

Introduction of KURARITY™ as modifier of PC / ABS and PC / AS

KURARITY business promotion dept.
Elastomer Division

kuraray

Advantages of KURARITY™ as a modifier of PC / ABS and PC / AS

PMMA-*b*-PnBA-*b*-PMMA



KURARITY™ as “MAM” structure
-> Made by controlled living anionic polymerization

Features of “MAM”

High polarity

Block co-polymer

High flow-ability

Advantages as modifier

Impact modification
(exist between PC and AS phase)

High flow
(Good for thin molding)

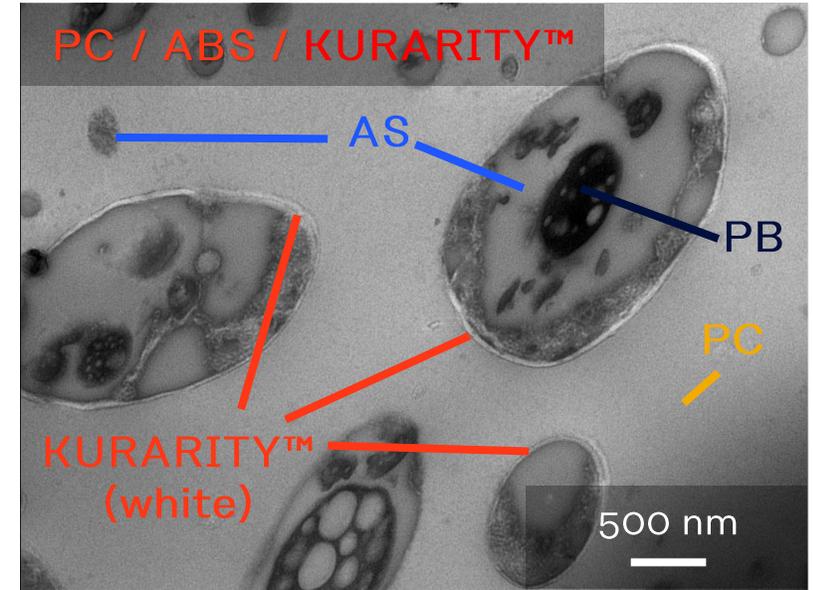
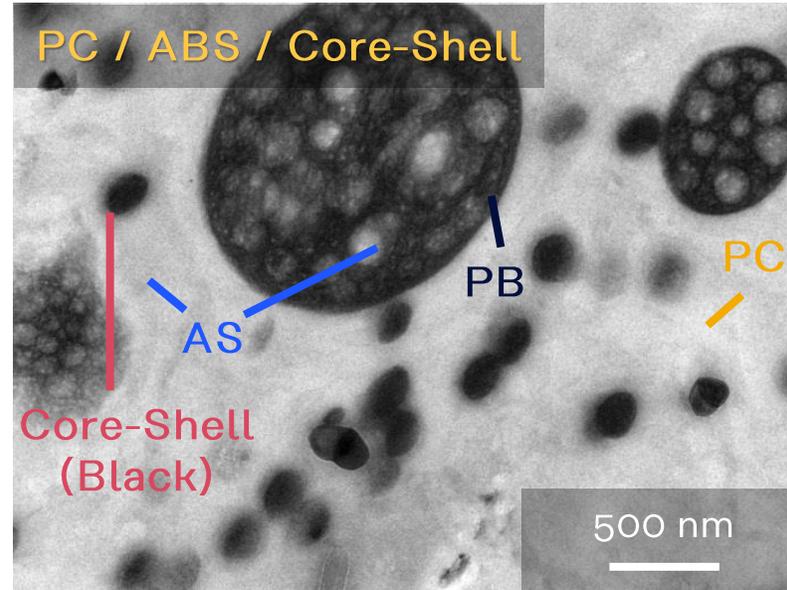
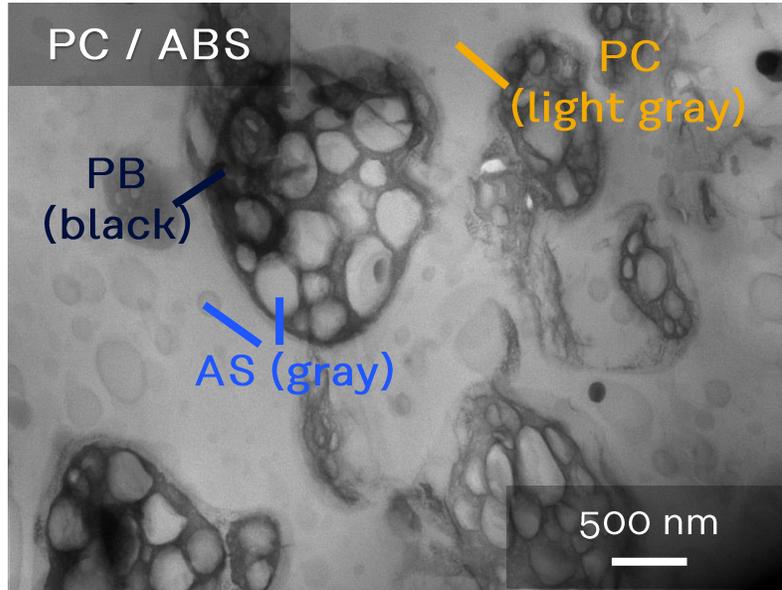
KURARITY™ as a modifier of PC / ABS

Overviewing of our new solution with KURARITY™ (Compare with conventional system)

Product types of PC / ABS	Core shell		KURARITY™	
	Impact resistance	Flow ability	Impact resistance	Flow ability
1. General grade	+ -	-	++	+
2. Flame retardant grade	+	-	++	++
3. GF reinforced grade	+ -	+ -	+ -	++

- ✓ Compare with conventional PC / ABS / Core-shell type modifier compounds,
Our new solution is;
 - (+) Excellent flow-ability and impact resistance
- ✓ Modification effect of KURARITY™ depends on product types of PC / ABS.

TEM morphology investigations



- ✓ Core-Shell disperses in PC or AS phase.
 - ✓ KURARITY™ exists between PC and AS phase.
- => Totally different morphology from conventional core-shell type impact modifiers

**1. KURARITY™ as a modifier for
PC / ABS general grade
(Non-reinforced, none flame retardant)**

Typical properties (PC/ABS=70/30)

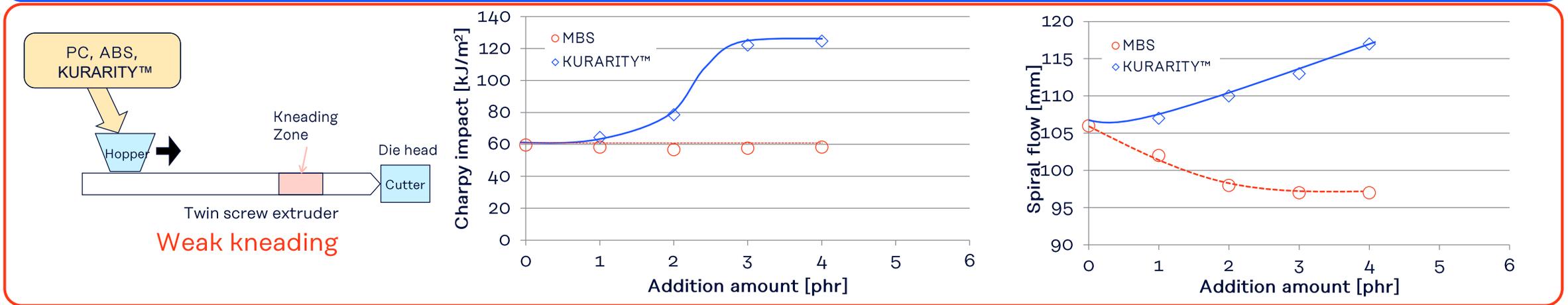
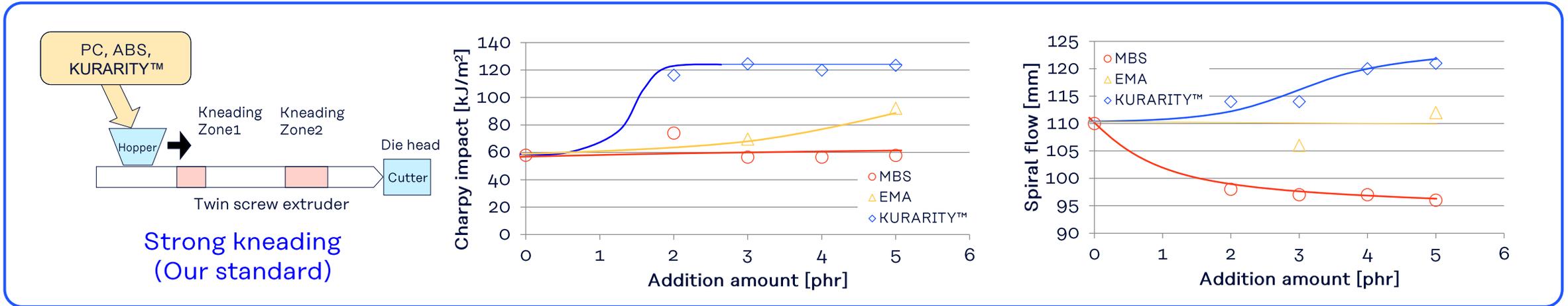
				Ref.1	Ref.2	Ref.3	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.6
PC	High flow grade, MFI* = 15			70	70	70	70	70	70	70	70	70
ABS	High flow grade, MFI** = 45			30	30	30	30	30	30	30	30	30
Modifier	MBS (core-shell type)				3						3	3
	EMA (Acrylate 30 wt% type)					3						
	KURARITY™ LA2270						2	3	4	5	2	5
Items	Methods	Conditions	Units									
MFR	ISO 1133	260 deg.C, 2.16 kgf	g / 10 min	20	10	16	22	20	18	20	11	12
Spiral flow	Kuraray	1 mmt***	mm	110	97	106	114	114	120	121	103	115
Charpy impact with notch	ISO 179	23 deg.C	kJ / m ²	58	56	70	116	124	120	123	90	124
		-30 deg.C	kJ / m ²	22	49	33	27	31	67	52	68	121
Flexural modulus	ISO 178	-	GPa	2.2	2.2	2.1	2.2	2.2	2.1	2.1	2.1	2.0
Elongation at break	ISO 527-2	-	%	81	88	100	79	90	97	108	98	114
DTUL	ISO 75	1.80 MPa	deg.C	106	104	105	104	104	104	105	103	103

*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf

***MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

- ✓ KURARITY™ can enhance impact-resistance and flowability with lower addition amount
- ✓ Considering with cost effect, **we recommend 2-3 phr addition to PC / ABS**
- ✓ High addition (4-5 phr) makes risks of delamination higher but can improve impact resistance at lower temperature
- ✓ Combination of KURARITY™ and core-shell type modifier can improve impact resistance especially at lower temperature.

Kneading effect on addition amount dependency



* phr = per hundred resin , * MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

✓ Kneading affects slightly to KURARITY™ addition amount dependency.

ABS rich formulation (PC / ABS = 60 / 40 ~ 50 / 50)

		Ref.4	Ref.5	Ex.7	Ref.6	Ref.7	Ex.8		
PC	High flow grade, MFI* = 15	60	60	60	50	50	50		
ABS	High flow grade, MFI** = 45	40	40	40	50	50	50		
Modifier	MBS (core-shell type)		3			3			
	KURARITY™ LA2270			3			3		
Items	Methods	Conditions	Units						
MFR	ISO 1133	260 deg.C, 2.16 kgf	g /10 min	24	12	23	26	13	27
Spiral flow	In-house method	1 mm [†]	mm	126	118	132	143	133	146
Charpy impact with notch	ISO 179	23 deg.C	kJ / m ²	78	63	120	62	90	120
		-30 deg.C	kJ / m ²	25	32	34	19	28	26
Flexural modulus	ISO 178	-	GPa	2.2	2.1	2.1	2.2	2.1	2.1
Elongation at break	ISO 527-2	-	%	83	103	98	87	103	93
DTUL	ISO 75	1.80 MPa	deg.C	101	100	99	94	93	94

*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf

†††MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

- ✓ Ex.7 and Ex.8 show high spiral flow and charpy impact compared to Ref. 4 to 7.
- ✓ KURARITY™ can improve flow ability and impact resistance even in ABS rich formulations (PC / ABS = 60 / 40 ~ 50 / 50).

2. KURARITY™ as a modifier for PC / ABS flame retardant grade (Non-reinforced)

Typical properties (Flame retardant grade)

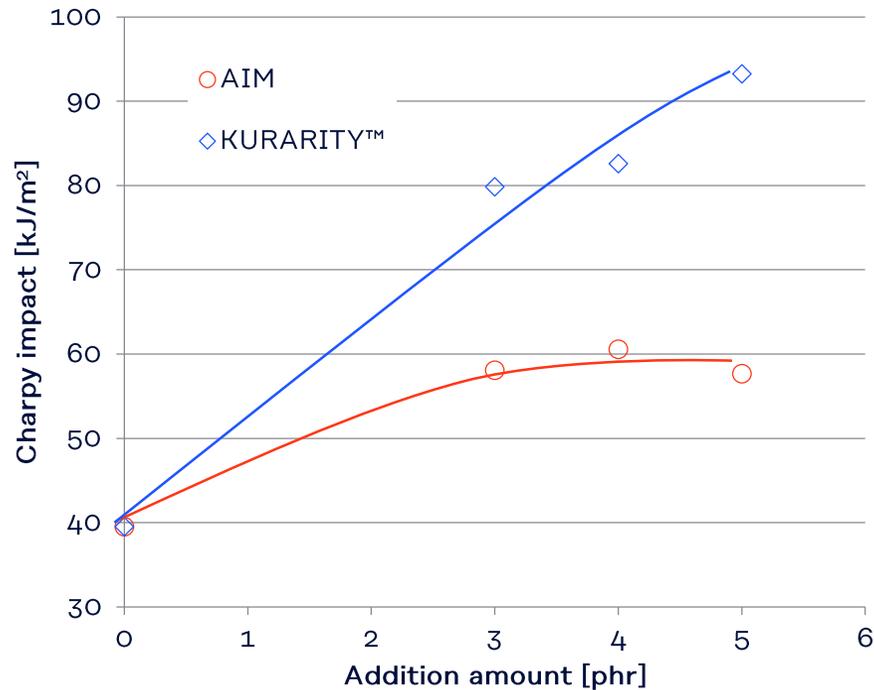
		Ref.1	Ref.2	Ex.1	Ex.2	Ex.3	Ex.4		
PC / ABS	High flow, flame retardant grade (MFI = 22*)	100	100	100	100	100	100		
Modifier	AIM** (Core-shell type)		3						
	KURARITY™ LA2330			3					
	KURARITY™ LA2250				3				
	KURARITY™ LA2270					3			
	KURARITY™ LA4285						3		
Items	Methods	Conditions	Units						
MFR	ISO 1133	260 deg.C, 2.16 kgf	g / 10 min	28	18	27	30	25	24
Spiral flow	In-house method	1mmt***	mm	131	130	149	151	142	132
Charpy impact with notch	ISO 179	23 deg.C	kJ / m ²	40	58	56	85	80	55
		-30 deg.C	kJ / m ²	14	20	15	15	16	14
Flexural modulus	ISO 178	-	GPa	2.8	2.6	2.6	2.6	2.6	2.6
Elongation at break	ISO 527-2	-	%	98	100	117	75	92	105
DTUL	ISO 75	1.80 MPa	deg.C	82	81	82	83	81	83
Flammability	UL 94	1.5mmt	---	V-0	V-1 equivalent				

*260 deg.C / 2.16 kgf, **Acrylic Impact Modifier,

*** MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

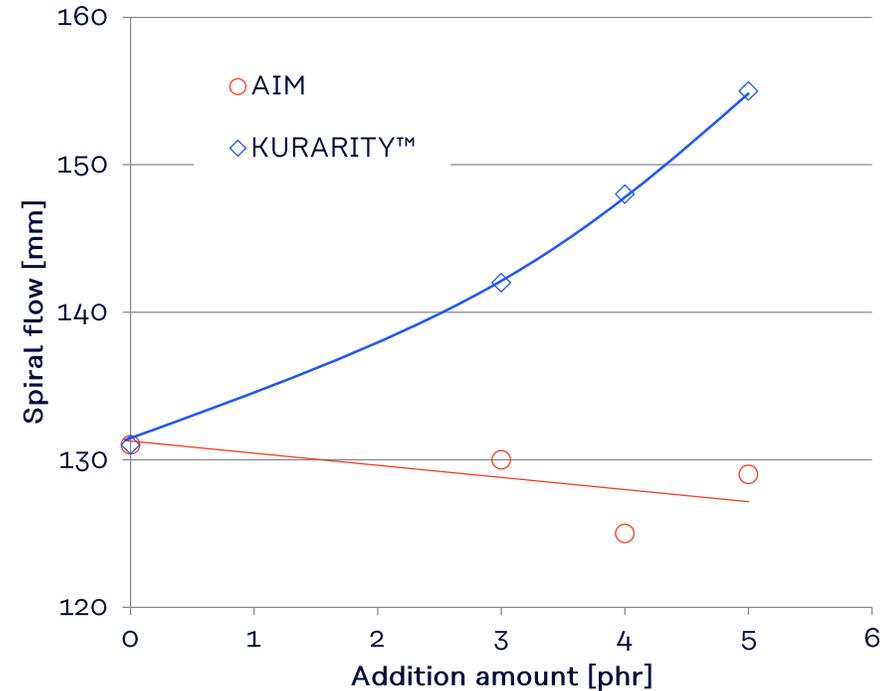
- ✓ Ex.2 and Ex.3 show high spiral flow and charpy impact compared to Ref.2

Addition amount dependency



* phr = per hundred resin.

* MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec



✓ KURARITY™ can increase Charpy impact and flow ability by adding a small amount to PC/ABS.

Puncture impact test

				Ref.1	Ref.2	Ref.3	Ex.3	Ex.5
PC / ABS	High flow, flame retardant grade (MFI = 22*)			100	100	100	100	100
Modifier	AIM (Core-shell type)				3	5		
	KURARITY™ LA2270						3	5
Items	Methods	Conditions	Units					
Maximum force	ISO 6603-2	Temp.: 23 deg.C, Speed: 4.4 m / sec, Thickness: 2 mmt	kN	4.7	4.5	4.5	4.5	4.5
Deflection at maximum point			mm	17.0	17.5	17.9	17.6	17.7
Energy to maximum point			J	49.2	49.6	50.2	49.9	49.5
Puncture deflection			mm	18.0	18.6	18.4	19.1	18.8
Puncture energy			J	54.0	54.7	52.3	56.3	54.3
Test piece appearance			---					

✓ KURARITY™ can increase puncture energy by improving its puncture deflection. *260 deg.C / 2.16 kgf

**3. KURARITY™ as a modifier for
PC / ABS GF reinforced grade
(Flame retardant / None flame retardant)**

Typical properties (GF reinforced formulations)

		Ref.1	Ref.2	Ex.1	Ex.2		
PC / ABS	High flow, flame retardant grade (MFI = 22*)	100	100	100	100		
GF	E-glass, Sizing: Silane type	20	20	20	20		
Modifier	AIM (Core-shell type)		5				
	KURARITY™ LA2270			5			
	KURARITY™ LA4285				5		
Items	Methods	Conditions	Units				
MFR	ISO 1133	260 deg.C, 2.16 kgf	g / 10min	14	9.4	18	17
Spiral flow	Kuraray	1 mmt**	mm	103	100	131	123
Charpy impact with notch	ISO 179	23 deg.C	kJ / m ²	6.6	8.8	9.0	8.7
		-30 deg.C	kJ / m ²	4.4	6.0	6.4	6.0
Flexural modulus	ISO 178	-	GPa	6.0	5.6	5.5	5.6
Elongation at break	ISO 527-2	-	%	2.0	1.9	2.1	2.1
DTUL	ISO 75	1.80 MPa	deg.C	101	102	101	102

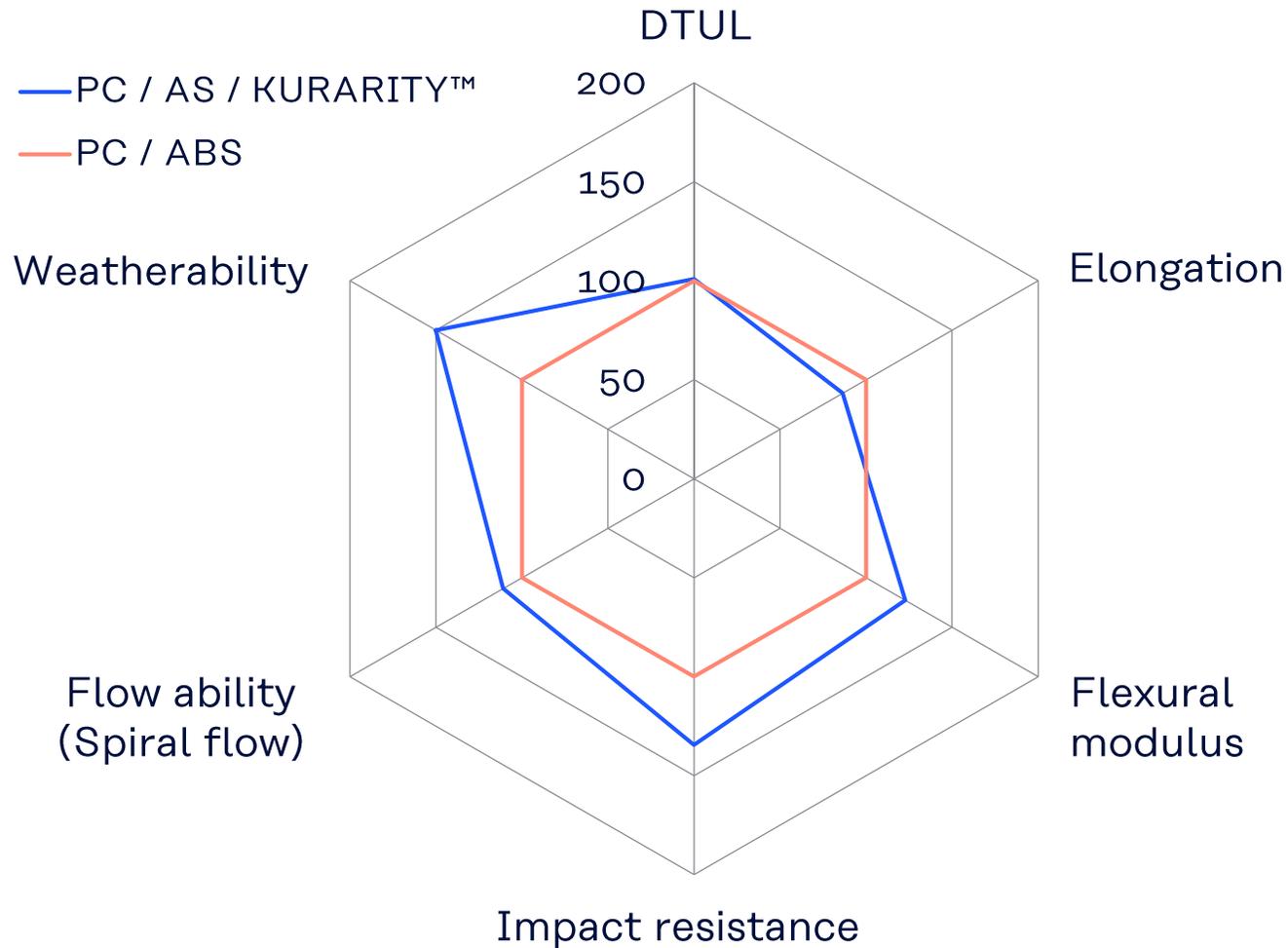
*260 deg.C / 2.16 kgf,

** MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

- ✓ Ex.1 and Ex.2 show high spiral flow and same level of charpy impact compared to Ref. 2.
- ✓ KURARITY™ can improve flow ability of PC / ABS / GF remarkably -> Enable to mold thinner

**KURARITY™ as a modifier for
PC / AS general grade
(Non-reinforced, none flame retardant)**

Overviewing of our new solution with KURARITY™ (Compare with conventional system)

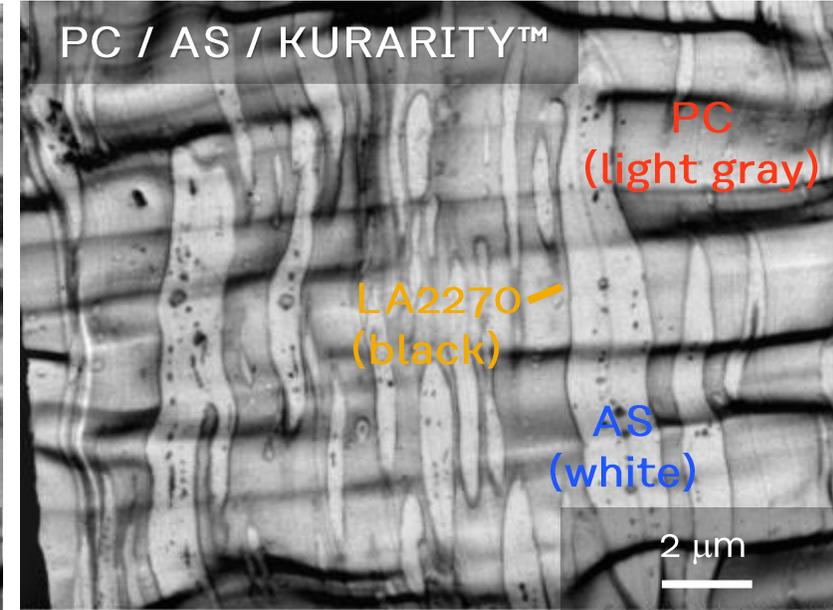
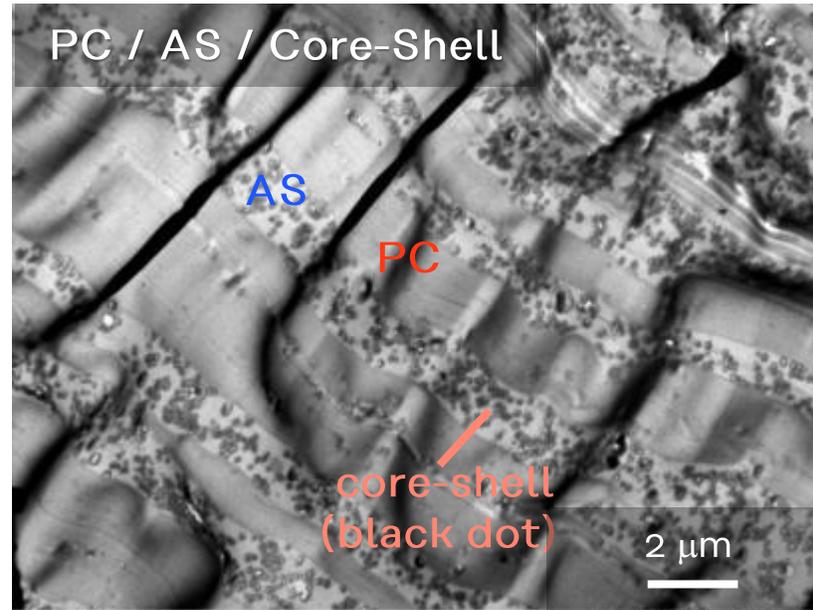
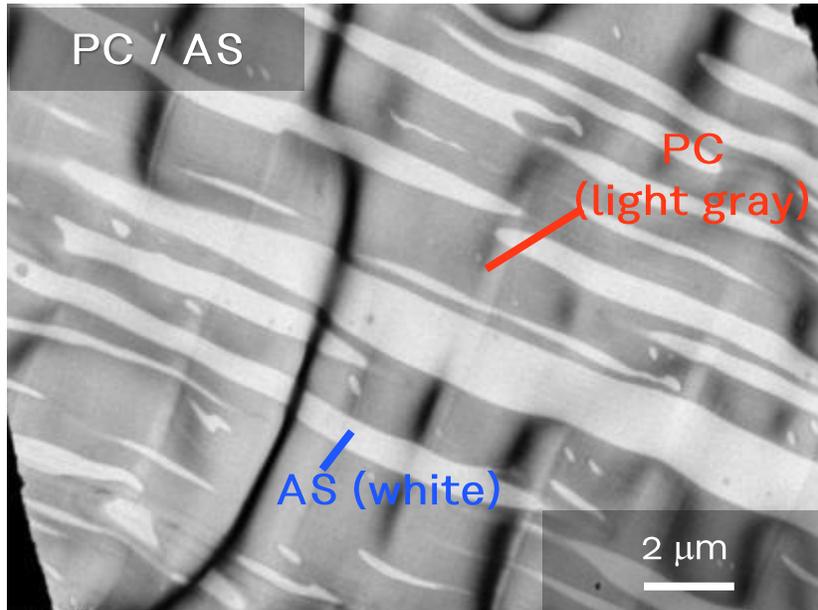


Compare with conventional PC / ABS
Our new solution is;

- ✓ (+-) Same level DTUL, elongation,
- ✓ (+) Flexural modulus, flow ability, Impact resistance and weatherability*.

*Thanks to PC / AS / KURARITY™ system not containing C=C bond, it shows better weatherability.

TEM morphology investigations



- ✓ Core-Shell disperses in PC or AS phase.
 - ✓ KURARITY™ exists between PC and AS phase.
- => Totally different morphology from conventional core-shell type impact modifiers

Typical properties (PC / AS = 70 / 30)

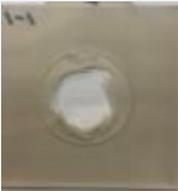
				Ref.1	Ref.2	Ref.3	Ref.4	Ref.5	Ex.1	Ex.2	Ex.3	Ex.4	Ex.5	Ex.6
PC	High flow grade, MFI* = 15			70	70	70	70	70	70	70	70	70	70	70
ABS	High flow grade, MFI** = 45			30										
AS	High flow grade, MFI** = 30				30	30	30	30	30	30	30	30	30	30
Modifier	Acrylic silicone type Core shell rubber					3	7	15						4
	KURARITY™ LA2270								1	2	3	4	5	3
Items	Methods	Conditions	Units											
MFR	ISO 1133	260 deg.C, 2.16 kgf	g / 10 min	20	13	11	9	7	12	13	13	14	15	11
Spiral flow	In-house method	1 mmt***	mm	110	111	113	113	114	120	120	122	126	131	120
Charpy impact with notch	ISO 179	23 deg.C	KJ / m ²	58	3.2	13	15	53	6.0	15	78	123	125	97
		-30 deg.C		22	3.0	8.9	9.1	4.2	5.2	6.2	11	15	13	7.8
Flexural modulus	ISO 178	-	GPa	2.2	2.7	2.7	2.5	2.2	2.7	2.7	2.7	2.7	2.6	2.5
Elongation at break	ISO 527-2	-	%	81	81	66	73	79	75	78	70	63	55	77
DTUL	ISO 75	1.80 MPa	deg.C	106	107	108	104	102	106	106	107	105	106	106

*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf

***MEIKI M100C, Injection temp.: 240 deg.C, Mold temp.: 80 deg.C, Injection pressure: 100 MPa, Injection rate: 50 mm / sec

- ✓ Ex.3 - Ex.6 show good impact resistance and flowability.
- ✓ Ex.6 (Co-addition of core-shell and KURARITY™) keeps elongation at break.

Puncture impact test

				Ref.1	Ref.2	Ref.4	Ex.3	Ex.5	Ex.6
PC	High flow grade, MFI* = 15			70	70	70	70	70	70
AS	High flow grade, MFI** = 30			30	30	30	30	30	30
Modifier	Acrylic silicone type Core shell rubber				3	15			4
	KURARITY™ LA2270						3	5	3
Items	Methods	Conditions	Units						
Maximum force	ISO 6603-2	Temp.: 23 deg.C, Speed: 4.4 m / sec, Thickness: 2 mmt	kN	5.3	5.1	4.8	5.1	5.1	4.9
Deflection at maximum point			mm	16.3	16.9	17.4	16.7	17.3	16.5
Energy to maximum point			J	51.7	52.2	49.9	51.8	53.5	48.0
Puncture deflection			mm	17.2	17.7	18.0	18.0	18.4	17.4
Puncture energy			J	55.8	55.8	52.9	58.5	58.9	52.3
Test piece appearance			---						

*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf

✓ The fracture mode of PC / AS changes to ductile fracture by adding KURARITY™ (Ex.3, 5, 6)

Weatherability

					Ref.1	Ref.2	Ref.4	Ex.3	Ex.6
PC	High flow grade, MFI* = 15				70	70	70	70	70
AS	High flow grade, MFI** = 30				30	30	30	30	30
Modifier	Acrylic silicone type Core shell rubber					3	15		4
	KURARITY™ LA2270							3	3
Items	Methods	Conditions	Units	SWOM test*** Exposure time					
Charpy impact with notch	ISO 179	23 deg.C	KJ/m ²	0hr	3.2	13	53	78	97
				500hr	4.1	11	18	73	110
				1000hr	3.1	10	18	110	92
		-30 deg.C		0hr	3.0	8.9	4.2	11	7.8
				500hr	3.8	6.8	3.0	8.6	6.4
				1000hr	2.9	4.8	4.9	6.7	5.9
ΔE				500hr	3.4	7.2	12	7.0	9.8
				1000hr	6.0	11	14	8.6	13
Test piece appearance	-	Reflection mode	-	-					

*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf,

***SWOM (ISO4892-4) Black Panel temp.: 63 deg.C, Exposure intensity: 255 W / m² (300 - 700 nm)

- ✓ After weather resistance test, Ex.3 and Ex.6 keep good impact resistance.
- ✓ Ex.3 shows smaller color change compared to Ref.2 - Ref.4.

Weatherability (Filler added formulation)

					Ref.5	Ref.6	Ref.8	Ex.7	Ex.8	Ex.9
PC	High flow grade, MFI* = 15				70	70	70	70	70	70
AS	High flow grade, MFI** = 30				30	30	30	30	30	30
Filler	TiO ₂ (Average diameter: 0.21 μm)				4	4	4	4	4	4
Modifier	Acrylic silicone type Core shell rubber					3	15			4
	KURARITY™ LA2270							3	5	3
Items	Methods	Conditions	Units	SWOM test* Exposure time						
Charpy impact with notch	ISO 179	23 deg.C	KJ/m ²	0hr	7.7	8.3	22	97	120	49
				1000hr	6.6	9.1	17	82	120	16

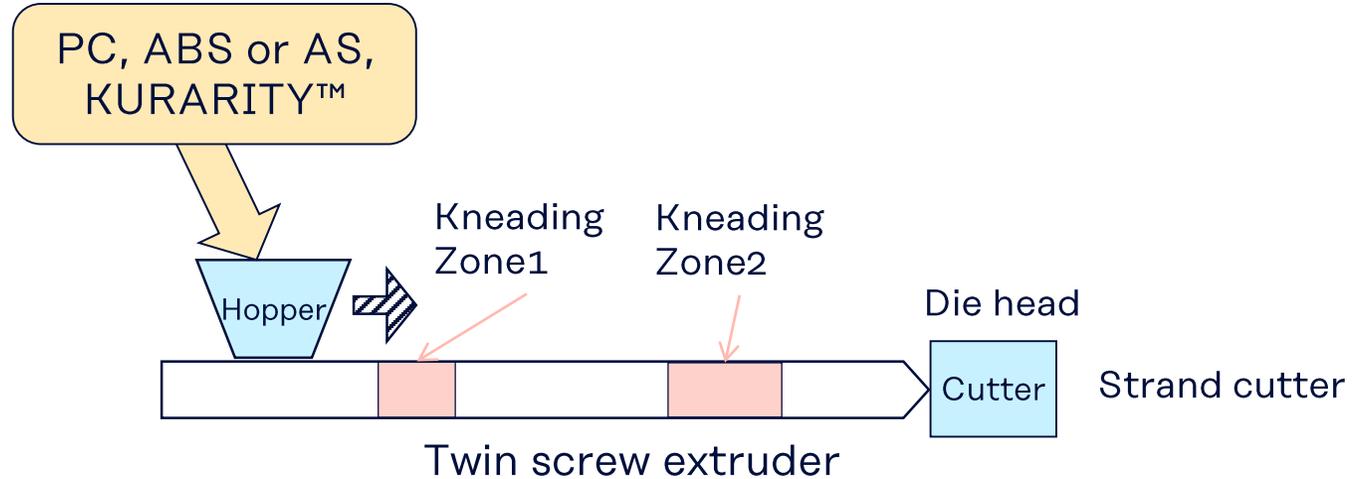
*300 deg.C / 1.2 kgf **220 deg.C / 10 kgf,

***SWOM (ISO4892-4) Black Panel temp.: 63 deg.C, Exposure intensity: 255 W / m² (300 - 700 nm)

✓ Ex.7 and 8 show excellent impact resistance even if the filler is added.

Test compounding conditions (Non - reinforced)

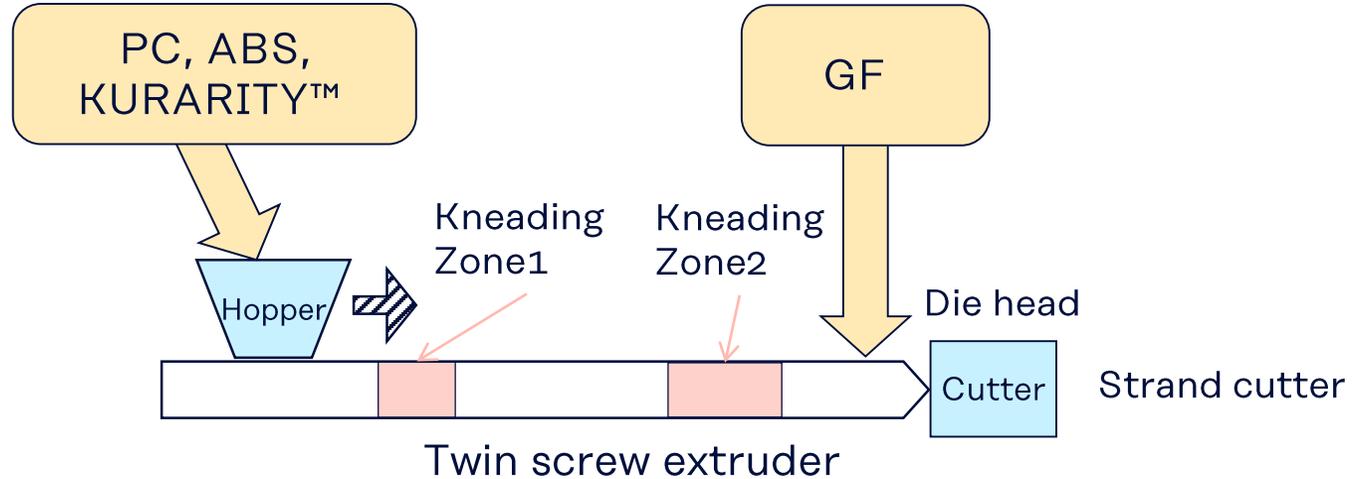
Equipment example
 Twin extruder: ZSK 25 (Coperion)
 Screw: 25 mmφ, L / D = 54



Temperature [deg.C]	C2 (hopper)	C3~C11	C12	Die head
	50	250-270	240-260	230-250
Screw rotation [rpm]	200			
Vent	Pull			
PCW temperature [deg.C]	30-50			

Test compounding conditions (GF - reinforced)

Equipment example
 Twin extruder: ZSK 25 (Coperion)
 Screw: 25 mmφ, L / D = 54



	C2 (hopper)	C3~C11	C12	Die head
Temperature [deg.C]	50	290-310	280-300	270-290
Screw rotation [rpm]	200			
Vent	Pull			
PCW temperature [deg.C]	30-50			

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For medical, health care and food contact applications, please contact your Kuraray representative for specific recommendations. Even so, users must conduct their own assessment, revisions, registrations as well rely in their own technical and legal judgment to establish the safety and efficacy of their compound and/or end product with SEPTON™, HYBRAR™ and KURARITY™ for any application. SEPTON™, HYBRAR™ and KURARITY™ should not be used in any devices or materials intended for implantation in the human body. Nothing contained herein constitutes a license to practice under any patent and it should not be construed as an inducement to infringe any patent and the user is advised to take appropriate steps to be sure that any proposed use of the product will not result in patent infringement.

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