

Technical Insight of KURARAY LIQUID RUBBER

Silane modified LBR for E-SBR / Silica formulation

Elastomer R&D Department
Elastomer Division

kuraray

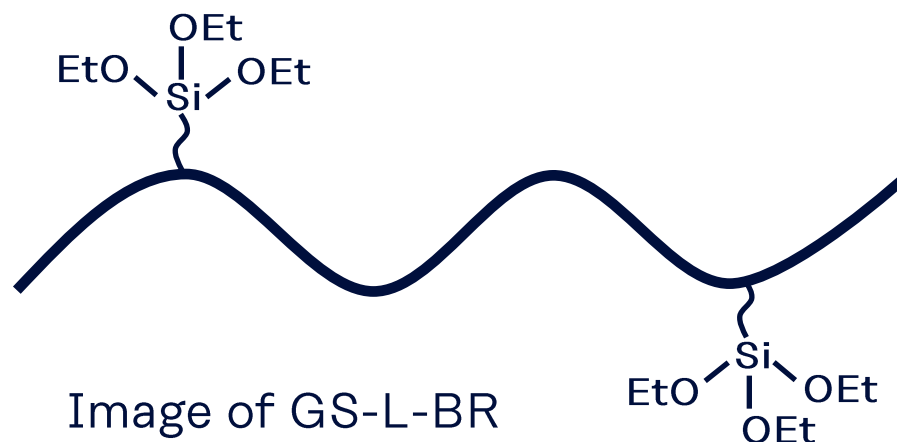
Agenda

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 E-SBR / Silica formulation

Silane modified LBR (GS-L-BR)

Grade Name [Development Code]	Structure	Functional Group	Mw	Tg (°C)	Number of functional group / chain	Viscosity at 38°C (Pa • s)
GS-L-BR-114 [SB-005]	Polybutadiene /Graft silane	Triethoxysilane	6,000	-50	2	6
GS-L-BR-188 [SB-006]	Polybutadiene /Graft silane	Triethoxysilane	38,000	-88	4	124



- High reactivity with silica
- Improve silica dispersion
- Crosslinkable with base rubber

Agenda

- 1. Silane modified LBR (GS-L-BR)**
2. Evaluation in E-SBR / Silica formulation

Concept

Function of Silane Coupling Agent

Interaction enhancement

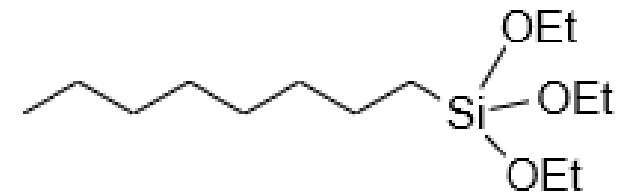
GS-L-BR

Si 69[®], Si 75[®]

Silquest[™] A-137

Silica dispersion

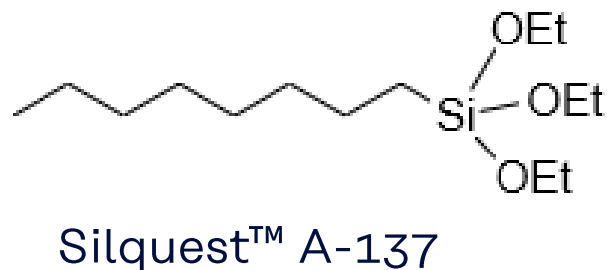
- High temperature mixing
- Strong interaction with low vinyl polymer
- Relaxed silica-polymer interaction



Silquest[™] A-137
(n-Octyltriethoxysilane)

- Appropriate mixing temperature control
- Low reactivity with low vinyl polymer
- Rigid silica-polymer interaction

Formulation



	Control	Formulation	Reference
SBR1500	100	100	100
Silica	80	80	80
Silquest™ A-137		7.3	7.3
Si 75®	6.4		
TDAE	20	10	10
GS-L-BR-114		10	
GS-L-BR-188		10	
Chemicals	ZnO 3.0, Stearic acid 2.5, 6PPD 2.5		
Sulfur	S 3.0		
Accelerator	DPG 1.5, MBT 0.3, TBBS 1.5		

Mixing Conditions

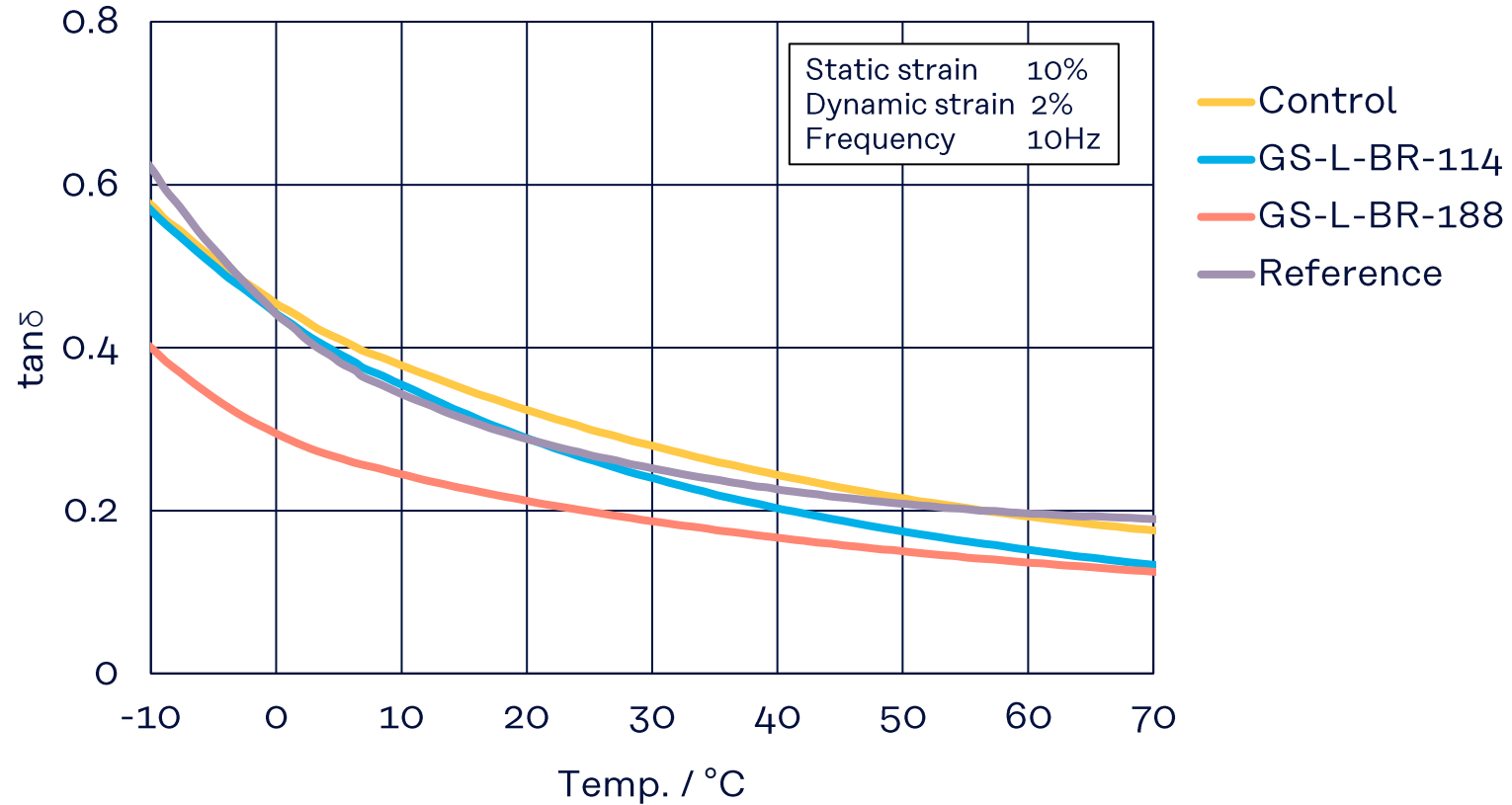
Mixing Conditions		
NP1	sec	Banbury-type mixer*
	0	Solid rubber (60°C)
	20	Silica, SCA, TDAE, LR, Chemicals
	180	Sweep
	360	Dump out (150-160°C)
NP2		Banbury-type mixer*
	0	1 st mixed compound(90°C)
	240	Dump out (150-160°C)
FM		Banbury-type mixer*
	0	Compound, Sulfur, Accelerators (50°C)
	75	Dump out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

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

Summary of properties

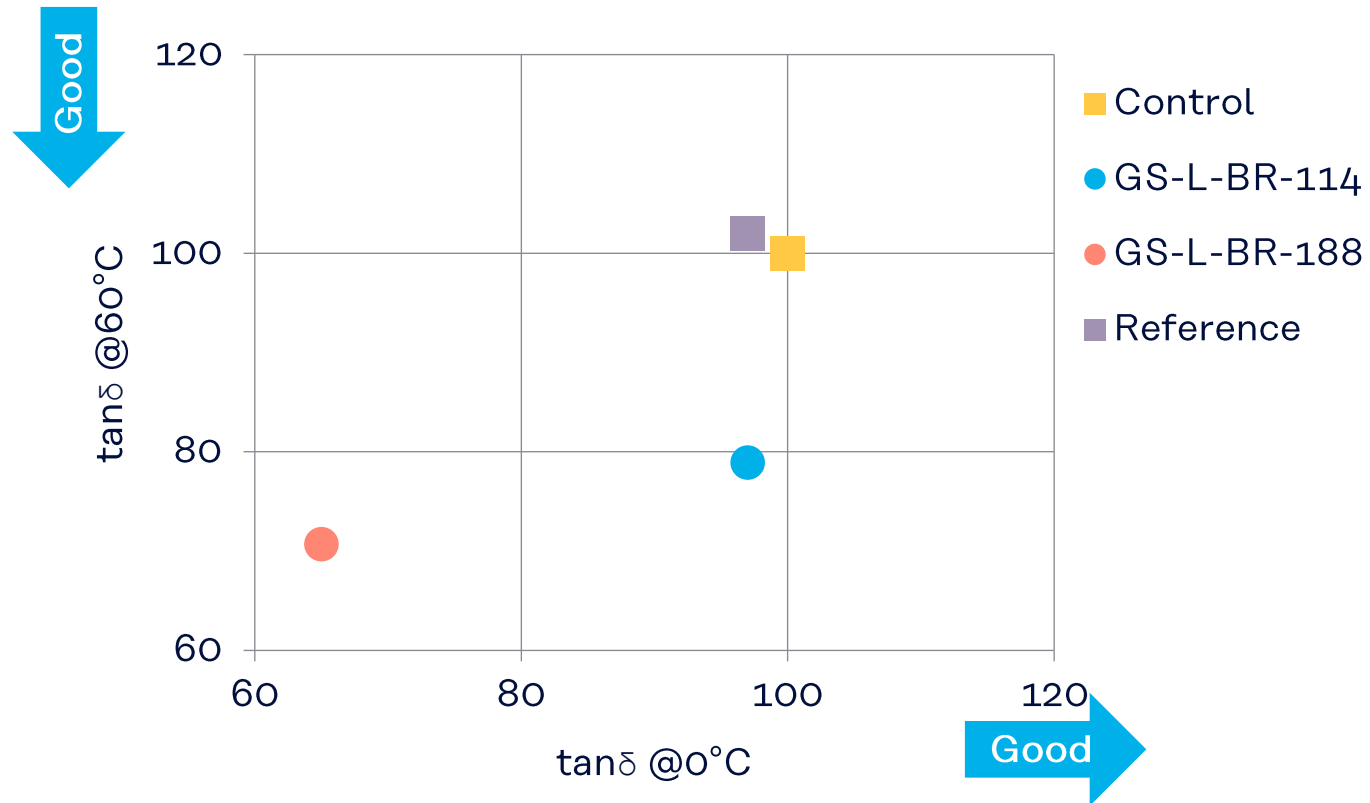
			Control	GS-L-BR-114	GS-L-BR-188	Reference
Mooney Viscosity (ML1+4, @130°C)			36.3	45.8	47.9	28.0
DIN Abrasion index			100	70	134	56
Mechanical Properties						
Hardness	Type A		73	75	74	54
EB	(%)		425	400	305	630
TB	(MPa)		23.5	16.9	21.7	17.2
M100	(MPa)		3.39	3.09	4.72	1.13
M300	(MPa)		15.8	11.7	20.4	2.41
DMA (Dynamic Mechanical Analysis)						
E'	0°C	(MPa)	16.2	15.5	11.4	7.55
	25°C	(MPa)	11.3	10.4	9.13	5.5
	60°C	(MPa)	9.75	8.26	8.17	4.86
tanδ	0°C	(-)	0.454	0.442	0.295	0.441
	25°C	(-)	0.3	0.263	0.199	0.268
	60°C	(-)	0.193	0.152	0.136	0.197
Payne effect (0.5%E'-5.0%E') index			100	65	57	55

DMA [Dynamic Mechanical Analysis]



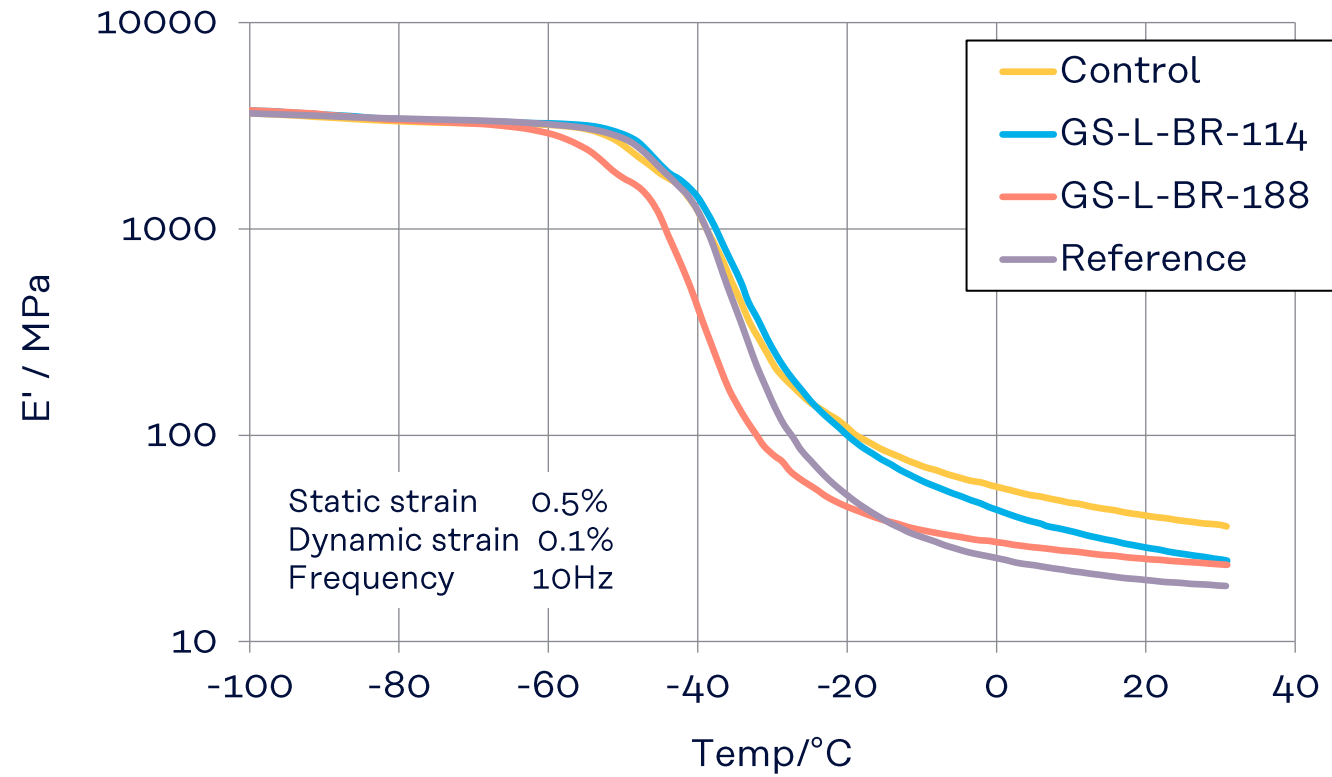
GS-L-BR shows better rolling resistance.

DMA [Dynamic Mechanical Analysis]



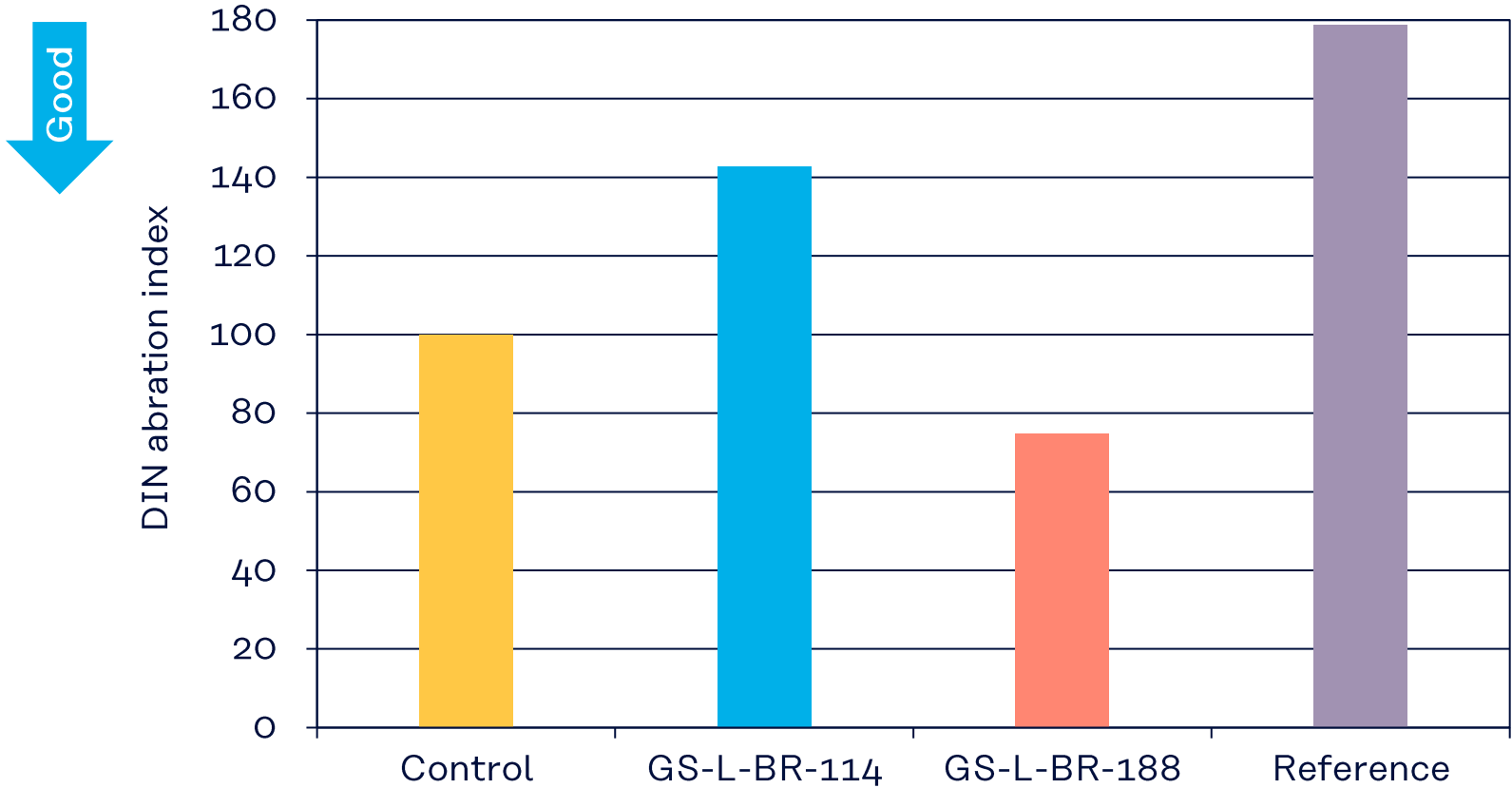
GS-L-BR shows better rolling resistance.

DMA [Dynamic Mechanical Analysis]



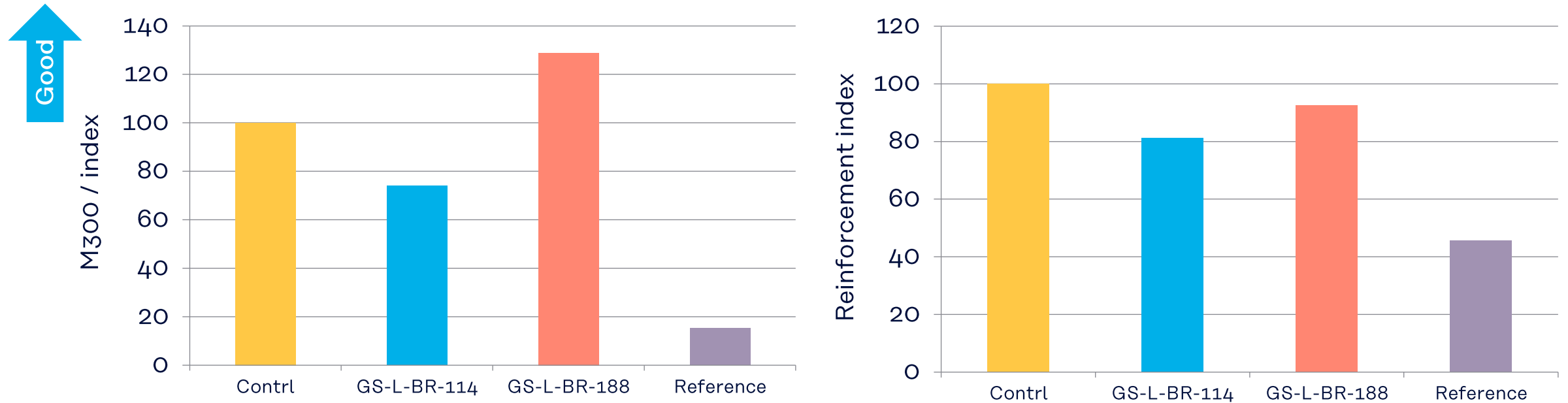
GS-L-BR-188 improves ice grip from the result of low E' at -20°C .

DIN abrasion resistance



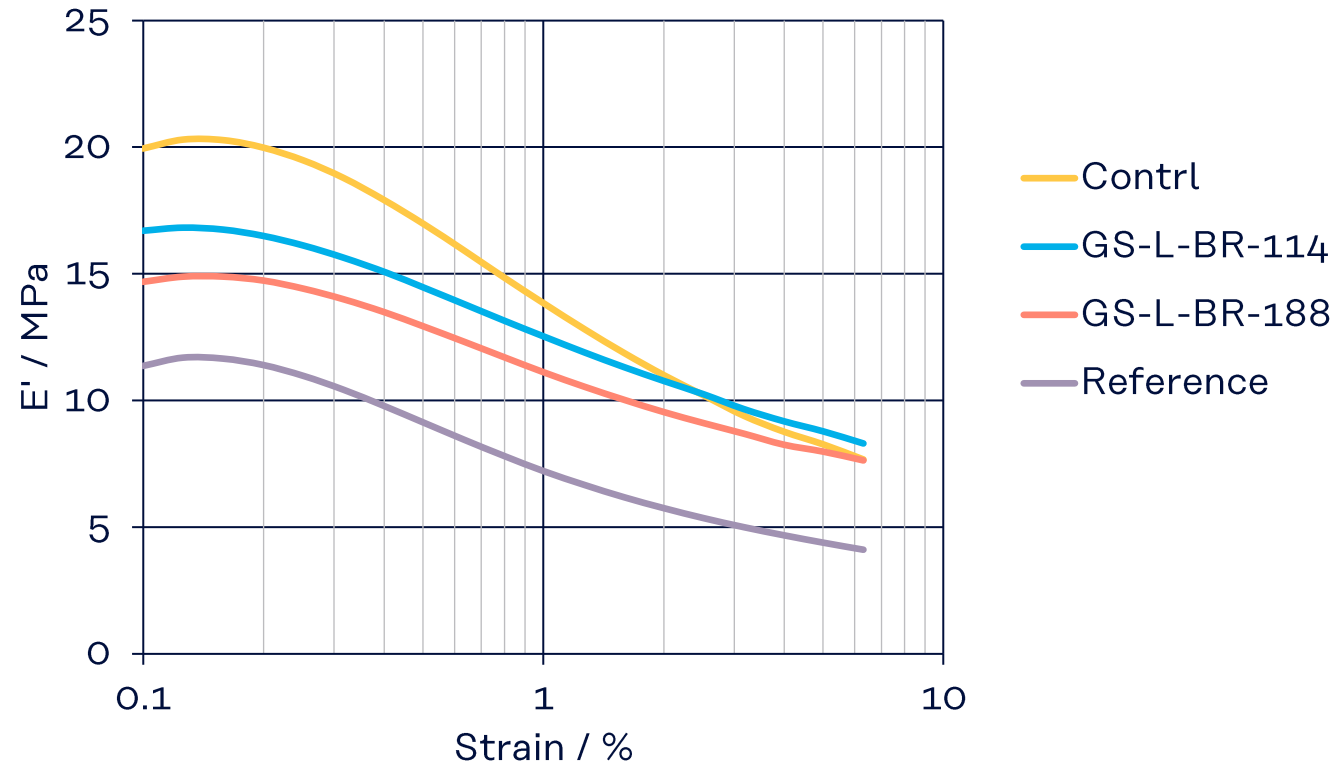
GS-L-BR-188 is able to improve abrasion resistance significantly.

Silica-polymer interaction Analysis of 300% modulus and Reinforcement Index



GS-L-BR reinforced silica-polymer interaction as much as Si 75[®].

Payne effect



GS-L-BR improves silica dispersion.

Summary

- **GS-L-BR**
 - improves dispersibility of silica
 - crosslinkable with base rubber
 - improves silica-polymer interaction
- **GS-L-BR-114**
 - enhanced interaction between silica-polymer for better rolling resistance
- **GS-L-BR-188**
 - enhanced interaction between silica-polymer for better abrasion resistance
 - for better rolling resistance

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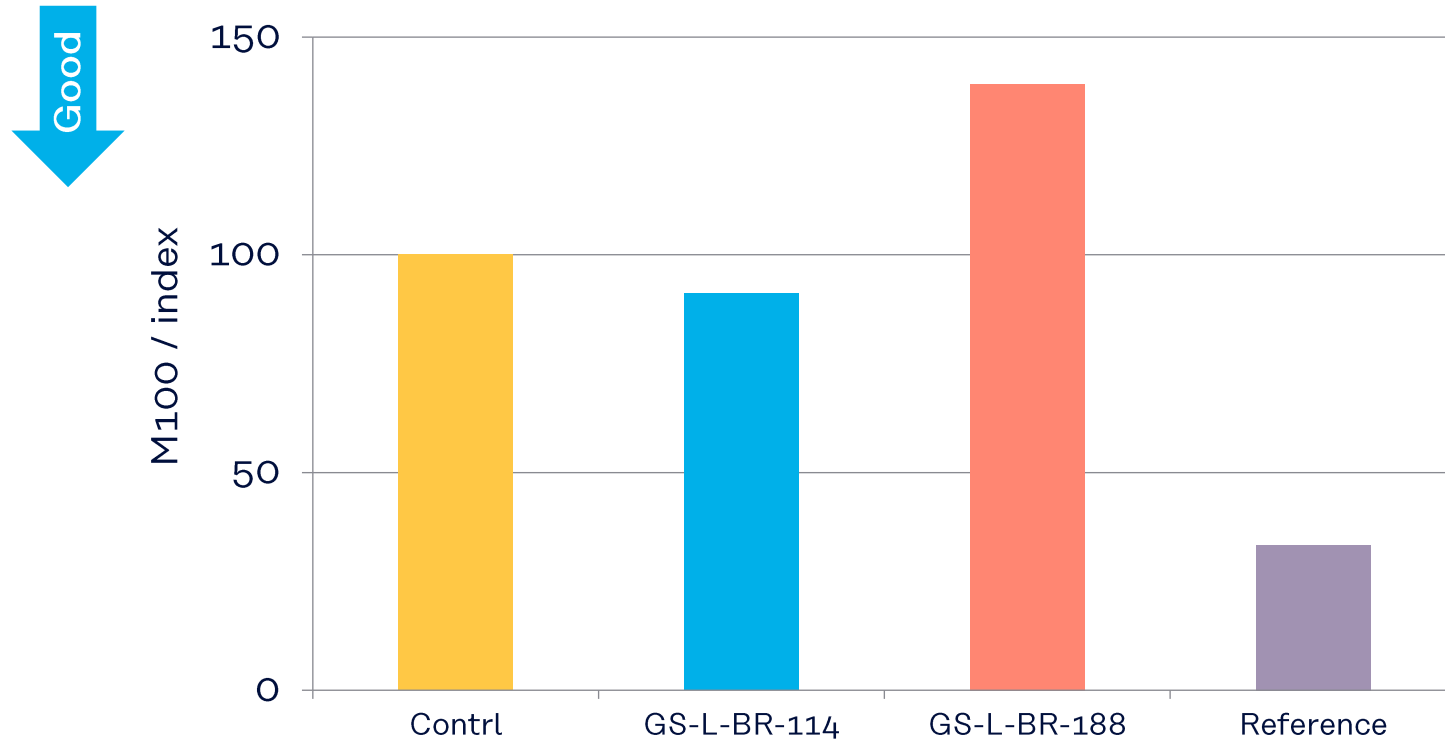
Precautions should be taken in handling and storage. Please refer to the appropriate Safety Data Sheet for further safety information. In using KURARAY LIQUID RUBBER, please confirm related laws and regulations, and examine its safety and suitability for the application.

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.

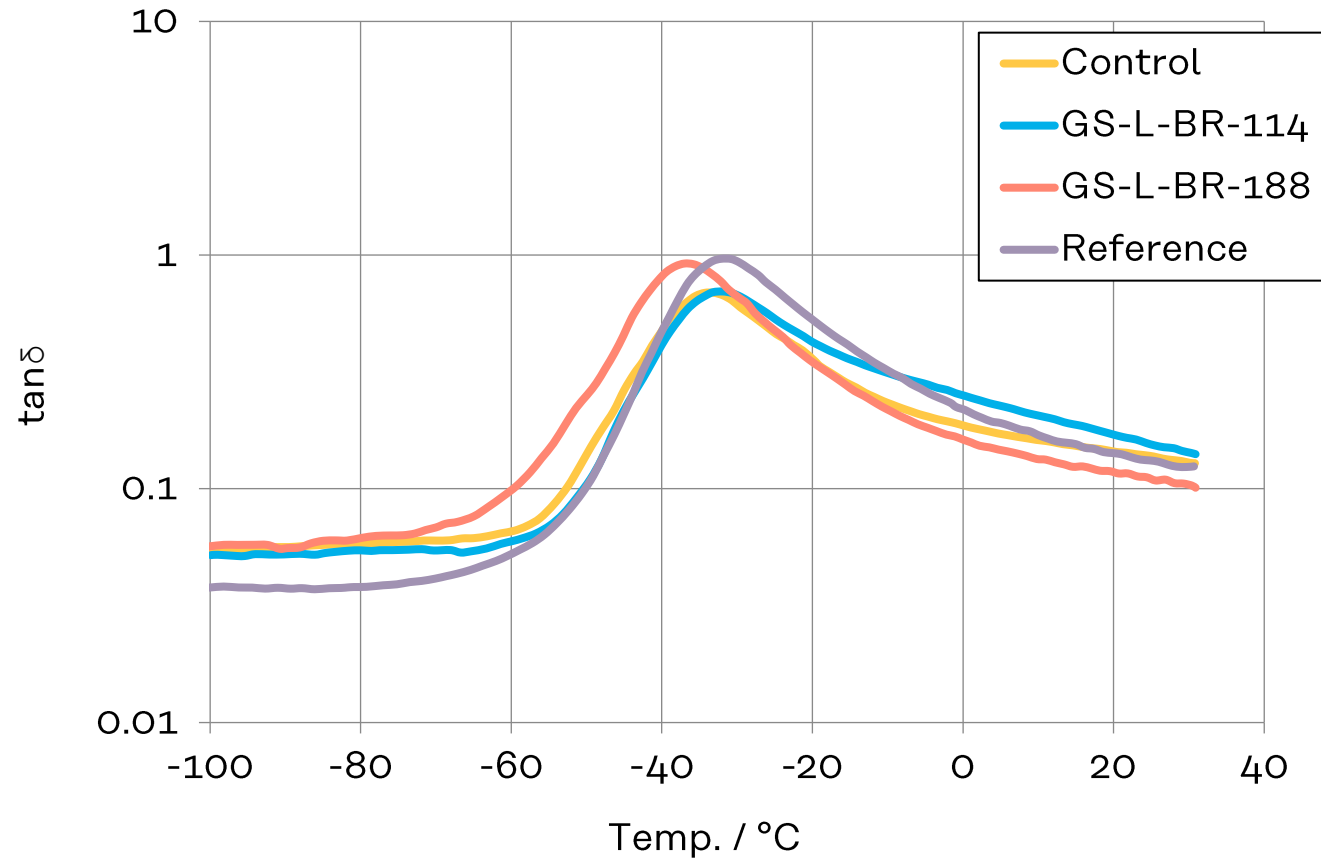
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APPENDIX

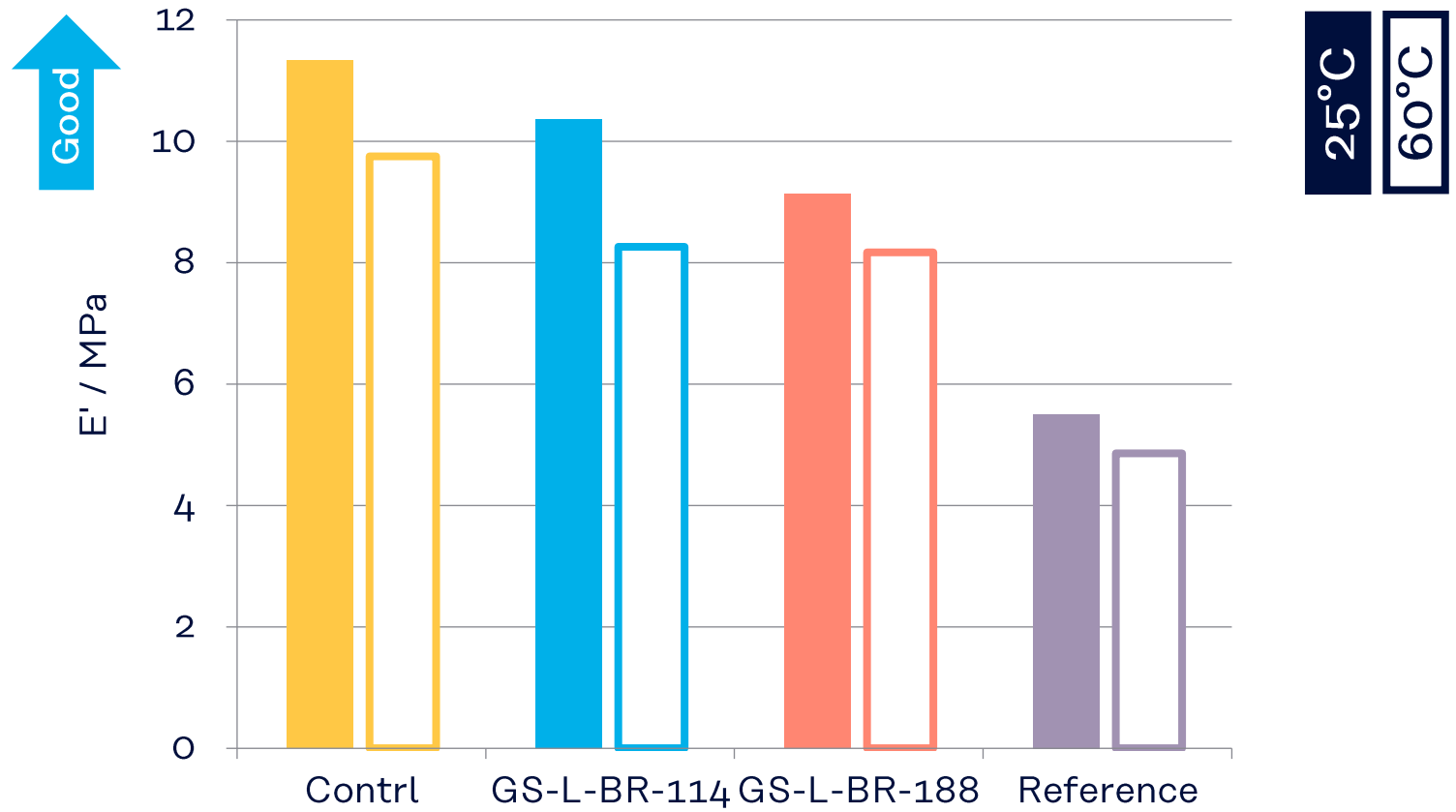
Analysis of 100% modulus [M100] for silica-silica interaction



DMA [Dynamic Mechanical Analysis]



E' [Steering stability]



Raw material

Material	Product Name	Manufacturer	Note
Styrene-butadiene rubber	JSR 1500	JSR Corporation	St/Bd: 23.5/76.5 (wt/wt) Vinyl content: 15% Tg: -53 °C
Silica	ULTRASIL [®] 7000GR	Evonik Industries AG	Specific surface area (N2) 175 m ² /g
Silane Coupling Agent	Silquest [™] A-137	Momentive Performance Materials Inc.	
Silane Coupling Agent	Si 75 [®]	Evonik Industries AG	
TDAE	VIVATEC 500	H&R GmbH Co. KGaA	