TECHNICAL UPDATE

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Improving EPDM Wire and Cable Insulating Compounds Using Dymalink® Metallic Coagents

Benefits

- Enhanced adhesion to metals
- Efficient crosslinking
- High modulus
- Improved tensile strength
- Good electrical properties
- Improved electrical resistivity

Suggested Applications

- Wire and cable insulation
- Engineered products (power transmission and conveyor belts, fluid routing hoses)

Additional Information

SDS: Dymalink® 633

Description

Dymalink® metallic coagents are multi-functional additives that can be used in peroxide-cured systems to improve cure characteristics and physical properties of rubber compounds.

Due to the increased demand for better performance, coagents are frequently employed in rubber compounding in order to improve physical properties of the insulating materials, e.g., tensile strength, cure times, and heat resistance.

Insulating materials, such as ethylene propylene diene monomer (EPDM) rubber, usually require the residual ionic content be kept at a minimum in order to maintain good electrical properties.

In this study, physical and electrical properties of a model EPDM wire and cable compound (Table II, Appendix) were investigated. The effects of Dymalink 633 zinc-containing coagent are compared with those of a commonly used liquid coagent, trimethylol propane triacrylate (TMPTA). A rubber compound containing four parts of organic peroxide and no coagent was used as a control. The results are highlighted in Table I.

Table I: Physical and electrical properties of a model EPDM compound

PROPERTY	UNIT	CONTROL (no coagent)	TMPTA (phr)			Dymalink 633 (phr)		
			2	5	10	2	5	10
Dielectric Strength	V/mil	23.9	25.6	25.3	25.7	25.5	25.0	24.8
Volume Resistivity	x10^{15} Ω*cm	3.64	3.75	4.09	4.94	4.89	6.78	6.9
Delta Torque (MH-ML)	dNm	10.97	14.85	16.77	19.39	15.51	18.54	22.32
Scorch Time (ts_2)	min	3.16	1.00	0.93	0.89	1.13	1.11	1.15
Tensile Strength	psi	1087	1060	1079	1084	1171	1368	1687
Elongation	%	785	511	403	326	539	399	326
Tear Strength	lbf/in	167	152	145	147	205	225	241
Lap Shear Adhesion (steel)	lbf/in^2	53 (A)**	52 (A)	61 (A)	73 (A)	118 (A)	184 (A)	272 (A)

** Mode of failure: (A) – Adhesive; (C) – Cohesive

Dymalink 633 (zinc diacrylate) was shown to dramatically improve physical properties of a model EPDM compound (Table II, Appendix) without any negative effects on electrical properties such as dielectric breakdown voltage (Figure 1) and volume resistivity (Figure 2). Moreover, Dymalink 633 offered some improvement in volume resistivity over TMPTA.

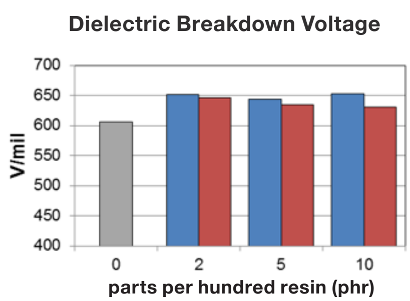

Figure 1: Dielectric breakdown voltage
(ASTM D149-13, method A, AC 2000 V/s)

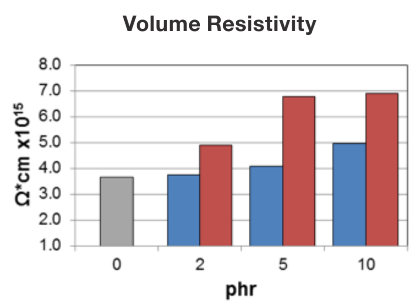

Figure 2: Volume resistivity
(ASTM D257-07, 500 VDC)

Control **TMPTA** **Dymalink 633**

The data shows that delta torque (Figure 3), tensile strength (Figure 4) and tear strength (Figure 5) are dramatically increased. The improvements in crosslink density, modulus and tensile strength are believed to be due to homopolymerization and subsequent grafting of the coagent onto the polymer backbone.

Processing safety is always a concern when curing rubber with peroxides. Coagents can be used to minimize premature vulcanization. Figure 6 shows that the scorch time remains nearly constant with the increasing loading of Dymalink 633. In the case of TMPTA, scorch time is gradually reduced. It is important to point out that the scorch time for both coagents is shorter than with peroxide alone. Values in Figures 3, 4, 5 and 7 are normalized to the control sample containing no coagent.

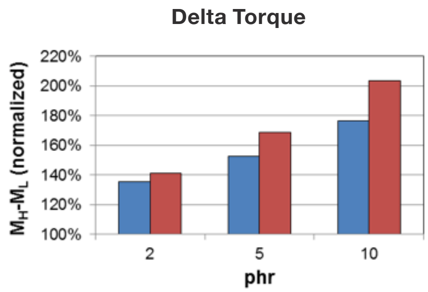

Figure 3: Delta torque M_H-M_L
(ASTM D2058, 160 °C for 35 min)
100% = no coagent

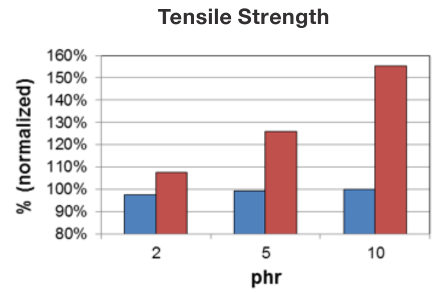

Figure 4: Tensile strength
(ASTM D412, method A, Die D)

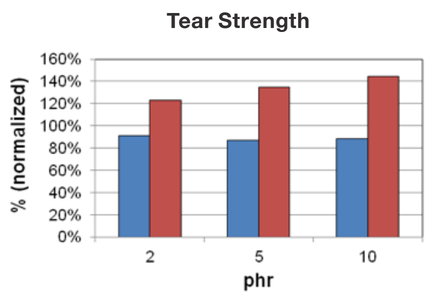

Figure 5: Tear strength
(ASTM D624, Die C)

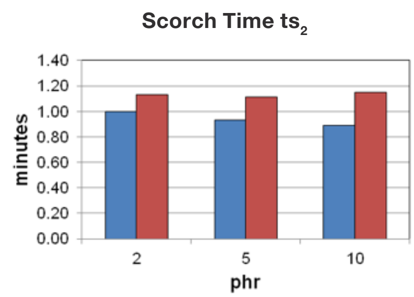

Figure 6: Scorch time ts_2
(ASTM D2058, 160 °C for 35 min)

TMPTA **Dymalink 633**

Dymalink coagents also possess a zinc metal center that allows for the formation of "ionic" crosslinks during vulcanization. It has been postulated that these crosslinks can facilitate reversible chain slippage without sacrificing network integrity. This results in improved dynamic properties, tear strength and extremely strong rubber-to-metal adhesion without the use of primers or adhesives.

An example in Figure 7 shows that even at 2 phr loading, Dymalink 633 improves adhesion to steel twofold compared to the control.

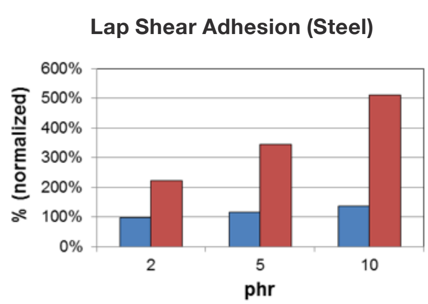

Figure 7: Lap shear adhesion to cold-rolled steel
(ASTM D814)

TMPTA **Dymalink 633**

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Summary

The use of Dymalink metallic coagents in insulating EPDM compounds can provide significant improvements in tensile and tear strength, modulus and delta torque without sacrificing good electrical properties and flexibility inherent to EPDM.

Improved tensile and tear strength may permit the use of a reduced cross-sectional area without compromising the load-carrying capacity in high- and medium-voltage cables.

Additionally, rubber compounds cured with peroxides and Dymalink coagents produce excellent adhesion properties that may ensure a strong bond between rubber and metal interfaces.

Appendix

Table II: Model EPDM Formulation

Ingredient	phr
Vistalon® 2504(PE) EPDM[1]	100.0
Translink® 37[2]	70.0
ZnO Kadox® 911C[3]	5.0
Akrowax® 5030[4]	5.0
Stearic acid	1.0
TMQ[5]	2.0
Di-Cup® 40KE (40% Active)[6]	4.0
TMPTA[7] or Dymalink® 633[8]	0, 2, 5, 10

[1] Vistalon is a trademark of ExxonMobil Chemical.
[2] Translink is a trademark of BASF.
[3] Kadox is a trademark of HallStar, Inc.
[4] Akrowax is a trademark of Akrochem, Inc.
[5] Flectol TMQ (2,2,4-Trimethyl-1,2-Dihydroquinoline) is a trademark of Flexsys.
[6] Di-Cup is a trademark of Arkema, Inc.
[7] Trimethylol propane triacrylate (Sigma-Aldrich).
[8] Dymalink is a trademark of Total Cray Valley.

Table III: Test Methods

Test Description	ASTM Designation
Volume Resistivity	ASTM D257-07, 500 VDC
Dielectric Breakdown Voltage	ASTM D149-13, Method A
Tensile Strength	D412, Method A, Die D
Tear Strength	D624, Die C
Cure Characteristics (ts_2, M_H, M_L)	D2084, 160 °C, 35 min
Lap Shear Adhesion	D814

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About Total Cray Valley

Total Cray Valley is the premier global supplier of specialty chemical additives, hydrocarbon specialty chemicals, and liquid and powder tackifying resins used as ingredients in adhesives, rubbers, polymers, coatings and other materials. Cray Valley has pioneered the development of these advanced technologies, introducing hundreds of products that enhance the performance of products in energy, printing, packaging, construction, tire manufacture, electronics and other demanding applications.