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TECHNICAL BULLETIN

BIMS Inner Liner Compounds

Thermax® N990 medium thermal carbon black is manufactured by the thermal decomposition of natural gas. The thermal process provides a unique carbon black characterized by a large particle size and low structure.

Thermax® N990 can be blended with GPF carbon black for application in halobutyl (BIIR, CIIR) tire inner liners. Performance benefits from Thermax® N990 include:

- High loadability in halobutyl inner liners, compared to using only GPF grades
- Reduction of permeability in inner liners at high carbon black loading
- Reduction of compound cost due to high carbon black loading
- Possibility for reduction of liner gauge providing cost savings

In this report, Thermax® N990 is evaluated in tire inner liner compounds using Exxon's new brominated isobutylene paramethyl styrene (BIMS) polymer. The BIMS polymers have the same air diffusion resistance as butyl polymers but are much more heat stable. Because they have no unsaturation in the backbone, they are impervious to attack by oxygen or ozone. These properties make BIMS polymers ideal for use where inner liners see extreme environments of heat and flexing or where extended life is desired.[1]

The BIMS inner liner test formulations are provided in Table 1. The Thermax® N990 carbon black loading was calculated to provide hardness equivalent to the control compound.

Table 1: Test Formulations

Control	#1	#2	#3	#4
Exxpro 89-4	100	100	100	100
N660 Carbon Black	60	45	30	15
Thermax® N990	-	30	60	90
Naphthenic Oil	8	8	8	8
SP1068 Tackifier	2	2	2	2
Escorez 1102 Resin	2	2	2	2
Struktol 40 MS	7	7	7	7
Stearic Acid	2	2	2	2
Zinc Oxide	3	3	3	3
MBTS	1.5	1.5	1.5	1.5
Sulphur	0.5	0.5	0.5	0.5

[1] Jones, Glenn E., Inner Liners for Truck Tires: A Review, Presented at ACS Rubber Division, April 2000 Meeting, Dallas, Paper #56

Key Findings:

- The compound with 90 phr Thermax® N990 had a 23% improvement in fatigue life cycle over the control compound
- Equivalent crack growth for all compounds up to 500,000 cycles. At one million cycles, the control compounds crack growth was twice as long as that for the compounds with 60 phr and 90 phr of Thermax® N990
- Similar tan delta values across the full temperature range of -100°C to 50°C in the BFGoodrich Flexometer test
- Substantial improvement in adhesion to the carcass compound for the test compounds with 60 phr and 90 phr of Thermax® N990
- Improvement in impermeability ranged from 7% to 23.5% as compared to the control compound
- Reduction in tensile strength as the N660 loading decreased and the Thermax® N990 loading increased, although hardness remained equal

Detailed compound test results are provided below in Table 2.

Table 2: Compound Data

Compound #	**#1**	**#2**	**#3**	**#4**
Exxpro 89-4	100	100	100	100
Thermax® N990	-	30	60	90
N660 Carbon Black	60	45	30	15
ODR, ASTM D2084-95, 320°F, 1° Arc				
T_{min} (in-lb)	6.3	6.6	6.6	6.8
T_{max} (in-lb)	13	13.5	13.4	13.9
t_s1 (min)	5.9	6	6.7	6.9
t_s2 (min)	7.5	7.5	8.4	8.1
t_c50 (min)	9	9.1	9.9	9.8
t_c90 (min)	13.3	13.3	14.6	13.9
t_c95 (min)	15.7	15	16.3	15.7
Mooney Scorch, ASTM D1656-96, 125°C, M_L				
Minimum Torque	50.59	50.64	48.91	48.74
Minutes to 1 pt. rise	13.58	13.42	14.08	14.33
Minutes to 5 pt. rise	25.5	25.58	27.08	27.67
Minutes to 10 pt. rise	31.33	31.58	34.08	34.75
Minutes to 35 pt. rise	38.33	38	41.42	41.92
Minutes to (35 pt.- 5 pt.) rise	12.83	12.42	14.34	14.25
Originals, Cured 17 Minutes @ 160°C, ASTM D412-99				
100% Modulus (MPa)	1.08	1.19	1.23	1.23
300% Modulus (MPa)	3.14	3.6	3.61	3.54
Tensile Strength (MPa)	9.09	7.91	6.96	5.7
Elongation at break (%)	937	891	842	735
Shore A Hardness	48.8	47.3	47.8	48.4

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	#1	#2	#3	#4
Cured 17 Minutes @ 160°C, Aged 7 days @ 150°C				
100% Modulus, MPa	3.1	3.12	3.29	3.29
300% Modulus, MPa	8.77	8.52	6.89	7.08
Tensile Strength, MPa	10.77	9.32	7.96	7.11
Elongation at break (%)	487	438	408	392
Fatigue to Failure, 23°C, Originals, Extension Cycles x 100, ASTM D4482-99				
Average of 6	7342	4356	6072	9019
Crack Growth, Pierced Samples, 23°C, ASTM D813-95				
1 = no growth 2 = 2x original crack				
300,000 cycles	1	1	1	1
500,000 cycles	1	1	1	1
800,000 cycles	1.5	2	1	1
1,000,000 cycles	2	2	1	1
BFGoodrich Flexometer Tan Delta, 1Hz				
-100°C	0.04617	0.04709	0.04868	0.04306
-50°C	0.59637	0.61134	0.60539	0.60074
0°C	0.39256	0.38440	0.42234	0.42250
23°C	0.15768	0.14084	0.15685	0.15618
50°C	0.11329	0.10393	0.11421	0.11117
Adhesion, Compound to Carcass Ply, Instron 4465, RT				
Mean Peel Strength (lbs/in)	107	117	129	127
Mean Peel Strength = Average load of entire pull/test thickness				
Exxon Air Permeability				
Ft.3 - 0.001"/Ft2-day-psi x 1000	1.53	1.37	1.17	1.42
% Difference vs. Compound #1	0	-10%	-23.50%	-7.10%

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