TECHNICAL Bulletin

Subject: Halobutyl Tire Inner Liners I

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THERMAX® MEDIUM THERMAL BLACK N990 BLENDED WITH N660 IN HALOBUTYL INNER LINERS

Thermax® medium thermal carbon black N990 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. Thermal black can be blended with GPF carbon black for application in halobutyl (BIIR, CIIR) tire inner liners. Performance benefits from this unique carbon black 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 black loading
- Possibility for reduction of inner gauge providing cost savings

The following data demonstrates the application of Thermax® N990 as a filler in BIIR inner liner compounds.

FORMULATION

	Control	#2	#3	#4
Polysar Bromobutyl 2030	100.0	100.0	100.0	100.0
N660 Carbon Black	60	-	20.0	30.0
Thermax® N990 Black	-	110.0	90.0	80.0
Stearic Acid	1.0	1.0	1.0	1.0
Pentalyn A, Hercules tackifier	4.0	4.0	4.0	4.0
Sunpar 2280 paraffinic oil	7.0	7.0	7.0	7.0
MBTS (Vulkacit DM/C)	1.3	1.3	1.3	1.3
Zinc Oxide	3.0	3.0	3.0	3.0
Sulphur	0.5	0.5	0.5	0.5
Total	**176.8**	**226.8**	**226.8**	**226.8**

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	Control	#2	#3	#4
Thermax® N990	-	110.0	90.0	80.0
N660 Carbon Black	60	-	20	30
COMPOUND PROPERTIES				
Compound viscosity	67.5	55.1	64	67.9
(ML 1 + 4 @ 100°C)				
Mooney scorch time				
(t5 @ 138°C)	12.0	11.8	9.0	8.4
(t35 @ 138°C)	18.7	24.1	22.5	21.1
Monsanto Rheometer @ 166°C (1° arc, 50 range)				
MH (dN.m)	19.61	15.52	18.78	20.29
ML	7.13	5.72	6.75	7.18
Delta torque	12.48	9.6	12.03	13.11
tc50 (min)	4.95	6.13	5.77	5.53
tc90 (min)	9.05	16.87	10.95	9.97
ts1 (min)	2.89	3.85	3.01	2.74
GREEN STRENGTH				
Stress @ 100% elong (MPa)	0.335	0.238	0.289	0.303
Stress @ 300% elong (MPa)	0.192	0.136	0.171	0.165
Stress @ 500% elong (MPa)	-	0.093	0.109	0.104
Peak Stress (MPa)	0.359	0.284	0.328	0.349
Ultimate tensile (MPa)	0.076	0.152	0.155	0.158
Ultimate elongation (%)	466	1078	1136	1134
VULCANIZATE PROPERTIES				
Cured 30 minutes @ 166°C				
Hardness, Shore A2	64	71	68	70
Modulus @ 100% elong (%)	1.5	1.2	1.4	1.6
Modulus @ 300% elong (MPa)	4.9	2.0	3.3	3.9
Modulus @ 500% elong (MPa)	8.0	2.4	4.2	4.7
Tensile strength (MPa)	9.9	4.7	5.9	6.5
Ultimate elongation (%)	710	860	780	745
DeMattia cut growth – Aged 168 h @ 120°C Kc to 600% growth	>250	25	>250	>250
Permeability to air @ 65°C (Q x log 8)	2.9	2.5	2.4	2.4
Pirelli adhesion @ 100°C – constant volume mold (to typical NR carcass – kNm)	10.3	9.6	8.3	10.9

Compound Properties

Compound viscosity was reduced with 110 phr of Thermax® N990 but equalled the control N660 compound when the blend of 80/30 phr of N990/N660 was used. Scorch time at 138°C was reduced slightly with N660 loading but the time to a 35 point rise and ts1 at 166°C was favourable when compared to the control compound.

It is recognized that N990 alone provides low green strength. This is due to the non-reinforcing properties of the low structure/large particle black. The inclusion of the N660 raised the green strength of the N990 based compound to sufficient levels, roughly between the N990 compound and the control.

Vulcanizate Properties

Hardness was 7 points higher for the compound with 110 phr of N990 and 6 points higher for the N990/N660, 80/30 blend compound, compared to the control.

As is typical of compounds loaded with N990, modulus and tensile strength are low. Although they increase with higher loadings of N660, they remain below the control compound. The levels of tensile strength provided, however, are sufficient for inner liners and to prevent cord break-through.

Carcass adhesion, as measured by Pirelli's adhesion test, was similar for all compounds.

Air Permeability

Carbon blacks are impermeable to gases and should be included in the inner liner compound at as high a level as possible, in order to reduce the volume fraction of permeable rubber. Halogenated butyl rubber is used in inner liners to provide maximum impermeability, flex life and heat resistance. Due to its non-reinforcing properties, medium thermal black can be loaded at higher levels than other carbon blacks, thereby adding to the impermeation of the halobutyl inner liner. The compounds with 110 phr of carbon black showed roughly a 14% improvement in impermeability over the 60 phr N660 control compound.

Cost Reduction

The higher loading of carbon black to 110 phr serves to reduce the volumetric polymer content in the compound. With the cost of BIIR and other halogenated butyl polymers being significantly higher than medium thermal black, tire manufacturers can achieve substantial cost savings with the higher black loading.

Since impermeability improves with increased black loading, it follows that at higher black loadings, a thinner inner liner can be used without sacrificing impermeability. Assuming similar permeability for all carbon blacks, a compound with 110 phr of carbon black will deliver the same level of impermeability in a thinner gauge inner liner. The net result of the thinner liner and higher proportion of carbon black is a lower weight in the tire. Although most passenger tire manufacturers have achieved maximum "thinness", the thicker gauges of truck/bus tires could be reduced with significant cost savings due to the reduction in high-cost polymer content.

Summary

Evaluations of high loadings of carbon black in BIIR inner liner compounds have shown that a blend of 80 phr of N990 and 30 phr of N660 will provide the necessary physical properties while substantially improving the impermeability of the inner liner. The non-reinforcing, large particle and low structure medium thermal black N990 allows for significant cost savings by polymer substitution and may provide further cost savings through a reduction in inner liner gauge.