

# High bio-based content compounds using SEPTON™ BIO-series

Elastomer R&D department  
Elastomer division

***kuraray***

# Without oil : Physical properties of SEPTON™ BIO-series based compounds

Dry blend (without compounding process) <sup>1)</sup>		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)															
Elastomer <sup>2)</sup>	SEPTON™ BIO-series SF902 (Bio-based cont.=82wt%)	70	50	30	10	50	50	-	-	-	-	-	-	-	-	-															
	SEPTON™ BIO-series SF904 (Bio-based cont.=50wt%)	-	-	-	-	20	10	80	70	50	30	10	-	-	-	-															
	SEPTON™ BIO-series SF903 (Bio-based cont.=70wt%)	-	-	-	-	-	-	-	-	-	-	-	70	50	30	10															
Bio-LDPE (MFR=30g/10min) <sup>3)</sup>	(Bio-based cont.=95wt%)	30	50	70	90	30	40	20	30	50	70	90	30	50	70	90															
Total Bio-based cont. (wt%)		86	89	91	94	80	84	59	64	73	82	91	78	83	88	93															
Coefficient of static friction	Dry	3.8	2.1	0.8	0.6	3.9	3.5	9.0	4.8	3.4	1.0	0.7	2.5	1.2	0.6	0.5															
	Wet	2.0	0.9	0.6	0.4	1.4	1.9	5.2	3.1	1.1	0.8	0.6	1.3	0.7	0.6	0.4															
Hardness	(Type A)	62	81	91	94	56	72	55	61	81	90	95	66	83	92	94															
	(Type D)	-	-	28	36	-	-	-	-	-	29	39	-	-	31	37															
Specimen: Injection molded sheet (2mmt)		MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD	MD	TD		
100% modulus	(MPa)	2.7	1.9	4.6	3.7	7.0	7.4	9.6	7.4	2.4	1.6	3.6	2.8	1.2	1.1	2.1	1.7	5.2	3.9	7.5	5.6	9.9	7.4	1.6	2.0	6.6	3.7	8.4	6.4	11	8.2
Tensile strength	(MPa)	3.9	4.1	4.9	4.9	7.4	8.9	10	8.9	3.6	4.6	4.2	4.4	3.6	4.5	4.2	4.7	7.0	7.1	9	8.6	11	10	4.2	7.0	6.9	6.6	8.4	8.5	11	9.7
Elongation	(%)	280	500	200	420	160	480	170	480	360	580	240	580	500	670	410	650	280	600	210	570	200	580	320	500	160	480	120	480	110	470
MFR (230deg.C, 2.16kg)	(g/10min)	3.8	1.2	27	47	6.7	7.2	95	82	90	76	69	0.8	8.5	26	49															

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

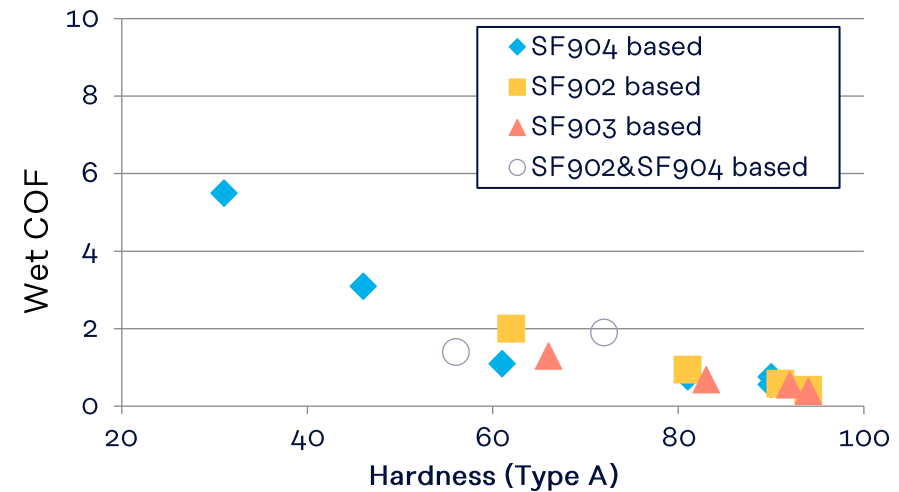
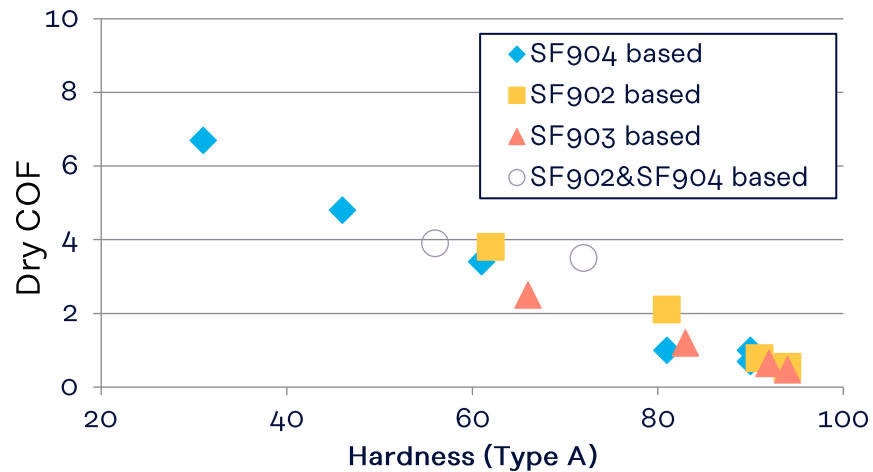
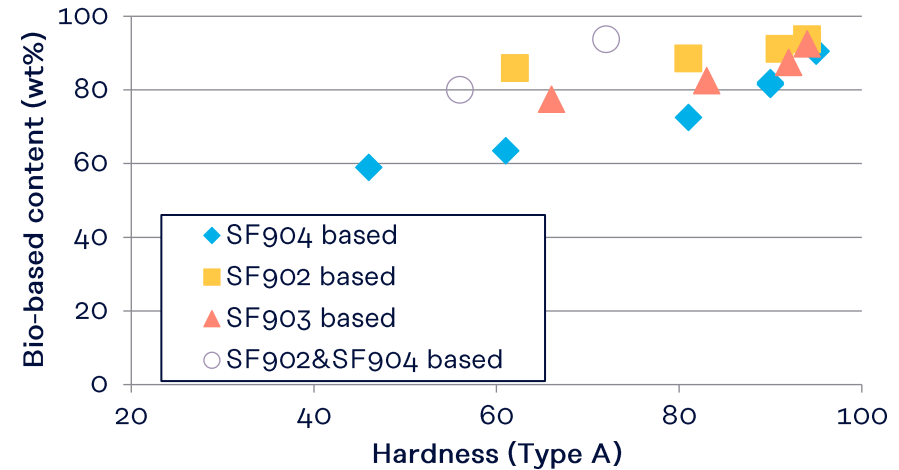
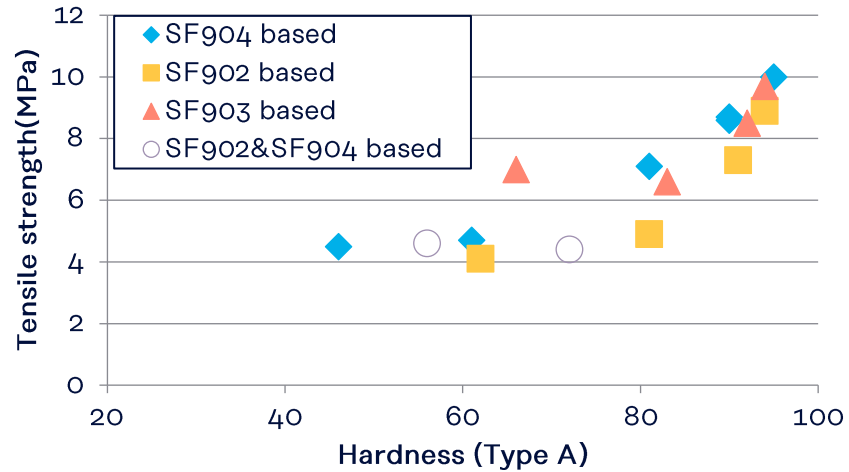
Injection molding conditions: Cylinder temp. / Mold temp. = 200/40(deg.C), Injection pressure = 60MPa(Hold pressure:30MPa), Injection speed = 20mm/sec(Hold pressure speed:10mm/sec)

2) Manufactured by Kuraray Co., Ltd.

3) Manufactured by Braskem S.A., MFR=30 @190deg.C, 2.16kg

# Without oil : Physical properties of SEPTON™ BIO-series based compounds (SF902, SF903, and SF904)

\*COF = Coefficient of static friction



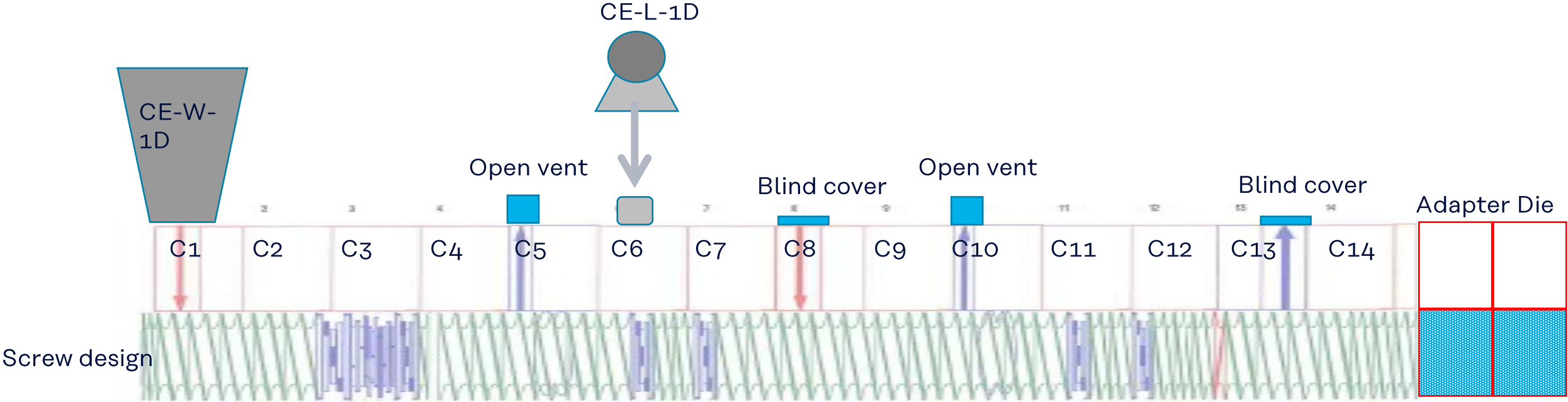
# With oil : Extrusion equipment

## Addition port

C1 : SEPTON™ BIO-series + PO (Pellet)

C6 : Oil (Liquid)

Mixing	Twin screw extruder : ZSk26Mc (Coperion GmbH)		
L/D	56 (D=φ25.5)		
Feeder	Main feeder	CE-W-1D (Kubota Corporation)	SEPTON™ BIO-series, PO
	Liquid weighing feeder	CE-L-1D (Kubota Corporation)	Oil
Pelletizing system	Underwater Pelletizer (Gala Industries, Inc.)		



# With oil : Mixing conditions

		Compound-1	Compound-2	Compound-3	Compound-4	Compound-5
SEPTON™ BIO-series SF903		100	100	100	100	-
SEPTON™ BIO-series SF902		-	-	-	-	100
Paraffin oil	Viscosity=96cSt (40deg.C)	100	150	150	100	100
Homo-PP	MFR=18	20	30	44	-	-
Bio-LDPE	MFR=2.7	-	-	-	20	-
Mixing conditions						
C2	(deg.C)	180	140	140	160	140
C3	(deg.C)	190	150	150	200	150
C4-C14	(deg.C)	200	180	180	200	180
Adapter	(deg.C)	200	180	180	180	180
Die	(deg.C)	200	180	180	180	180
Screen mesh		100	100	100	100	100
Rotation of screw	(rpm)	300	300	300	300	300
Torque	(A)	10.7	9.3	9.5	15.3	
	(%)	16.8	12.1	16.1	21.1	
Feeder (Pellet)	(kg/h)	8.25 (SF903+PP)	5.4 (SF903+PP)	7.35 (SF903+PP)	11 (SF903+PE)	7.5 (SF902)
Feeder (Oil)	(kg/h)	6.75	8.1	7.65	9.0	7.5
Out put (Total)		15	15	15	20	
Resin temp.	(deg.C)	195	176	176	178	
Resin pressure of die	(MPa)	2.6	2.2	2.3	3.5	
Pelletizer speed	(rpm)	2500	1500	1200	2000	
Motor load	(A)	3.9	3.5	3.6	3.8	
Water temp.	(deg.C)	28	23	28	20	
Result (Peletization)		Good	Good	Good	Good	NG <sup>1)</sup>

1) It could not be extruded, because the melt viscosity was too low.

## With oil : Physical properties

		Compound-1		Compound-2		Compound-3		Compound-4	
SEPTON™ BIO-series SF903*	(Bio-based cont.=70wt%)	100		100		100		100	
Paraffin oil (96cSt at 40deg.C)		100		150		150		100	
Homo-PP (MFR=18g/10min)		20		30		44		-	
Bio-LDPE (MFR=2.7g/10min)	(Bio-based cont.=95wt%)	-		-		-		20	
Total Bio-based cont.	(wt%)	31.8		25.0		23.8		40.5	
MFR (190deg.C, 2.16kg)	(g/10min)	14		127		129		10	
Hardness	(Type A)	21		18		37		17	
Tensile properties		MD	TD	MD	TD	MD	TD	MD	TD
100% Modulus	(MPa)	0.6	0.4	0.5	0.4	1.1	0.8	0.3	0.2
300% Modulus	(MPa)	2.0	1.4	1.1	1.1	2.4	1.8	0.8	0.7
Tensile strength	(MPa)	2.2	4.1	1.9	2.5	3.0	3.0	1.9	2.9
Elongation	(%)	310	690	350	610	380	560	330	690

\*Manufactured by Kuraray Co., Ltd.

# High Bio-based content compounds based on SEPTON™ BIO-series for extrusion molding

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# Formulation and properties

	Bio-based cont. %	HSFC	HSBC
SEPTON™ BIO-series SF903	70	100	
SEPTON™ 4055	0		100
Paraffin oil *1	0	50	120
Homo-PP *2	0	60	60
Bio-based cont. in compound (wt%)		33.3	0
Hardness	Type A	72	73
Tensile strength	MPa	8.7	20
Elongation	%	390	840
Compression set (70deg.C)	%	51	45
Compression set (100deg.C)	%	70	59

\*1 Viscosity 96cSt (@40deg.C)

\*2 MFR=0.9g/10min (230deg.C/2.16kg)

## Test method

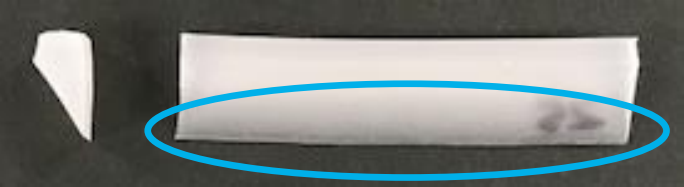
- Hardness: JIS K6253, Type A durometer
- Tensile strength, Tensile Elongation: JIS K6251, Cross-head speed 500mm/min. Dumbbell :JIS No.3
- Compression set: JIS K-6262, Temperature: 70deg.C, 120deg.C, Time:22h Sample size\*:φ13×6.3(mm), Compression ratio: 25%



# Extrusion moldability of Elastomer/Oil/PP

HSFC

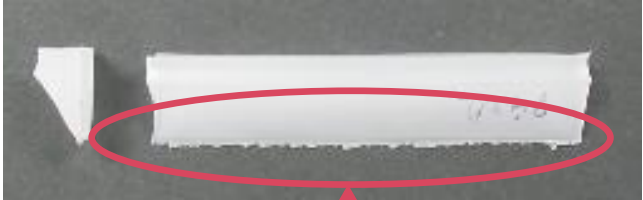
SEPTON™ BIO-series SF903/Oil/Homo-PP  
=47.6/23.8/28.6  
Hardness:72A



Smooth

HSBC

SEPTON™ 4055/Oil/Homo-PP  
=35.7/42.9/21.4  
Hardness:73A



Jagged

# Observation of morphology

## SPM images of microtome section of compounds

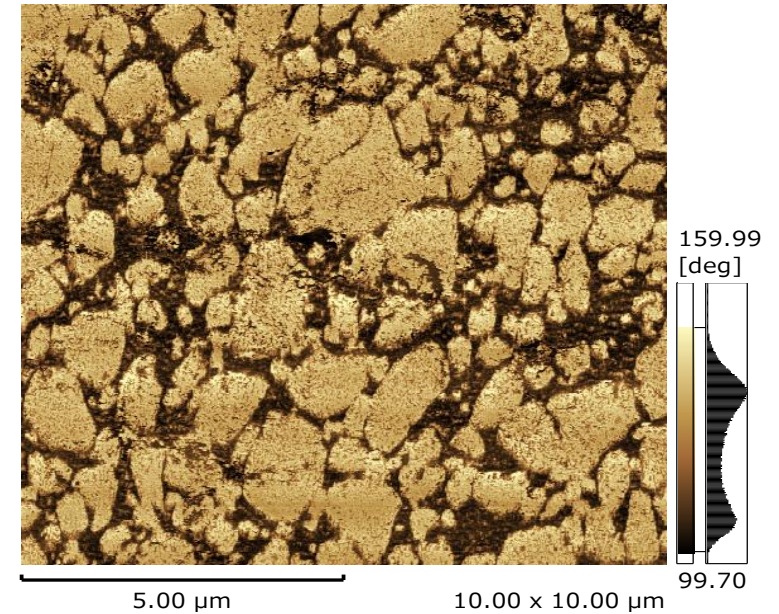
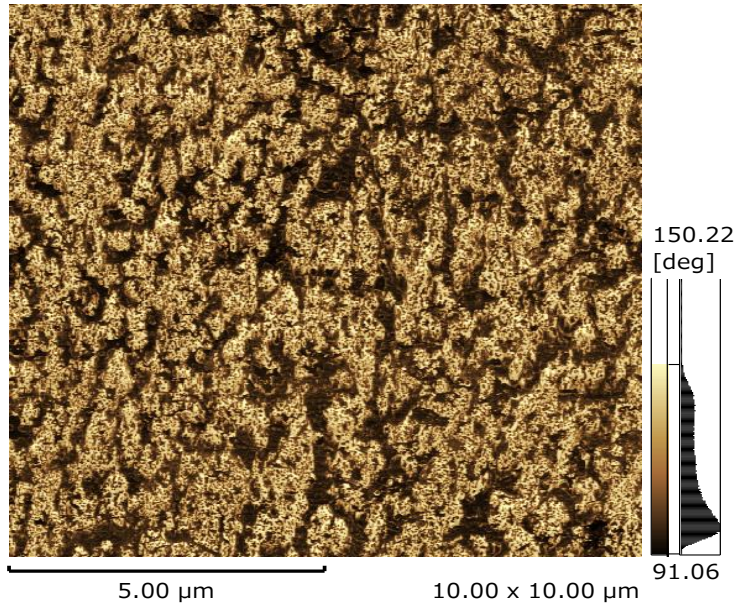
HSFC

SEPTON™ BIO-series SF903/Oil/Homo-PP  
=47.6/23.8/28.6  
Hardness:72A

HSBC

SEPTON™ 4055/Oil/Homo-PP  
=35.7/42.9/21.4  
Hardness:73A

MD



White part: Elastomer/Oil  
Black part: PP

# Conditions (Compounding and molding)

## Kneading conditions

Mixing	Twin screw extruder	
Extruder	ZSk26Mc (Coperion GmbH)	
L/D	56 (D=φ25.5)	
Temp.	C2-C14	200 deg.C
	Adapter	180 deg.C
	Die	170 deg.C
Screw rotation	300rpm	
Out put	20kg/h	
Pelletizer	Under water pelletizer (Gala Industries, Inc.)	
Water temp.	10-25 deg.C	
Feeder	CE-W-1D(Kubota Corporation): Pellet CE-L-1D(Kubota Corporation): Plasticizer	

## Molding conditions

Mixing	Single screw extruder	
Extruder	NV40mm (Freesia Macross Corporation)	
L/D	36 (D=φ25.5)	
Temp.	C1	180 deg.C
	C2-H	180 deg.C
Screw rotation	30rpm	
Die	Ribbon, Garvey die	

# Bio-based compounds using SEPTON™ BIO-series

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# General formulations (Bio-based content: >40%)

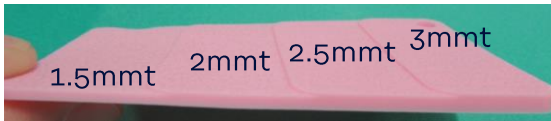


Step plate

Surface

Emboss : Green, Pink, Blue

Mirror surface : Clear



Thickness

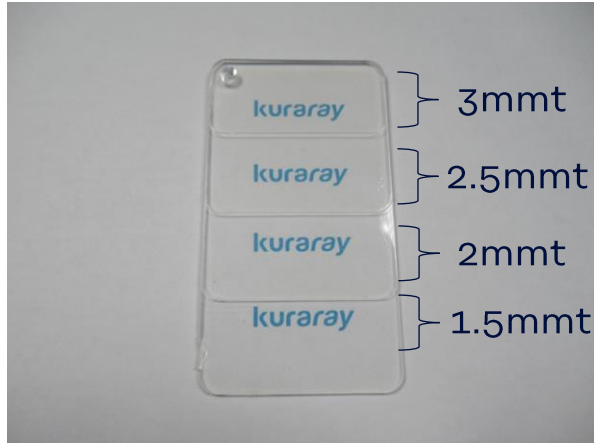
		Bio-based Cont.(%)	Hardness 40A		Hardness 60A		Hardness 80A	
			Green		Pink		Blue	
SEPTON™ BIO-series	SF903	68	10		70		60	
SEPTON™ BIO-series	SF902	80	70					
SEPTON™	4055	0	25		30		40	
Process oil *1		0	80		60		50	
Bio-LDPE *2		95	35		45		80	
Polypropylene-1 *3		0	20		20		50	
Mechanical properties	Bio-based content	wt%	40		40		42	
	MFR (230deg.C, 2.16kg)	g/10min	38		7.1		17	
	Hardness (0sec)	Type A	55		67		88	
	Hardness (after 3sec)	Type A	47		61		84	
	Hardness (after 15sec)	Type A	43		58		82	
			MD	TD	MD	TD	MD	TD
	M100	MPa	1.8	1.2	3.3	1.9	5.8	4.5
	Tensile strength	MPa	2.8	2.8	5.4	6.4	8.3	8.2
	Elongation	%	250	450	330	650	380	510
C.S	70 deg.C, 22h	%	52		50		59	
	100 deg.C, 22h	%	72		65		79	

\*1 Process oil : Paraffin oil, KV=95cSt @40deg.C

\*2 Bio-LDPE : MFR=30g/10min @190deg.C, 2.16kg

\*3 Polypropylene-1 : Homo-PP, MFR=30g/10min @230deg.C, 2.16kg

# Transparency formulation (Bio-based content: >40%)



		Bio-based Cont.(%)	Hardness 40A Clear	
SEPTON™ BIO-series	SF904	48	85	
Polypropylene-2 *4			15	
Slipping agent *5			0.1	
Anti-blocking agent *6			0.1 (External)	
Mechanical properties	Bio-based content	wt%	41	
	MFR (210deg.C, 2.16kg)	g/10min	43	
	Hardness 0s	TypeA	56	
	Hardness 3s	TypeA	47	
	Hardness 15s	TypeA	43	
			MD	TD
	M100	MPa	1.8	1.6
	Tensile strength	MPa	5.8	5.3
	Elongation	%	670	800
Transparency	Transmittance	%	90.6	
	Haze	%	6.0	

\*4 Polypropylene-2 : Random-PP, MFR=20g/10min @230deg.C, 2.16kg

\*5 Slipping age : Erucamide

\*6 Anti-blocking agent : PP powder

# Conditions

## Mixing condition

Machine	Twin screw extruder ZSK26Mc (Coperion GmbH)	
L/D	56 (D=φ25.5)	
Temp.	C2-C14	210 deg.C
	Adapter	120 deg.C
	Die	110 deg.C
Screw rotation	500rpm	
Out put	20kg/h	
Pelletizer	Under water pelletizer (Gala Industries, Inc.)	
Water temp.	10deg.C	
Feeder	CE-W-1D(Kubota Corporation): Pellet	

## Molding condition

Molding machine	Injection molding machine EC75SX (Shibaura Machine Co., Ltd.)	
Mold	110mm x 110mm x 2mmt Flat plate 88mm x 50mm x 1.5, 2, 2.5, 3mmt Step plate	
Cylinder temp	210deg.C	
Mold temp	50deg.C	
Screw rotation	150min-1	
Injection time	10sec	
Cooling temp	15sec	
Weighing position	55mm	
V-P	5mm	
Injection pressure	40MPa(Dweling:25MPa)	
Injection speed	15mm/s(Dewling:15mm/sec)	

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