Technical Insight of KURARAY LIQUID RUBBER

Localized Silane modified LR for SBR / Silica formulation

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) Localized Silane modified LR (GS-L-BR)

2) Evaluation in SBR / Silica formulation

Silane modified LR　(GS-L-BR)

Grade Name [Development Code]	Structure	Number of functional groups / chain	Mw	Tg (°C)	Viscosity at 38°C (Pa • s)
[SB-007]	Butadiene & Isoprene /both ends Localized silane 	2.2	7,000	-48	6
[SB-008]	Butadiene & Isoprene /one end Localized silane 	1.5	8,000	-64	3
[SB-002]	Butadiene /terminated silane	1	5,500	-50	3
GS-L-BR-114 [SB-005]	Butadiene /Graft silane	2	6,000	-50	6
GS-L-BR-188 [SB-006]	Butadiene /Graft silane	4	38,000	-88	124

● = functional group (triethoxysilane)

Silane modified LR (GS-L-BR)

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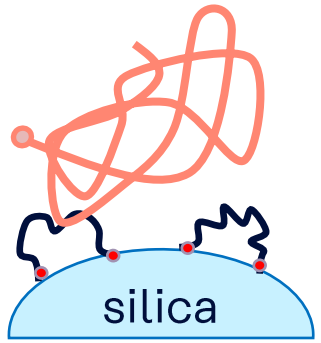
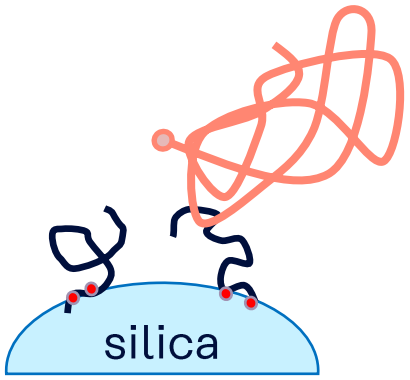


both ends localized



one end localized

- High reactivity with silica
- Crosslinkable with base rubber
- Functional groups are localized
  - Equal or better property than terminal silane modified LR (SB-002)

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Agenda

1) Localized Silane modified LR (GS-L-BR)

2) Evaluation in SBR / Silica formulation

Formulation & Mixing Conditions

	Formulation
f-SSBR	80
BR	20
Silica	100
SCA	8
TDAE	28
GS-L-BR	12
Chemicals	ZnO 3.0, Stearic acid 2.5 6PPD 2.5, Wax 2.0
Sulfur Accelerators	S 1.5 DPG 0.5, CBS 0.35, TBTD 1.5

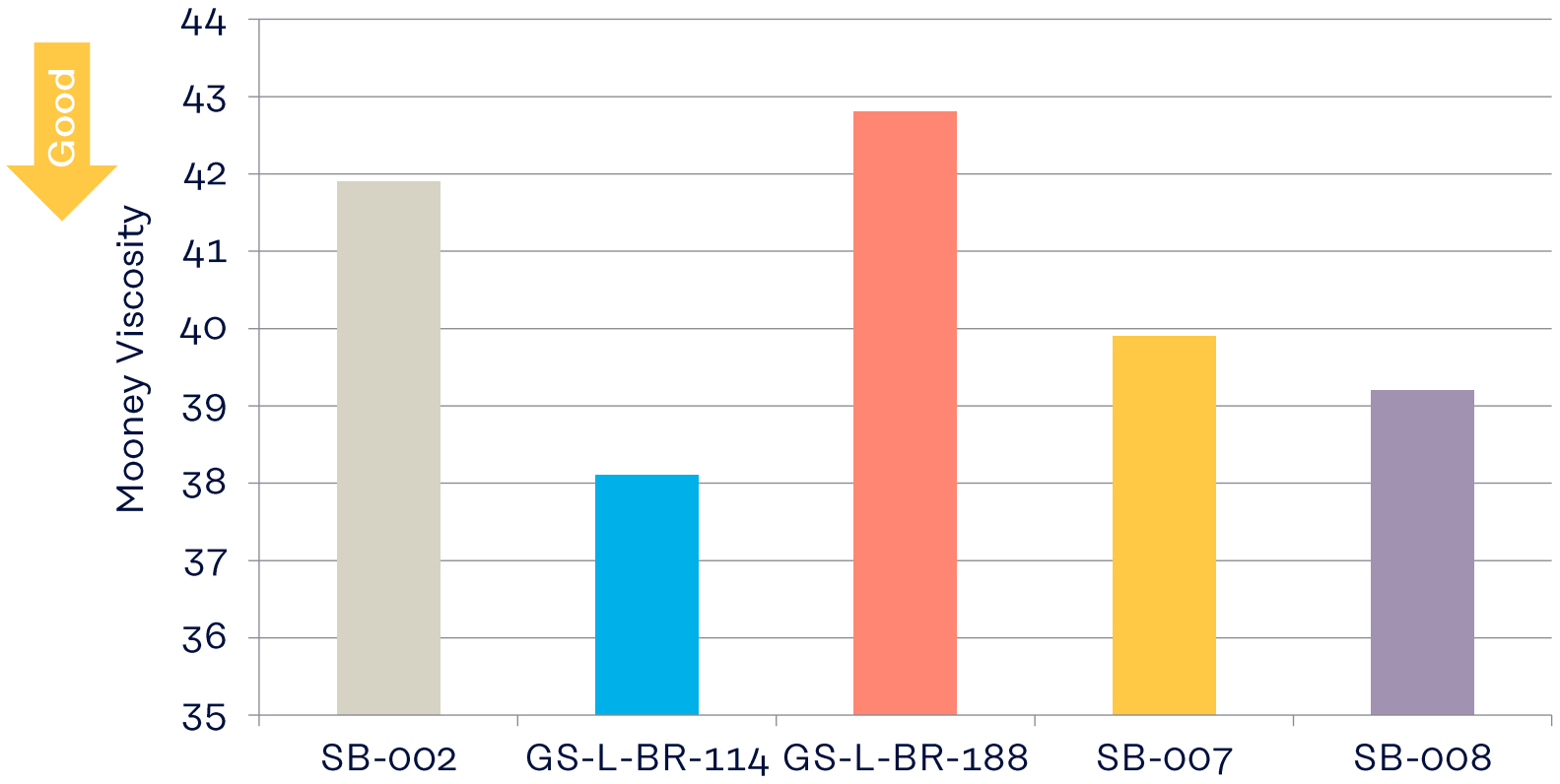
Mixing Conditions		
NP1	sec	Banbury-type mixer*
	0	Solid rubber (60°C)
	20	Silica, SCA, TDAE, LR, Chemicals
	180	Sweep
	360	Dump out (150-160°C)
NP2		Banbury-type mixer*
	0	1st mixed compound(90°C)
	240	Dump out (150-160°C)
FM		Banbury-type mixer*
	0	Compound, Sulfur, Accelerators (50°C)
	75	Dump out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

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

Summary of properties

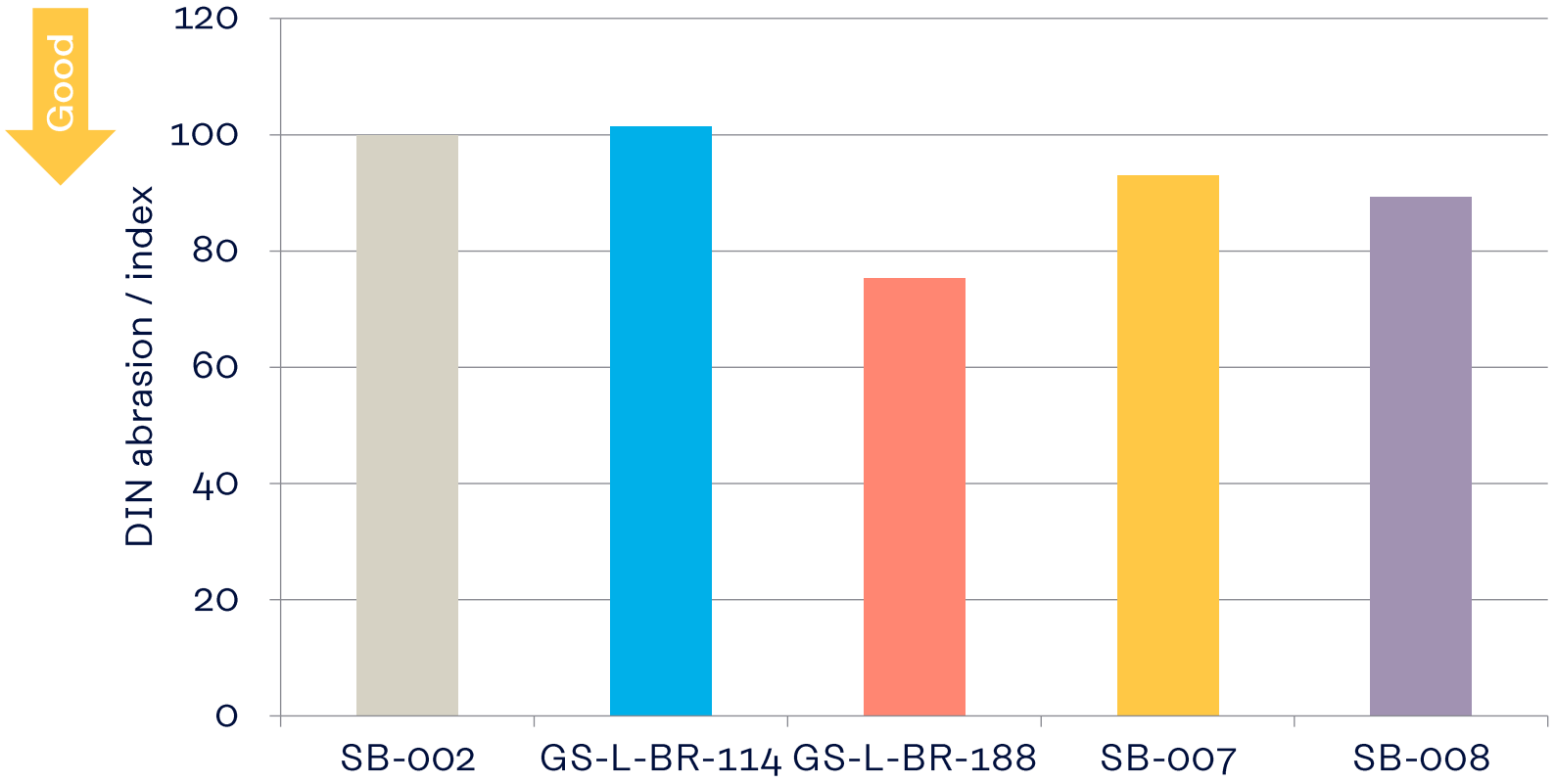
			SB-002 (Control)	GS-L-BR-114	GS-L-BR-188	SB-007	SB-008
Mooney Viscosity (ML1+4, @130°C)			41.9	38.1	42.8	39.9	39.2
DIN Abrasion		index	100	99	133	107	112
Mechanical Properties							
Hardness		Type A	59	66	63	65	59
EB		(%)	430	405	325	435	460
TB		(MPa)	20.7	20.3	17.6	22.3	21.6
M100		(MPa)	2.12	2.54	3.01	2.55	2.09
M300		(MPa)	12.1	13.1	15.4	13.9	11.7
DMA (Dynamic Mechanical Analysis)							
E′	0°C	(MPa)	9.93	14.55	8.79	13.44	10.06
	25°C	(MPa)	5.35	7.50	5.69	6.84	5.56
	60°C	(MPa)	3.92	5.15	4.39	4.77	3.98
tanδ	0°C	(-)	0.601	0.655	0.444	0.659	0.595
	25°C	(-)	0.285	0.330	0.219	0.320	0.293
	60°C	(-)	0.152	0.172	0.141	0.166	0.169
Payne effect (0.5%E′-5.0%E′)		(MPa)	1.90	3.93	1.58	3.43	2.20

Mooney Viscosity



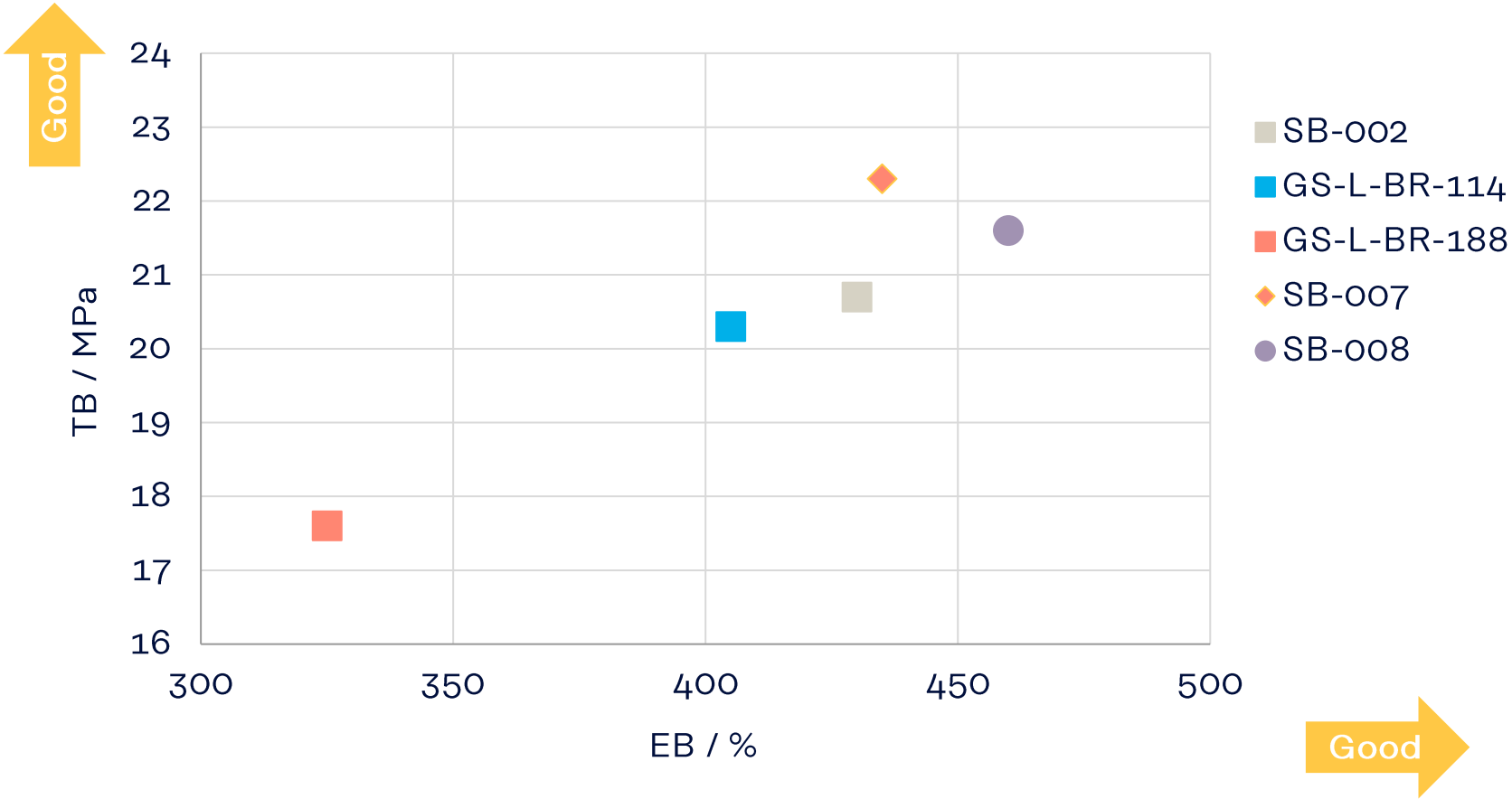
- SB-007 & SB-008 show lower Mooney Viscosity than SB-002.

DIN abrasion resistance



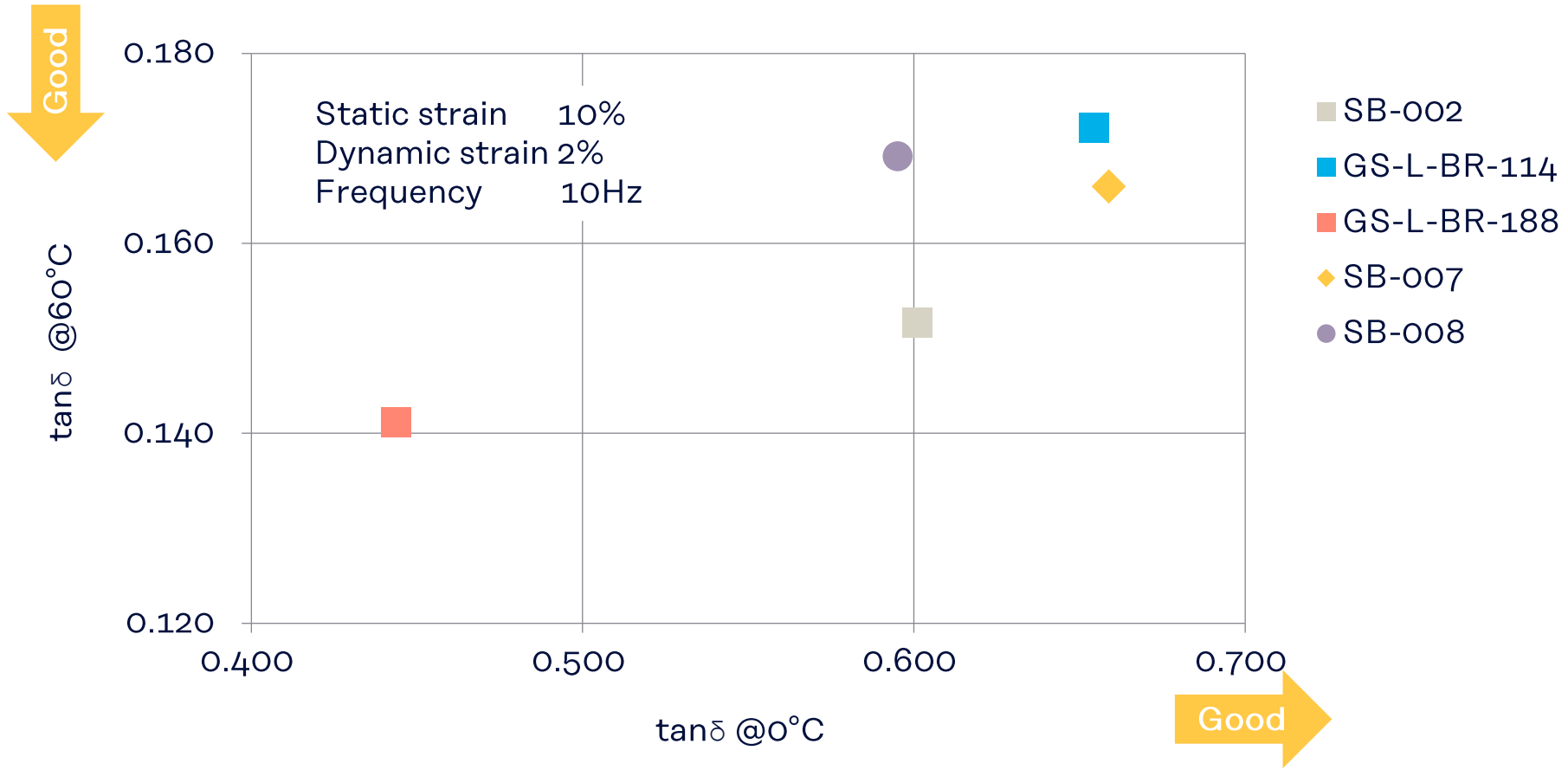
- SB-007 & SB-008 show better abrasion resistance than SB-002.

Tensile property



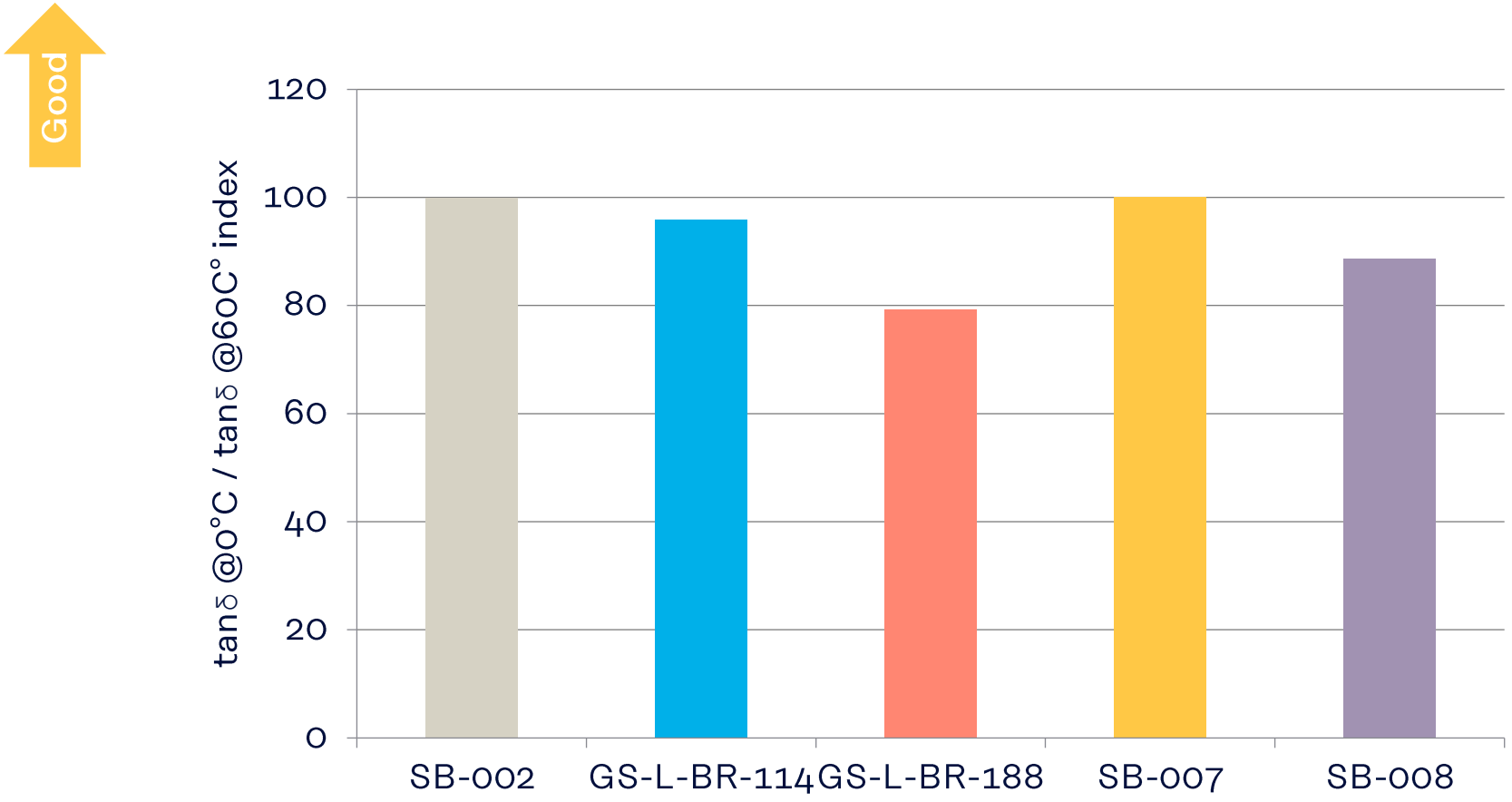
- SB-007 & SB-008 show better EB & TB than SB-002.

DMA [Dynamic Mechanical Analysis]



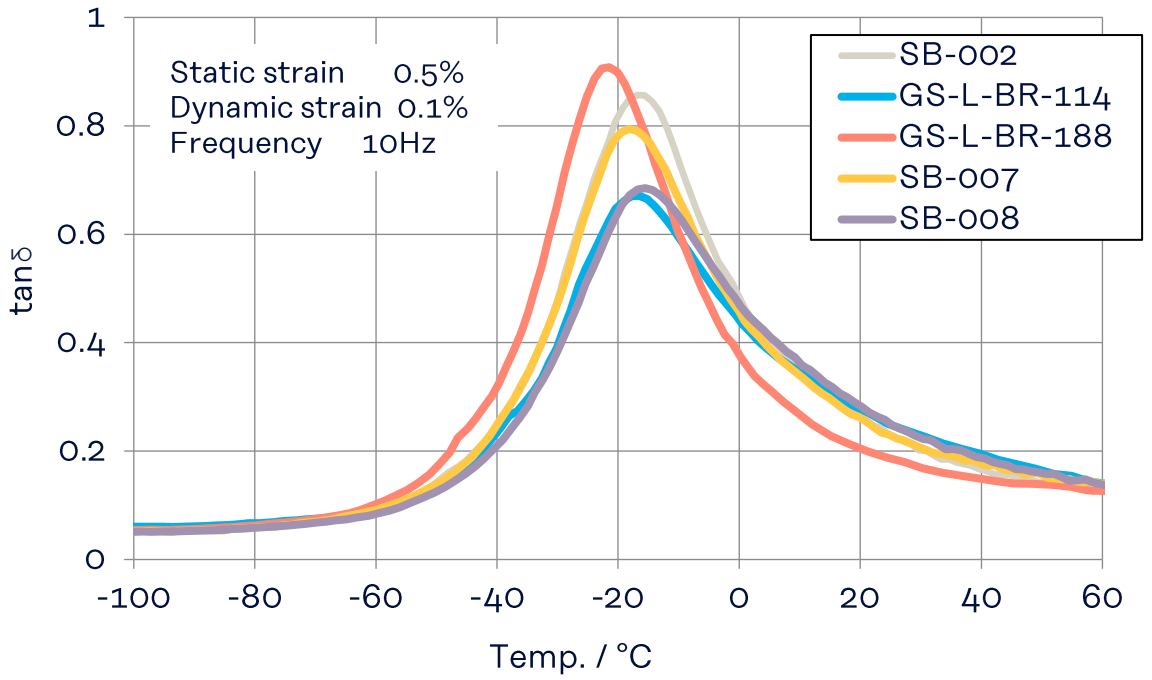
- SB-007 shows better wet grip than SB-002.

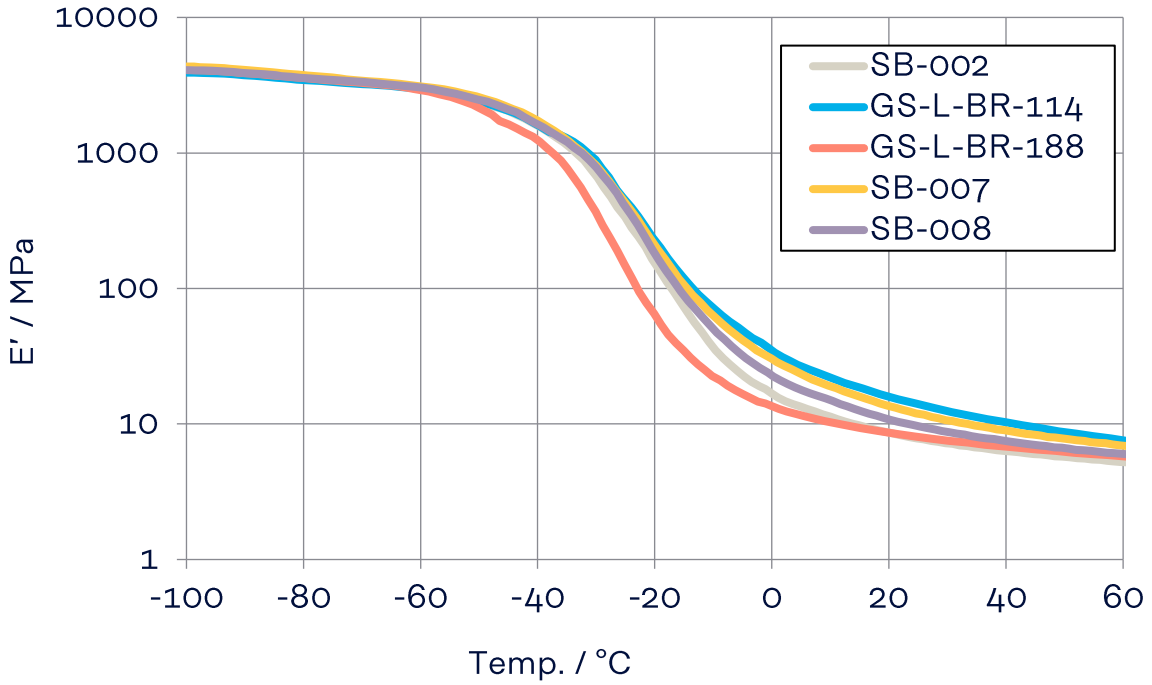
Tanδ balance (wet grip and rolling resistance)



- SB-007 shows same balance as SB-002.

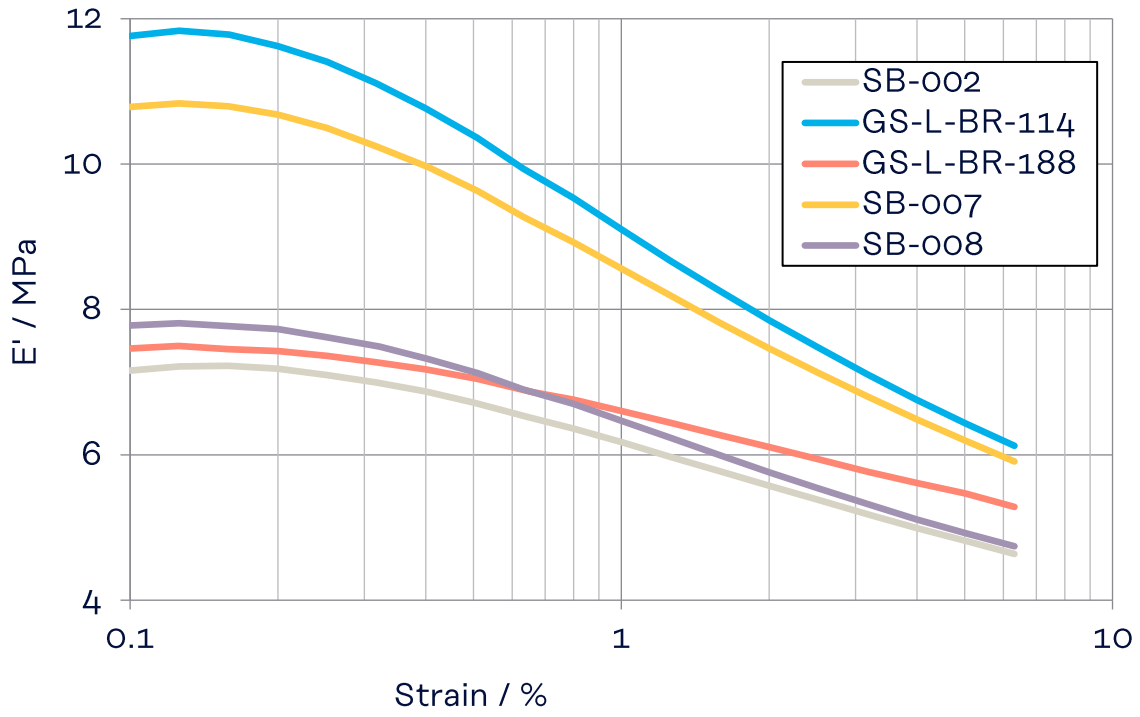
DMA [Dynamic Mechanical Analysis]

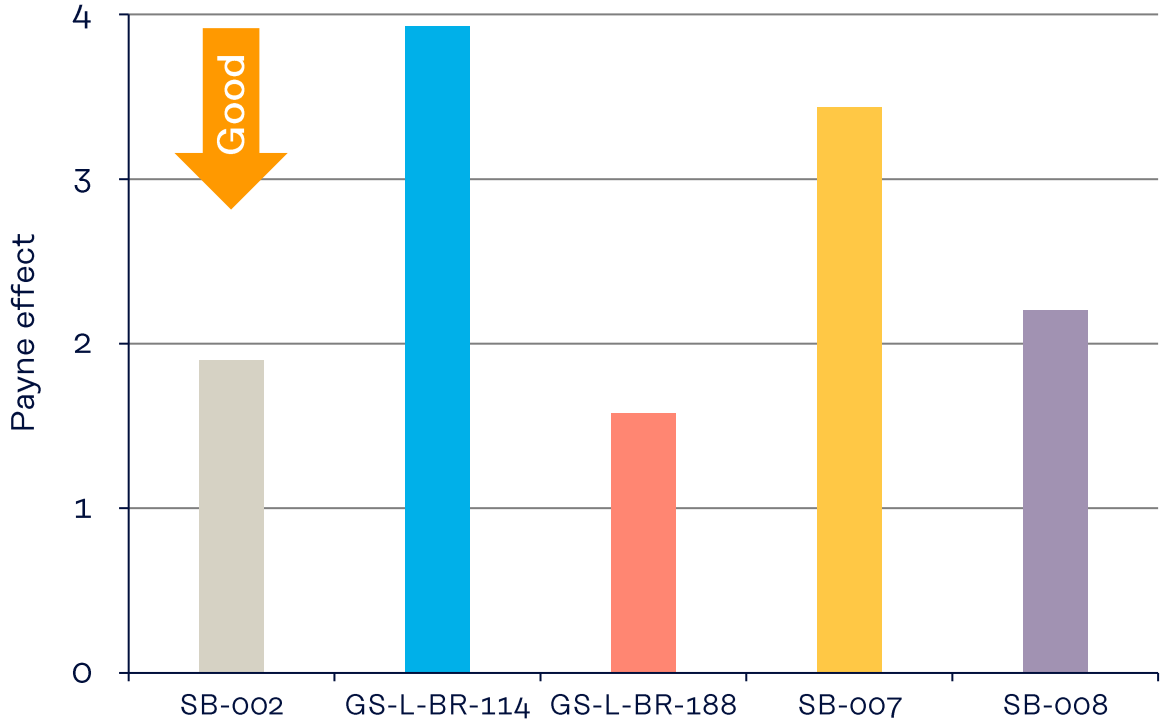




- SB-007 improves wet grip from the result of high tanδ at 0°C.

Payne effect





- SB-008 shows similar Payne effect to SB-002.

Summary

- SB-007 does not improve rolling resistance.
- SB-007 maintains tanδ balance.
- SB-007 improves Mooney viscosity, hardness, tensile properties, abrasion 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 RUBBAR 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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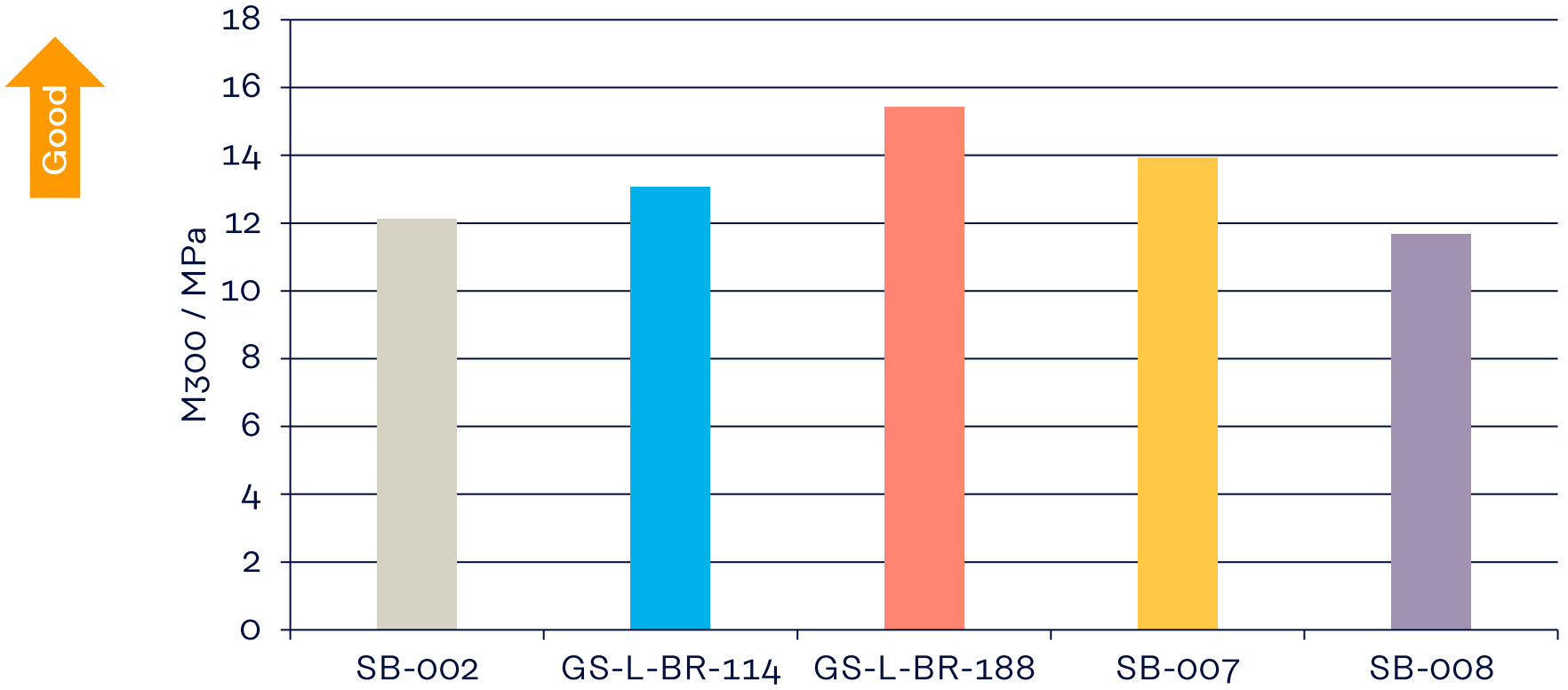
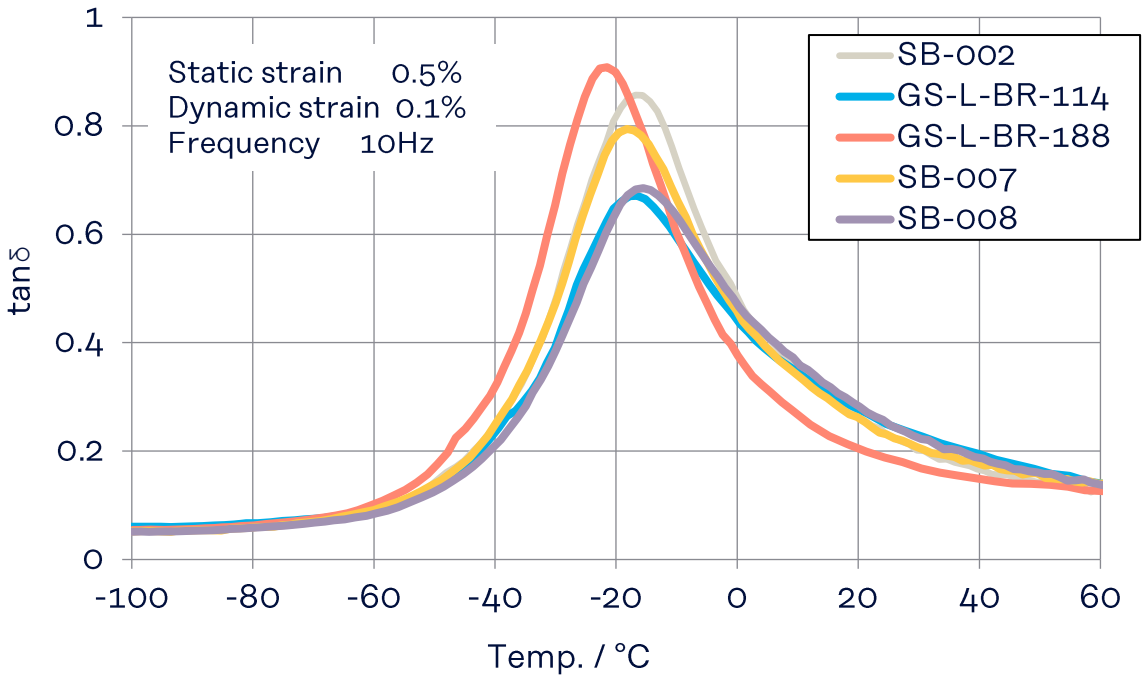
APPENDIX

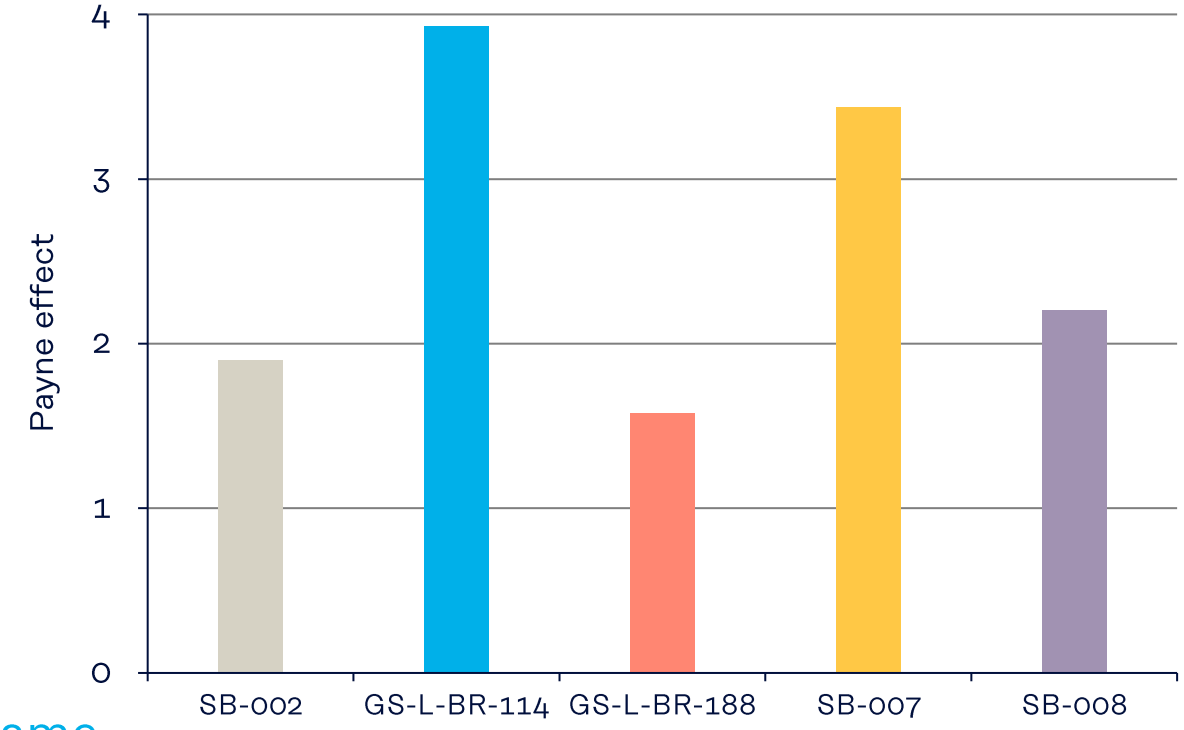
Analysis of 300% modulus (M300) for Silica-Polymer interaction



- SB-007 enhances silica-polymer interaction from the result of higher M300 than SB-002.

Correlation between sharpness of tanδ curve and silica dispersion





Sharpness of tanδ curve
(sharp) GS-L-BR-188 > SB-002 > SB-008 > GS-L-BR-114, SB-007 (broad)

same tendency

Payne effect (silica dispersion)
(good) GS-L-BR-188 > SB-002 > SB-008 > SB-007 > GS-L-BR-114 (poor)

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
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	