NO.RRA00-001-E1

Introduction of SEPTON™ Q-series

Elastomer R&D department
Elastomer division

kuraray Septon™

Kuraray Elastomer History

Achievement of continuous innovation of Kuraray Rubber & TPE

1972-1974
1st Generation
'Alternative of NR'
- Isoprene Rubber (IR) -

Ziegler-Natta type catalyst

1974-1990
2nd Generation
'Isoprene Based New Rubbers'
- Trans-Polyisoprene (TP)
- Liquid Isoprene Rubber (L-IR)

Anionic living polymerization

1990-
3rd Generation
'TPE'
- SEPTON™
- HYBRAR™

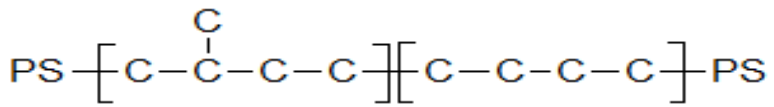
Advanced anionic living polymerization and Hydrogenation

Now
SEPTON™
Q/V/J/BIO-series

Unique synthetic technologies

Polymer alloy / Compounding technologies Process development

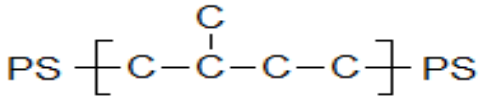
Polymer Structure and Kuraray's Product Lineup



High tensile strength
Better oil absorbency

SEEPS: SEPTON™ 4000-series

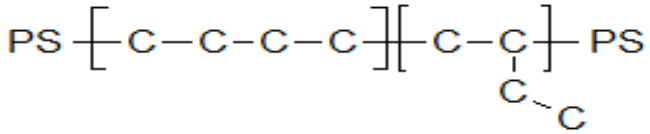
SEPS: SEPTON™ 2000-series



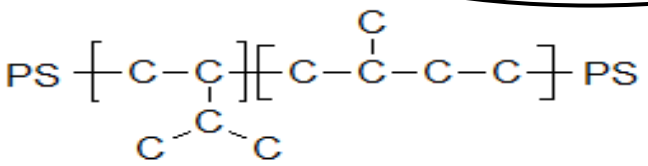
No crystallization
High elongation

\+
Branch / Sequence Control
\+
Hydrogenation

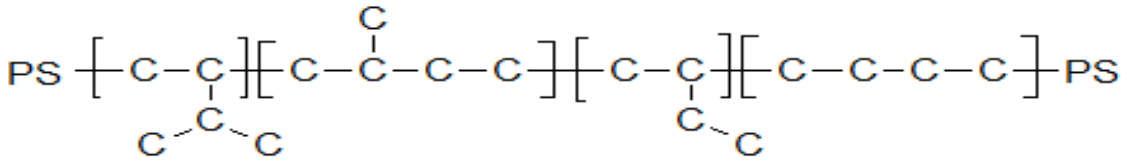
SEBS: SEPTON™ 8000-series



Moderate tensile strength



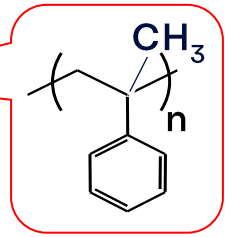
Vinyl-SEPS, Vinyl-SEEPS: HYBRAR™ 7000-series



Excellent compatibility with PP
High damping property

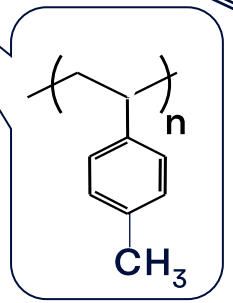
Polymer Structure and Kuraray's Product Lineup

SEPTON™ Q-series

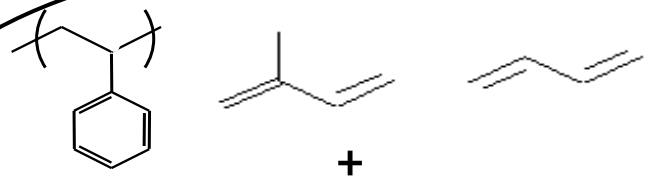


Hard block with high Tg
High scratch & abrasion resistance
High durability

SEPTON™ V-series



Crosslinkable styrene
High temperature property



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Branch / Sequence Control

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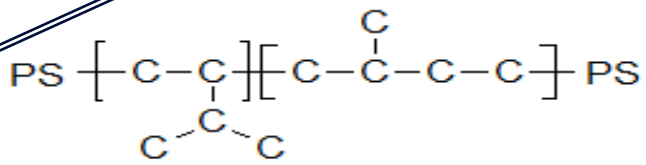
Hydrogenation

HYBRAR™



High damping property
High gas barrier

SEPTON™ BIO-series

β-Farnesene

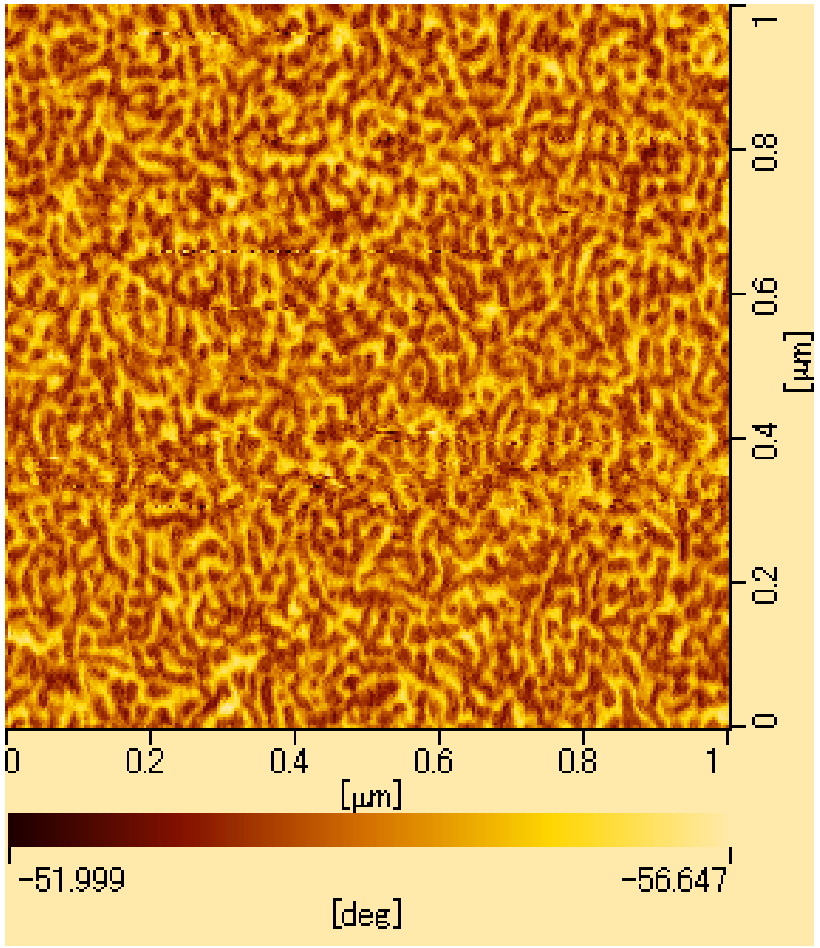
Bio-based
High flow
Wet/Dry grip

Typical Properties of SEPTON™ Q1250 (Typical grade of SEPTON™ Q-series)

			SEPTON™ Q1250	Conventional SEBS
Hard Content		(wt%)	29	30
Specific Gravity			0.93	0.91
Hardness (Type A)			74	80
100% Modulus	@25 deg. C	(MPa)	3.5	2.3
Tensile Strength	@25 deg. C	(MPa)	30	32
Elongation	@25 deg. C	(%)	500	520
100% Modulus	@80 deg. C	(MPa)	2.1	-
Tensile Strength	@80 deg. C	(MPa)	11.4	1.2
Elongation	@80 deg. C	(%)	600	380
MFR @230 deg. C, 2.16 kg		(g/10 min)	5.6	1.0
Solution Viscosity	(10 wt%)	(mPa.s)	15	25

Tensile test; Crosshead speed 500 mm/min
Solution viscosity; in toluene at 30 deg. C

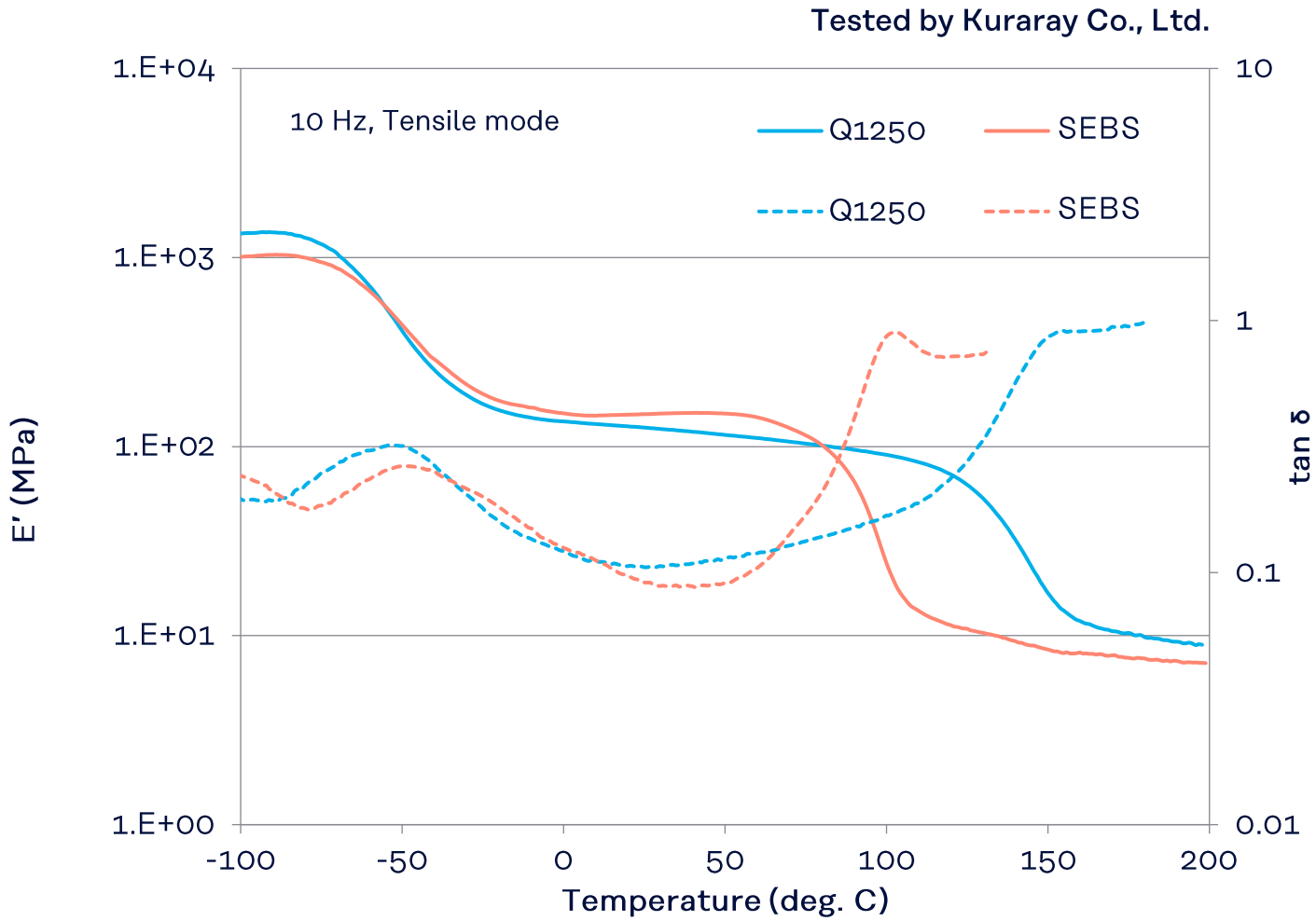
Morphology of SEPTON™ Q1250



Dark brown; Hard block
Bright Yellow; Soft block

Cylindrical micro phase separation structure is formed.

Dynamic Viscoelastic of SEPTON™ Q1250



Features and Applications of Polymer Alloy of SEPTON™ Q-series

Polymer alloy of SEPTON™ Q-series is a series of high performance thermoplastic elastomers in…

- Excellent Softness & Elasticity
  ⇒Soft Touch applications

- Excellent Durability
  ⇒Scratch & Abrasion Resistance

- Compatibility to PMMA and Polyolefins
  ⇒for Coextrusion or Overmolding

NO.RRA01-001-E1

Polymer Alloy of SEPTON™ Q-series and PMMA

Elastomer R&D department
Elastomer division

kuraray Septon™

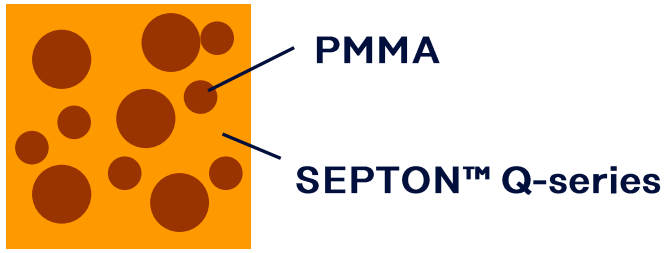
Typical Properties of Polymer Alloy of SEPTON™ Q-series and PMMA

Properties	Units			
SEPTON™ Q1250	wt%	50		
PMMA[1)]		50		
AO	phr	0.1		
			Test method	Test condition
Hardness	Type A	85	ISO 7619	instantaneous value
MFR	g/10 min	2.9	ISO 1133	230 deg. C, 2.16 kg
Tensile strength	MPa	32	ISO 37	Dumbbel No.5 500 mm/min
Elongation	%	290		
Taber abrasion	mm^3	6	ISO 4649	H-22, 1 kg, 1000 times

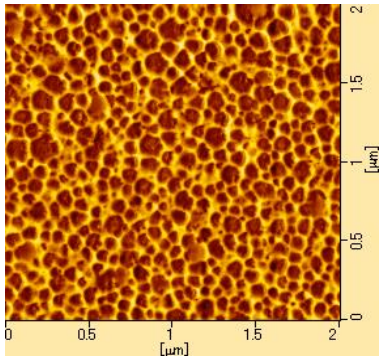
1) MVR=12 cm^3/10 min (230 deg. C, 3.8 kgf)

Morphology of Polymer Alloy of SEPTON™ Q-series and PMMA

- Polymer alloy of SEPTON™ Q-series and PMMA has sea-island structure.
  (Sea: SEPTON™ Q-series, Island: PMMA)
- It is necessary to keep morphology to obtain good appearance.
- Transparency and hardness are affected by morphology.



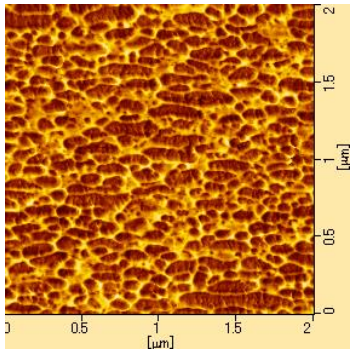
Good morphology design



Uniform particle size and shape

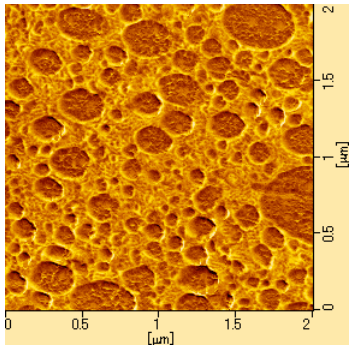
Clear and Elastic

Bad morphology design



Collapsed PMMA domain

Rigid

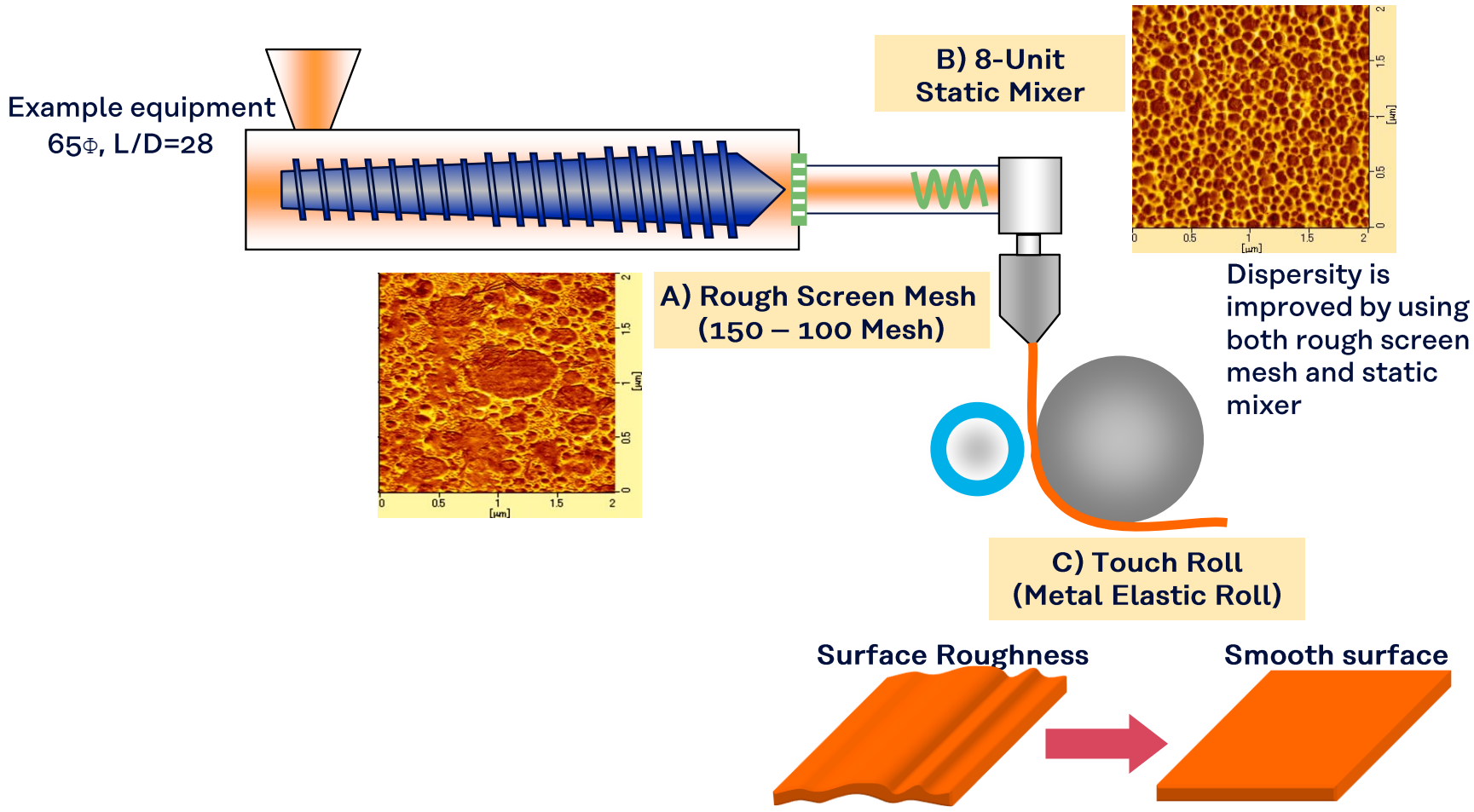


Non-uniform particle size

Hazy

Processing of Film of SEPTON™ Q-series and PMMA

Reference Setting		
Film Formulation		Q1250/PMMA (50/50)
Film Thickness		500 µm
Temp. Set.	Extrusion Zones	200-230 deg. C
	Adapter	235 deg. C
	Die Head	225-230 deg. C
Die Lip Gap		0.5 mm
Output		30 kg/h
Screw Speed		45 rpm
Line Speed		1.2 m/min
Air Gap		170 mm
Cast Roll Temp.		80 deg. C
Touch Roll		80 deg. C
Touch Pressure		350 N

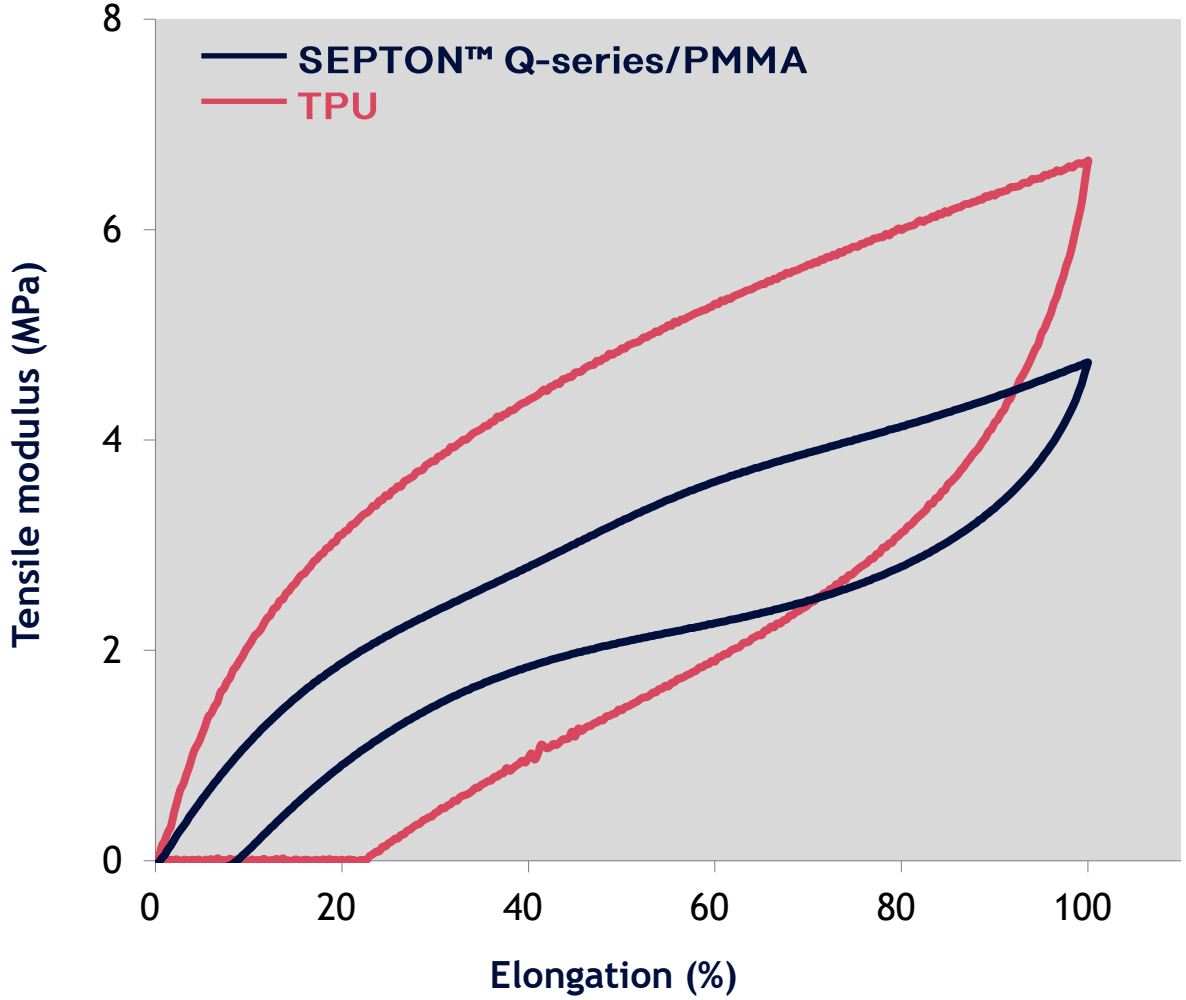


Typical Properties of Film of SEPTON™ Q-series and PMMA

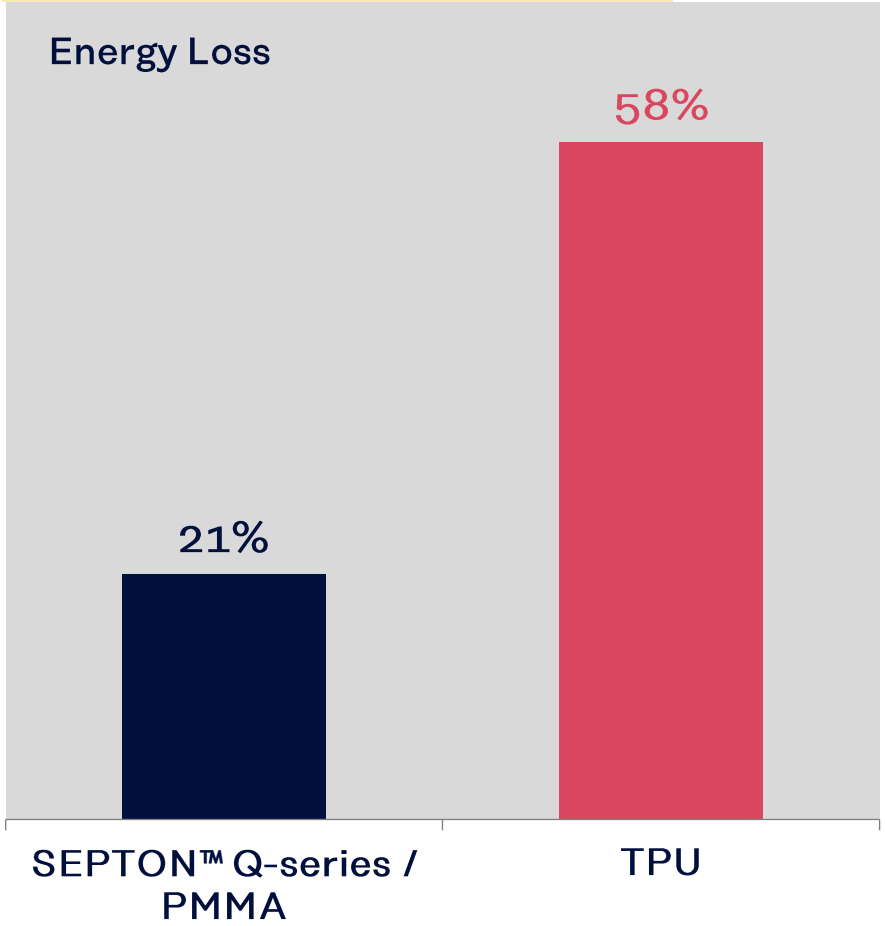
Properties	Units	Measurement method		SEPTON™ Q-series /PMMA	TPU	TPAE (TPA)	TPEE (TPC)
Thickness	μm			500	500	500	500
Specific gravity		ISO 1183		1.04	1.22	1.00	1.12
Transmittance	%	ISO 13468		93.0	92.5	90.8	66.9
Haze	%	ISO 14782		1.6	2	43	62
100%Modulus	MPa	ISO 37	MD	7	6	9	7
			TD	6	5	7	7
Tensile strength	MPa	ISO 37	MD	47	83	48	26
			TD	44	78	41	26
Elongation	%	ISO 37	MD	350	490	710	820
			TD	360	550	810	970
Pinhole test (puncture) Compression strength	N	JIS Z1707		55.2	52.7	15.6	10.1
Erichsen scratch test Scratch load	N	ISO 12137-2		1.0	0.9	0.1	0.1

TPAE; Thermoplastic polyamide elastomer
TPEE; Thermoplastic polyester elastomer

Energy Return of Film of SEPTON™ Q-series and PMMA

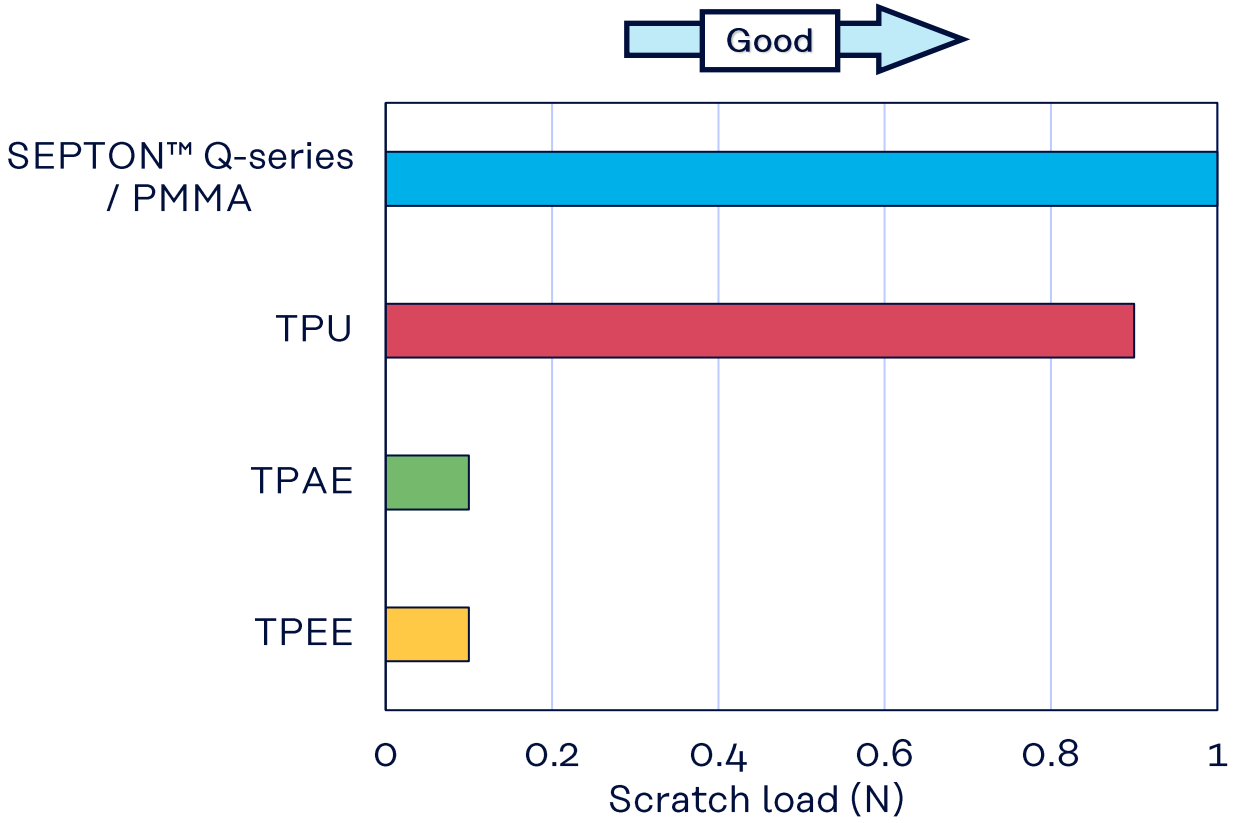


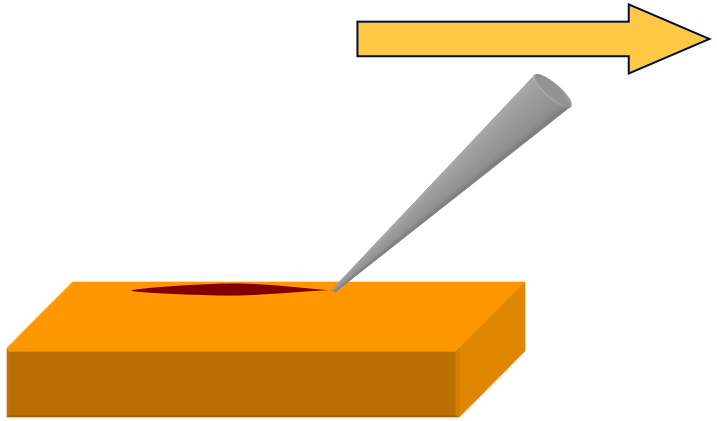
Better Elasticity than TPU



Tensile speed: 500 mm/min, Test piece: ISO 37 Type 1.

Scratch Resistance of Film of SEPTON™ Q-series and PMMA



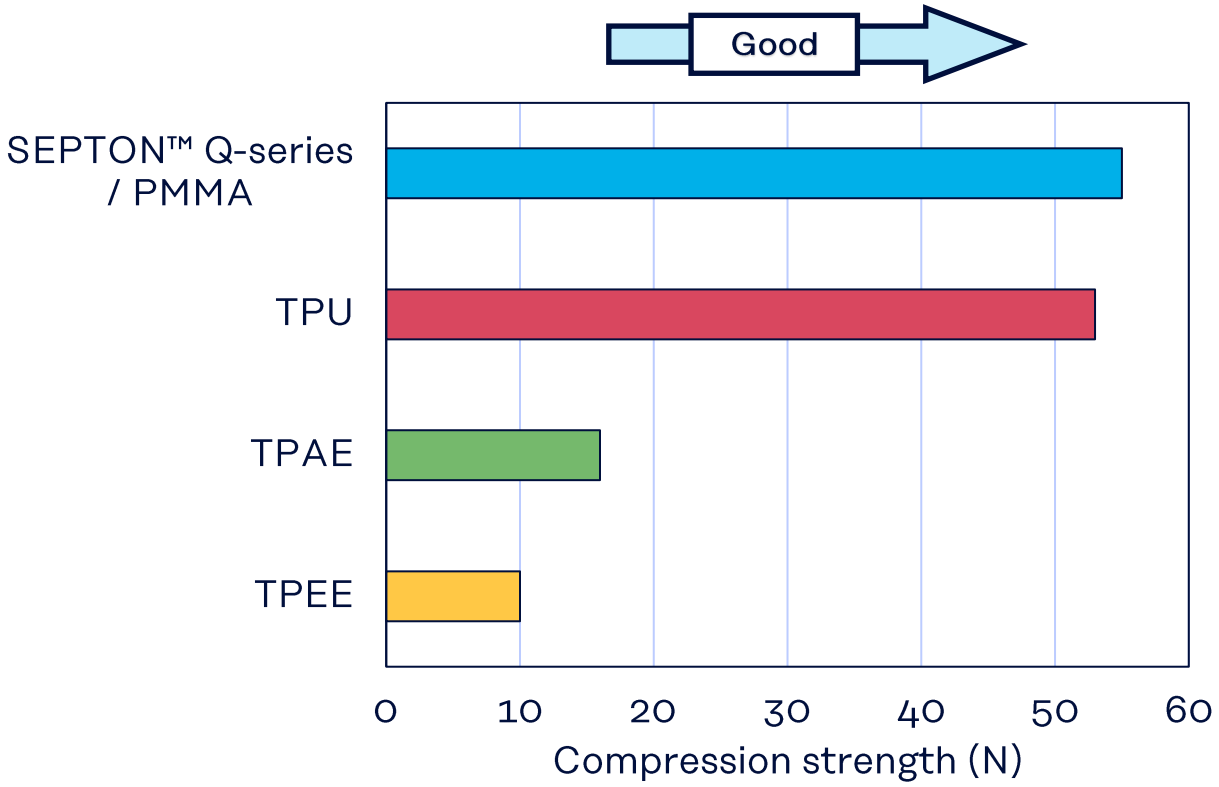


Erichsen scratch test

Test conditions:
Measurement method: ISO 12137-2
Film thickness: 500 µmt

Better scratch resistance compared to TPAE, TPU and TPEE.

Durability (Pinhole Test) of Film of SEPTON™ Q-series and PMMA

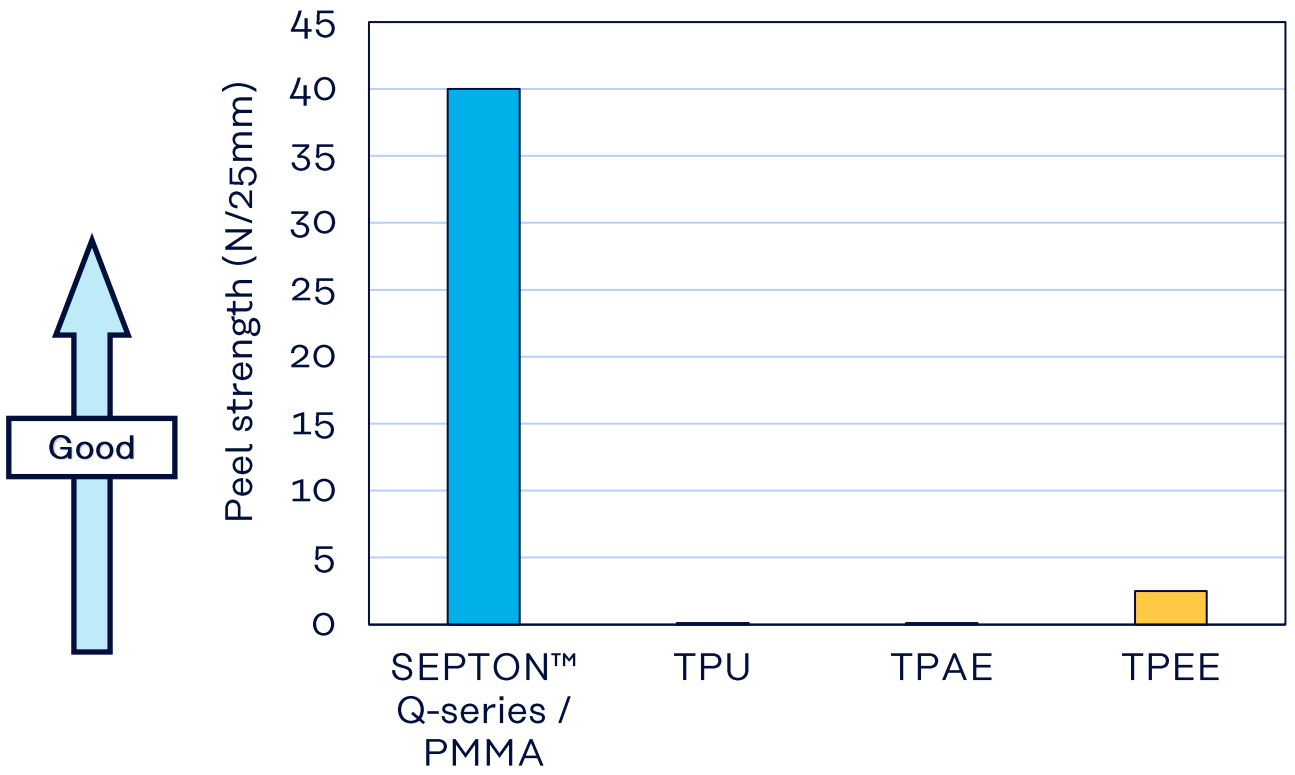


Pinhole test

Test Conditions:
Measurement method: JIS Z1707
Film thickness: 500 μmt

Better durability compared to TPAE, TPU and TPEE.

Adhesive Strength (Thermal Adhesion) of Film of SEPTON™ Q-series and PMMA



Test Conditions:
Measurement method: ISO 36
Adherend: Random-PP
Compression molding, 220 deg. C, 1 MPa

Better adhesive strength to polyolefin compared to TPAE, TPU and TPEE.

RRA02-001-E1

Polymer alloy of SEPTON™ Q-series and Polyolefin

Elastomer R&D department
Elastomer division

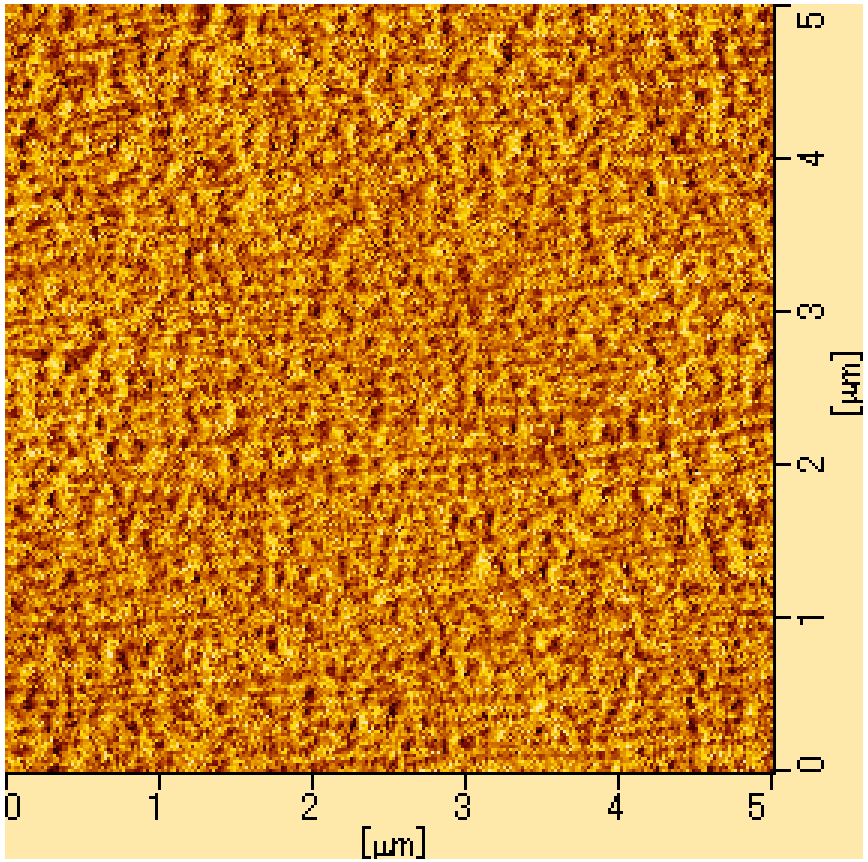
kuraray Septon™

Typical Properties of Polymer alloy of SEPTON™ Q-series and Polyolefin

Properties		SEPTON™ Q-series / Polyolefin			TPAE			TPU			
		A	B	C	A	B	C	A	B		
SEPTON™ Q1250	wt%	45	60	45							
PP[1)]		10	30	45							
LLDPE[2)]		45	10	10							
AO	phr	0.1	0.1	0.1							
										Test method	Test condition
Hardness	Shore D	46	50	61	65	54	41	62	46	ISO 7619	Instantaneous value
	Shore A	91	94								Instantaneous value
Flexural Modulus	MPa	200	275	380	260	148	68	89	36		
Specific gravity		0.91	0.92	0.90	1.02	1.02	1.01	1.21	1.22	ISO 1183	
MFR	g/10 min	6.7	6.6	7.8						ISO 1133	230 deg. C, 2.16 kg
100% modulus	MPa	6.2	9.0	13						ISO 37	Dumbbel No.5, 500 mm/min
Tensile strength	MPa	40	41	41	58	59	40	56	64		
Elongation	%	650	600	600	600	680	850	530	600		
DIN abrasion	mm^3	39	62	98	44	30	45	68	57	ISO 4649	10 N, 40 m, No rotation of specimen

1) Homo, MFR=15 g/10 min(230 deg. C, 2.16 kgf), 2) MFR=3.8 g/10 min(190 deg. C, 2.16 kgf)

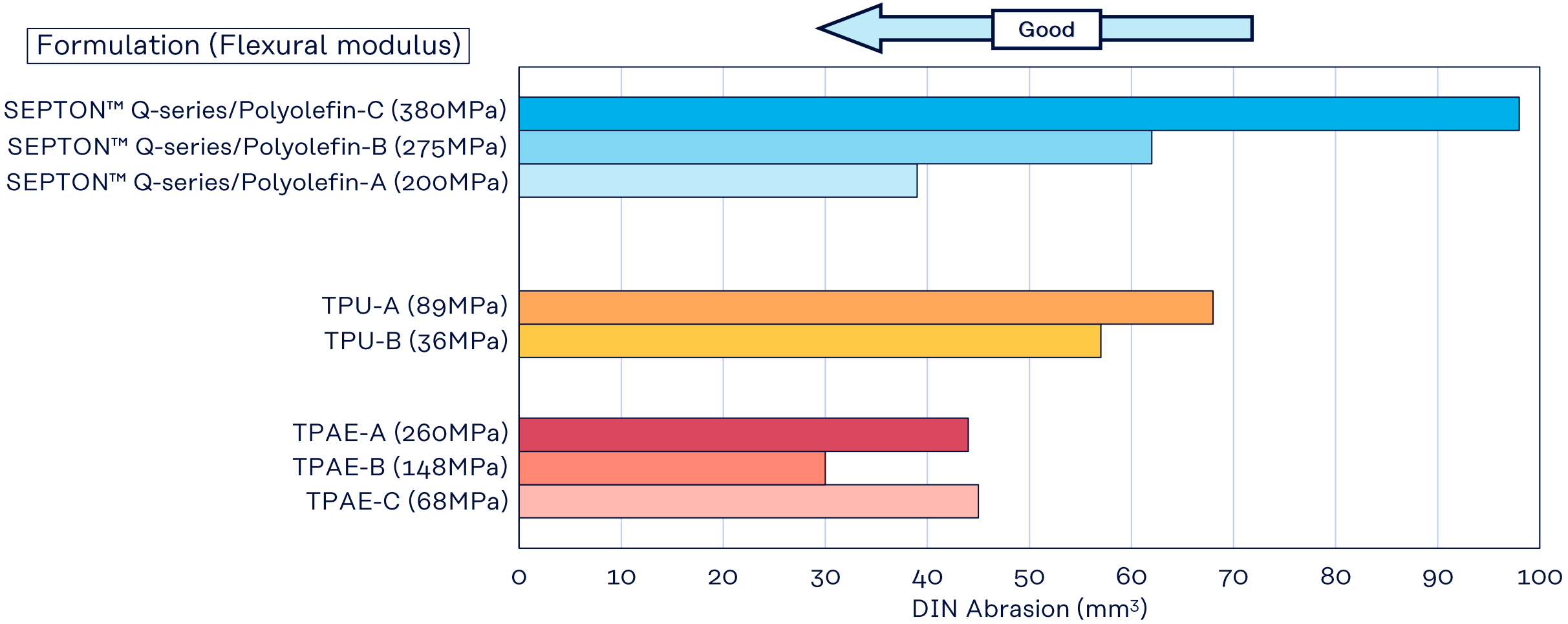
Morphology of Polymer Alloy of SEPTON™ Q-series and Polyolefin



SEPTON™ Q-series/Polyolefin-B
(Q1250/PP/LLDPE [60/30/10])

Dark brown;
Hard block of SEPTON™ Q-series
Other than dark blown;
Soft block of SEPTON™ Q-series, PP, and LLDPE

Abrasion Resistance of Polymer Alloy of SEPTON™ Q-series and Polyolefin

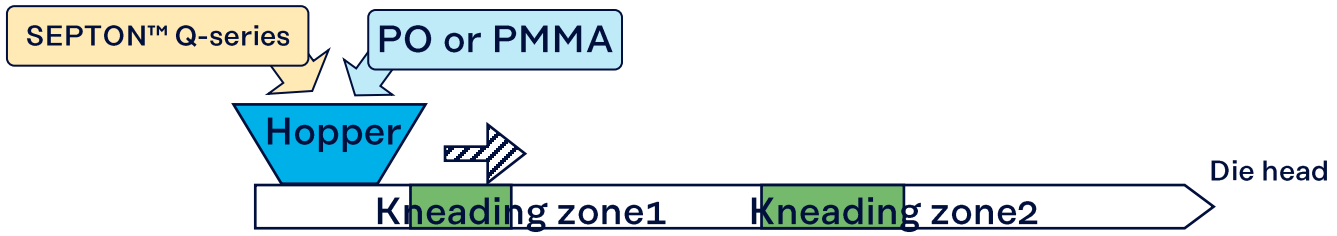


Compound Process Guide

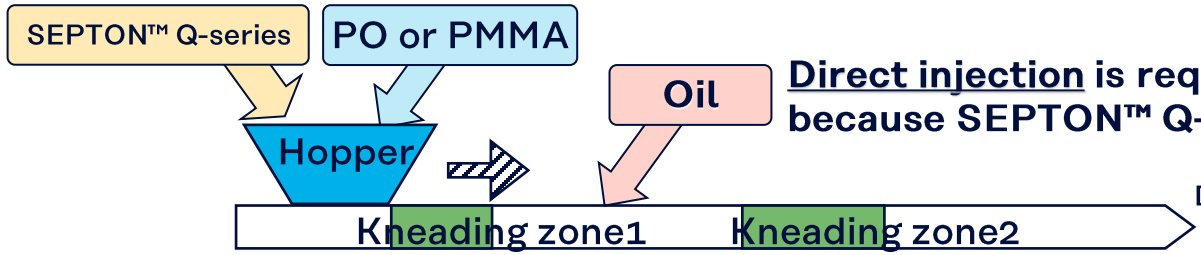
Basic Kneading conditions

Equipment : Twin Screw Extruder
Screw diameter: 37 mm, L/D=34
Barrel Temperature
C1 – C3 150 - 200 deg. C
C4 – C5 200 - 240 deg. C
Die head 200 - 240 deg. C
Screw rotation 200 rpm

Standard procedure



When you need to use process oil...



Direct injection is required because SEPTON™ Q-series are in pellet shape.

RRA03-001-E1

Injection Molding using SEPTON™ Q-series Standard Procedure and Tips

Elastomer R&D department
Elastomer division

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Standard Conditions of Injection Molding for SEPTON™ Q-series

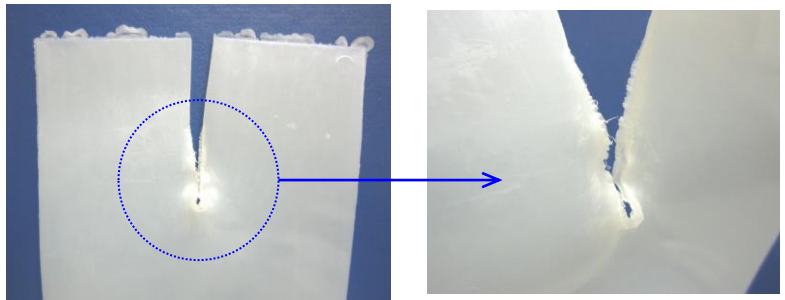
Recommendable molding temperature for SEPTON™ Q-series

Cylinder temperature	Hopper side	190-230 deg. C
	Center	210-250 deg. C
	Nozzle side	210-250 deg. C
	Nozzle	210-250 deg. C
Mold temperature	30-90 deg. C	

Preliminary drying is not required.

1) **Coloring**
Polyethylene-based color concentrate is recommendable for SEPTON™ Q-series.
Color conc. for TPU should be avoided because it might cause molding defect.

2) **Resin replacement**
Before molding, careful purging is required.
Recommendable resins for purging are polypropylene (PP) or high density polyethylene (HDPE), low MFR type (<1.0 g/10 min).
If any polar resin remains in the injection molding, it might cause molding defect such as delamination.



Molding defect of SEPTON™ Q-series caused by TPAE left in an injection machine

Countermeasure against sink marks

One of the common molding defects of SEPTON™ Q-series is sink mark.
In general, the following measures can be taken to solve the problem of the sink marks.

- Lowering the nozzle temperature.
- Setting the longer dwelling time and the higher dwelling pressure.
- Increasing the weighing value.

Mold shrinkage factor

Mold shrinkage factor varies from grade to grade. Some grades have different shrinkage factor from those of TPAE and TPU.

Molding shrinkage factors

		SEPTON™ Q-series /Polyolefin	TPAE-A	TPAE-B	TPAE-C	TPU-A	TPU-B
Mold shrinkage factor (MD)	%	0	0	0.2	0.1	0.4	0
Mold Shrinkage factor (TD)	%	0.1	0.6	0.2	0.2	0.3	0

Test conditions

Test piece: 110*110*2mm
All the test pieces were conditioned before testing for 48 h at 23 deg. C, 50% RH.
Each test piece was prepared in the following conditions.

(SEPTON™ Q-series/Polyolefin)
Injection temp. (deg. C): Hopper side / Center / Nozzle side / Nozzle (210 / 230 / 230 / 230)
Mold temp.: 40 deg. C
Injection time: 8 s
Cooling time: 15 s

(TPAE)
Injection temp.(deg. C): Hopper side / Center / Nozzle side / Nozzle (210 / 230 / 230 / 230)
Mold temp.: 40 deg. C
Injection time: 8 s
Cooling time: 20 s

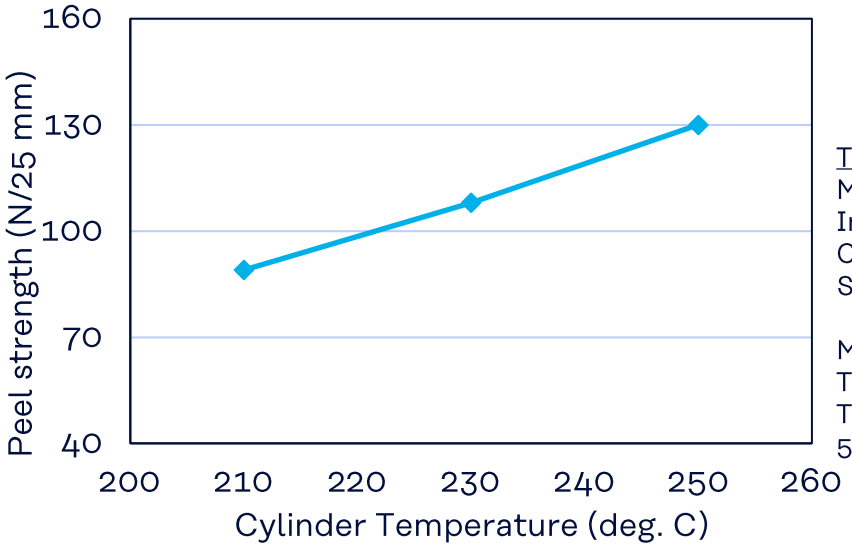
(TPU-A)
Injection temp.(deg. C): Hopper side / Center / Nozzle side / Nozzle (200 / 210 / 210 / 210)
Mold temp.: 40 deg. C
Injection time: 9 s
Cooling time: 20 s

(TPU-B)
Injection temp.(deg. C): Hopper side / Center / Nozzle side / Nozzle (200 / 210 / 220 / 220)
Mold temp.: 40 deg. C
Injection time: 20 s
Cooling time: 20 s

Improving adhesion (insert molding)

1) In case of poor adhesion occurs overall.
   Low adhesion strength caused by insufficient melting of secondary material.
   - Raising cylinder temperature of the secondary material.

Cylinder temp. vs. Insert injection molding between polymer alloys of SEPTON™ Q-series and Polyolefin



Test conditions
Mold temp.: 40 deg. C
Injection time: 10 s
Cooling time: 15 s
Sheet: 100*35*1 mm
〈Adhesion test〉
Method: ISO 36
Tensile speed: 200 mm/min
Test pieces were conditioned for 5 days at 23 deg. C,50%RH

2) In case of poor adhesion occurs at the flow end.
   Low adhesion strength caused by insufficient holding pressure.

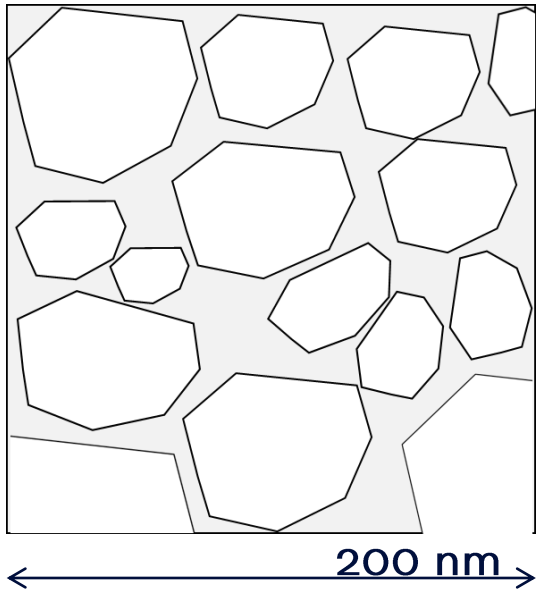
   - Increasing injection speed
   - Raising cylinder temperature
   - Raising mold temperature

3) In case of peeling off adhesive interface with smooth surface
   Peeling off caused by insufficient adhesive strength.

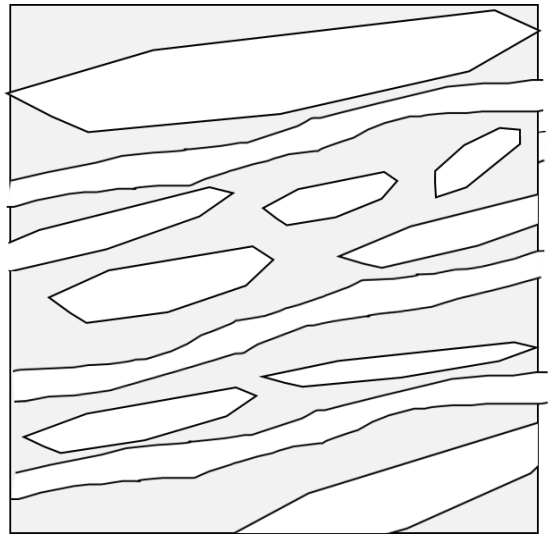
   - Changing the shape of studs.

Improving abrasion

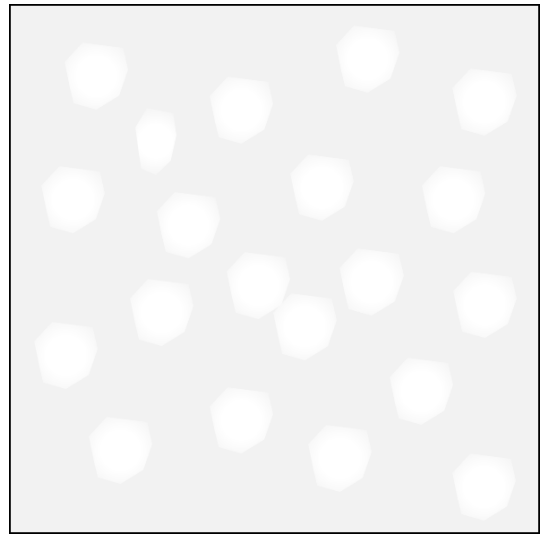
In case of breaking at studs (not peel off at adhesive interface)
Morphology deformation occurred by high shear during flow.
- Raising mold temp (= required extending cooling time)
- Raising cylinder temperature.



Suitable morphology
White: PP
Gray : SEPTON™ Q-series



Deformed morphology
White: PP
Gray : SEPTON™ Q-series



Ref. TPU
White: Hard-rich portion
Gray : soft –rich portion

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