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NXT Z* 45 Silane

Coupling Agent for Silica-Reinforced Tire Tread Compounds

MARKETING BULLETIN

SILANES - TIRE & RUBBER

NXT Z 45 silane offers a virtually ethanol emission-free option for enhanced tire performance with overall systems cost-efficiencies for tire manufacturers.

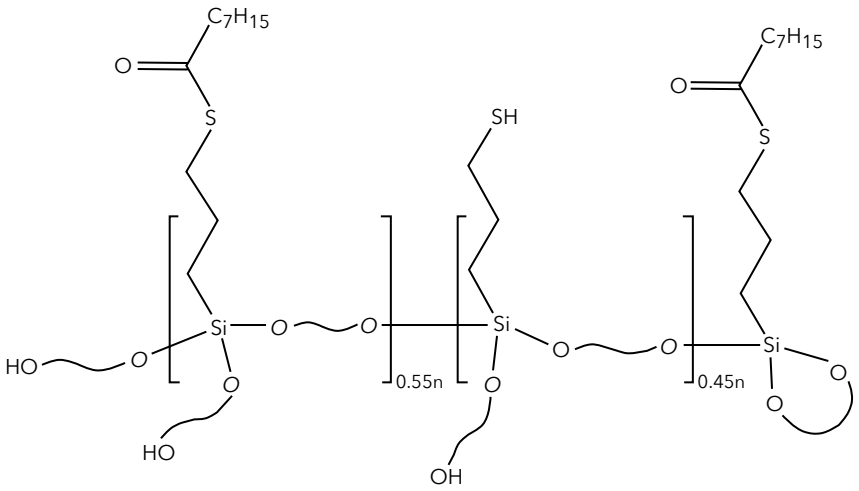
NXT Z 45 silane is an oligomeric combination of mercapto and thiocarboxylate functional silanes. It can help improve dynamic and physical properties, reduce overall manufacturing costs through improved processing, lower use levels and virtually eliminate ethanol emissions.

Silica compounds coupled with NXT Z 45 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 to 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 Z 45 silane can exhibit lower Payne Effect, improved tan δ 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)

*NXT Z is a trademark of Momentive Performance Materials Inc.

Table 1: Typical Silica-Reinforced Tire Tread Formulation Used to Evaluate NXT Z 45 Silane

	Compounds with DPG (2.0 phr)			Compounds with TBzTD (0.3 phr)		
Ingredients	**S2**	**S4**	**NXT Z 45 Silane**	**S2**	**S4**	**NXT Z 45 Silane**
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 Z 45 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 Z 45 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.

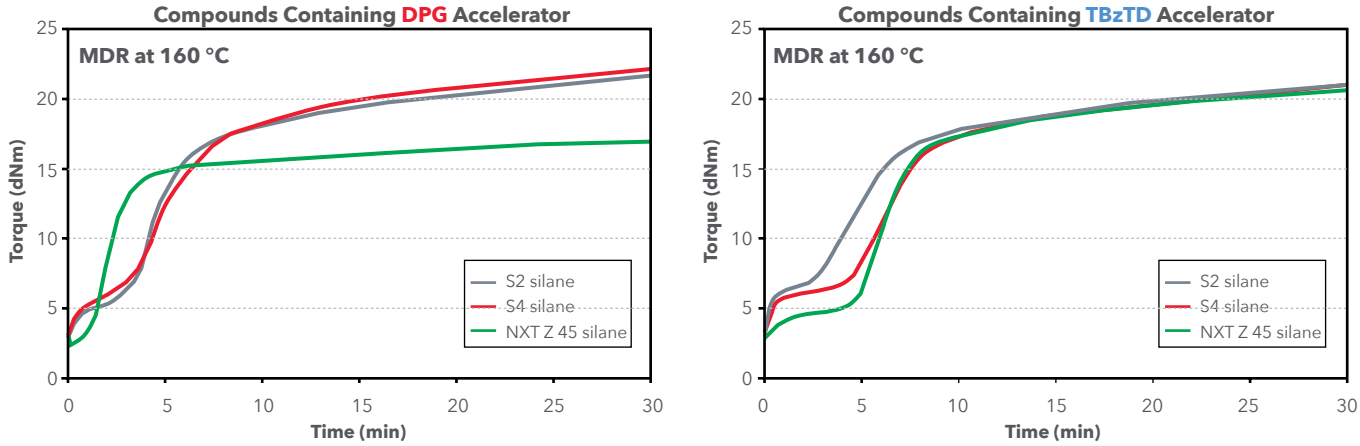
General Processing Considerations

Please refer to Table 5 for details regarding mixing procedures using NXT Z 45 silane.

Dynamic properties with NXT Z 45 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 Z 45 silane is essentially ethanol free.

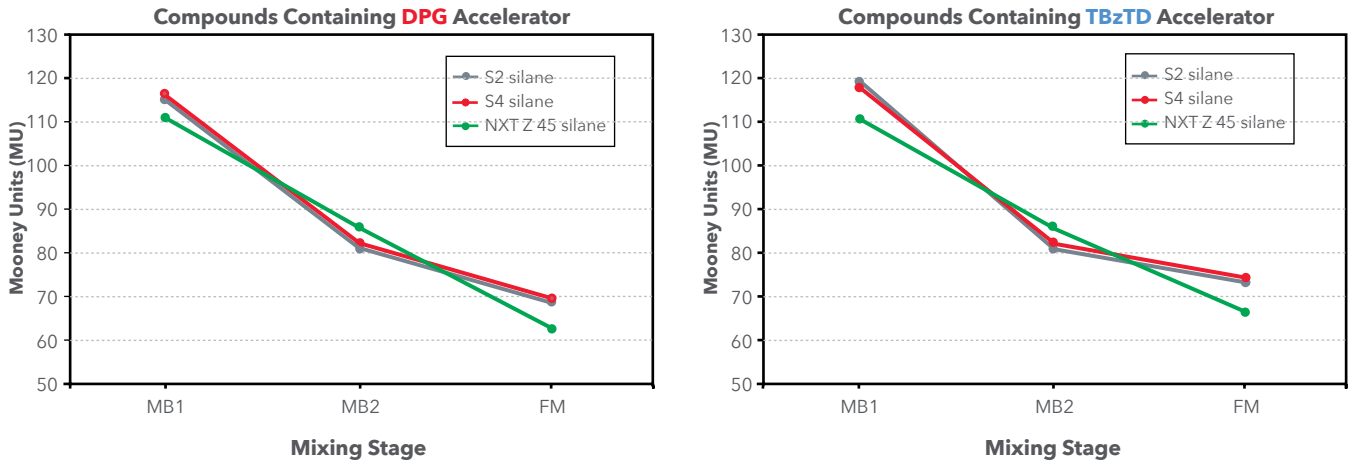
Significant improvements in compound properties may be achieved by mixing NXT Z 45 with the standard cure package seen in Table 2. However, if more scorch safety is needed (see Figure 1), then adding approximately 0.3 phr of TBzTD and completely eliminating DPG can increase scorch safety by almost 300% without loss of compound properties (see Figures 1-6, 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 Z 45 Silane in Rubber Compounds



Note: Test results. Actual results may vary.

Figure 2: Comparison of Batch Viscosities of S2 (TESPD) Silane, S4 (TESPT) Silane or NXT Z 45 Silane in Rubber Compounds



Note: Test results. Actual results may vary.

Table 3: NXT Z 45 Silane Typical Physical Properties Increase When TBzTD is Substituted for DPG

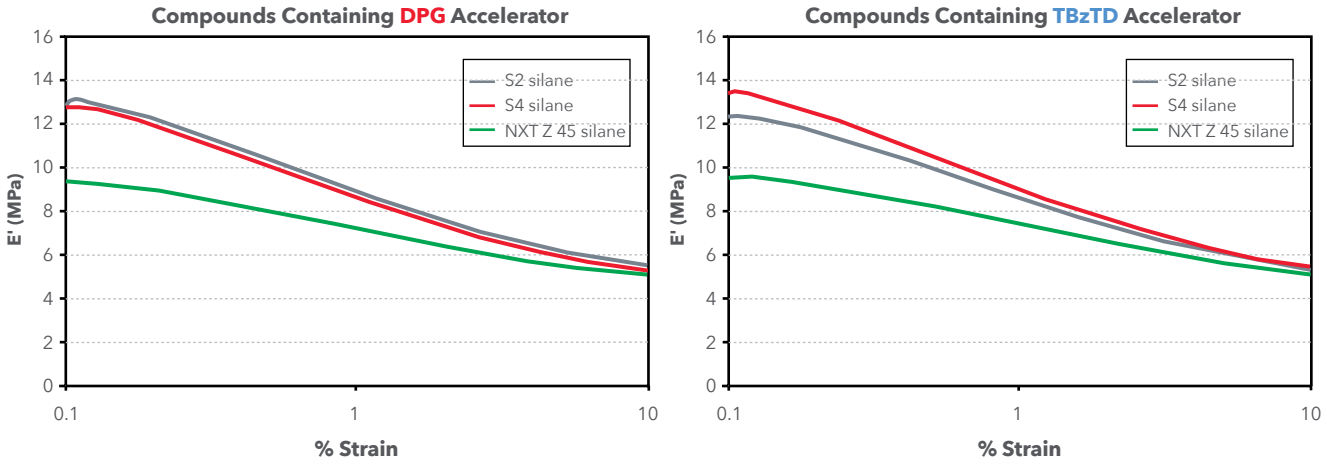
		Compounds with DPG (2.0 phr)			Compounds with TBzTD (0.3 phr)		
Ingredients	**Units**	**S2**	**S4**	**NXT Z 45 Silane**	**S2**	**S4**	**NXT Z 45 Silane**
Cure Package							
Sulfur		1.865	1.100	1.675	1.830	1.065	1.640
CBS	phr	2.0	2.0	2.0	2.0	2.0	2.0
DPG		2.0	2.0	2.0			
Total Sulfur Atoms (x 10^{22})		4.93	4.93	3.82	*4.93*	*4.93*	*3.82*
Scorch at 135 °C, t3	min	15	12	6	25	14	21
Scorch at 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 at RT	shore A	70	70	65	70	71	68
Graves Tear at 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 physical 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 Z 45 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 Z 45 Silane**	**S2**	**S4**	**NXT Z 45 Silane**
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 Z 45 Silane Having a Cure Package of CBS and DPG Versus CBS and TBzTD



Note: Test results. Actual results may vary.

Figure 4: E'' Strain Sweep of Rubber Compounds Containing S2 (TESPD) Silane, S4 (TESPT) Silane or NXT Z 45 Silane Having a Cure Package of CBS and DPG Versus CBS and TBzTD

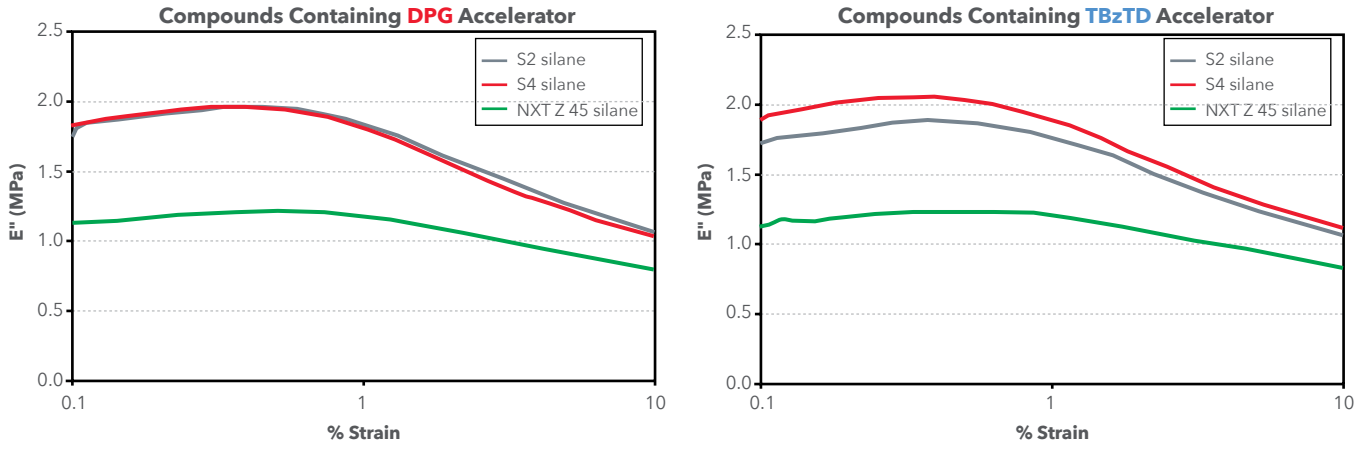
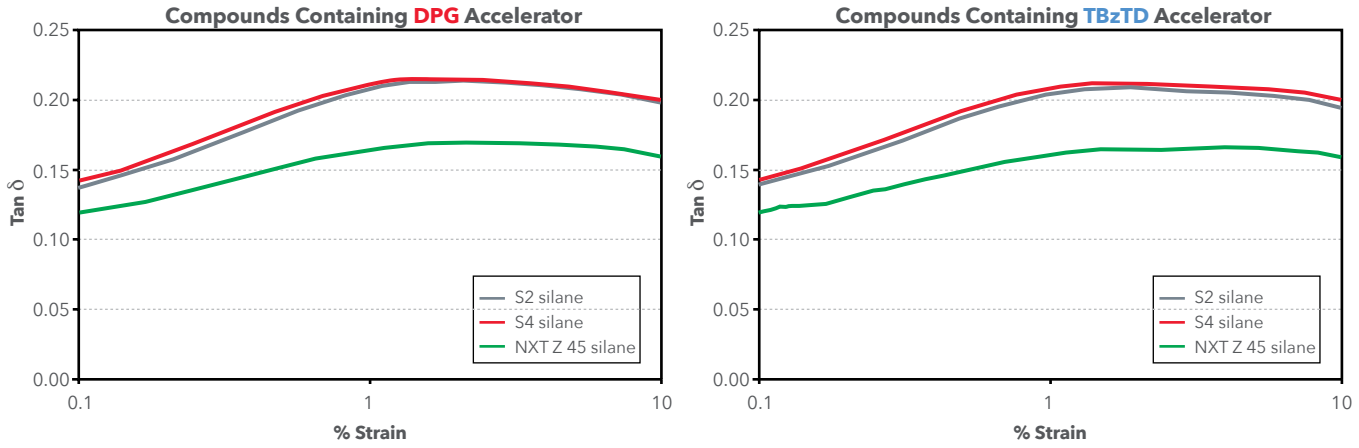
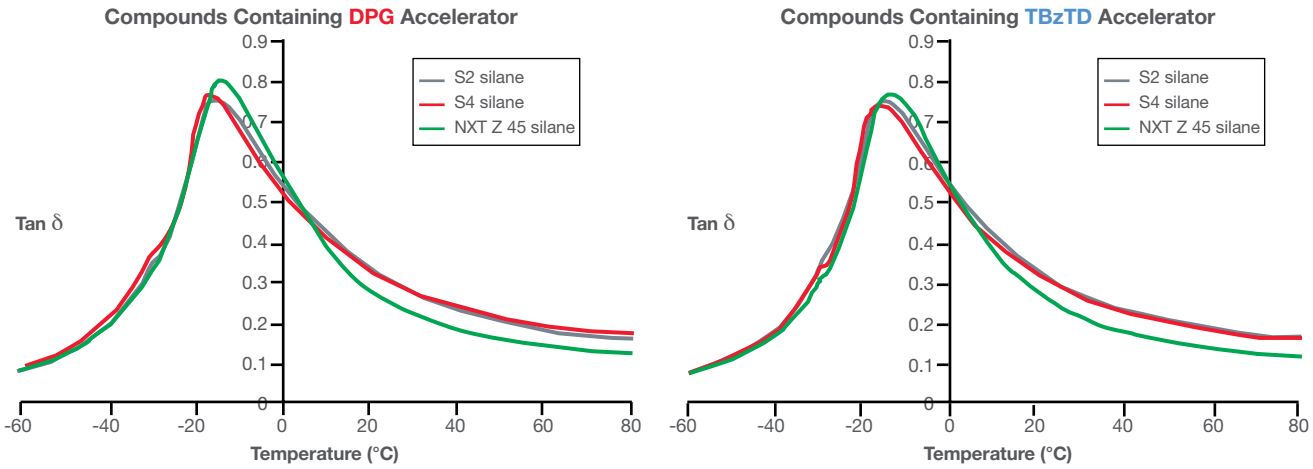


Figure 5: Tan δ Max Values for Rubber Compounds Containing S2 (TESPD) Silane, S4 (TESPT) Silane or NXT Z 45 Silane Having a Cure Package of CBS and DPG Versus CBS and TBzTD



Note: Test results. Actual results may vary.

Figure 6: Temperature Sweep of S2 (TESPD) Silane, S4 (TESPT) Silane or NXT Z 45 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 Z 45 Silane

1.6L Banbury Mixer, 80 rpm, 70% FF		
Time	**T (°C)**	**Ingredients**
Masterbatch (MB1)		
0:00	70	Polymers
0:40		1/2 silica, silane
1:30		1/2 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	Discharge
		Mill Blend
Final Mix (Productive Mix)		
0:00	50	Add MB2, Cure Package at 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.

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