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Momentive Performance Materials' New NXT* Z Ethanol Free Silane

Product Description

The most recent groundbreaking advancement in NXT* silanes for silica tires is NXT Z silane, which is expected to raise the tire-performance bar with improved dynamic and physical properties. Momentive Performance Materials' newest NXT silane coupling agent for silica tires is essentially ethanol-free and features the one-pass mixing and shelf-stable compounds for which NXT silanes are known. Compared with traditional silanes, this new silane will virtually eliminate(1) the ethanol that is released during manufacturing and use of silica tires.

(1) Contains less than 1% by weight total releasable ethanol.

Features and Benefits of NXT Z Silane

NXT Z silane is designed for improved dynamic and physical properties, with reduced overall manufacturing costs through improved processing, lower use levels and, virtual elimination of ethanol emissions.

Key Features and Benefits

- Superior performance property set at lower silane loading level
- Ethanol (VOC) emissions essentially eliminated
- Single non-productive mixing step & faster processing
- High temperature mixing without viscosity increase or scorch
- Long shelf life for uncured compounds
- Improved reinforcement properties
- Improved dynamic properties at low temperatures (+5° to -20°C)
- Very low maximum in tanδ over the 0 to 25% strain range
- Substantial reduction in small strain non-linearity, ΔG'
- Excellent silica dispersion & low reagglomeration

Momentive Performance Materials provides versatile materials as the starting point for our creative approach to ideas that help enable new developments across hundreds of industrial and consumer applications. We are helping customers solve product, process, and performance problems; our silanes, fluids, elastomers, sealants, resins, adhesives, urethane additives, and other specialty products are delivering innovation in everything from car engines to biomedical devices. From helping to develop safer tires and keeping electronics cooler, to improving the feel of lipstick and ensuring the reliability of adhesives, our technologies and enabling solutions are at the frontline of innovation.

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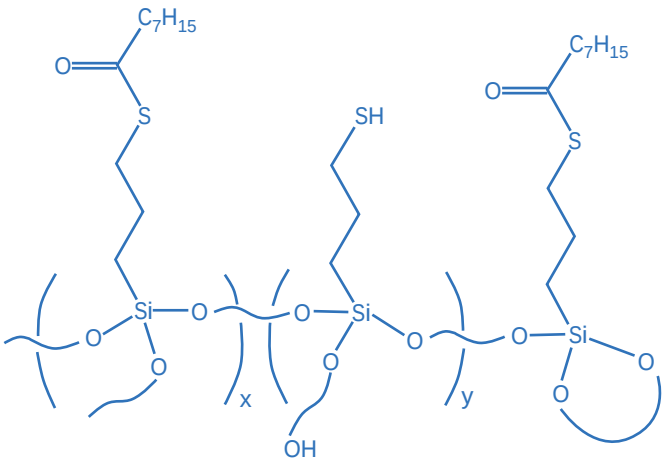
Generalized Structure of NXT Z Silane



The schematic above shows a generalized structure of NXT Z silanes. The silicon end of the molecule consists of silicon atoms bridged through non-volatile diols. These diols remain in the compound after mixing. The mercapto and blocked mercapto groups of the silane offer different coupling reactivity with the polymer. The mercapto group reacts with the polymer during the non-productive mixing stage, while the blocked-mercapto group aids in the dispersion of the silica. When the octanoyl-blocking group is removed during the productive mixing stage and curing step, additional mercapto silane is formed. Proton-donors, that include the vulcanization ingredients, assist in the removal of the octanoyl-blocking group. These newly generated mercapto groups react with the polymer during vulcanization and increase the coupling between silica and polymer.

Processing and Performance of NXT Z Silane

Testing Procedures: NXT Z silane was evaluated in a typical silica-filled tread compound. The formulation is given in Table 1. The control compound containing a traditional tetrasulfide coupling agent, Silquest* A-1289 silane, was mixed at 160°C in two non-productive mix steps. Compounds containing NXT and NXT Z silanes were mixed at 170°C in a single non-productive mix step. The total mixing time for both NXT* silane and the new NXT Z silane was 12 minutes. The control compound containing Silquest A-1289 silane required 18 minutes and a cool down step between the two non-productive mix steps. NXT Z silane exhibits excellent processing characteristics similar to those of NXT silane.

Table 1. Typical Silica-Reinforced Tire Tread Formulation Used to Evaluate NXT and NXT Z silanes

PHR	Ingredient
103.2	sSBR - (~50% vinyl content)
25	BR - (high cis butadiene rubber)
80	Silica (precipitated)
Variable	Silquest A-1289 silane, NXT, NXT Z silane - (Momentive Performance Materials)
4.5	Oil - (Aromatic or non-aromatic)
2.5	Zinc Oxide
1.0	Stearic Acid
2.0	6 PPD - (antioxidant/antiozonant)
3.0	N-330 Carbon Black
1.5	Wax
Final Mix Ingredients	
1.4	Sulfur
1.7	CBS - (primary accelerator)
2.0	DPG - (secondary accelerator)

Processing and Performance of NXT Z Silane (continued)

Table 2 shows a comparison of performance characteristics with rubber compounds made with Silquest* A-1289, NXT*, and NXT Z silanes. Based on this data, NXT Z silane shows a 7% reduction in Mooney viscosity, and a reduction of approximately 50% in cure times, when compared to the control. Non-linearity under small strains (ΔG') and tanδ values are substantially reduced with NXT Z silane. These dynamic properties predict a rubber compound with reduced rolling resistance. The reinforcement index of NXT Z silane is 15% higher than Silquest A-1289 silane, which suggests better wear characteristics. The higher tanδ values at low temperatures indicate a strong potential to improve wet traction properties of tire treads made with NXT Z silane.

Table 2: Comparison of Performance Characteristics: Silquest A-1289, NXT and NXT Z silanes

Ingredient (phr)	Silquest A-1289 silane	NXT silane	NXT Z silane
solution SBR	103	103	103
Butadiene rubber	25	25	25
Silica	80	80	80
Silquest A-1289	7		
NXT silane		8.2	
NXT Z silane			8.2
No. Mixing Steps	2	1	1
Mixing Temperature	160°C	170°C	170°C
Thermal Step (min)	8	8	8
Compound Properties			
Processing			
Mooney Viscosity	69.27	56.84	64.52
Scorch Time (min)	7.44	9.33	7.31
Cure Time t90 (min)	21.86	18.32	9.39
M_L (dNm)	9.78	7.19	9.42
M_H (dNm)	33.24	26.31	30.36
Properties in the Cured State			
-Non-linearity (0-10%) @ 60°C			
$G'_{initial}$ (MPa)	3.70	2.89	2.67
ΔG' (MPa)	2.02	1.51	1.19
G''_{max} (MPa)	0.51	0.38	0.33
$tan\delta_{max}$	0.21	0.17	0.14
Wet-skid Indicator, 10 Hz, 1% DSA tanδ 0°C	0.45	0.52	0.54
Properties in the Cured State			
-Reinforcement			
Hardness (Shore A)	63	56	58
M 25% (MPa)	0.953	0.798	0.866
M100% (MPa)	2.06	1.66	2.29
M300% (MPa)	10.89	8.23	13.98
M300%/ M100%	5.29	4.96	6.10
Elongation at rupture (%)	456.1	570.4	392.8
Stress at rupture (MPa)	20.48	21.26	20.36

Processing and Performance of NXT Z Silane (continued)

A loading optimization study was conducted with NXT Z silane using the formulation in Table 1. The performance of the rubber compounds using NXT Z silane at different loading levels is presented in Table 3. Lower silane loading levels provided better scorch safety with a modest change in dynamic properties.

Table 3. Comparison of NXT Z silane Loading on Performance Characteristics

Ingredient	Silquest A-1289 silane	NXT Z silane	NXT Z silane	NXT Z silane	NXT Z silane
Silane phr	7	4.9	6.5	7.4	8.2
Silica Loading	80	80	80	80	80
No. Mixing Steps	2	1	1	1	1
Mixing Temperature	160ºC	170ºC	170ºC	170ºC	170ºC
Thermal Step (min)	8	8	8	8	8
Compound Properties					
Processing					
Mooney Viscosity	60.3	54.1	53.4	53.2	53.5
Scorch Time (min)	5.49	10.37	9.01	8.38	8.02
Cure Time t90 (min)	21.61	13.05	10.7	10.03	9.58
M_L (dNm)	8.63	7.6	7.56	7.76	7.99
M_H (dNm)	29.60	28.14	28.27	28.89	29.53
Properties in the Cured State					
-Non-linearity (0-10%) @ 60ºC					
$G'_{initial}$ (MPa)	2.73	2.23	2.25	2.19	2.17
$\Delta G'$ (MPa)	1.29	0.88	0.89	0.86	0.86
G''_{max} (MPa)	0.380	0.264	0.250	0.251	0.242
$\tan\delta_{max}$	0.186	0.142	0.131	0.131	0.129
Wet-skid Indicator, 10 Hz, 1% DSA tanδ 0ºC	0.488	0.565	0.570	0.568	0.545
Properties in the Cured State					
-Reinforcement					
Hardness (Shore A)	59	57	56	56	56
M 25% (MPa)	0.926	0.920	0.885	0.927	0.936
M100% (MPa)	1.90	1.93	2.02	2.16	2.22
M300% (MPa)	10.12	10.37	11.64	12.57	13.00
M300% / M100%	5.33	5.37	5.76	5.82	5.86
Elongation at rupture (%)	482.3	510.4	446.8	426.0	423.1
Stress at rupture (MPa)	19.66	22.01	19.97	20.88	20.51

Processing and Performance of NXT Z Silane (continued)

The large improvement in silica dispersion of compounds made with NXT Z silane leads to a decrease in filler-filler interactions and results in lower G', ΔG' and Shore A hardness when compared to the control. In order to take full advantage of improved silica dispersion, some compounds reformulation may be advisable to adjust hardness. Equal hardness may be important for tire handling and cornering. To raise hardness, we recommend increasing the amount of precipitated silica or carbon black, adding low levels of fumed silica or reducing the amount of processing oil. Table 4 shows the effect of these hardness adjustments in the formulation. The NXT Z silane tread compound hardness was adjusted to the same level as the control compound, without sacrificing other properties, by the addition of 10 phr of precipitated silica or carbon black filler, or by reducing the processing oil.

Table 4. Comparison of Performance Characteristics with NXT Z silane and Hardness Adjustments

Ingredient	Silquest A-1289 silane	NXT Z silane	NXT Z silane	NXT Z silane	NXT Z silane	NXT Z silane
Silane phr	7	5.75	5.75	5.75	5.75	5.75
Silica Loading	80	80	80	80	80	80
Hardness Adjustment		None	+10phr N-330	+10 phr silica	+5 phr N-330 +5 phr silica	- 4.5 phr oil
No. Mixing Steps	2	1	1	1	1	1
Mixing Temperature	160°C	170°C	170°C	170°C	170°C	170°C
Thermal Step (min)	8	8	8	8	8	8
Compound Properties						
Processing						
Mooney Viscosity	67.87	55.3	57.82	61.87	53.21	60.47
Scorch Time (min)	9.36	7.04	6.34	7.23	7.38	7.30
Cure Time t90 (min)	21.43	14.05	12.83	17.14	14.87	13.95
M_L (dNm)	9.32	7.69	7.81	8.87	7.09	8.67
M_H (dNm)	31.81	29.58	29.85	30.58	28.27	31.21
Properties in the Cured State						
-Non-linearity (0-10%) @ 60°C						
$G'_{initial}$ (MPa)	3.83	2.14	2.37	3.04	2.22	2.04
ΔG' (MPa)	2.11	0.92	0.99	1.51	0.97	0.69
G''_{max} (MPa)	0.52	0.25	0.31	0.41	0.26	0.23
$tan\delta_{max}$	0.20	0.15	0.17	0.18	0.16	0.14
Wet-skid Indicator, 10 Hz 1% DSA tanδ 0°C	0.46	0.43	0.45	0.47	0.45	0.44
Properties in the Cured State						
-Reinforcement						
Hardness (Shore A)	59	54	59	58	57	57
M 25% (MPa)	1.06	1.01	1.07	1.09	1.00	0.97
M100% (MPa)	2.17	2.15	2.37	2.26	2.04	2.11
M300% (MPa)	11.58	12.05	12.70	11.82	10.73	12.48
M300% / M100%	5.34	5.60	5.37	5.23	5.25	5.93
Elongation at rupture (%)	421	464	440	450	463	438
Stress at rupture (MPa)	19.2	22.79	21.70	21.80	20.72	22.57
Abrasion loss (mm^3) DIN	123	118	108	109	120	103

Patent Status

NXT Z silane is the subject of multiple pending U.S. patent applications.

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 considering the use of this product should review the latest Material Safety Data Sheet and label for product safety information, handling instructions, personal protective equipment if necessary, and any special storage conditions required. Material Safety Data Sheets are available at www.momentive.com or, upon request, from any Momentive Performance Materials representative. Use of other materials in conjunction with Momentive Performance Materials 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.

Emergency Service

Momentive Performance Materials maintains an around-the-clock emergency service for its products. The American Chemistry Council (CHEMTREC), Transport Canada (CANUTEC), and the Chemical Emergency Agency Service also maintain an around-the-clock emergency service for all chemical products:

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Canada	518.233.2500	CANUTEC: 613.996.6666 (collect) or CHEMTREC: 800.424.9300
Europe, Middle East, Africa	+32.(0)14.58.45.45 (Belgium)	CHEMTREC: +1-703.527.3887 (collect)
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