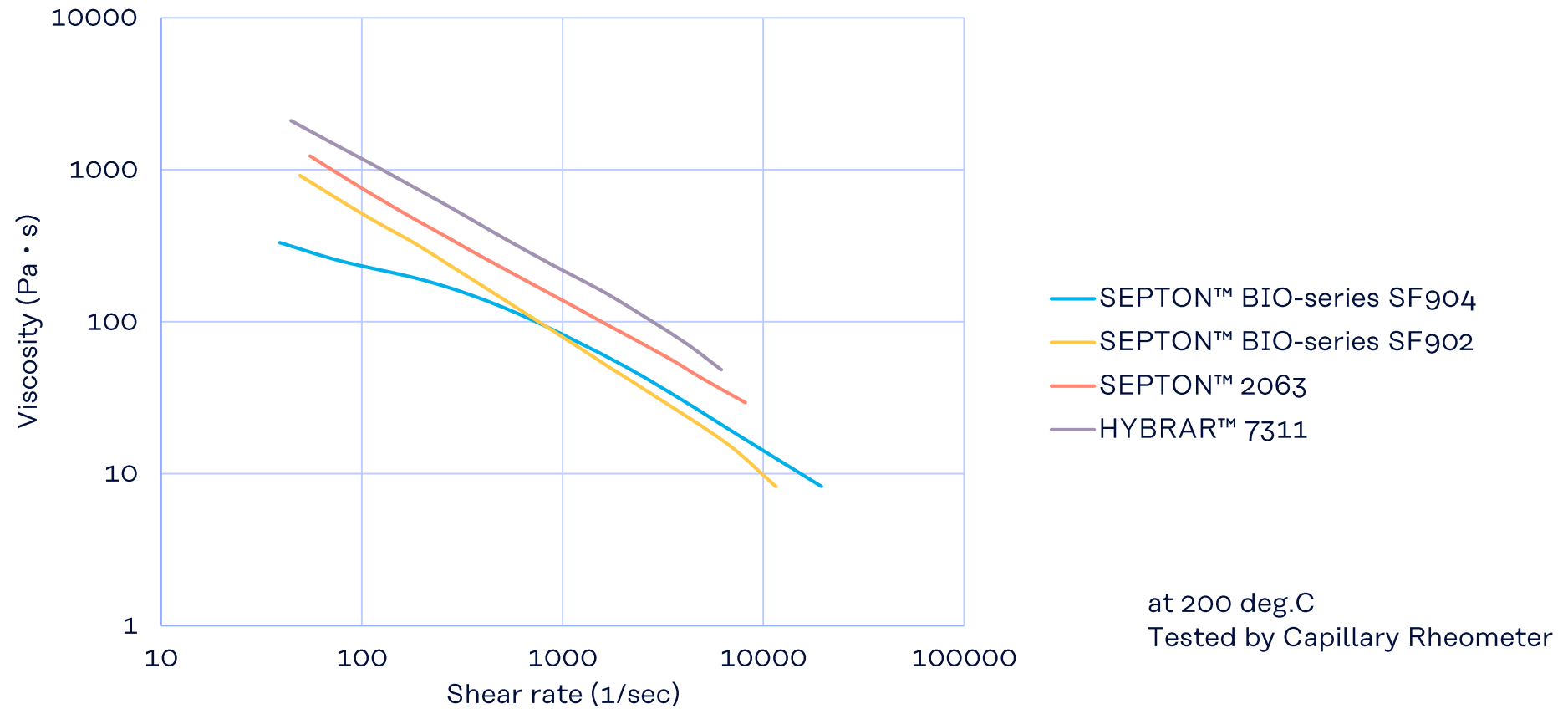
*3: Tackifier; Arkon P-125 (Arakawa Chemical Industries, Ltd.)

Formulation; SEPTON™ BIO-series/TF or HSBC-2/TF = 80/20 by weight

Test Specimen; Cyclohexane solvent (TS=25wt%) coating to PET film(50µm)

Shear Viscosity

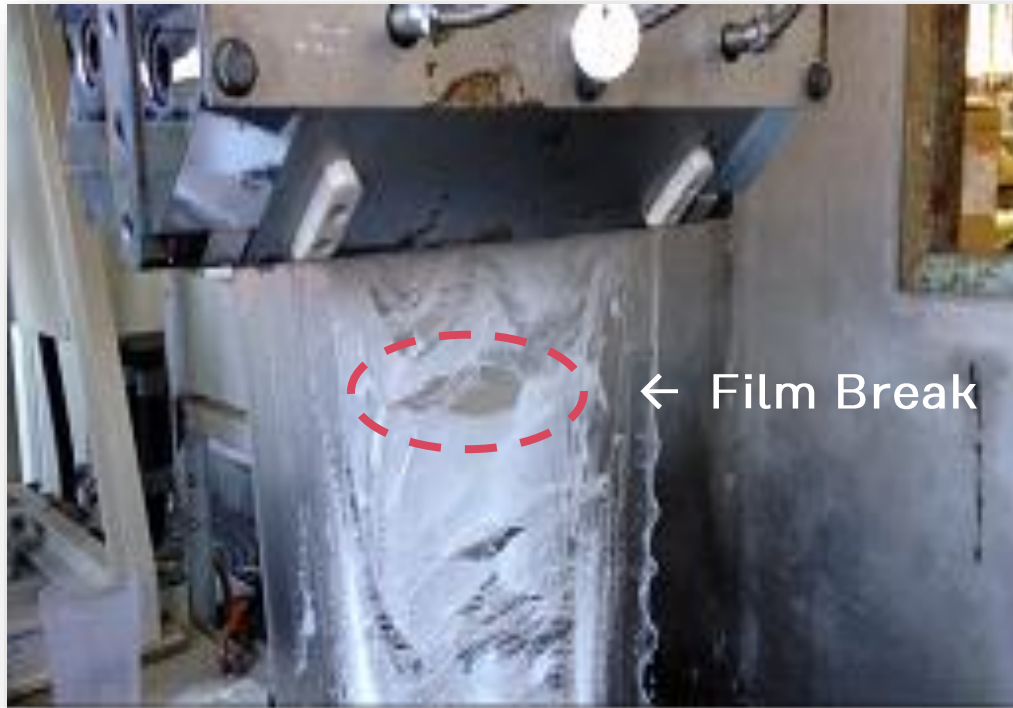
- SEPTON™ BIO-series SF904 shows similar shear dependency to HSBCs with lower viscosity.



T-die Cast Film

- SEPTON™ BIO-series SF904 shows good T-die film casting mold-ability and co-extrusion with polyolefin.

SEPTON™ BIO-series SF902



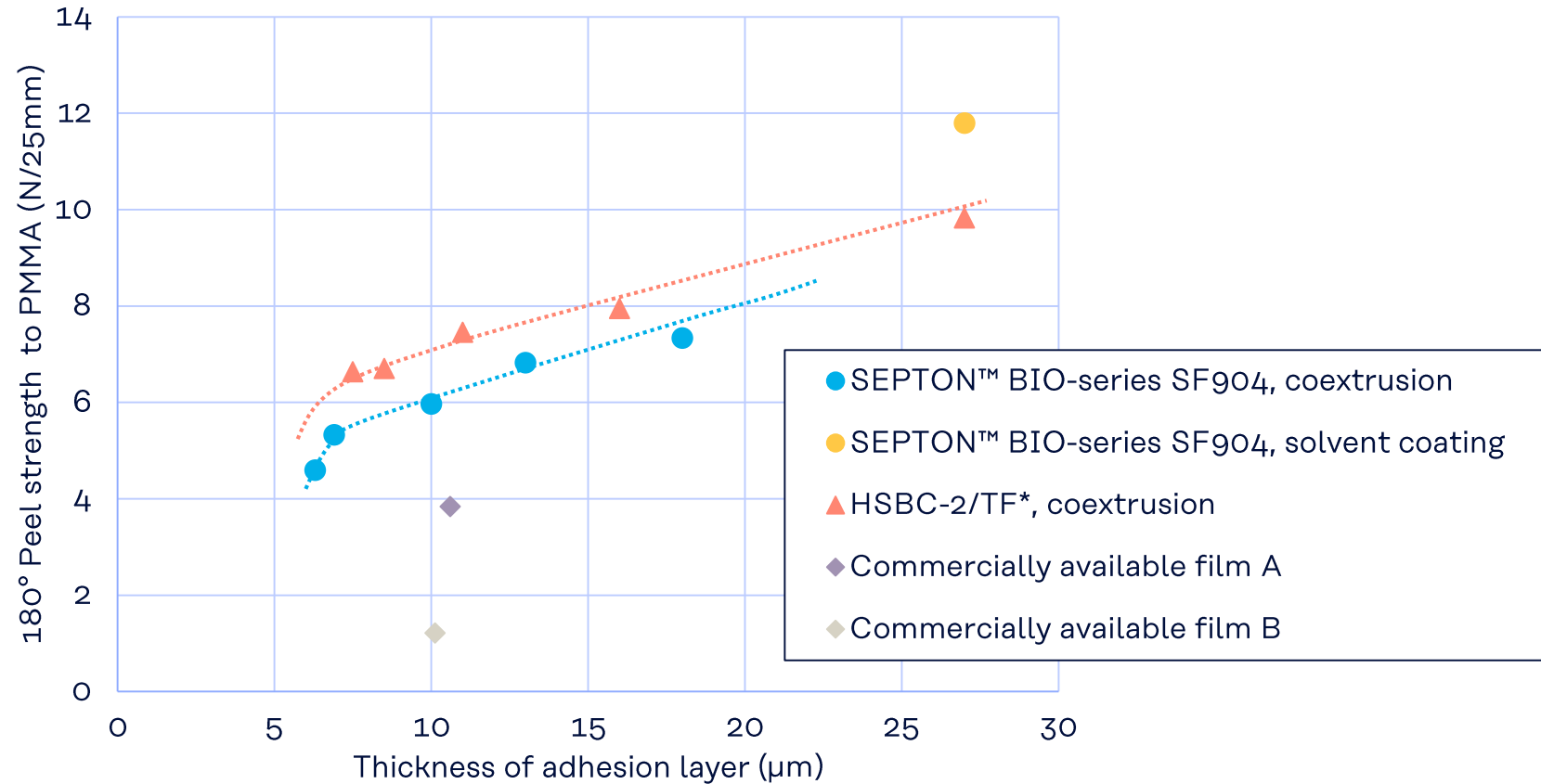
SEPTON™ BIO-series SF904



@ 200deg. C

Adhesive Properties of T-die Cast Film

- SEPTON™ BIO-series SF904 shows good adhesiveness equivalent to HSBC/TF.



*80/20 by weight

Sealant

Features

- SEPTON™ BIO-series shows good damping property to high frequency sound at any temperature.
- Softness without oil

Sound Damping

Test Conditions

Confirm to JIS K7391

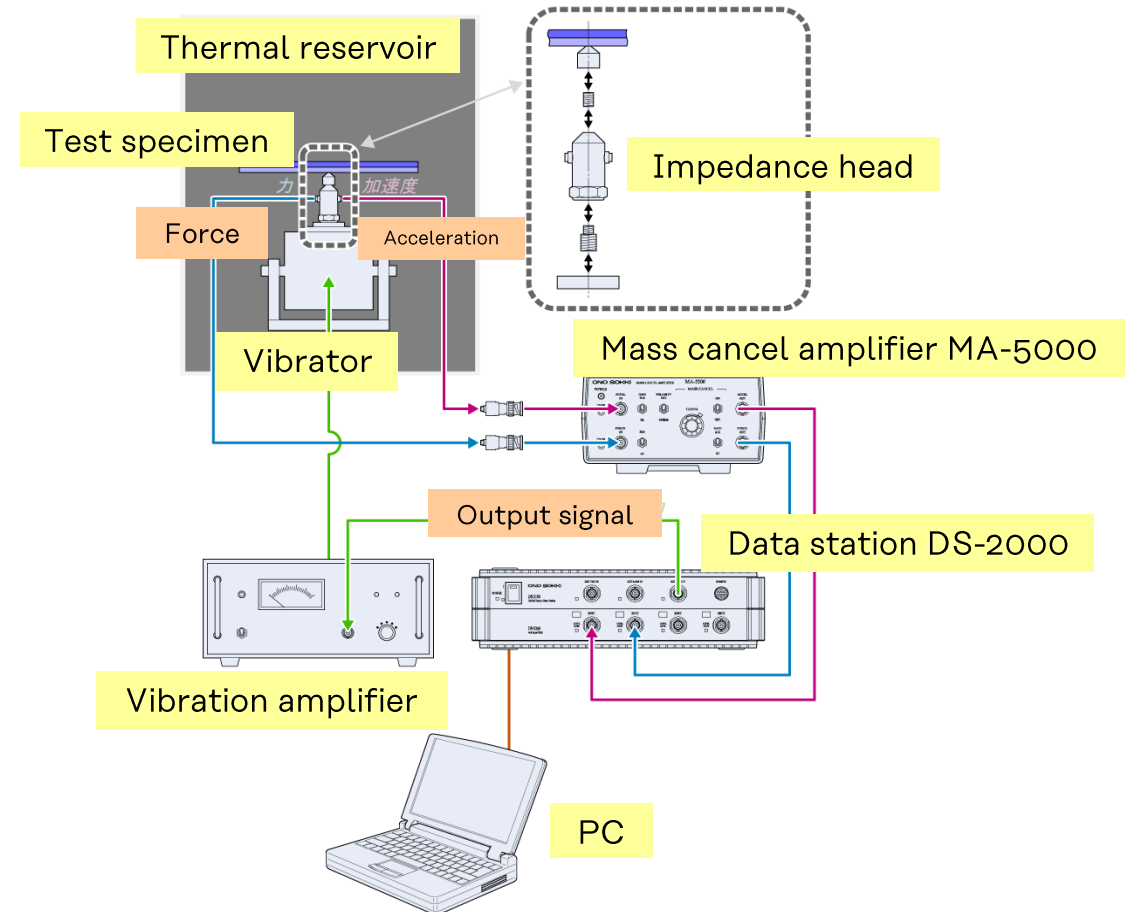
Temperature; 0, 25, 40, 60, 80 deg.C

Frequency; 70 - 8000 Hz

Apparatus; DS-2000, MA-5000
(ONO SOKKI Co., Ltd.)

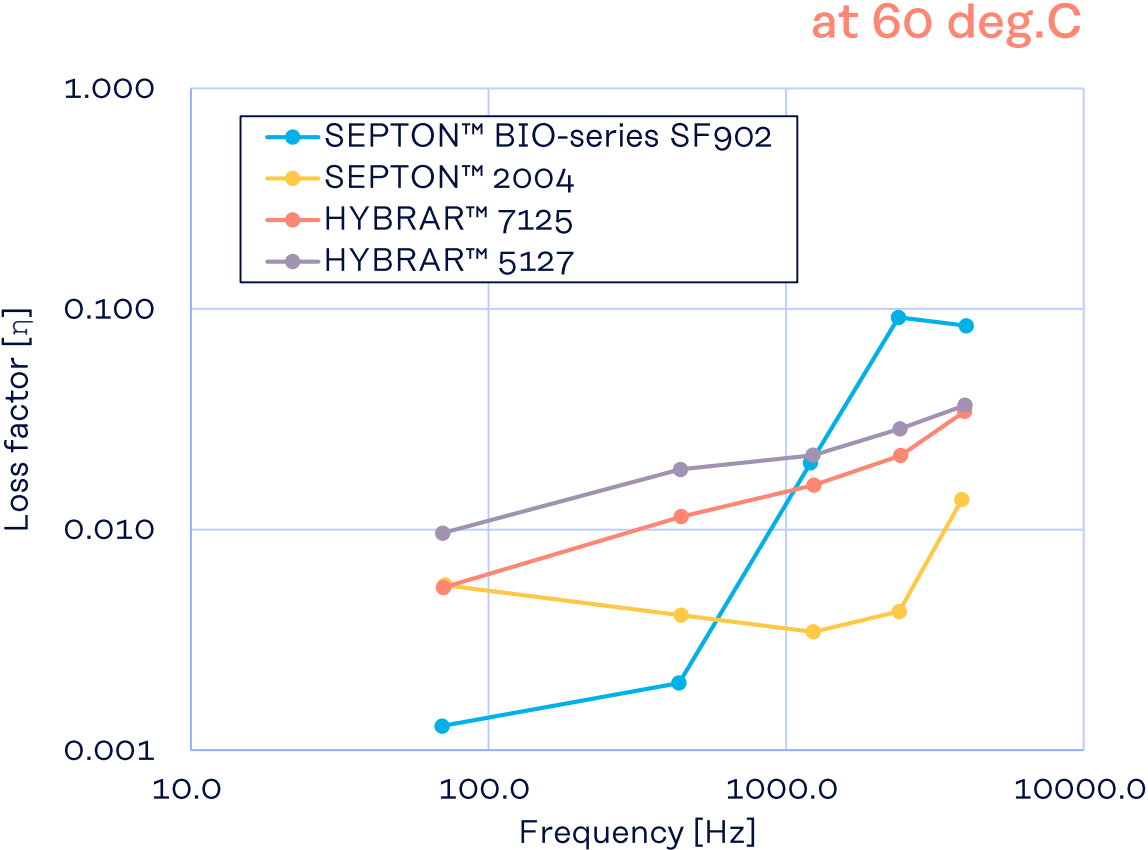
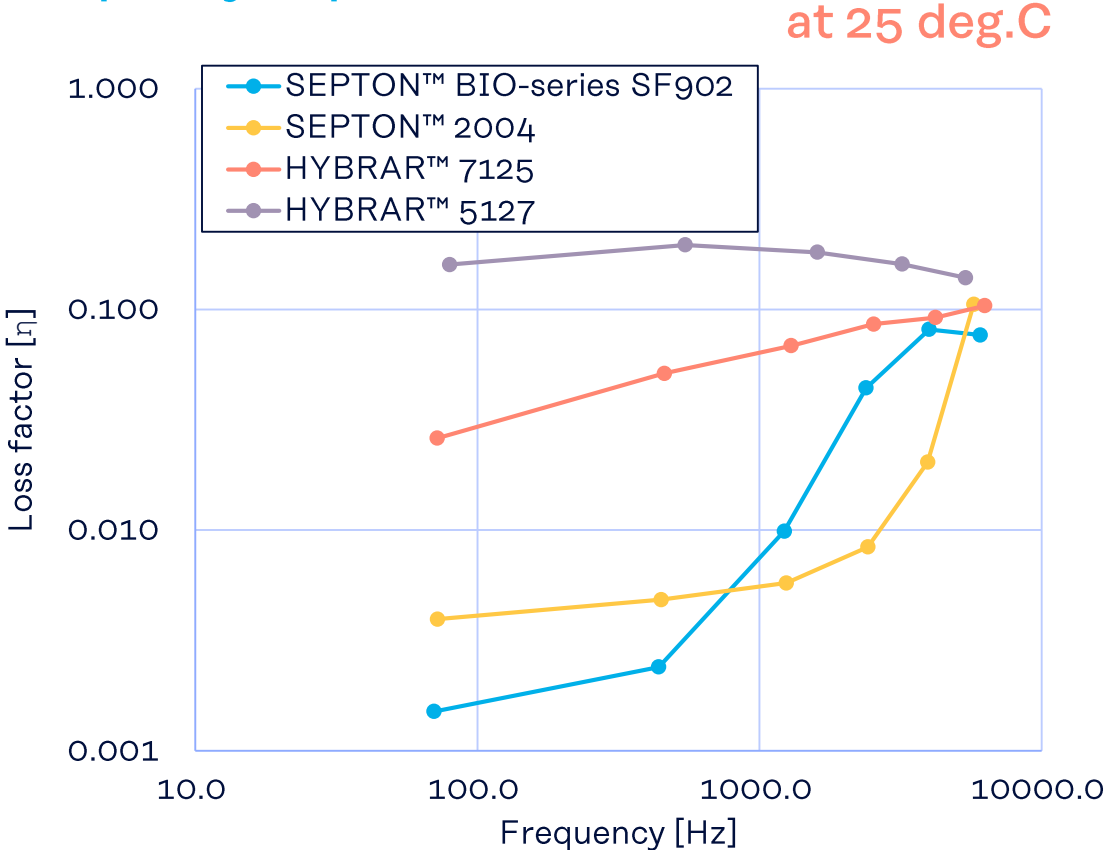
Test specimen; W × L × T: 10 × 200 × 3 (mm)
Compress molded sheet of elastomer
bonded to cold-rolled steel sheet.

Scheme of center support excitation method



Sound Damping

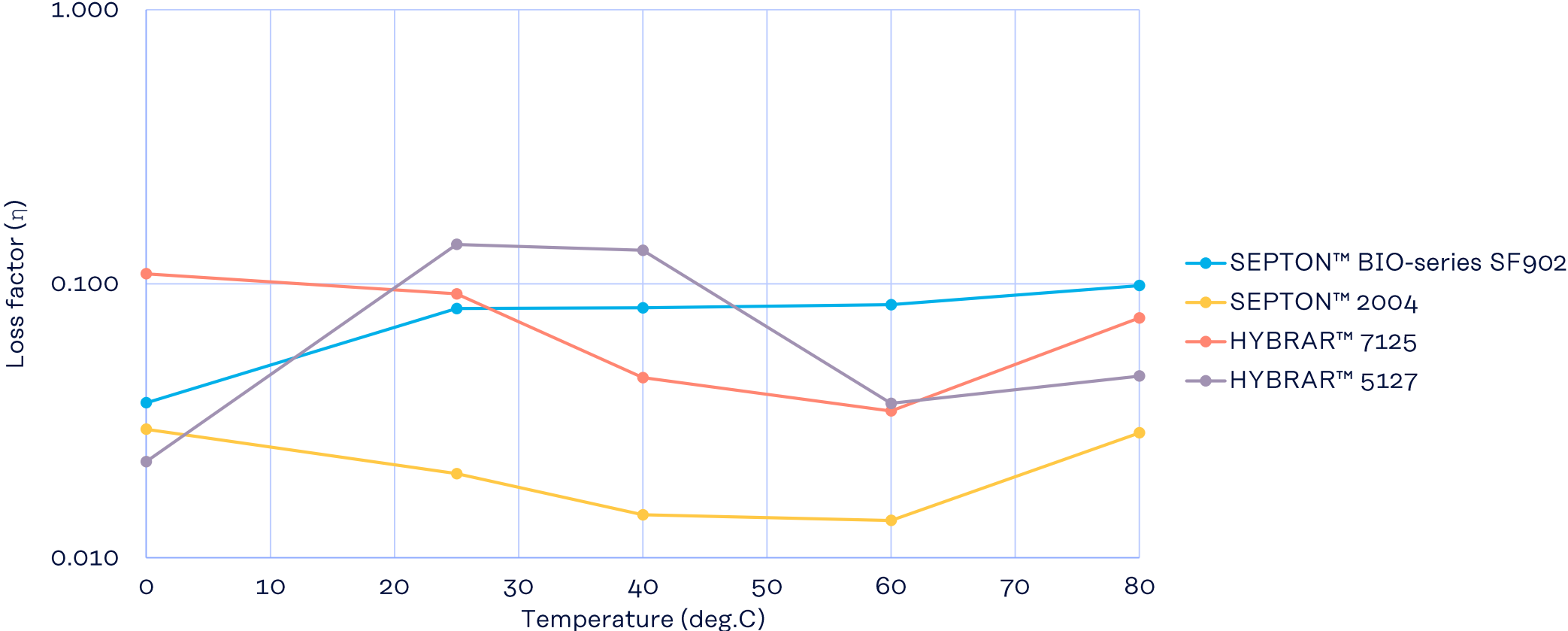
Frequency Dependence



Sound Damping

Temperature Dependence

Frequency; 4 kHz



Compounds

Features

- Adhesive compounds show good adhesion to various polar and non-polar adherent with extrusion molding.
- Adhesive compounds show good adhesion to various polar adherent with insert injection molding.
- Thermoplastic vulcanizates (TPV)/SEPTON™ BIO-series compounds show good extrusion moldability.
- For weather seal application, TPV/SEPTON™ BIO-series compounds show good softness and adhesion to EPDM.
- SEPTON™ BIO-series/Oil/PP compounds show good softness.

Adhesive Compound for extrusion molding

- SEPTON™ BIO-series based adhesive compounds show good adhesiveness to various polar and non-polar adherent.

Formulation; SEPTON™ BIO-series/EMA/MAh-PP = 70/20/10
 Adherent; 1mm thickness plate
 Bonding condition; Pre-heating at 160 deg.C, 0.5 min
 Compression at 160 deg.C, 2MPa, 2.5 min

EMA; ELVALOY® AC1820 (DuPont de Nemours, Inc.), MAh-PP; ADMER™ QF551 (Mitsui Chemicals, Inc.)

	Thickness [mm]	Hs [Type A]	180° Peel strength [N/25mm]					Al
			PC	PMMA	ABS	PA6	PP	
SEPTON™ BIO-series SF902 Compression sheet	1.0	37	34	30	31	21	30	34
SEPTON™ BIO-series SF904 Compression sheet	1.0	41	55	30	6.2	56	68	90

Adhesive Compound for insert injection molding

- Excellent Adhesive strength to polar materials by insert injection

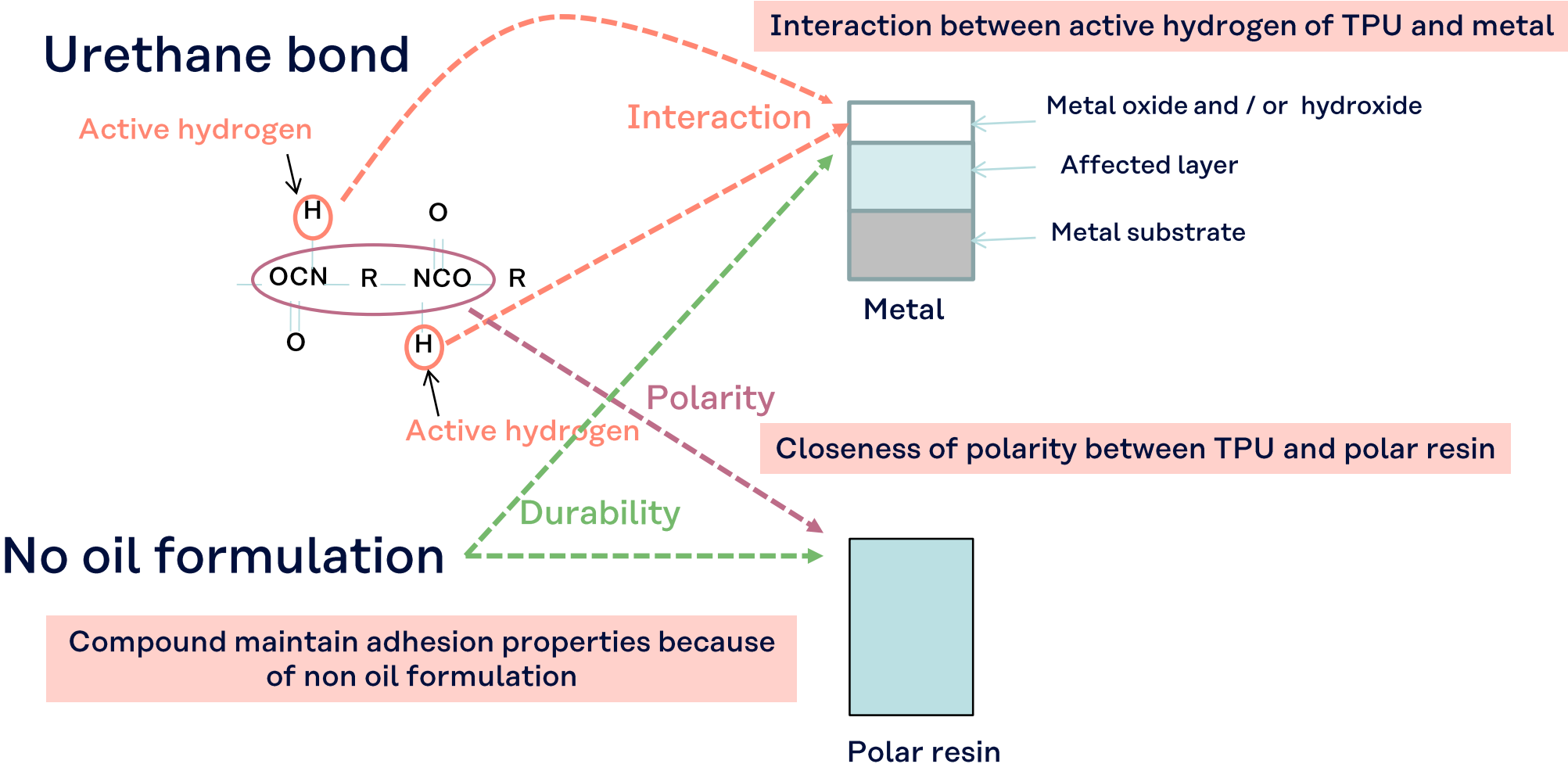
		HSFC	HSBC
SEPTON™ BIO-series SF904		100	-
SEPTON™ 8006		-	100
TPU (Elastollan® C80a: BASF SE)		200	200
TU-S5265 (Kuraray Co., Ltd.)		50	50
Paraffin oil (Kinetic viscosity=96mm ² /s@40deg.C)		-	100
Antioxidant (ADKSTAB AO-60, ADEKA Corporation)	to compound (wt%)	0.1	0.1
Antiblocking agent: Talc FFR (Asada Milling Co., Ltd.)	to compound (wt%)	0.1	-
Mixing condition: Barrel temp.	¹⁾ deg.C	220	240
Moisture (Pellet)	²⁾ ppm	453	479
MFR (230deg.C, 2.16kg)	g/10min	22	5.2
Hardness	TypeA	65	55
Tensile strength	MPa	7.4	2.9
Elongation	%	260	480
Molding condition: Cylinder temp./Mold temp.	³⁾ deg.C	260/40	260/40
Adherend		180° Peel strength (N/25mm)	
PC		96	50
ABS		87	50
PMMA		64	46
PA6		70	26
Aluminum		48	6.1
Magnesium alloy		52	5.6

1) ZSK26Mc: φ26mm, L/D=56 (Coperion GmbH)

2) Drying condition: 80deg.C, 4hrs

3) EC75SX: 75ton (Shibaura Machine Co., Ltd.)

Estimation of the adhesive mechanism



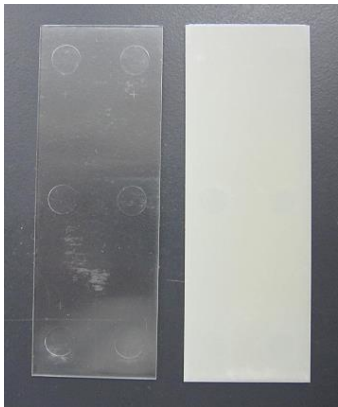
Adherend washing



Polar resin

Polar resin

Just wiping surface with methanol



Metal

Metal











- 1) Washing the surface by mixed solution
Clean ace S / distilled water = 20 / 80 (v / v)
- 2) Then washing the surface by distilled water with ultrasonic for 10min
- 3) Drying the metal at 100deg.C for more than 1hr
Clean ace S : Neutral detergent (AS one Corporation)

Thermoplastic vulcanizates (TPV)/SEPTON™ BIO-series compound (extrusion)

				Hardness 60A		Hardness 40A	
TPV-1		100			70		
TPV-2				100			70
TPV-3						100	
SEPTON™ BIO-series SF904					30		30
MFR	(210deg.C, 2.16kg)	g/10min	-	-	22	-	29
	(210deg.C, 5kg)	g/10min	1.5	0.6	94	14	148
C.S.	(70deg.C, 22hrs)	%	29	27	74	25	59
	(120deg.C, 22hrs)	%	25	29	62	27	85
Properties							
Hardness		(Type A)	76	60	56	40	35
100% Modulus		MPa	4.6	2.0	1.9	0.9	0.7
Tensile strength		MPa	8.9	5.3	3.1	2.9	1.7
Elongation		%	450	380	318	320	337
Tear strength		N/mm	16.0	8.7	9.5	3.9	5.0
Resilience		%	46	54	42	55	52
Extrusion Moldability			Good	Fair	Excellent	Bad	Good

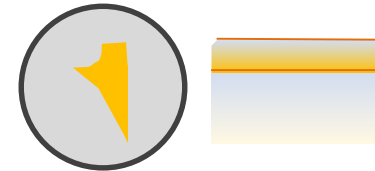
TPV/SEPTON™ BIO-series compound (extrusion)

- SEPTON™ BIO-series SF904 improves extrusion mold-ability of TPV.

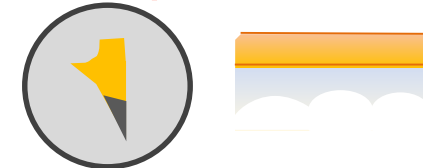
	Hardness	MFR 210deg.C, 5kg			Moldability (Garvey die)
TPV-1	76	1.5			Good
TPV-2	60	0.6			Fair
TPV-1/SF904 =70/30	56	94			Excellent
TPV-3	40	14			Bad
TPV-2/SF904 =70/30	35	148			Good

Garvey die test

Excellent



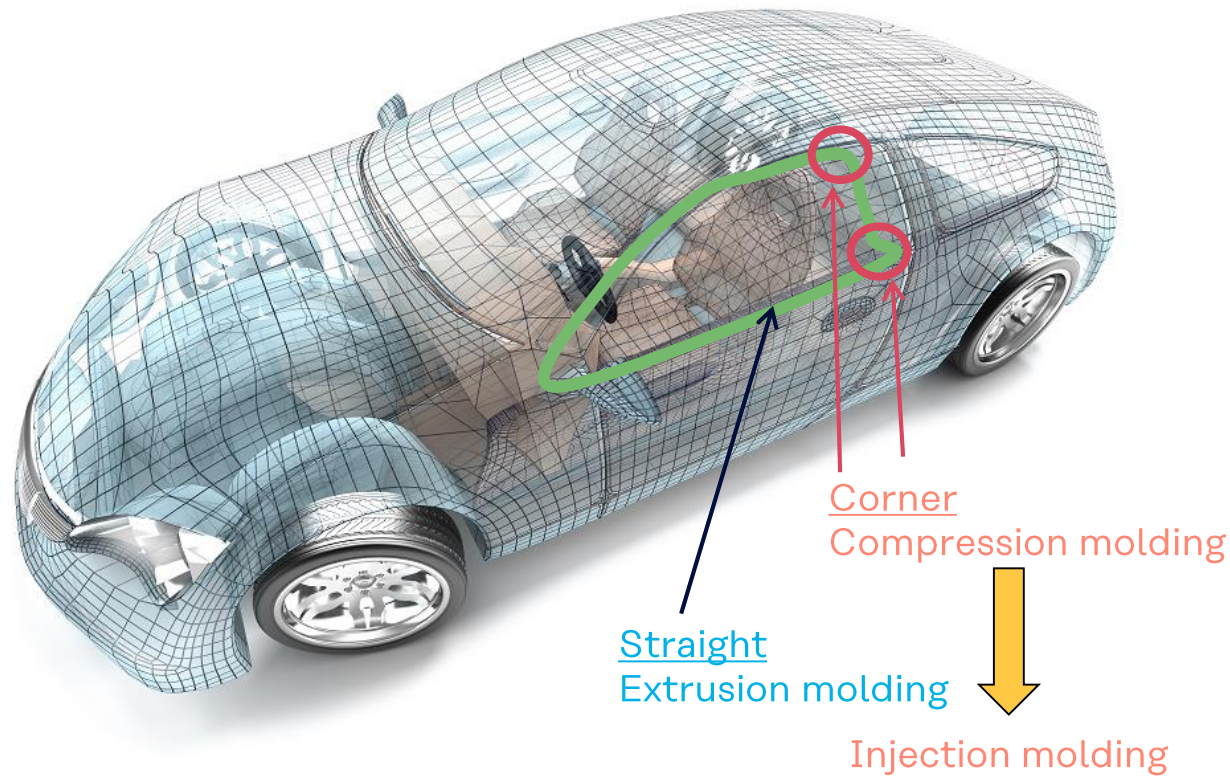
Bad



Weather Seal (SEPTON™ BIO-series/PP compound)

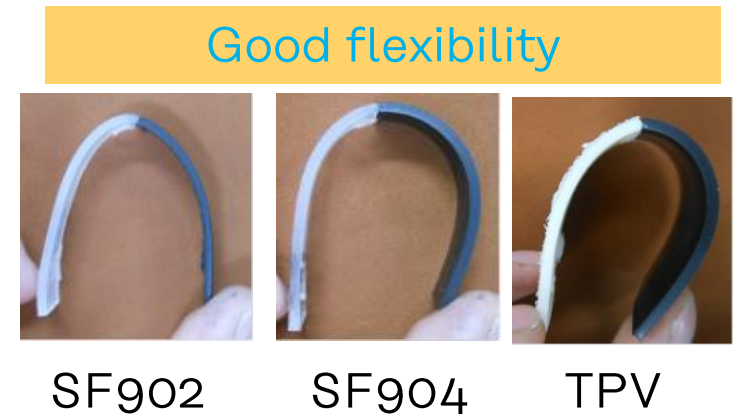
Formulation; SEPTON™ BIO-series/Random-PP/Erucamide=75/25/0.2

Random PP; MFR=20g/10min @ 230deg.C, 2.16kg
 Erucamide; (DIAMID L-200, Nippon Kasei Chemical Co., Ltd.)



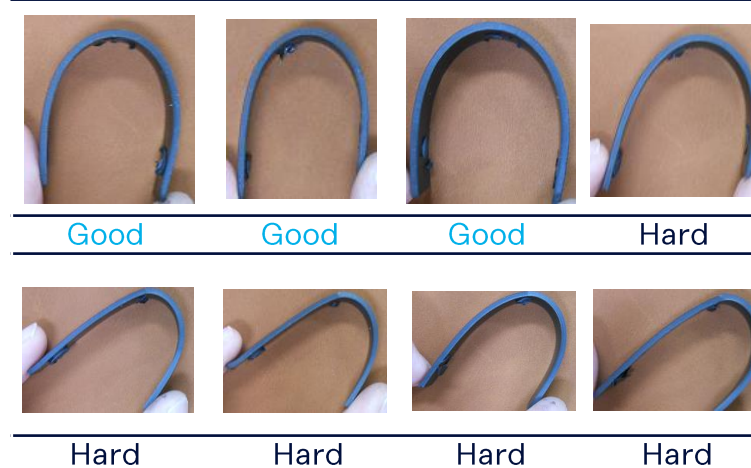
		SEPTON™ BIO-series SF902	SEPTON™ BIO-series SF904	TPV
Hardness	Type A	70	75	62
Adhesion	N/cm ²	169	198	105

Insert injection molding to EPDM



Window seal (TPV/SEPTON™ BIO-series compound)

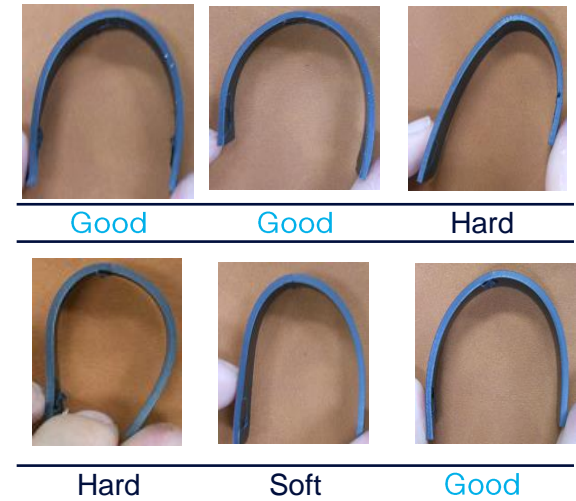
Glass-run corner (Window seal)						
TPV-4			100	75	75	75
SEPTON™ BIO-series SF902				15		
SEPTON™ BIO-series SF904					18.75	15
r-PP (MFR 20 g/10min)				10	6.25	10
Hardness	Type A		71	76	67	76
Adhesive force	to TPV	N/cm ²	310	288	243	286
	to EPDM	N/cm ²	239	246	222	283
MFR (230deg.C, 2.16kg)		g/10mim	9.4	16	67	61
Flexibility	to TPV		Good	Good	Good	Hard
	to EPDM		Hard	Hard	Hard	Hard



Window seal (TPV/SEPTON™ BIO-series compound)



Door seal corner					
TPV-5			100	75	75
SEPTON™ BIO-series SF904				18.75	15
r-PP (MFR 20 g/10min)				6.25	10
Hardness	Type A		42	48	54
Adhesive Force	to TPV	N/cm ²	140	120	135
	to EPDM	N/cm ²	100	115	150
MFR (230deg.C, 2.16kg)		g/10mim	3.6	134	107
Flexibility	to TPV		Good	Good	Hard
	to EPDM		Hard	Soft	Good



HSBC/Oil/PP Compound

Physical properties of HSBC based compound with process oil

SEPTON™ BIO-series SF902	HSFC	100				
SEPTON™ BIO-series SF903	HSFC		100			
SEPTON™ 4033	SEEPS			100		
SEPTON™ 4055	SEEPS					100
Process Oil		50	50	50	50	
Polypropylene		20	20	20	20	
Antioxidant		0.1	0.1	0.1	0.1	
MFR						
	(200deg.C, 2.16kg)	(g/10min)	8.1	3.5	2.4	No flow
	(200deg.C, 5kg)	(g/10min)	115	82	9.7	No flow
Properties (Press molding, 230deg.C)						
Hardness	(Type A)	18	20	67	62	
100% Modulus	(MPa)	0.4	0.4	2.4	1.4	
Tensile strength	(MPa)	1.1	3.1	21	20	
Elongation	(%)	340	590	690	740	
C.S	(23deg.C/22h)	(%)	4	10	18	12
	(70deg.C/22h)	(%)	66	20	100	30
	(100deg.C/22h)	(%)	100	46	-	43
	(120deg.C/22h)	(%)	-	60	-	Broken
P.S	(100%, 10min - 10min)	(%)	2.3	2.3	1.8	4.8

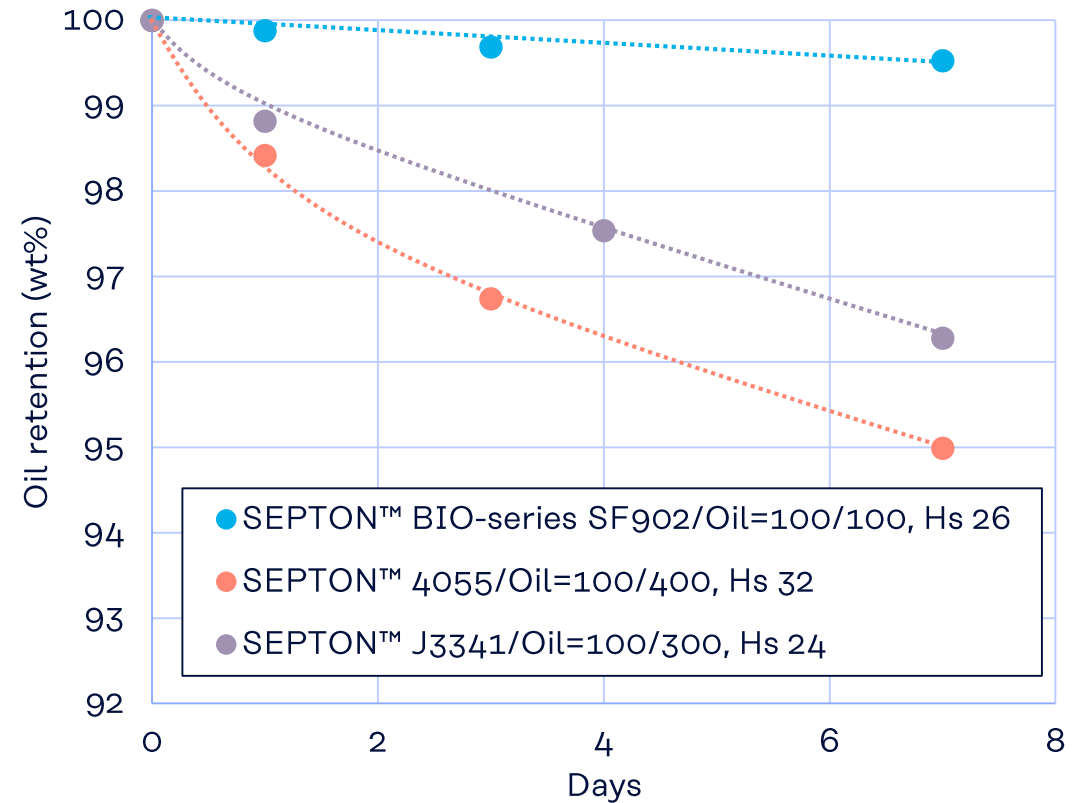
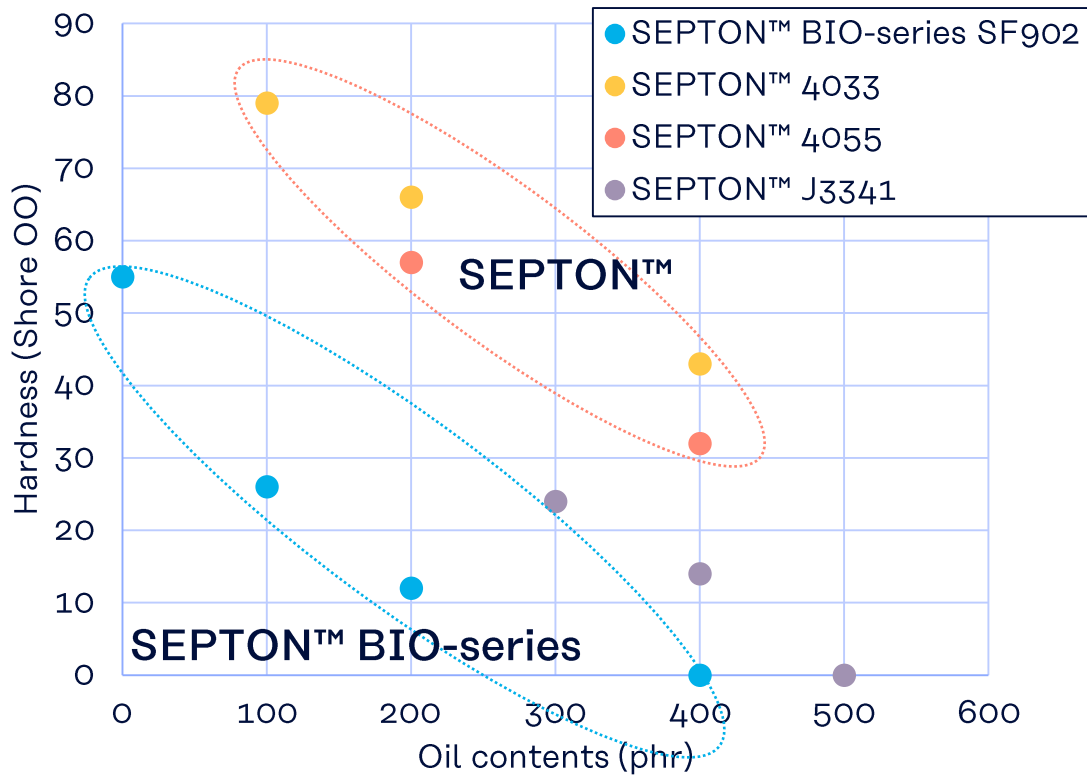
Jelly

Features

- Excellent Softness with low amount of oil
- Low bleeding
- Good Compression Set
- High flow-ability

Jelly

- SEPTON™ BIO-series based jelly shows excellent softness with lower amount of oil addition



Jelly

SEPTON™ BIO-series SF902		100	100									
SEPTON™ BIO-series SF903				100	100	100						
SEPTON™ 4033							100	100	100			
SEPTON™ 4055										100	100	
SEPTON™ J3341												100
Paraffin Oil		100	200	100	200	400	100	200	400	200	400	400
Hardness	(SHORE OO)	26	12	< 10	< 10	< 10	79	66	43	57	32	14
MFR (160 deg. C, 2.16kg)	g/10min	68	> 700	69	700	> 700	8.5	> 700	> 700	No flow	2.7	44
C.S. (40 deg. C, 22hrs)	%	43	80	6	3	18	74	96	100	15	15	8
Oil Retention (wt%)	1 day	99.9	99.4	99.7	99.1	95.7	99.9	99.9	97.7	99.8	98.4	97.5
	3 days	99.7	98.7	99.2	98.3	91.9	99.9	99.7	95.4	99.4	96.7	94.9
	7 days	99.5	98.1	98.8	97.3	88.0	99.9	99.3	93.1	98.9	95.0	92.6

Nonwoven

Features

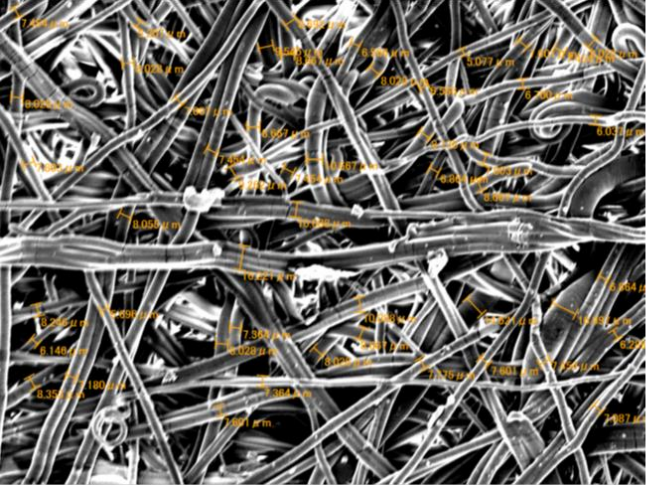
- Good melt blow mold-ability by controlling molecular structure (SEPTON™ BIO-series SF904)
- Excellent elastic recovery compared to conventional HSBC
- Good drape-ability

Nonwoven

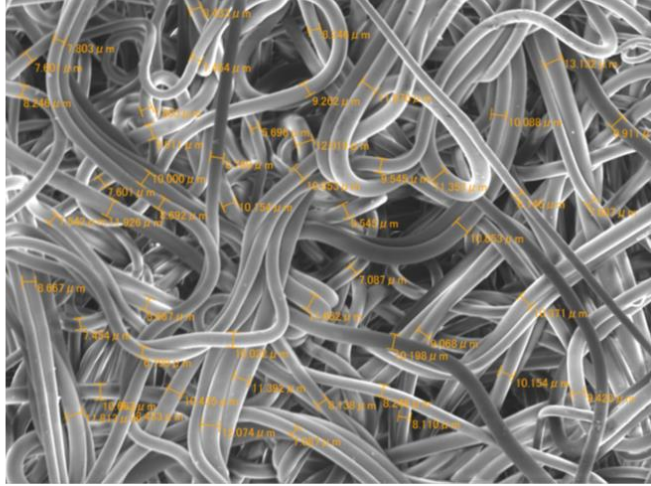
- SEPTON™ BIO-series SF904 shows good melt blow mold-ability.

SEM Image

SEPTON™ BIO-series SF904



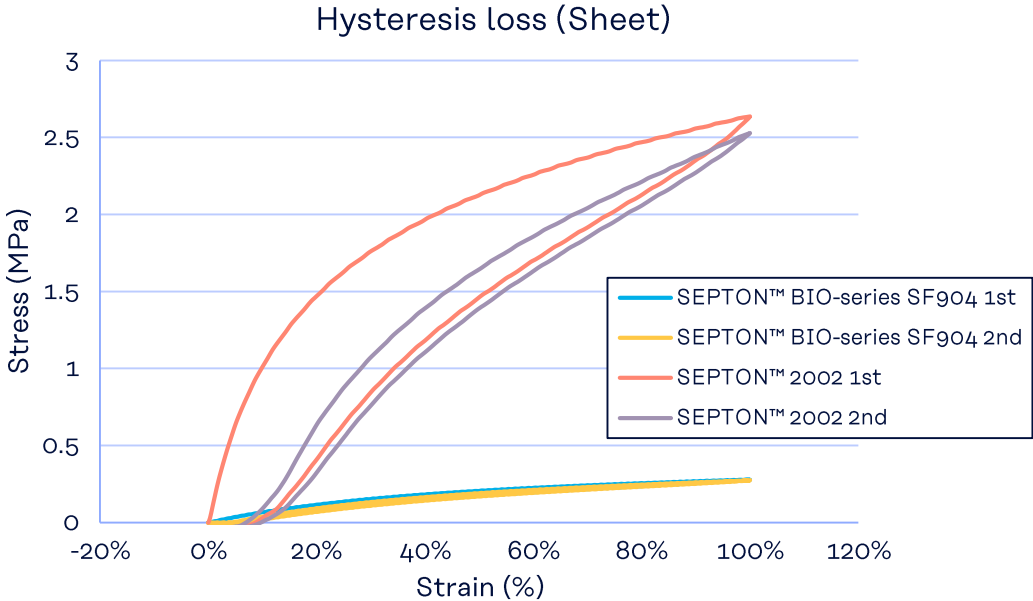
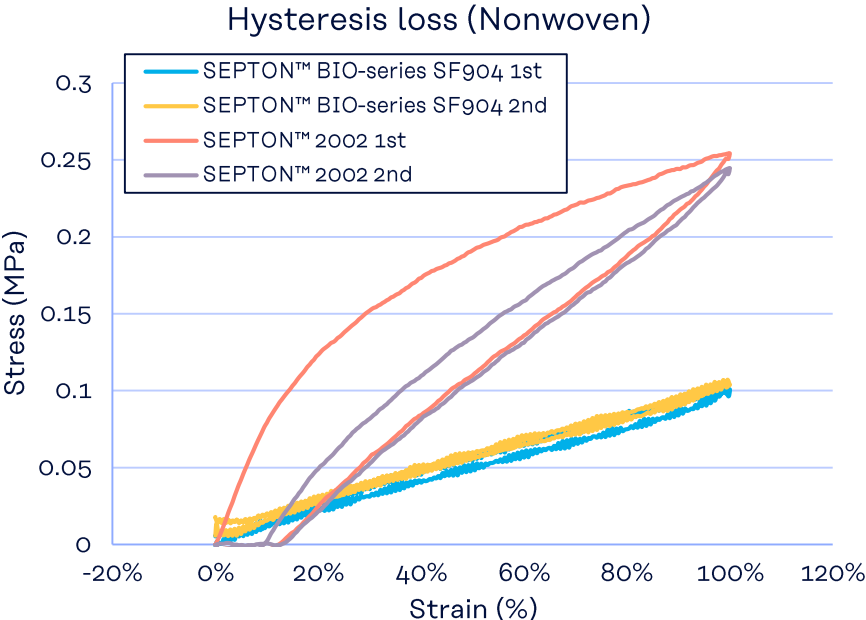
SEPTON™ 2002



	SEPTON™ BIO-series SF904	SEPTON™ 2002
Fiber Diameter [μm] (average of 50 points)	8.2	9.2
Thickness [μm]	260	520

Nonwoven

- SEPTON™ BIO-series SF904 shows excellent elastic recovery.



		Hysteresis loss 1st cycle	Hysteresis loss 2nd cycle
		(%)	(%)
SEPTON™ BIO-series SF904	Nonwoven	11	4
	Sheet	15	10
SEPTON™ 2002	Nonwoven	39	17
	Sheet	33	11

Composite molded article based on SEPTON™ BIO-series SF904

Features

- Good foam-ability and cell uniformity
- High peel strength between fabric and foamed layer without primer

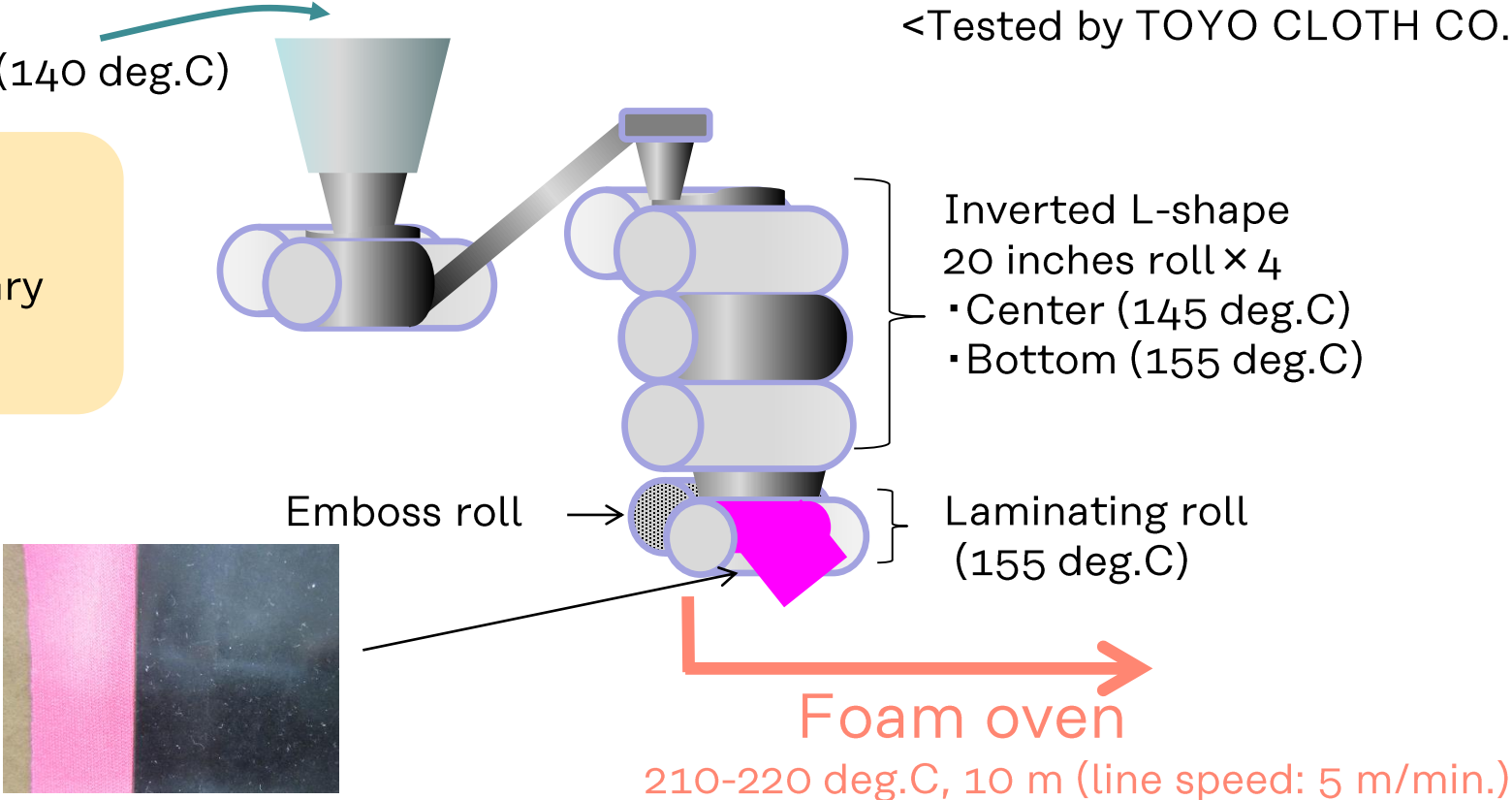
Calendering process

- 1) 2-layer: Fabric / SEPTON™ BIO-series SF904 (100) + SEPTON™ 2002 (20)* *Reduction of tack
- 2) 3-layer: Fabric / SEPTON™ BIO-series SF904 / Fabric

100L of banbury mixer (140 deg.C)

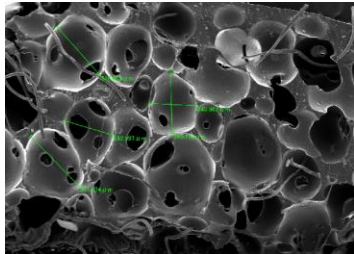
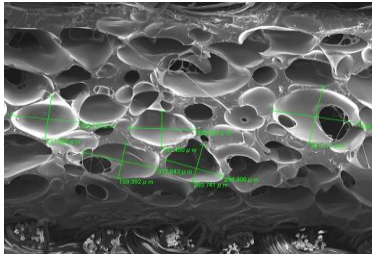
- SF904 (+2002)
- Foaming agent
- Foaming auxiliary
- Antioxidant
- Carbon M.B.

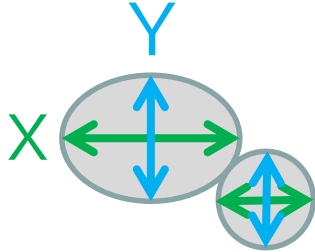
<Tested by TOYO CLOTH CO., LTD.>



Foaming process

- Good foam-ability and cell uniformity
- High peel strength between fabric and foamed layer without primer

Configuration	2-layer			3-layer		
Foam cells						
	Foam cells (μm)			Foam cells (μm)		
	X	Y	X/Y	X	Y	X/Y
Average	318	253	1.26	354	224	1.58
Expansion ratio*	2.64			2.39		
Peeling strength (To fabric)	N/3cm			N/3cm		
	4.7 Material break			8.8 Material break		



Expansion ratio*: After foaming / Before foaming

Foaming condition: 210-220 deg.C, 10 m (line speed: 5 m/min.)

Which would you like to evaluate, SEPTON™ BIO-series itself or the composite molded articles?

Potential applications

		Strength	Potential applications
Grip compound	Injection molding (Non-vulcanized)	High grip, High bio-cont.	Grip (Golf, Bicycle, Jet ski)
	Compression molding (Vulcanized)	High wet-grip, Lightweight, High tear strength	Shoe sole (Hiking, Bouldering) Fisheries for boots
Adhesive compound	Injection molding	Softness, High adhesive force, Plasticizer less, High flowability	Cross car beam (Automobile)
	Compression molding Extrusion molding	Excellent chipping resistance	Decoration film (Adhesive layer)
Adhesive	Coating	Excellent high adhesion to the substrate, Tackifier less, Excellent moldability	Protective film (Strong adhesive)
	Co-extrusion		
Jelly	Injection molding	Softness, High flowability, Less oil bleeding, High bio-cont.	Cushion gel (Shoes)
Composite molding	Calendering	Softness, Good foamability, Excellent adhesion to the substrate	Wet suit, Sports supporter
Emulsion	Coating	Softness, Plasticizer less, High friction resistance, Low hysteresis loss	Protective film (Weak adhesive), Coating of gloves (ex) Golf gloves
	Dipping	Softness	Disposable gloves
TPV modifier	Injection molding	Softness, High flowability	Window seal (Automobile)
Nonwoven	Melt blow	Softness, High flowability, Low hysteresis loss	Diaper, Mask
Plastics modifier	Injection molding 3D printing	High impact strength, High flowability, Good low-temperature characteristics, High bio-cont.	3D printing filament, Trays, Housings of home electric appliances, Automotive parts

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