RBR-AOPA-3-01

Rubber Processing & Antiozonant Wax

Evaluation of Marcus M300 in Model Black Sidewall Compounds

Key Benefits in using Marcus M300 *

- **Reduced processing energy and time**
- **Increased resistance to ozone attack**
- **Increased green tack**

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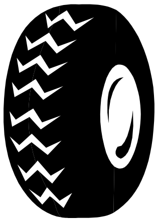
* Application covered by US patent 6,639,003

To improve the resistance of rubber to the effects of ozone and UV light, rubber compounders have traditionally used combinations of static and dynamic antidegradants.

Microcrystalline waxes have traditionally been used to protect against static ozone attack and work by providing a physical barrier on the surface of a rubber article, such as a tire. This physical barrier prevents attack on the rubber from ozone present in the atmosphere. The surface film of microcrystalline wax is sacrificial and is constantly being regenerated through a phenomenon called blooming. Blooming is the process where the microcrystalline wax, due to its incompatibility with rubber, continually migrates to the rubber surface. Microcrystalline wax use in tires has been limited due to the adverse effect high levels have on adhesion and green tack of the rubber compound.



Marcus M300 is a low molecular weight polyethylene (LMWPE) polymer with properties as shown in Table 1. Marcus M300 has been shown effective in rubber compounds (patents pending) to both reduce the degradation effects of ozone on the rubber article and provide for improved processing of the rubber compound without the negative effect of reducing green tack of the unvulcanized rubber compound.

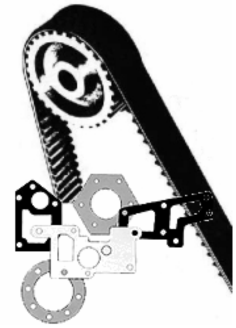
Marcus M300 polyethylene wax was evaluated in a model tire formulation shown in Table 2. Marcus M300 was evaluated against a Control formulation utilizing a conventional (LMWPE) wax and microcrystalline wax. Formulation M300 #1 eliminated the conventional LMWPE wax while Formulation M300#2 eliminated the conventional LMPE wax and half the microcrystalline wax.

Table 1: Marcus 300 Low Molecular Weight Polyethylene Properties

	Molecular weight (Mn)	Mettler Drop Point (ASTM D—3954)	Hardness Dmm (ASTM D-5)	Density g/cc (ASTM D-1505)	Viscosity-cps @140C (Brookfield)	Acid Number mg KOH/g
M300	1000	118	2.7	0.94	37	Nil

Table 2: Model Radial Passenger Tire Sidewall Recipe (PHR)

RAW MATERIAL	RAW MATERIAL TYPE	M300 #1	M300 #2	CONTROL
POLYMER	Natural Rubber	50	50	50
POLYMER	HIGH-CIS BR	50	50	50
LOW MOLECULAR WT. PE	A-C 617	0	0	2
LOW MOLECULAR WT. PE	M300 PASTILLES	2	3.5	0
CARBON BLACK	N550	54	54	54
PROCESS OIL	NAPHTHENIC	7	7	7
ACTIVATOR	ZINC OXIDE	3	3	3
ACTIVATOR	STEARIC ACID	1.5	1.5	1.5
STATIC ANTIOZONANT WAX	MICROCRYSTALLINE	3.0	1.5	3.0
ANTIDEGRADANT	6PPD	2	2	2
PRIMARY ACCELERATOR	SANTOCURE NS	0.9	0.9	0.9
TOTAL SULFUR	CRYSTEX OT	2.0	2.0	2.0



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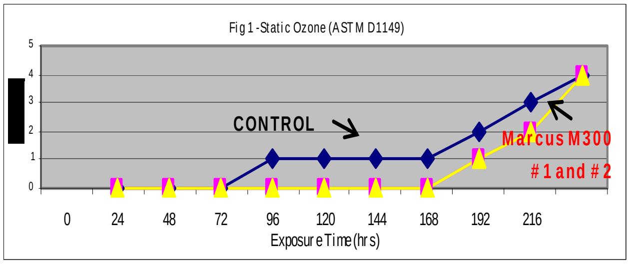

TABLE 3: VULCANIZATION CHARACTERISTICS (ODR Curemeter : 320F)

	CONTROL	M300 #1	M300 #2
Min. Torque: in-lbs.	14.0	15.1	15.8
Max. Torque: in-lbs.	68.0	68.8	68.6
Scorch;Ts2: minutes	3.2	3.2	3.2
T(90%); minutes	7.3	7.2	7.1

Table 4:BFGoodrich Portable Universal Tack-tester

	CONTROL	M300 #1	M300 #2
Peak Force; lbs/sq. in.	18.3	26.7	25.5
Tack Energy; in-lb./sq. in.	0.716	1.231	1.151

n=5; 3 second dwell; 10 in./min. test speed

Table 5: Average Adhesion
ASTM D413 - Adhesion to Model Plyskim (60 NR/40SBR; 50 phr N660 black)

	CONTROL	M300 #1	M300 #2
Adhesion (KN/m; n=4).	29.6	24.1	33.1

Table 6: Physical Properties
ASTMD412 & D2240

	CONTROL	M300 #1	M300 #2
Tensile Strength; PSI	2619	2691	2773
Hardness; Shore A	61	62	64
Ultimate Elongation;%	481.3	496.9	473.7
Modulus @ 100% Elongation;PSI	320.1	349.1	372.1
Modulus @ 200% Elongation;PSI	806.3	904.5	947.5
Modulus @ 300% Elongation;PSI	1456	1584	1617

Table 7: Gardner Glossmeter

	CONTROL	M300 #1	M300 #2
Gloss Reading (Gardner Units)	5.1	1.9	4.9

Figure 1 shows the improved performance in static ozone tests with the use of Marcus M300 vs conventional LMWPE wax. Performance was maintained when substituting M300 for half of the microcrystalline wax.

The testing indicates that vulcanization characteristics (Table 3) were not significantly impacted with the use of Marcus M300.

Marcus M300 did indicate a statistically significant - higher auto-adhesion (tack) (Table 4) in the unvulcanized state. While peal strength after, vulcanizing, was not statistically different.

Physical properties of the samples (Table 6) indicated that tensile and ultimate elongation characteristics were not significantly influenced by the use of Marcus M300. Modulus tended to increase with the substitution of M300 for conventional LMWPE and microcrystalline wax.

The use of Marcus M300 also showed a reduction in gloss (Table 6) for the formulation tested. This reduction was most apparent with formulation M300 #1.

Rubber Processability tests (Table 7) indicated a reduction in unvulcanized shear strain when M300 was substituted for conventional LMWPE. Strain sweep when vulcanized revealed little impact when using Marcus M300.

Table 7: Rubber Processability Analysis: RPA 2000

Type Test	Vulcanization State	Temp; Deg. C	Strain; %	Frequency; hz	Parameter	CONTROL	M300 #1	M300 #2
Frequency Sweep	unvulcanized	100	2	0.33	G';kPa	188.5	153	224.1
					Tan delta	0.638	0.696	0.598
Frequency Sweep	unvulcanized	100	15	0.83	G';kPa	181.7	156.9	208.6
					Tan delta	0.596	0.648	0.567
Frequency Sweep	unvulcanized	100	2	3.3	G';kPa	371.6	325.2	426.2
					Tan delta	0.485	0.513	0.474
Frequency Sweep	unvulcanized	100	15	8.3	G';kPa	348.9	320.2	387.1
					Tan delta	0.446	0.475	0.433
Strain Sweep	vulcanized	100	1	1	G';kPa	1169	1114	1301
					Tan delta	0.117	0.108	0.122
Strain Sweep	vulcanized	100	10	1	G';kPa	863.3	832.5	940.4
					Tan delta	0.13	0.127	0.134
Strain Sweep	vulcanized	100	50	1	G';kPa	515.2	522.3	568
					Tan delta	0.292	0.284	0.287

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