MOMENTIVE™

NXT* Z45 silane

coupling agent for silica-reinforced tire tread compounds

SILANES - TIRE & RUBBER

NXT Z45 silane offers a virtually ethanol emission-free option for enhanced tire performance with overall systems cost-efficiencies for tire manufacturers.

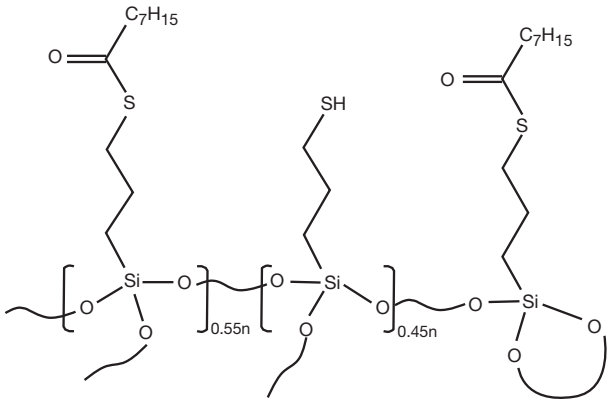
NXT Z45 silane is an oligomeric combination of mercapto and thiocarboxylate functional silanes. It can help improve dynamic and physical properties, reduce overall manufacturing costs through improved processing, lower use levels, and virtually eliminate ethanol emissions.

Silica compounds coupled with NXT Z45 silane generally exhibit improved silica dispersion, easier mixing, and faster pliable processing. The free mercaptan functionality helps provide high reactivity and increased coupling. The blocked mercaptan aids silica dispersion improve processability. Scorch safety can be increased by the partial or complete substitution of diphenylguanidine (DPG) with Tetrabenzylthiuram disulfide (TBzTD) in the cure package. Compounds containing NXT Z45 silane can exhibit lower Payne Effect, improved tan delta values, and better resilience properties.

Key Features and Typical Benefits

- Fewer non-productive mixing steps
- Reduced compound viscosity
- Faster extrusion
- Improved Payne Effect
- Increased resilience
- Decreased Tan δ max
- Excellent dynamic properties at low temperature (-20 °C to +10 °C)
- Reduced Heat Build-up (HBU)
- Lower use level than standard silanes

Chemical Structure



Mercapto – thiocarboxylate Oligomer (Mol. Wt. 440)

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Table 1: Typical Silica-Reinforced Tire Tread Formulation Used to Evaluate NXT Z45 silane

	Compounds with DPG (2.0 phr)			Compounds with TBzTD (0.3 phr)		
Ingredients	**S2**	**S4**	**NXT Z45**	**S2**	**S4**	**NXT Z45**
NP1						
Buna VSL 5025-1, OE	96.3	96.3	96.3	96.3	96.3	96.3
Buna CB 24	15.0	15.0	15.0	15.0	15.0	15.0
TSR-20	15.0	15.0	15.0	15.0	15.0	15.0
Zeosil 1165MP	80.0	80.0	80.0	80.0	80.0	80.0
N-330 CB	10.0	10.0	10.0	10.0	10.0	10.0
Sundex 8125 Proc. Oil	5.0	5.0	5.0	5.0	5.0	5.0
6PPD	2.0	2.0	2.0	2.0	2.0	2.0
MC Wax	1.5	1.5	1.5	1.5	1.5	1.5
TESPD, S2 silane[1]	5.64			5.64		
TESPT, S4 silane[2]		**6.40**			**6.40**	
NXT Z45 silane			**5.30**			**5.30**
ZnO	2.5	2.5	2.5	2.5	2.5	2.5
Steric Acid	2.0	2.0	2.0	2.0	2.0	2.0

(1) S2 (TESPD) silane and S4 (TESPT) silane containing compounds were formulated having equivalent number of silane molecules (2 molecules per mole) and total sulfur content.

(2) The NXT Z45 silane compounds contained slightly less silane molecules and total sulfur content than the S2 and S4 compounds.

Table 2: Typical Cure Package for Silica-Reinforced Tire Tread Formulation Using Standard Sulfur Silane as a Coupling Agent

Ingredients	phr	Description
NP2		
Remill	—	—
FM		
Sulfur	variable	Varies per silane
CBS	2,0	N-cyclohexyl-2-benzothiazolesulfenamide
DPG	2.0	N,N-Diphenylguanidine

Product formulations are included as illustrative examples only. Momentive makes no representation or warranty of any kind with respect to any such formulations, including, without limitation, concerning the efficacy or safety of any product manufactured using such formulations.

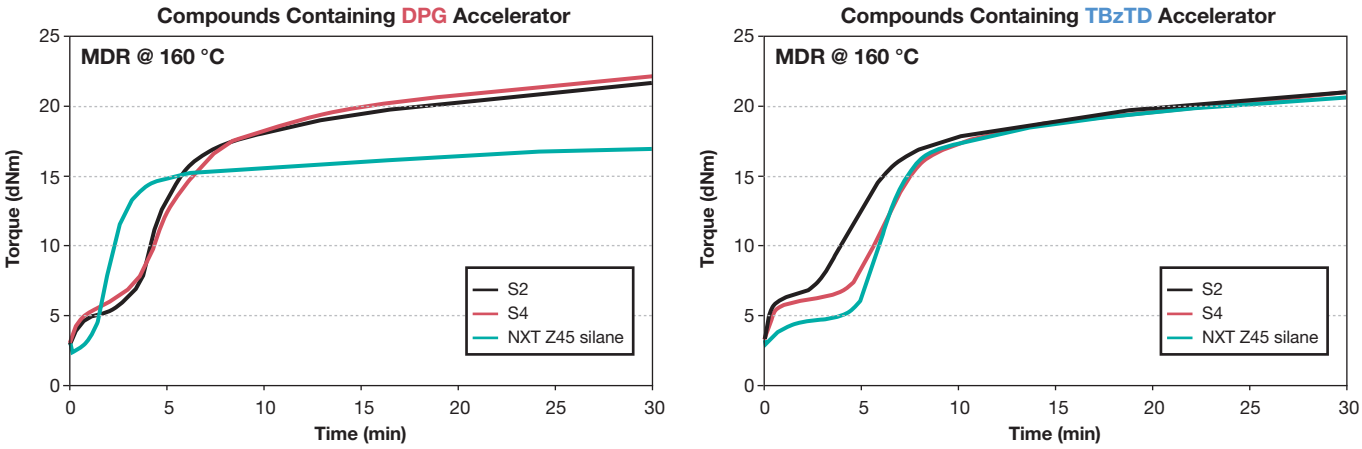
General Processing Considerations

Please refer to Table 5 for details regarding mixing procedures using NXT Z45 silane.

Dynamic properties with NXT Z45 silane compounds are typically superior to standard S2 (TESPD) and S4 (TESPT) silane compounds in the 60-110 phr equivalent silica loading range. The unique design of the NXT Z45 silane is essentially ethanol free.

Significant improvements in compound properties may be achieved by mixing NXT Z45 with the standard cure package seen in Table 2. However, if more scorch safety is needed (See Figure 1), then adding approximately 0.3 phr of TBzTD and completely eliminating DPG can increase the scorch safety by almost 300% without the loss of compound properties (See Figures 1-7, and Table 3). If some DPG is desired, then using a cure package of CBS 2.0 phr, DPG 0.5 phr, and TBzTD 0.2 phr can achieve similar scorch safety and compound properties (data not shown).

Figure 1: Cure Curve Comparison of S2 (TESPD) silane, S4 (TESPT) silane, and NXT Z45 silane in rubber compounds shows NXT Z45 silane typically has a lower initial torque. Mercapto silanes with a standard cure package tend to shorten scorch safety. By eliminating DPG and adding 0.3 phr TBzTD in the cure package, scorch safety may be increased by almost 300%.



Note: Test results. Actual results may vary.

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Figure 2: Comparison of batch viscosities of S2 (TESPD) silane, S4 (TESPT) silane or NXT Z45 silane in rubber compounds containing CBS and DPG versus CBS and TBzTD in the cure package.

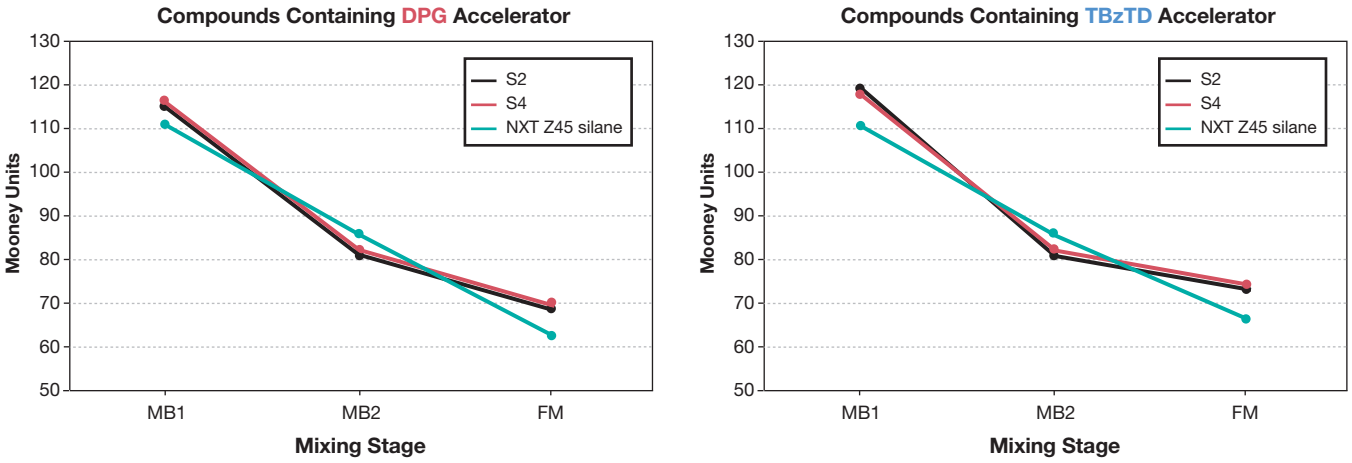

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Table 3: NXT typical physical properties increase when TBzTD is substituted for DPG.

		Compounds with DPG (2.0 phr)			Compounds with TBzTD (0.3 phr)		
Ingredients	**Units**	**S2**	**S4**	**NXT Z45**	**S2**	**S4**	**NXT Z45**
Cure Package							
Sulfur		1.865	1.100	1.675	1.830	1.065	1.640
CBS	phr	2.0	2.0	2.0	2.0	2.0	2.0
DPG		2.0	2.0	2.0			
Total Sulfur Atoms (x 10^{22})		4.93	4.93	3.82	*4.93*	*4.93*	*3.82*
Scorch @ 135 °C, t3	min	15	12	6	25	14	21
Scorch @ 135 °C, t10	min	18	16	7	27	17	24
100% Modulus	MPa	2.8	2.7	2.7	2.7	2.6	2.9
300% Modulus	MPa	13.0	12.2	14.0	12.8	12.0	14.2
RI (M300/M100)		4.6	4.5	5.2	4.7	4.6	4.9
Elongation	%	332	364	322	325	403	404
Shore A @ RT	shore A	70	70	65	70	71	68
Graves Tear @ 100 °C		35	37	32	31	37	33
DIN Abrasion (normalized)	%	94	100	123	101	98	122
Heat Build Up, Delta Temp.	°C	17	18	13	17	18	13
Percent Set	%	14	15	9	12	13	8

Typical properties are average data and are not to be used as or to develop specifications.

Table 4: Comparison of Rebound Values for Rubber Compounds Containing S2 (TESPD) silane, S4 (TESPT) silane or NXT Z45 silane having a Cure Package of CBS and DPG versus CBS and TBzTD.

		Compounds with DPG (2.0 phr)			Compounds with TBzTD (0.3 phr)		
Rebound	**Units**	**S2**	**S4**	**NXT Z45**	**S2**	**S4**	**NXT Z45**
0 °C	%	8	9	6	8	8	7
RT	%	20	21	23	20	21	23
70 °C	%	40	40	45	41	41	47
100 °C	%	49	49	54	50	50	52
100 °C - RT	%	29	28	31	30	29	29

Figure 3: E' Strain Sweep of rubber compounds containing S2 (TESPD) silane, S4 (TESPT) silane or NXT Z45 silane having a cure package of CBS and DPG versus CBS and TBzTD.

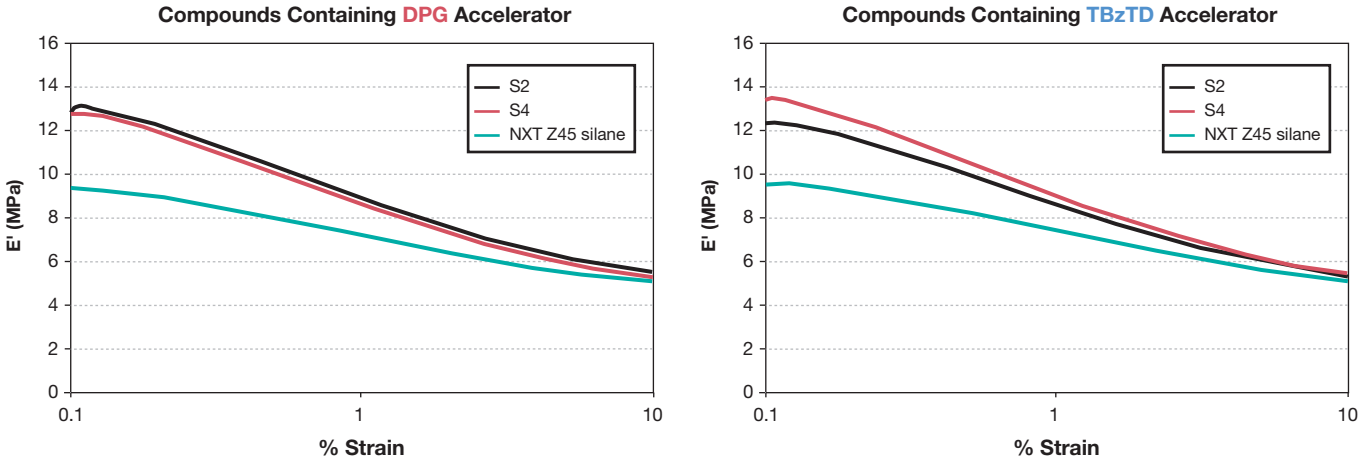

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Figure 4: E" Strain Sweep of rubber compounds containing S2 (TESPD) silane, S4 (TESPT) silane or NXT Z45 silane having a cure package of CBS and DPG versus CBS and TBzTD.

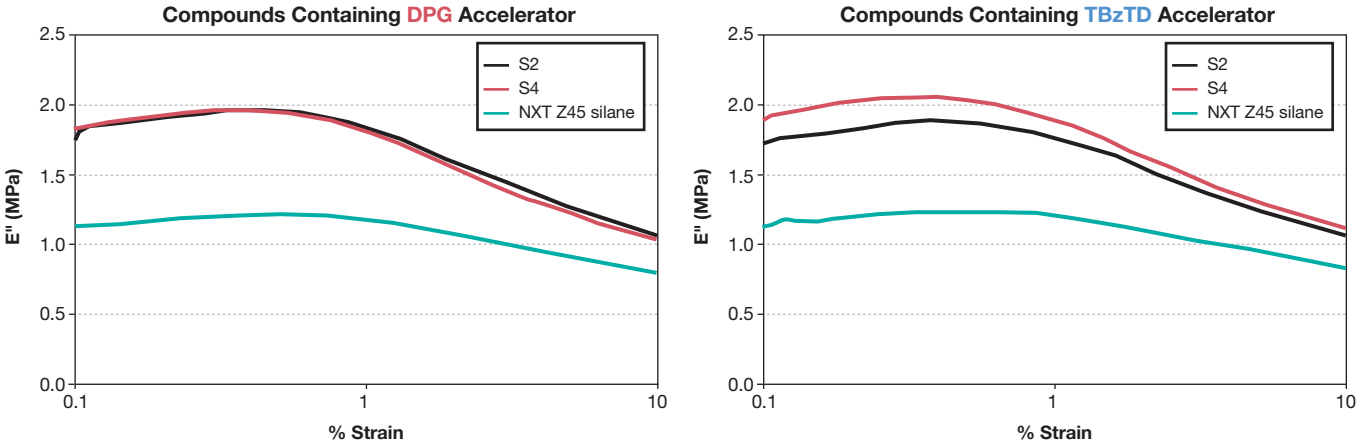
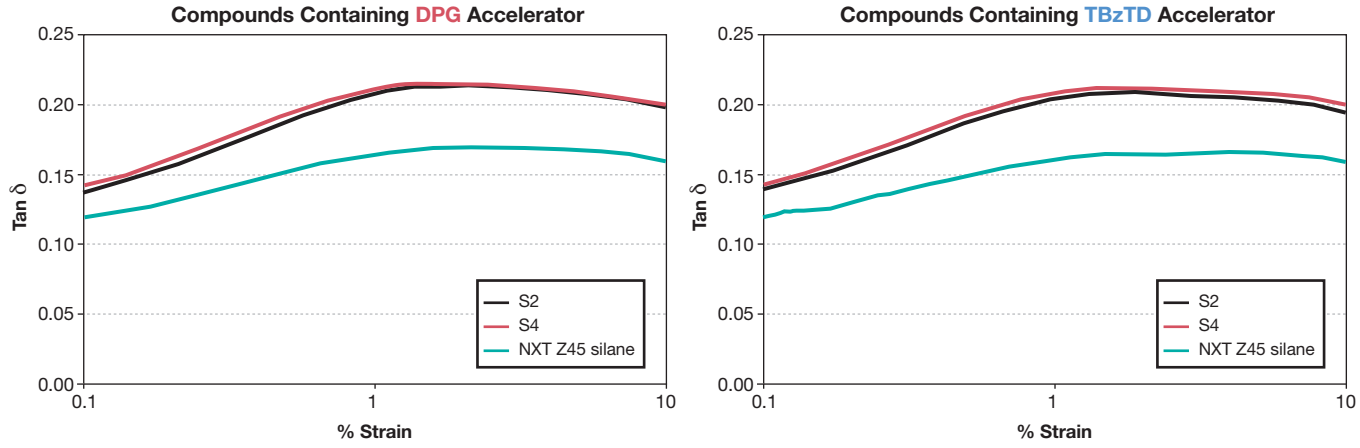


Figure 5: Tan δ $_{max}$ values for rubber compounds containing S2 (TESPD) silane, S4 (TESPT) silane or NXT Z45 silane having a cure package of CBS and DPG versus CBS and TBzTD.



Note: Test results. Actual results may vary.

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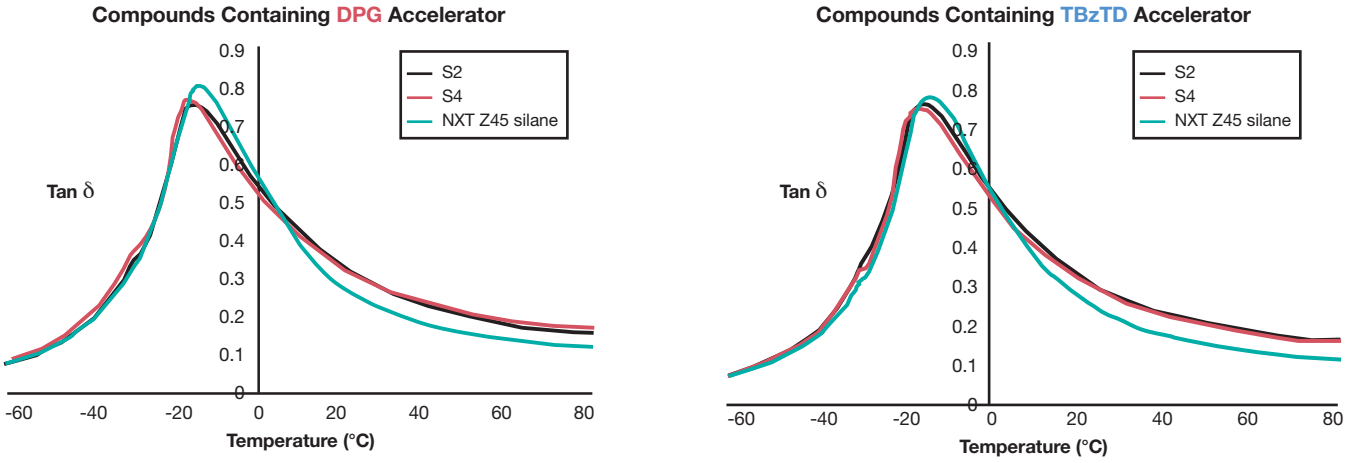
Figure 6: Temperature Sweep of S2 (TESPD) silane, S4 (TESPT) silane, or NXT Z45 silane rubber compounds having a cure package of CBS and DPG versus CBS and TBzTD.



Note: Test results. Actual results may vary.

Table 5: Mix Procedure for NXT Z45 silane

1.6L Banbury Mixer, 80 rpm, 70% FF		
Time	**T (°C)**	**Ingredients**
Masterbatch (MB1)		
0:00	70	Polymers
0:40		½ silica, silane
1:30		½ silica, chemicals
2:30	125	Carbon black, Oil
4:00	135	Sweep
6:00	155	Discharge
		Mill Blend
Masterbatch (MB2)		
0:00	70	Add MB1
1:00		Add any chemicals
2:00	135	Sweep
4:00	155	Dischange
		Mill Blend
Final Mix (Productive Mix)		
0:00	50	Add MB2, Cure Package @ 50 rpm
3:10	105	Discharge
		Mil Blend

Patent Status

Nothing contained herein shall be construed to imply the nonexistence of any relevant patents or to constitute the permission, inducement or recommendation to practice any invention covered by any patent, without authority from the owner of the patent.

Product Safety, Handling and Storage

Customers should review the latest Material Safety Data Sheet (MSDS) and label for product safety information, safe handling instructions, personal protective equipment if necessary, emergency service contact information, and any special storage conditions required for safety. Momentive Performance Materials (MPM) maintains an around-the-clock emergency service for its products. MSDS are available at www.momentive.com or, upon request, from any MPM representative. For product storage and handling procedures to maintain the product quality within our stated specifications, please review Certificates of Analysis, which are available in the Order Center. Use of other materials in conjunction with MPM products (for example, primers) may require additional precautions. Please review and follow the safety information provided by the manufacturer of such other materials.

Limitations

Customers must evaluate Momentive Performance Materials products and make their own determination as to fitness of use in their particular applications.

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