No.RRL10-021

Technical Insight of KURARAY LIQUID RUBBER

GS-L-BR for Winter tire and All season tire (2)

Elastomer R&D Department
Elastomer Division

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Agenda

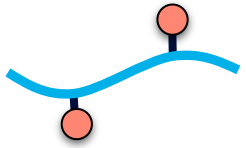
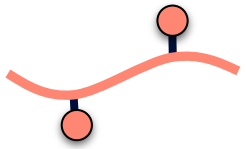
Our silane-modified LBR; GS-L-BR is the latest development of KURARAY LIQUID RUBBER grades.

1) Silane modified LBR (GS-L-BR)

2) Evaluation in winter tire formulation

3) Formulation adjustment

Silane modified LBR (GS-L-BR)

Grade Name [Development Code]	Structure	Mw	Tg (°C)	Number of functional groups / chain	Viscosity at 38°C (Pa • s)
GS-L-BR-114* [SB-005]	Polybutadiene 	6,000	-50	2	6
[SB-018*]	Polybutadiene 	6,500	-84	2	2

*All polymers are in development stage.

Formulation & Mixing Conditions

	Control	Formulation
S-SBR	40	40
NR	30	30
BR	30	30
TDAE	30	10
Liquid Rubber	-	20
CB	10	10
Silica	80	80
SCA	6.4	6.4
ZnO	2.0	2.0
Stearic acid	2.0	2.0
Anti oxidant 6PPD	2.0	2.0
Wax	1.0	1.0
OT-20	2.75	2.75
Accelerator DPG	0.2	0.2
Accelerator CBS	1.6	1.6

Mixing Conditions		
NP1	sec	Banbury-type mixer*
	0	Solid rubber (60°C)
	20	CB, Silica, SCA, TDAE, LR, Chemicals
	180	Sweep
	360	Dump out (150-160°C)
NP2		Banbury-type mixer*
	0	1st mixed compound(90°C)
	240	Dump out (150-160°C)
FM		Banbury-type mixer*
	0	Compound, Sulfur, Accelerators (50°C)
	75	Dump out (90-100°C)

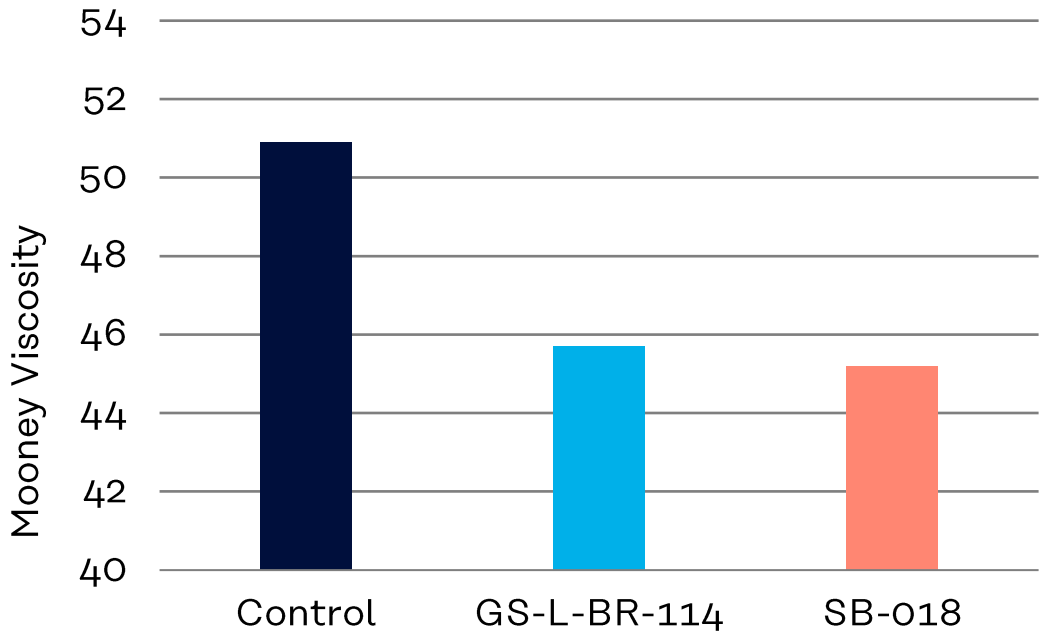
*MIXTRON® BB Mixer (by Kobe Steel, Ltd.)

Summary of Properties

			Control	GS-L-BR-114	SB-018
Mooney Viscosity (ML1+4, @130°C)			51	46	45
Curelastometer (t90, 160°C)		(min)	19	29	26
Mechanical properties					
Hs		Type A	65	68	66
EB		(%)	626	554	590
TB		(MPa)	20.7	19.8	20.4
M100		(MPa)	1.94	2.39	2.17
M300		(MPa)	8.14	9.15	8.89
Viscoelasticity (10% to 2%, -50 to +70°C)					
E'	-20°C	(MPa)	17.1	25.3	15.2
	0°C	(MPa)	8.99	12.41	9.15
	60°C	(MPa)	4.63	5.69	5.18
tanδ	-20°C	(-)	0.694	0.65	0.544
	0°C	(-)	0.445	0.445	0.344
	60°C	(-)	0.225	0.201	0.175
Abrasion resistance FPS , 5%		index	100	115	119
Friction coefficient					
Wet	20°C	index	100	104	97
Ice	-10°C	index	100	88	105

Processability

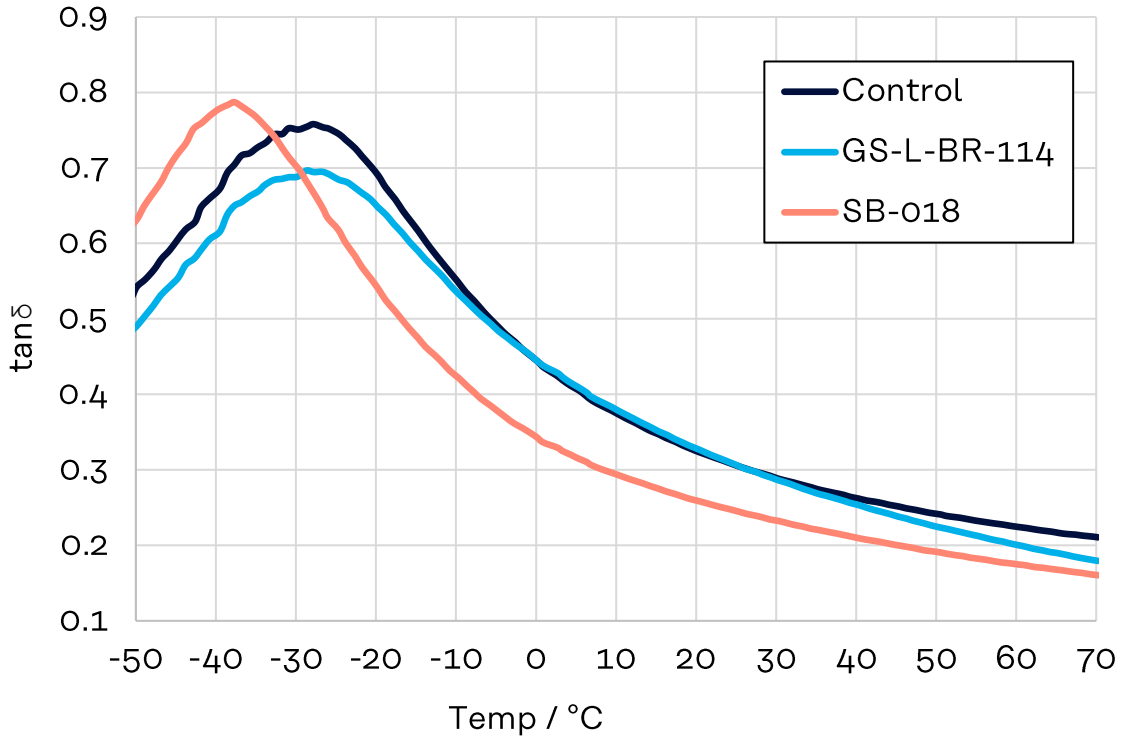
	GS-L-BR-114	SB-018
Melt Viscosity @38°C (Pa • s)	6	2

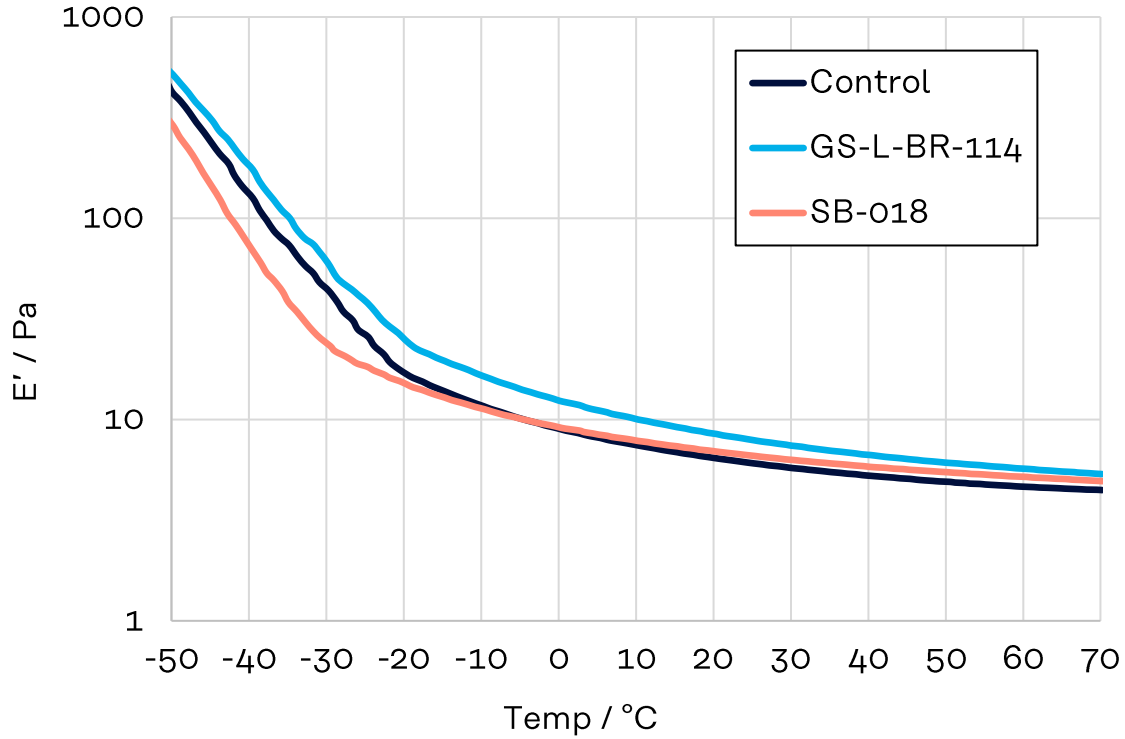


GS-L-BR-114 & SB-018

- Easy to handle due to low viscosity.
- Oil replacement of GS-LR results in a decrease in Mooney viscosity.

Change in viscoelasticity with liquid rubber





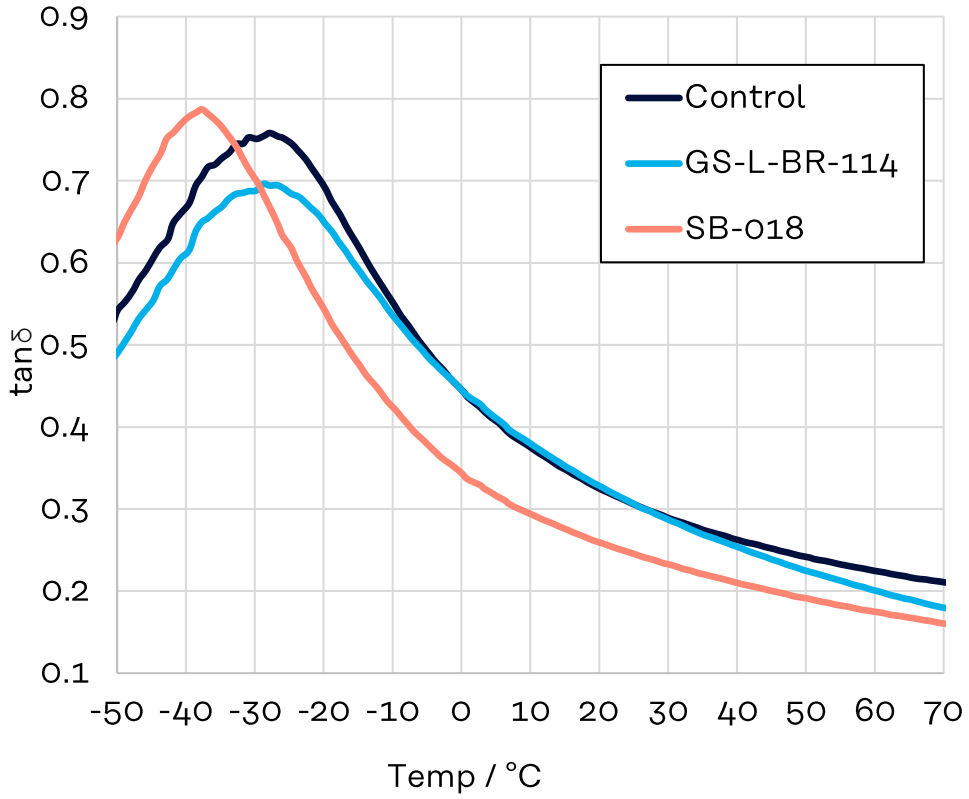
GS-L-BR-114 (High Tg)

- Lowering the tanδ at 60°C while maintaining the tanδ at 0°C.

SB-018 (Low Tg)

- Sharpening tanδ and moving to lower temperatures.
- Decrease in elastic modulus at low temperatures.

Effect of changes in viscoelasticity on physical properties



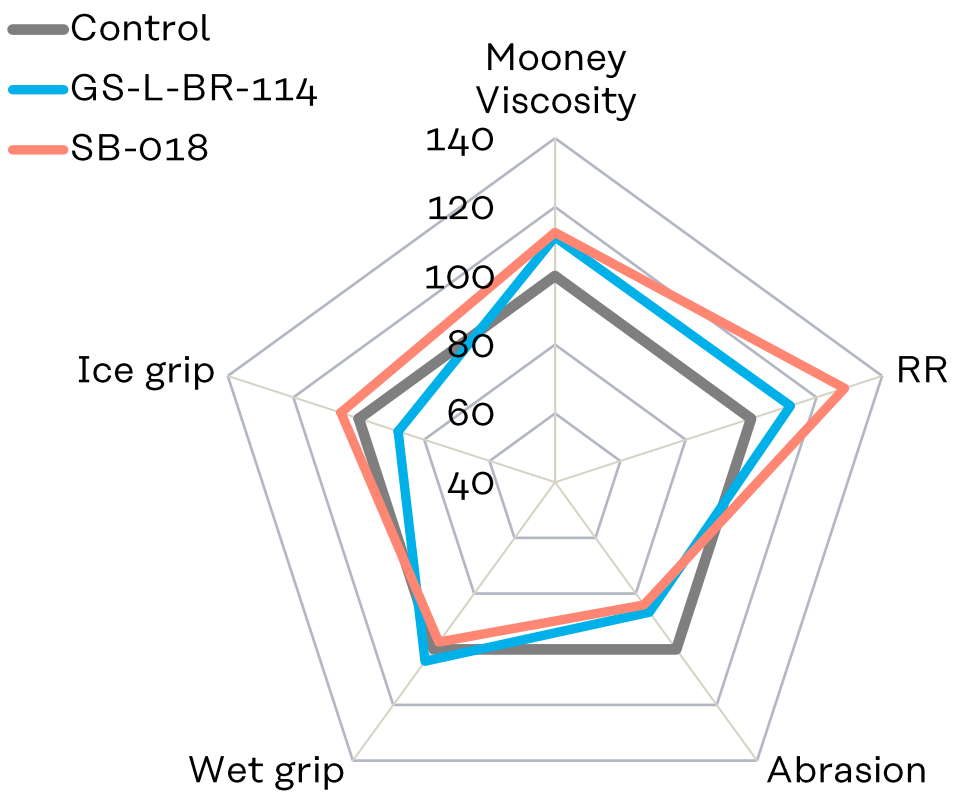
(normalized value to TDAE)

	GS-L-BR-114	SB-018
E'@-20°C	148	89
Ice μ	89	105
tanδ@0°C	104	77
Wet μ	103	97
tanδ@60°C	87	78

Improvement effect

- GS-L-BR-114 improves RR without reducing wet grip.
- SB-018 improves RR without reducing Ice & wet grip.

Test results



GS-L-BR-114 & SB-018

- Easy to handle due to low viscosity.
- Improve processability

Improvement effect of GS-L-BR-114

- Rolling resistance
- Wet grip
  - Suitable for all-season tire.

Improvement effect of SB-018

- Rolling resistance
- Ice grip
  - Suitable for winter tire.

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Raw material

Material	Product Name	Manufacturer	Note
Styrene-butadiene rubber	JSR HPR355	JSR Corporation	Styrene content: 27% Mooney Vis. @100°C: 44 Tg: -24°C
Natural Rubber	STR20	Von Bundit Co., Ltd.	
Butadiene Rubber	JSR BR01	JSR Corporation	Cis content: 95% Mooney Vis. @100°C: 45
Carbon black	DIABLACK™ I	Mitsubishi Chemical Corporation	ASTM N220
Silica	ULTRASIL® 7000GR	Evonik Industries AG	Specific surface area (N2) 175 m^2/g
Silane Coupling Agent	Si 75®	Evonik Industries AG	
TDAE	VIVATEC 500	H&R GmbH Co. KGaA	
Insoluble sulfur	MUCRON OT-20	SHIKOKU CHEMICALS CORPORATION	Sulfur/Oil = 80/20