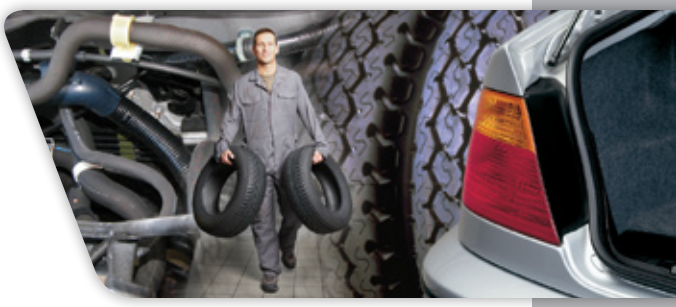
TECHNICAL UPDATE

CRAY VALLEY
Hydrocarbon Specialty Chemicals

Blending Coagents Improves Rubber Performance



Benefits

- Provides rubber adhesion while optimizing compression set
- Improves tear properties at high modulus
- Maintains ultra-high hardness, while minimizing migration/blooming of coagent
- Improves flexural fatigue properties
- Provides moderate scorch safety while maintaining modulus

Suggested Applications

- High-hardness compounds (e.g., rubber rolls, engineered products)
- Adhesion to metal or reinforcing textiles (e.g., hoses and belts)
- Peroxide-cured compounds demanding high tear or flexural fatigue (e.g., vibration mounts, belts, tires)

Additional Information

MSDS/TDS: SR517R, SR522, Dymalink® 633, Dymalink® 634 & Ricon 154

Description

Multifunctional coagents are used to improve the cure kinetics and ultimate physical properties of elastomers cured with organic peroxides. A wide variety of coagents are available from Cray Valley, each having unique structure-property relationships. Coagents are typically selected to impart specific performance attributes to the compound. However, improvements in certain physical properties may come at the expense of others, and it is not uncommon for physical property specifications to be gained at the expense of processing requirements. By blending certain classes of coagents, it may be possible to optimize physical properties that would be mutually exclusive if working only with a single coagent. In addition, coagent blends may allow for improvements in both physical properties and processing.

Certain classes of coagents can best improve physical properties through blending. It can be advantageous to blend certain Type I coagent products. Examples provided below will demonstrate how metallic and liquid (meth) acrylate esters can be blended to optimize certain physical properties. In the case of blending Type I coagents, it is important to note that mixing acrylate and methacrylate esters is not desirable; when blending Type I coagents, the best results are provided through either acrylate-acrylate or methacrylate-methacrylate pairs. As a rule, Type I and Type II coagents can be blended to take advantage of the different cure kinetics and compound solubility inherent to each class. Often the technology yields results that can be accurately predicted based on the coagent blend ratio.

CRAY VALLEY
Hydrocarbon Specialty Chemicals

Table 1
Coagent Descriptions

Coagent Type	Type I		Type II
	Liquid Coagent	Metallic Coagent	Polymeric Coagent
Acrylate	SR522	Dymalink® 633	
Methacrylate	SR517R	Dymalink® 634	
Allylic			Ricon 154

SR517R and SR522 are products of Sartomer USA, LLC, an Arkema company.

Metallic monomer coagents (Dymalink® 633, Dymalink® 634) are often selected to generate rubber adhesion to polar substrates (metal, textiles) or improve the tear and dynamic properties of the compound. However, due to the unique structure and cure mechanism of these coagents, permanent set under compression is often dramatically increased. By replacing part of the coagent loading with a liquid monomer (SR517R, SR522), adhesion or dynamic properties can be maintained at an acceptable level while improving compression set.

A model EPDM formulation cured with coagents and peroxide (Appendix) was used to demonstrate trends in physical properties across the spectrum of SR517R/Dymalink® 634 blend ratios. Total coagent loading was held constant at 10 phr, which resulted in a 100% modulus of nearly constant value (2.60 +/- 0.7 MPa). Results are shown below as a function of % Dymalink® 634 in the coagent blend. Adhesion was maintained at levels of liquid monomer that provide improved compression set. Tear and flex fatigue were improved with Dymalink® 634 loading while maintaining modulus and hardness. The results indicate that a predictable relationship between coagent blend ratio and physical properties exists. Through judicious selection of blend components and ratio, the specified physical properties of the compound may be optimized.

Figure 1
Lap Shear Adhesion (Steel) Versus Coagent Blend Ratio

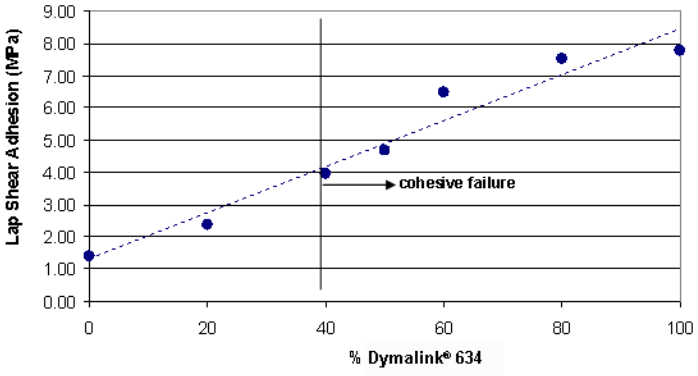


Figure 2
Tear Strength Versus Coagent Blend Ratio

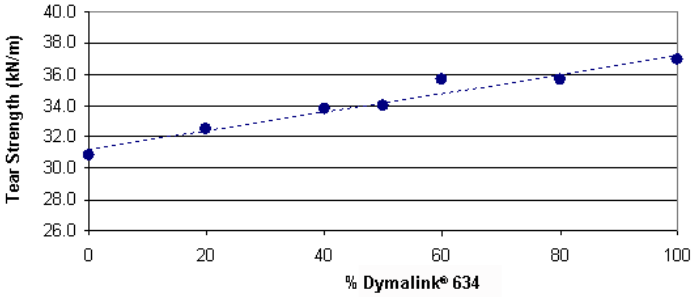
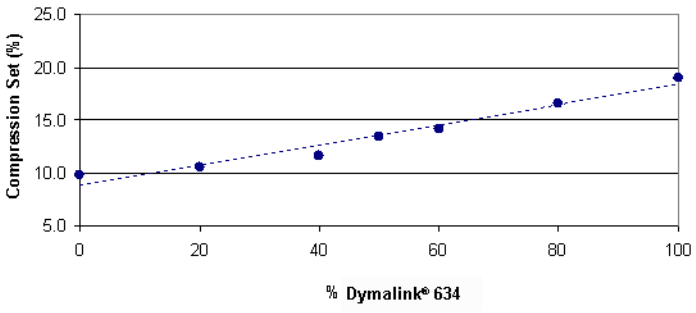


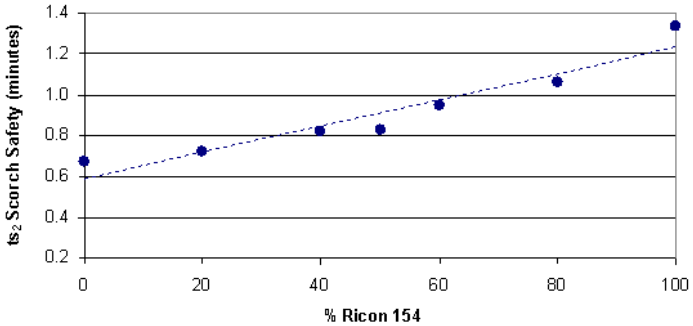
Figure 3
Compression Set Versus Coagent Blend Ratio



While the opportunities for blending Type I coagents are somewhat restricted to metallics and liquid (meth) acrylate esters, blending Type I with Type II coagents offers more possible combinations. Liquid Type I (meth) acrylate esters (e.g., SR517R) are often used at very high loadings (>10 phr) to not only increase the final hardness of the compound, but also to maintain processing characteristics. Unfortunately, most (meth)acrylate ester liquid coagents are only slightly soluble in hydrocarbon rubber and can migrate between components or bloom to the surface prior to cure if loaded at elevated levels. In some formulations, particularly EPDM-based, the substitution of part of the coagent loading with a polymeric Type II coagent (Ricon 154) can maintain hardness and other physical properties while extending scorch safety. In addition, surface characteristics can be improved, as the diene-based polymeric coagent is much more soluble in the rubber compound than the liquid coagent.

The same model EPDM formulation was used to evaluate SR517R/Ricon 154 blends at 10 phr total coagent. Again, modulus was constant (2.83 +/- 0.2 MPa) as SR517R was replaced with Ricon 154. As the percentage of Ricon 154 was increased in the blend, uncured shear modulus was maintained (processing), and aged surface characteristics were improved. Scorch time was greatly increased with Ricon 154 percentage, while tensile and compression properties were largely maintained. Results are shown below as a function of % Ricon 154 in the coagent blend.

Figure 4
Scorch Safety Versus Coagent Blend Ratio



CRAY VALLEY
Hydrocarbon Specialty Chemicals

Figure 5
Uncured Shear Modulus Versus Coagent Blend Ratio

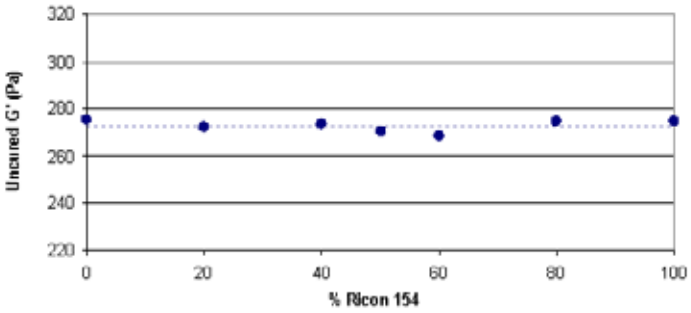
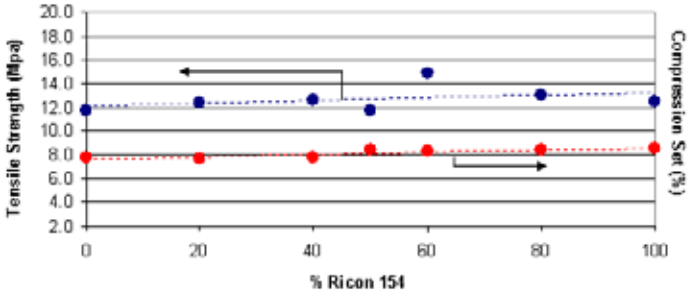


Figure 6
Tensile and Compression Set Versus Coagent Blend Ratio



By blending certain classes of coagent products, the compounder can achieve a better balance of physical properties or improve upon cured properties while not sacrificing scorch safety or processing characteristics. Only Cray Valley provides a complete portfolio of Type I and Type II coagents, with many different products available. By blending these products, compound performance can be improved in many applications, including:

- High-hardness compounds for rollers or other engineered products
- Adhesion to metal or reinforcing textiles
- Peroxide-cured compounds demanding high tear or flexural fatigue properties

CRAY VALLEY
Hydrocarbon Specialty Chemicals

Appendix

Model EPDM Formulation

Ingredient	phr
EPDM (Nordel™ IP 4640)	100
Carbon Black (N 660)	100
Oil (Sunpar® 2280)	50
Stearic Acid	1
Antioxidant (Naugard® Q)	1

Nordel™ is a trademark of Dow Plastics
Sunpar® is a registered trademark of Sun Oil Company
Naugard® is a registered trademark of Chemtura Corporation

Test Methods

Test	ASTM	Comments
Scorch Safety	D 5289	ts_2
Tensile Modulus	D 412	-
Tear Strength	D 624	Die C
Compression Set	D 395	100 °C, 22 hrs.
Hardness	D 2240	Shore A

*The listed properties are illustrative only, and not product specifications. Cray Valley disclaims any liability in connection with the use of the information, and does not warrant against infringement by reason of the use of its products in connection with other materials or in any process.