TECHNICAL UPDATE

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Using Cleartack® W Resins to Modify the Performance of Styrene Butadiene Block Copolymers

Benefits

- Improved processing
- Increased melt flow index (MFI)
- Increased tear strength
- Increased tensile strength, elongation, yield strength and modulus

Target Markets

- Plastic modification
- SEBS (SBC) modification
- Soft touch

Description

By choosing the appropriate Cleartack® W resin for their styrene butadiene block copolymer (SBC), formulators can increase one or more of many tensile properties and increase tear strength.

Styrene ethylene butylene styrene (SEBS) is a thermoplastic elastomer belonging to the generic class of materials commonly referred to as "block polymers" (also, styrenic block copolymers or SBC). Specifically, SEBS is a hydrogenated grade of styrene-butadiene-styrene (SBS) such that the unsaturation that was once prevalent in the mid-block, a mixture of 1,2- and 1,4- polybutadiene polymer, has been removed, leaving a mid-block that now resembles a copolymer of ethylene and butylene (hence the name SEBS). These polymers offer improved heat resistance, compression set and environmental resistance. Thus, they have found their way into a wide variety of applications.

If a standard grade of SBC does not perform in an ideal fashion, it is possible to enhance properties like tensile strength, yield strength, tear strength and also melt flow index (MFI) with the addition of relatively small amounts of resin. In this Tech Update, the effects of aromatic resins on the properties of a widely used SEBS manufactured by Kraton Polymers, LLC, known as Kraton G1652M will be shown. In future updates the effects of aliphatic and functional additives will be studied. The typical properties of G1652M are taken from literature and shown in Table 1.

Table 1. Typical properties of Kraton G1652M.

Property	Value/Description
Structure	Linear SEBS
Tensile Strength, MPa	31
300% Modulus, MPa	4.8
Elongation @ Break, %	500
Styrene/Rubber Ratio	30/70
Diblock, %	<1

SBCs have a distinct two-phase (domain) structure and each phase contributes to their unique properties. The styrenic domain provides a rigid crosslink-type function while the low-Tg mid-block will impart flexibility and toughness. The two phases also provide the opportunity to "modify" or enhance the performance of the entire polymer by judicious selection of an additive to modify the targeted phase. For example, the hard polystyrene end-block phase can be can be enhanced by choosing additives that are compatible with the aromatic domains. In contrast, the softer, low-Tg, rubbery mid-block phase can be enhanced by choosing additives that are primarily aliphatic in their chemical composition or nature.

In this update, the effects of four grades of Cray Valley's Cleartack W series of aromatic resins will be presented. The resins chosen cover a wide range of ring and ball softening points (SP) from relatively soft to hard, as shown in Table 2.

Table 2. Ring and ball softening points of Cleartack resins.

Abbreviation	Grade	Description
W-85	Cleartack W-85	Pure monomer aromatic hydrocarbon resin with a 85 °C SP
W-100	Cleartack W-100	Pure monomer aromatic hydrocarbon resin with a 100 °C SP
W-120	Cleartack W-120	Pure monomer aromatic hydrocarbon resin with a 120 °C SP
W-140	Cleartack W-140	Pure monomer aromatic hydrocarbon resin with a 140 °C SP

Experimental

The additives were mixed into the SEBS at levels ranging from 2 percent by weight to 10 percent by weight. All compositions were compounded on a 20 mm co-rotating intermeshing twin-screw extruder (Brabender TSE-20) with a L/D ratio of 40:1. Samples were bag-mixed and fed at the feed throat with an increasing temperature profile from 200 °C to 220 °C. All compounds were extruded into a water bath, dried with an air knife and then pelletized.

All samples were pressed into sheets with nominal dimensions of 4" x 4" x 0.07" thick at 220 °C using a Carver press at 15,000 psi for 4 minutes. Samples were conditioned in a 23 °C and 50% relative humidity environment overnight before continuing.

Specimens were tested according to ASTM D412 in conjunction with a Type C die. All testing was completed in triplicate using a Thwing-Albert twin-screw tensile tester.

Results

The physical properties are summarized in Table 3.

Table 3. Physical properties.

Cleartack Additive	Percent Additive	Tensile Strength (psi)	Elongation (%)	Yield Strength (psi)	Modulus at 50% (psi)	Modulus at 100% (psi)	Modulus at 300% (psi)	Tear Strength (psi)	MFI (g/10 min)
Control	0	3588	667	2830	326	392	879	309	5.8
W-85	5	4398	698	4253	333	397	898	331	6.9
W-85	10	4641	687	4454	375	433	928	267	8.6
W-100	2	4308	693	4148	397	458	961	317	5.5
W-100	5	4553	706	4387	338	398	921	335	6.9
W-100	10	4527	702	546	542	533	960	360	9.3
W-120	5	4946	703	3328	429	484	1029	407	6.6
W-120	10	4083	669	1663	647	744	1307	435	9.2
W-140	5	4965	726	4821	355	401	894	344	7.0
W-140	10	4328	693	1578	490	540	1081	343	6.9

With the use of moderate amounts of Cleartack W series aromatic resins, one can choose to harden or soften the styrenic end-blocks of the SEBS block copolymer. At a 5% level by weight, all grades of Cleartack W tested had a very similar positive effect upon the elongation, 50% modulus and 100% modulus as shown in Figure 1, with all being approximately equivalent or higher than the control. The tensile strength, however, increases significantly as the ring and ball softening point (SP) increases from 85 °C to 120 °C and then flattens out. Cleartack W-120 is a great choice to dramatically increase the tensile strength by almost 40% while maintaining or increasing all other properties.

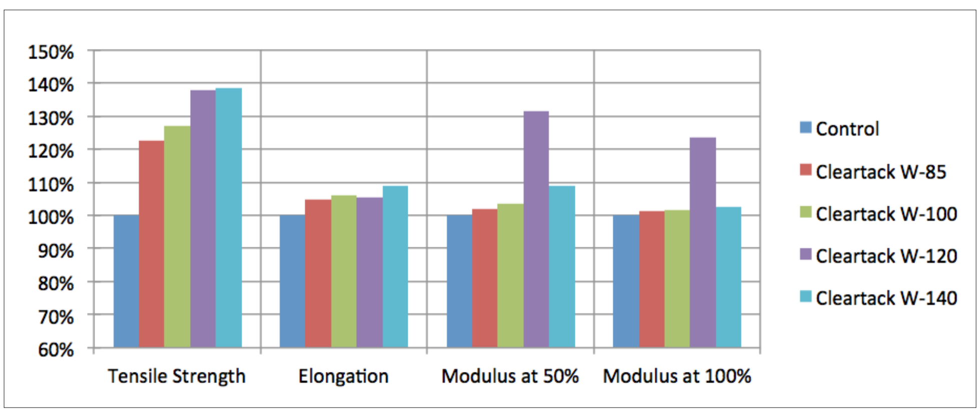

Figure 1. Relative effect of 5% of various grades of Cleartack on SEBS properties.

One of the driving forces behind this investigation was to determine if any of the Cleartack W resins can be used to increase the tear strength of SEBS. The data in Figure 2 confirms that using 5% Cleartack W-120 can improve the tear strength of SEBS by 100 psi (one-third).

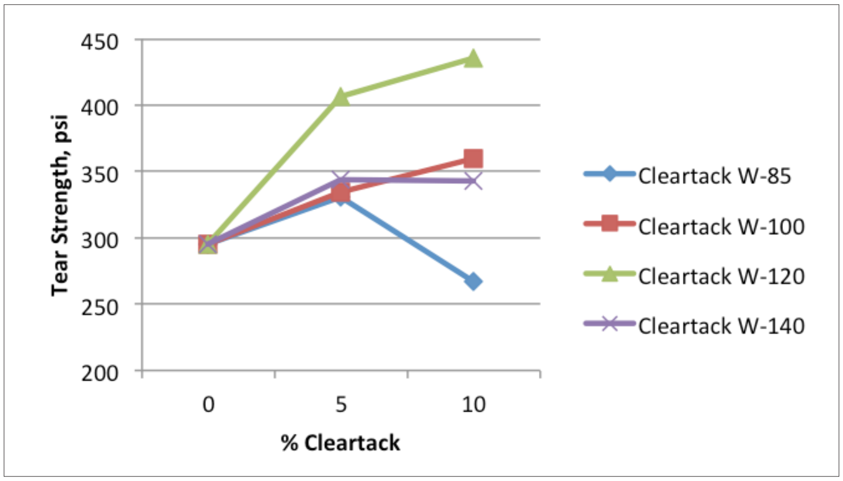

Figure 2. SEBS tear strength.

In addition to physical property enhancement, the processability of SEBS is also critical to compounders and end users. A quick look at the melt flow index (MFI) data in Figure 3 shows that the addition of as little as 5 weight percent of any of the Cleartack W-series resins will increase the MFI by 15% (from 5.8 to 6.6 or so g/10 min). This is a modest but significant increase with no loss of properties.

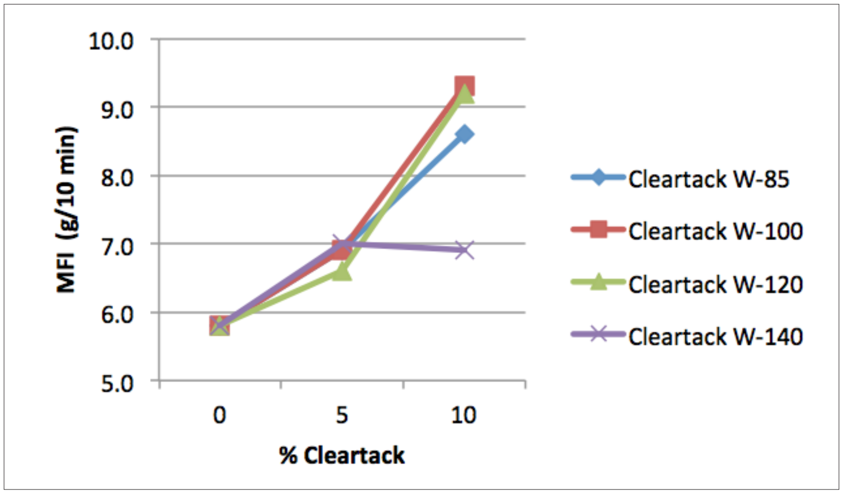

Figure 3. MFI of SEBS at various loadings.

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Summary & Future Work

By choosing the right Cleartack W resin for their SBC, formulators can increase one or more of many tensile properties and increase tear strength, while improving the processability of the SEBS as measured by the melt flow index (rate).

Future work will include the investigation of the effects of aliphatic resins such as Wingtack® 10, as well as functionalized aromatic and aliphatic resins.

For more information, please visit **www.crayvalley.com**

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. Total 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.

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