

Technical Insight of KURARAY LIQUID RUBBER

GS-L-BR for Winter tire and All season tire

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
GS-L-BR-188* [SB-006]	Polybutadiene 	38,000	-88	4	124

*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

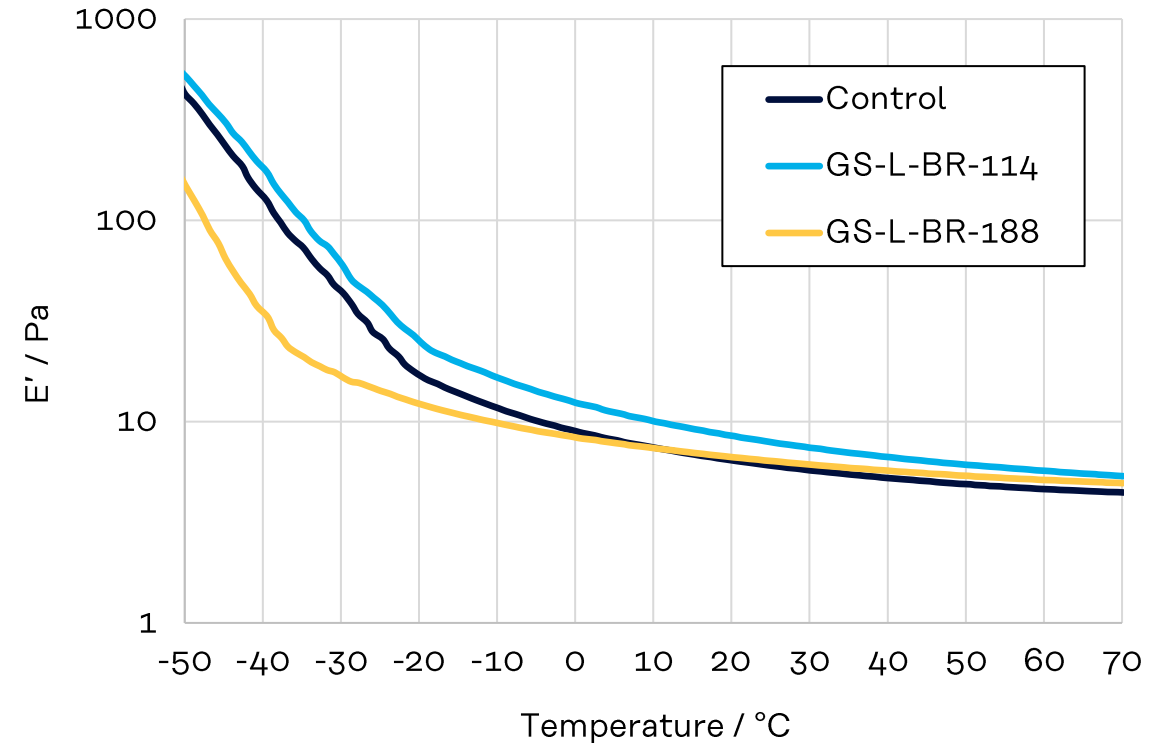
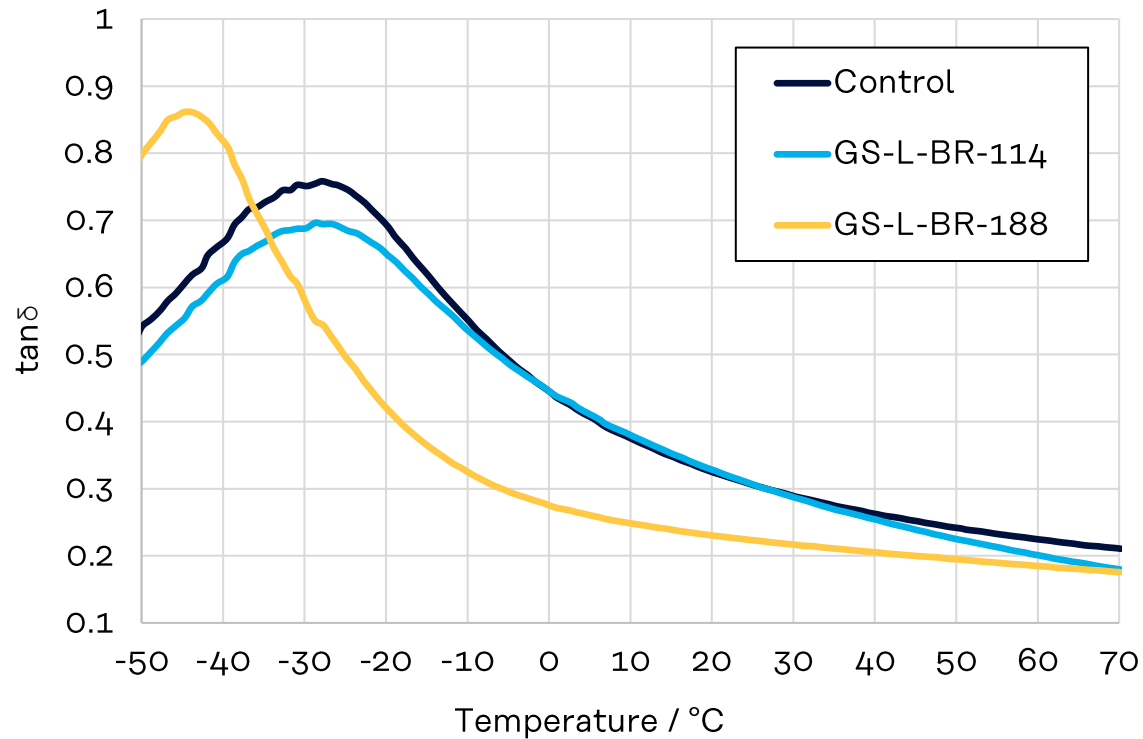
Mixing Conditions		
NP1	sec	Banbury-type mixer*
	0	Solid rubber (60°C)
	20	CB, Silica, SCA, TDAE, LR, Chemicals
	180	Sweep
	360	Dump out (150-160°C)
NP2		Banbury-type mixer*
	0	1 st mixed compound(90°C)
	240	Dump out (150-160°C)
FM		Banbury-type mixer*
	0	Compound, Sulfur, Accelerators (50°C)
	75	Dump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

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

Summary of Properties

			Control	GS-L-BR-114	GS-L-BR-188
Mooney Viscosity (ML1+4, @130°C)			51	46	56
Curelometer (t90, 160°C) (min)			19	29	27
Mechanical properties					
Hs	Type A		65	68	65
EB	(%)		626	554	459
TB	(MPa)		20.7	19.8	19.6
M100	(MPa)		1.94	2.39	3.09
M300	(MPa)		8.14	9.15	11.19
Viscoelasticity (10% to 2%, -50 to +70°C)					
E'	-20°C	(MPa)	17.1	25.3	12.3
	0°C	(MPa)	8.99	12.41	8.34
	60°C	(MPa)	4.63	5.69	5.12
tanδ	-20°C	(-)	0.694	0.65	0.421
	0°C	(-)	0.445	0.445	0.275
	60°C	(-)	0.225	0.201	0.185
Abrasion resistance FPS, 5%					
	index		100	115	127
Friction coefficient					
on Wet	20°C	index	100	104	88
on Ice	-10°C	index	100	88	119

Change in viscoelasticity with liquid rubber



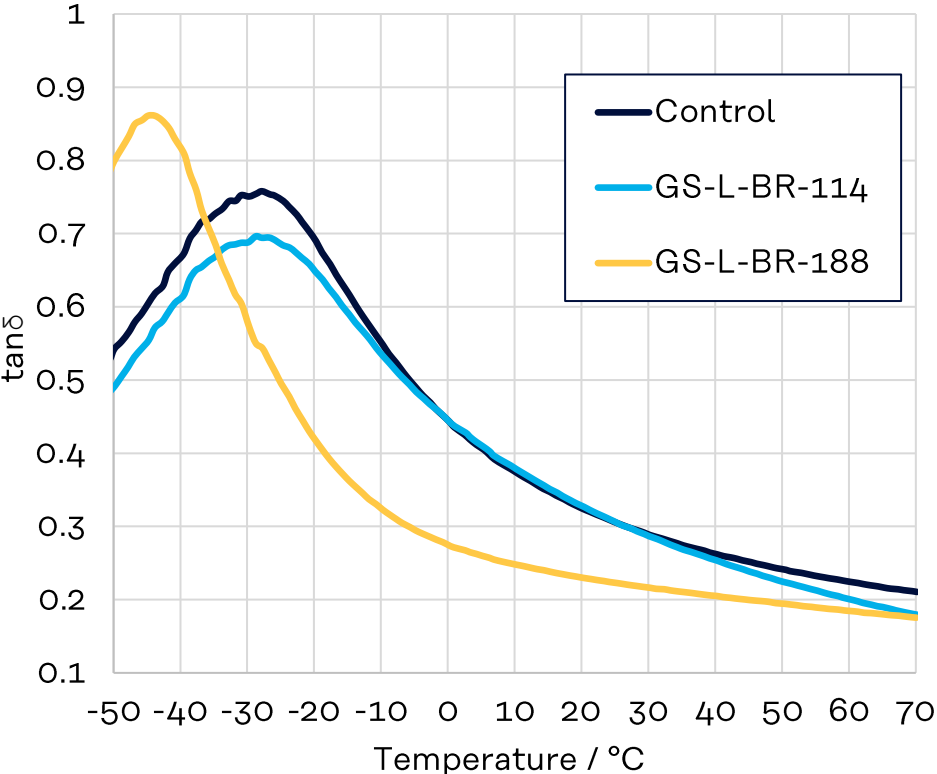
GS-L-BR-114 (High Tg)

- Lowering the $\tan \delta$ at 60°C while maintaining the $\tan \delta$ at 0°C.

GS-L-BR-188 (Low Tg)

- Sharpening $\tan \delta$ and moving to lower temperatures.
- Decrease in elastic modulus at low temperatures.

Effect of changes in viscoelasticity on physical properties



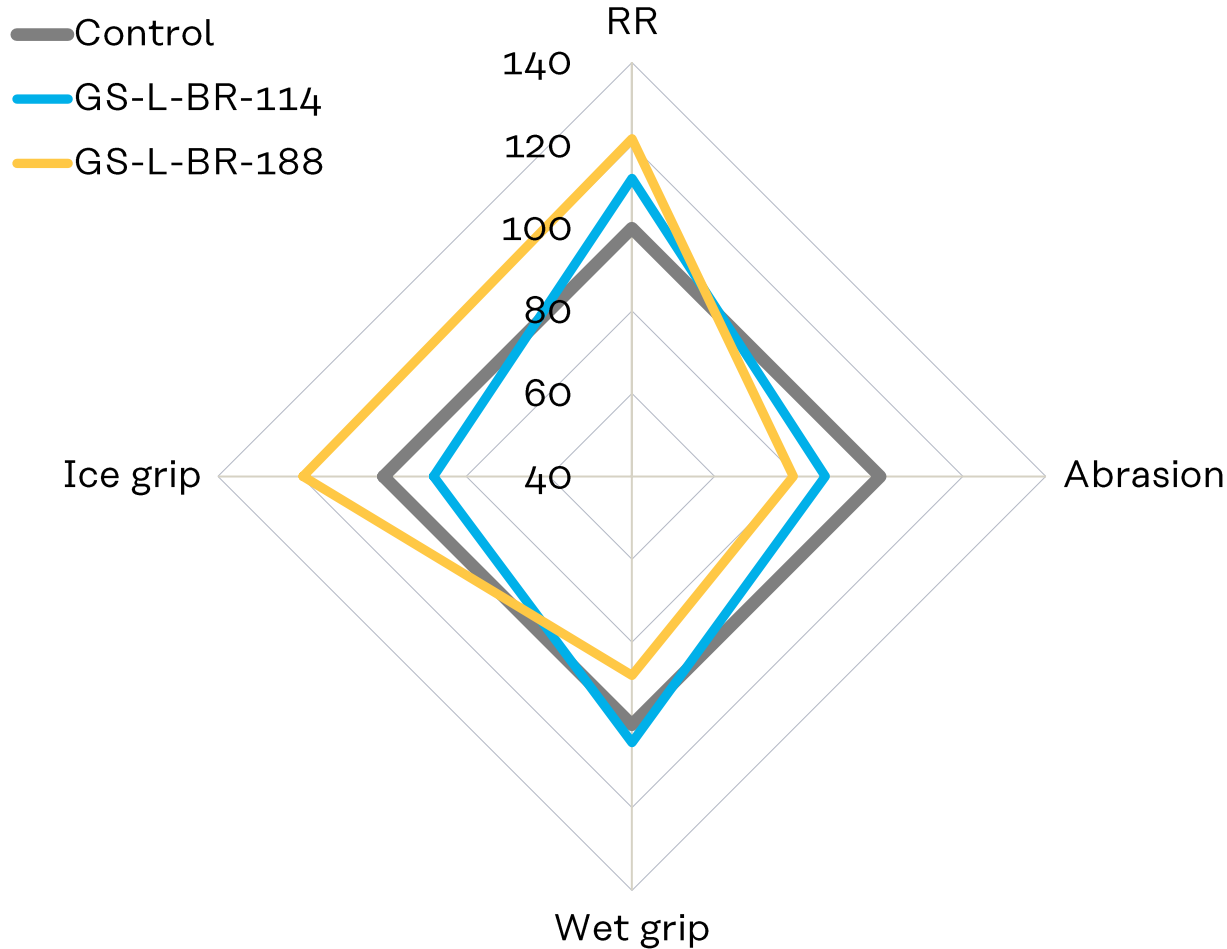
(normalized value to TDAE)

	GS-L-BR-114	GS-L-BR-188
E'@-20°C	148	72
Ice-μ	89	113
tanδ@0°C	104	64
Wet-μ	103	88
tanδ@60°C	87	83

Improvement effect

- GS-L-BR-114 improves RR without reducing wet grip.
- GS-L-BR-188 improves RR and ice grip.

Test results



Improvement effect of GS-L-BR-114

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

Improvement effect of GS-L-BR-188

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

Kuraray Co., Ltd.
Elastomer Division
Tokiwabashi Tower
2-6-4, Otemachi
Chiyoda-ku, Tokyo 100-0004, Japan

✉ elastomer@kuraray.com

→ www.kuraray.com

→ www.elastomer.kuraray.com

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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 KURARAY LIQUID RUBBER for any application. KURARAY LIQUID RUBBER 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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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