No.RRL10-017

Technical Insight of KURARAY LIQUID RUBBER

Silane functionalized LBR

Comparison of graft type vs. end functionalized type

Elastomer R&D Department
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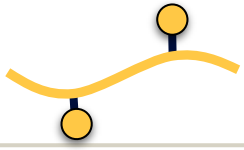
Agenda

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

1) Polymer structure & typical properties

2) Evaluation in f-SSBR formulation

Structure & typical properties of silane functionalized liquid polybutadiene

Sample name [Development code]	Structure	Mw	Tg (°C)	Number of functional group / chain
GS-L-BR-114 [SB-005]	Graft functionalized 	6,000	-50	2
LBR-Si*	Mono end-functionalized 	5,500	-50	0.97
LBR-diSi*	Telechelic 	6,300	-41	1.4
LBR	Non-functionalized 	5,500	-49	none

*Only for the research purpose.

Formulation & Mixing Conditions

	Control	Formulation
S-SBR	80	80
BR	20	20
TDAE	40	30
Liquid Rubber	-	10
Silica	100	100
SCA	8.0	8.0
ZnO	3.0	3.0
Stearic acid	2.5	2.5
Anti oxidant 6C	2.5	2.5
Wax	2.0	2.0
OT-20	1.9	1.9
Accelerator DPG	0.5	0.5
Accelerator CBS	3.5	3.5
Accelerator TBTD	1.5	1.5

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	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)

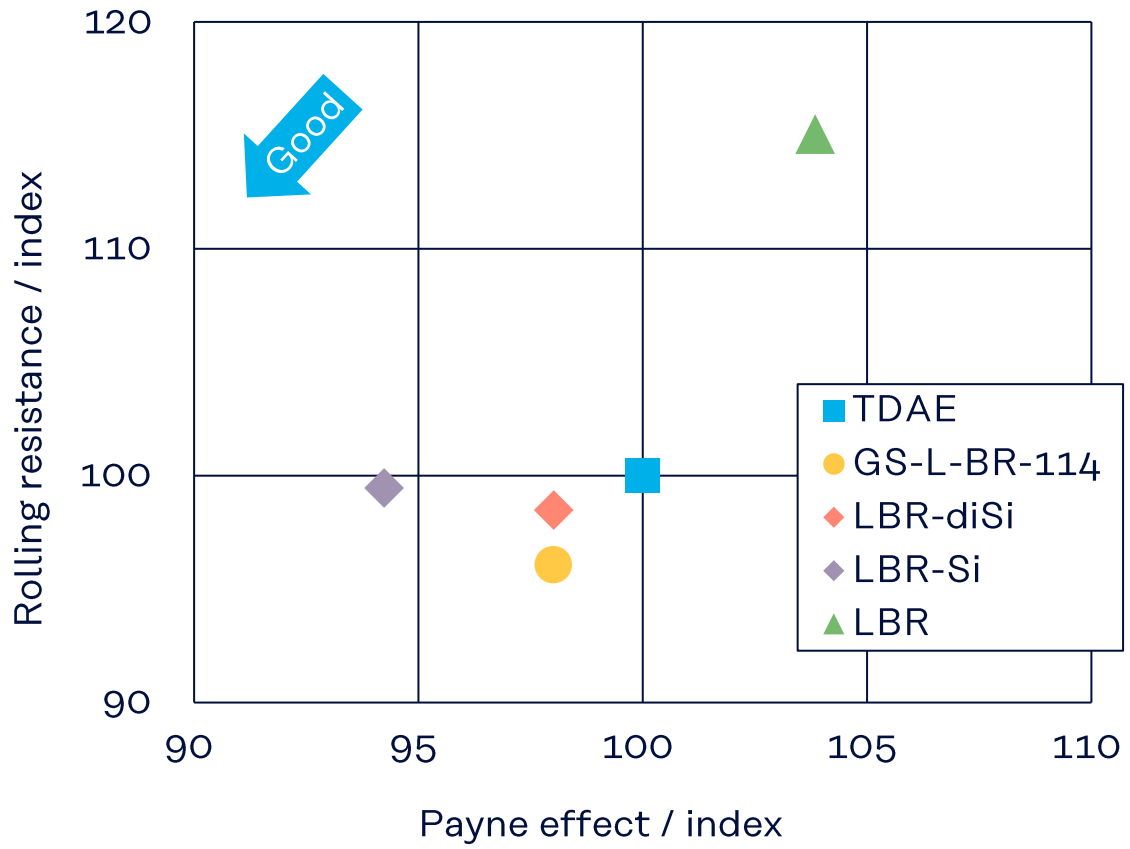
*MIXTRON® BB Mixer (by Kobe Steel, Ltd.)

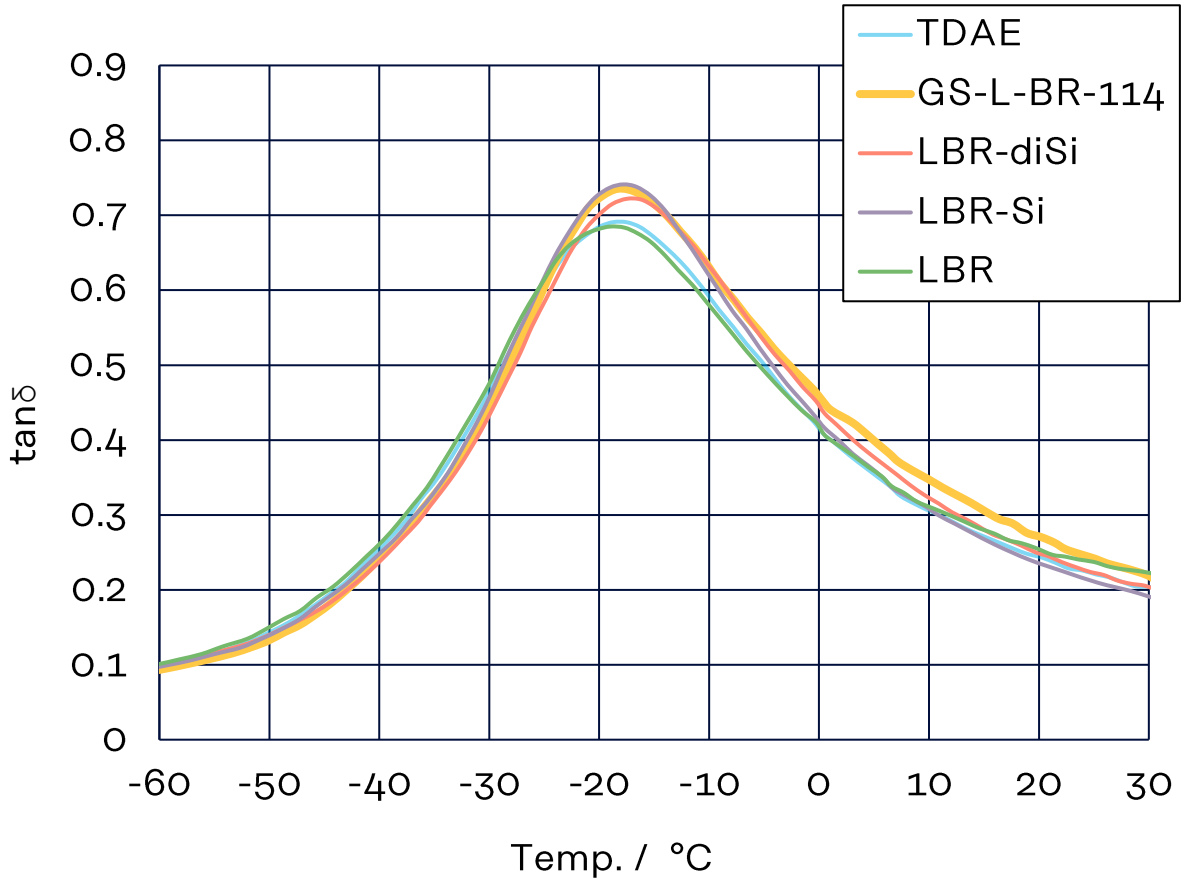
Summary of Properties

(normalized value to TDAE)

		TDAE	GS-L-BR-114	LBR-diSi	LBR-Si	LBR
Mw			6.0k	6.3k	5.5k	5.5k
Number of functional group			2	1.4	0.97	none
Mooney Vis. (130°C, ML1+4)		100	99	105	107	102
t90 (160°C)		100	180	139	123	115
Mechanical properties						
Hardness		100	103	102	100	100
Elongation at Break		100	98	100	105	106
Tensile at Break		100	101	107	106	105
Modulus 100%		100	107	112	103	96
Modulus 300%		100	106	111	102	94
Payne effect		100	98	98	94	104
Viscoelasticity (10% to 2%, -50 to +70°C)						
E'	0°C	100	111	110	105	106
	60°C	100	113	112	110	101
tanδ	0°C	100	94	97	94	100
	60°C	100	96	98	99	115
Abrasion resistance (FPS, 5%)		100	95	118	126	88
Friction coefficient on Wet		100	103	99	97	102

Silica dispersion

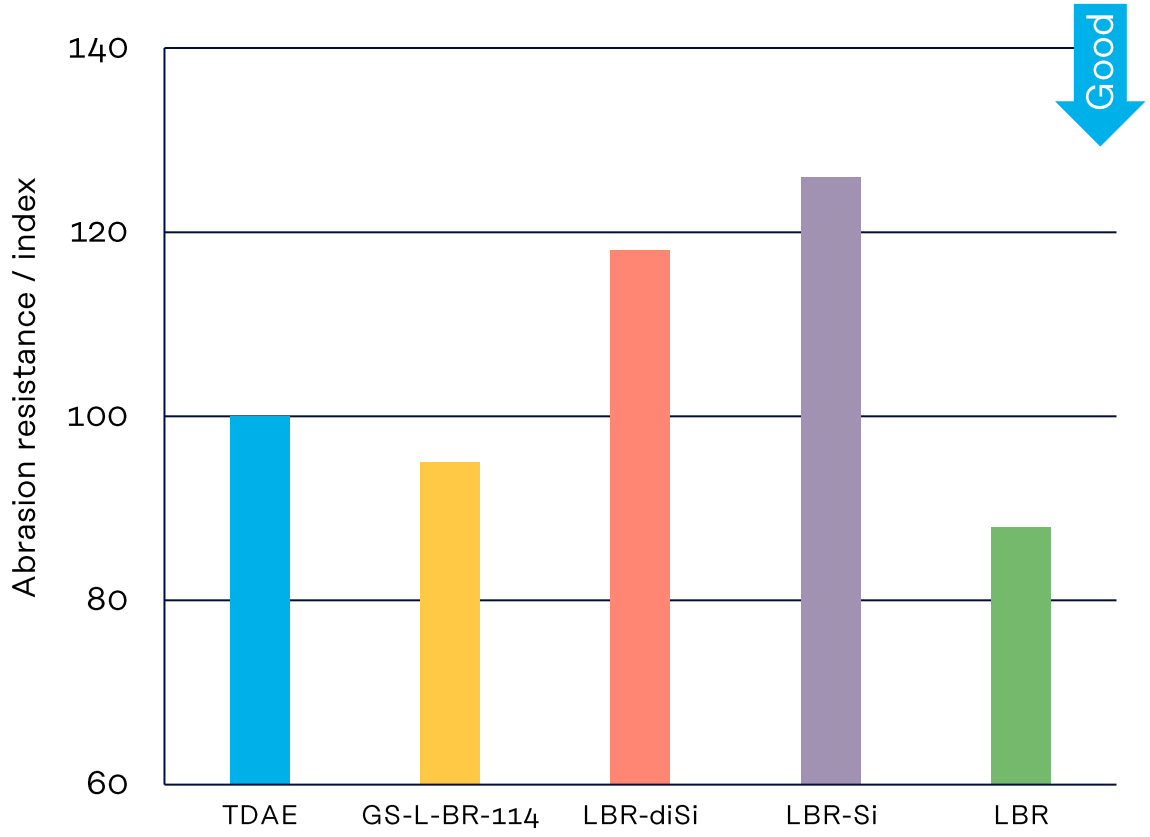


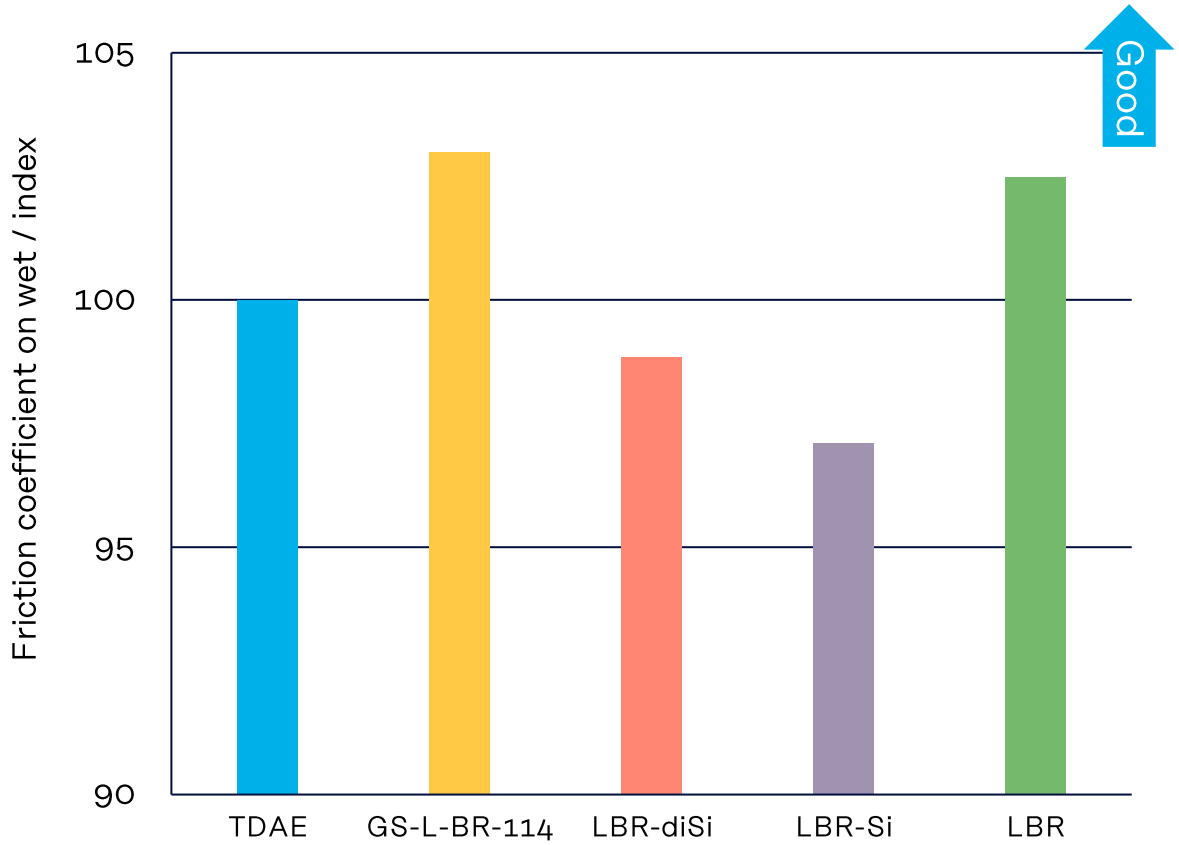


Comparison of graft type and end functionalized type

- Equivalent effect on silica dispersion as well as rolling resistance

Abrasion resistance and Friction on wet





Comparison of graft type and end functionalized type

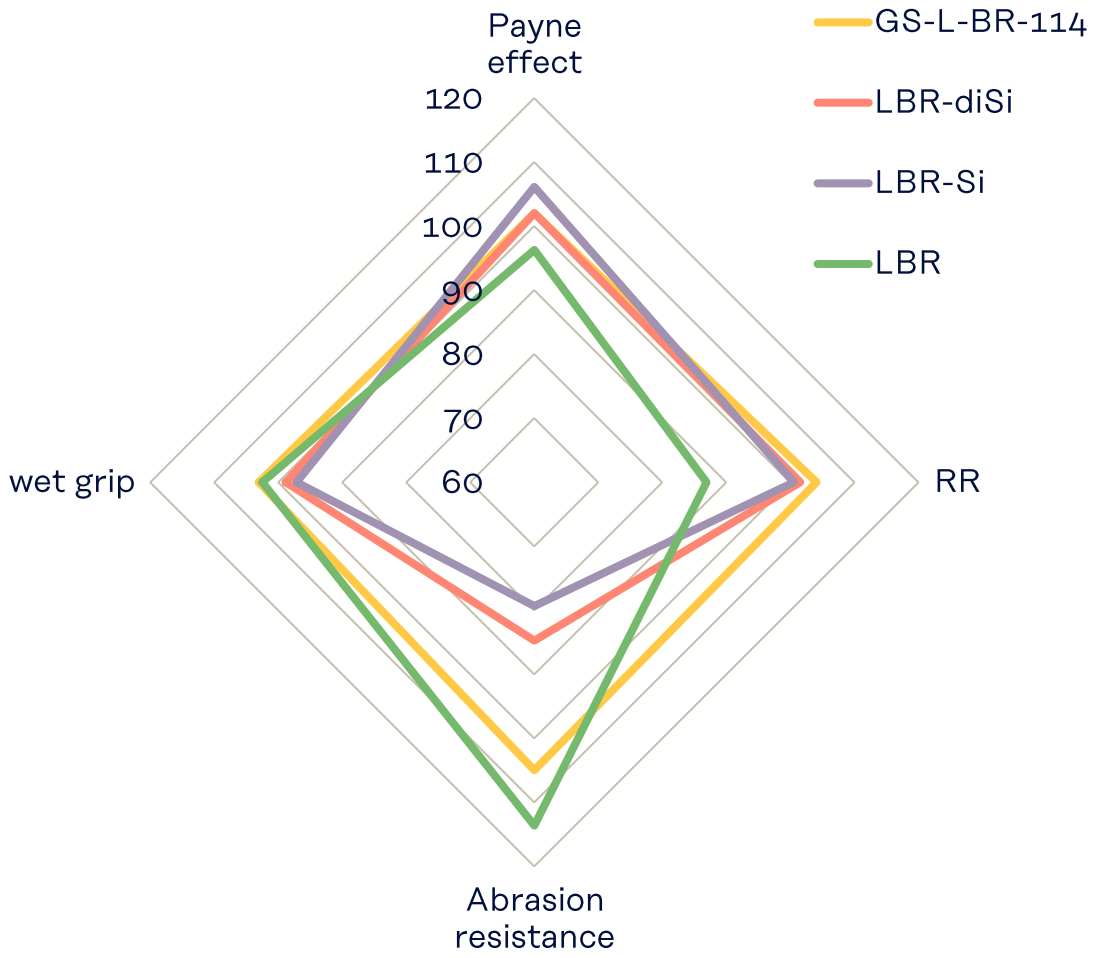
- Graft type exhibited better abrasion and wet grip performance.

Summary

Feature of graft type compared with terminal type

- Equivalent rolling resistance & silica dispersion
- Better abrasion and wet grip performance

Graft functionalized LBR is superior in terms of well-balanced properties.



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APPENDIX

Raw materials

Material	Product Name	Manufacturer	Note
Styrene-butadiene rubber	JSR HPR355	JSR Corporation	Styrene content: 27% Mooney Vis. @100°C: 44 Tg: -24°C
Butadiene Rubber	JSR BR01	JSR Corporation	Cis content: 95% Mooney Vis. @100°C: 45
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