Adhesives Market Technical Tip

Kristalex and *Endex* Hydrocarbon Resins for Improved PSA Performance (TT-85)

Introduction

Pressure sensitive tape and label adhesives (PSAs) are frequently formulated using styrenic block copolymers (SBCs). SBCs contain two different types of blocks or phases. The mid-block is typically an olefinic or hydrogenated olefinic polymer that provides tack and adhesion. The two polystyrene end blocks form a phase that reduces the adhesive melt viscosity, but provides physical reinforcement when the adhesive is cooled. The concentration and rheology of the styrenic phase affects the cohesive properties of the adhesive, the temperature resistance, and the application temperature.

Endex and *Kristalex* aromatic hydrocarbon resins preferentially modify the styrenic end-blocks of SBCs and can be used to balance the cohesion, viscosity, and temperature resistance of a PSA formulation. *Endex* and *Kristalex* pure monomer resins (PMRs) are water-white, highly color stable, polar, low molecular weight, thermoplastic materials prepared from purified aromatic monomers.

- *Kristalex* 3070 and *Kristalex* 3085 Hydrocarbon Resins

  These low softening point, water-white resins decrease melt viscosity and increase ambient temperature hardness and cohesion.

- *Kristalex* 3100 Hydrocarbon Resin

  This intermediate softening point, water-white resin decreases melt viscosity and increases ambient temperature hardness and cohesion.

- *Endex* 155 and *Kristalex* 5140 Hydrocarbon Resins

  These very high softening point, water-white resins increase melt viscosity and increase both the room temperature and the high temperature cohesion of the PSA.

The physical properties of *Kristalex* and *Endex* resins are compared in Table 1. Values shown are an average of typical samples and should not be interpreted as product specifications.

Technical Discussion

SBC adhesive formulations were prepared with *Kristalex* and *Endex* hydrocarbon resins to better understand the effect these resins have on the end blocks. The adhesives were tested for viscosity, shear resistance at 70°C, 40°C, and room temperature (RT), and 180-degree peel and loop tack on stainless steel. Temperature resistance was also tested by measuring shear adhesion failure temperature (SAFT). The resins were formulated with KRATON D1161 (linear styrene-isoprene-styrene block copolymer or SIS, 15% styrene) and KRATON D1126 (radial SIS, 19% styrene) block copolymers. The formulations were based on 100 phr SIS, 110 phr *Piccotac* 1095, 10 phr *Calsol* 5550 naphthenic oil and two levels of *Kristalex* or *Endex* hydrocarbon resin, as shown in Table 2.

Table 1: Typical Physical Properties

Hydrocarbon Resin	RBSP[a] °C	Tg °C	OMSCP[b] °C	MMAP[c] °C	Molecular Weight Distribution		
					Mn	Mw	Mz
Kristalex 3070	70	32	8/3	0	650	950	1450
Kristalex 3085	85	41	36/32	1	650	1150	1900
Kristalex 3100	100	53	76/68	5	700	1500	2550
Kristalex 5140	139	85	>180	9	1500	4900	12100
Endex 155	153	99	129/121	16	2400	6950	13850

[a]*Ring and Ball Softening Point,* [b]*Odorless Mineral Spirits Cloud Point,* [c]*Mixed Methylcyclohexane-Aniline Cloud Point*

Note: Lower cloud point temperatures indicate a greater degree of polarity or aromaticity at a similar molecular weight. Full explanations of these tests can be found in the Eastman Publication WA-86A, *Spectrum of Hydrocarbon Resins.*

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Table 2: Formulations Tested

Ingredient	No End Block Resin	*Kristalex* 3070		*Kristalex* 3085		*Kristalex* 3100		*Kristalex* 5140		*Endex* 155	
		20 phr	50 phr	20 phr	50 phr	20 phr	50 phr	10 phr	20 phr	10 phr	20 phr
KRATON D1161 or D1126[a]	100	100	100	100	100	100	100	100	100	100	100
Piccotac 1095[b]	110	110	110	110	110	110	110	110	110	110	110
Kristalex 3070[b]	—	20	50	—	—	—	—	—	—	—	—
Kristalex 3085[b]	—	—	—	20	50	—	—	—	—	—	—
Kristalex 3100[b]	—	—	—	—	—	20	50	—	—	—	—
Kristalex 5140[b]	—	—	—	—	—	—	—	10	20	—	—
Endex 155[b]	—	—	—	—	—	—	—	—	—	10	20
Calsol 5550[c]	10	10	10	10	10	10	10	10	10	10	10
Irganox 1010[d]	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

[a]*KRATON Polymers LLC.*, [b]*Eastman Chemical Company*, [c]*(Naphthenic oil) - Calumet Specialty Products* [d]*Ciba Specialty Chemicals Holding, Inc.*

End block resins preferentially enter the styrene domains of an SBC adhesive. At 360°F, the lower molecular weight *Kristalex* end block resins soften the styrene domains and reduce the adhesive viscosity, as seen in Figure 1. In contrast, the higher molecular weight *Kristalex* 5140 and *Endex* 155 resins physically reinforce the styrenic phase and increase the adhesive viscosity.

The adhesive viscosity can be adjusted for a particular application by changing the amount of end-block resin added to the SBC. Increasing the amount of lower molecular weight resin gives additional reduction in viscosity, while increasing the amount of higher molecular weight resin gives additional increase in viscosity, as illustrated in Figure 2.

Figure 1: Effect on Adhesive Viscosity with 20 phr End Block Resins

Formulated with KRATON D1126 *radial block copolymer*

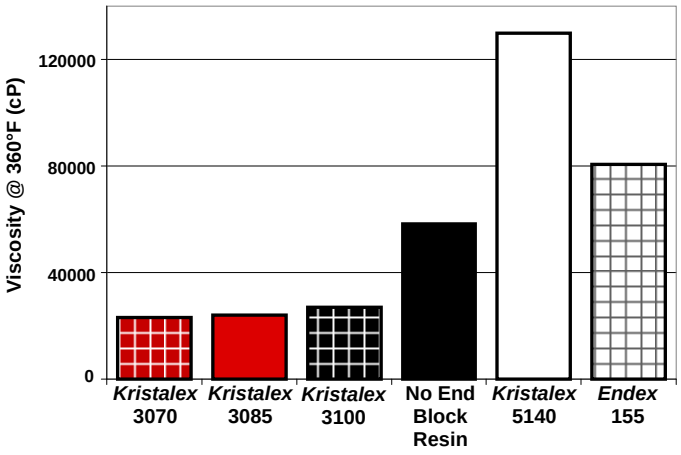
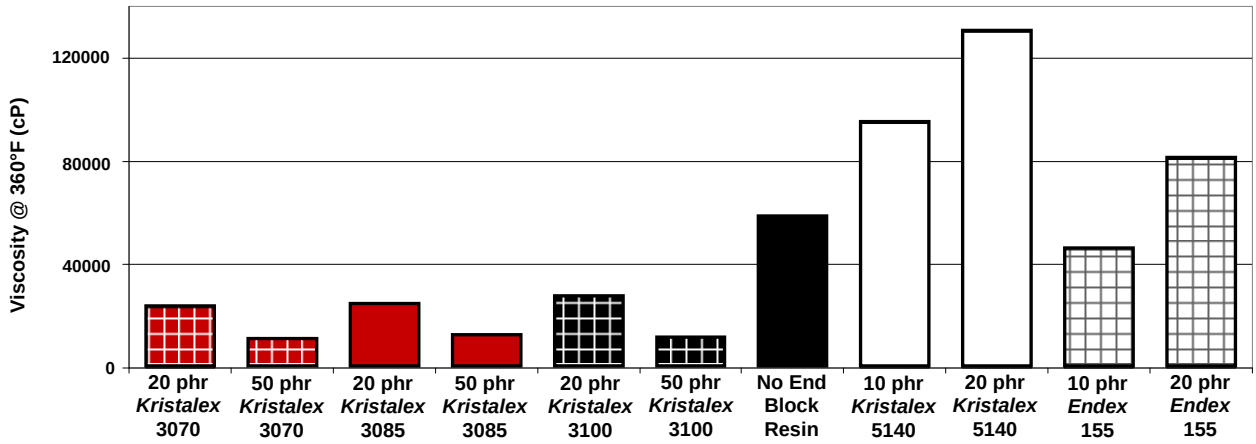


Figure 2: Effect on Adhesive Viscosity Relative to the Amount of End Block Resin



The ability to adjust adhesive viscosity by varying the amount of different molecular weight end block resins is a useful tool for the adhesive formulator. It is important to note, however, that addition of these resins also affects the RBSP and SAFT of the adhesive. The *Kristalex* 3070, 3085, and 3100 resins lower the softening point of the styrenic end block domains, and significantly reduce the adhesive RBSP and SAFT, as shown for the KRATON D1126 formulations in Table 3. Conversely, *Kristalex* 5140 and *Endex* 155 resins increase the adhesive RBSP and SAFT, even at 10 phr addition levels. This effect is similar in both linear D1161 and radial D1126.

Figure 3: Increase in 40°C Hold Power with 20 phr End Block Resin

Formulated with KRATON D1126 *radial block copolymer*

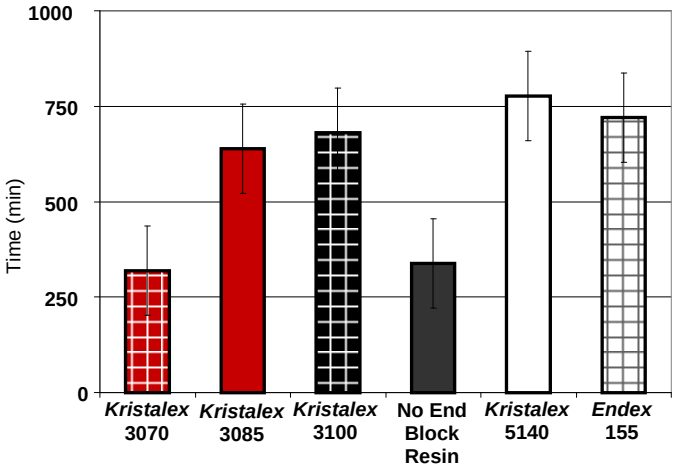


Table 3: Effect on Adhesive SAFT and RBSP Relative to the Amount of End Block Resin

Ingredient	*Kristalex* 3070		*Kristalex* 3085		*Kristalex* 3100		No End Block Resin	*Kristalex* 5140		*Endex* 155	
	20 phr	50 phr	20 phr	50 phr	20 phr	50 phr		10 phr	20 phr	10 phr	20 phr
RBSP (°C, STDV=3)	122	118	135	122	133	121	140	142	161	147	156
SAFT (°C, STDV=3)	99	90	100	96	104	98	105	110	113	113	112

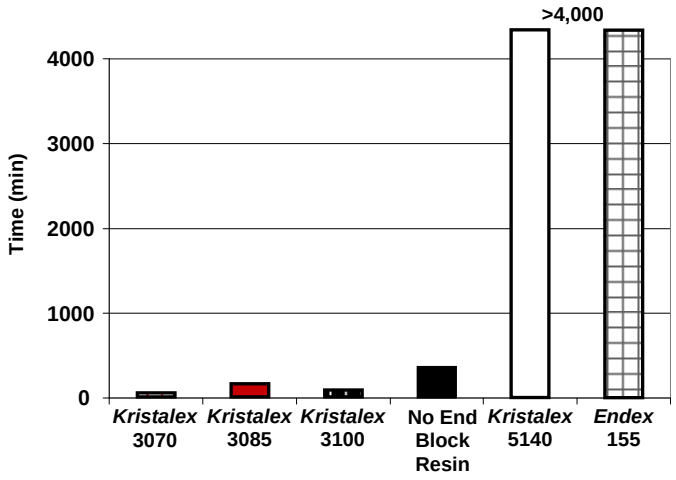
Adjusting adhesive viscosity must be balanced with the cohesive strength requirements for the adhesive. All of the *Kristalex* and *Endex* resins increase adhesive RT cohesion, as seen in a dramatic increase in room temperature hold power from about 5,000 minutes to over 10,000 minutes when 20 phr end block resin is added. Figure 3 illustrates that when the hold power test temperature is raised to 40°C, the cohesive strength of the PSA containing *Kristalex* 3070 does not increase, but the other end block resins tested do show increased adhesive cohesion and hold power.

As illustrated in Figure 4, if increased cohesion at 70°C is needed, *Kristalex* 5140 and *Endex* 155 can be used to reinforce the styrenic phase of SBCs and increase the high temperature cohesion and 70°C hold power. The effect on adhesive cohesion and the measured shear hold times is maintained after aging the tapes at 40°C for two weeks.

In addition to allowing the formulator to adjust the viscosity and cohesive strength of SBC-based PSAs, the lower molecular weight end block

Figure 4: 70°C Hold Power for Tapes with 20 phr End Block Resin

Formulated with KRATON D1126 *radial block copolymer*



resins can also improve loop tack and 180-degree peel to stainless steel, with excellent performance retention after aging as shown in Table 4.

Table 4: Effect on Adhesive Properties Before and After Aging at 40°C for Two Weeks

Formulated with KRATON D1126 *radial block polymer and 20 phr end block resin*

Adhesive Property	*Kristalex* 3070	*Kristalex* 3085	*Kristalex* 3100	No End Block Resin	*Kristalex* 5140	*Endex* 155
RT Hold Power (min)						
Initial mean (STDV)	>10,000	>10,000	>10,000	5,300 (4,200)	>10,000	>10,000
Aged mean (STDV)	7,400 (2,500)	5,300 (1,600)	>10,000	3,400 (2,100)	>10,000	>10,000
40°C Hold Power (min)						
Initial mean (STDV)	320 (90)	640 (230)	700 (200)	340 (90)	780 (260)	720 (150)
Aged mean (STDV)	147 (29)	140 (30)	280 (60)	163 (40)	410 (40)	764 (170)
70°C Hold Power (min)						
Initial mean (STDV)	300 (40)	330 (80)	2,700 (300)	440 (290)	>2,880	>2,880
Aged mean (STDV)	320 (60)	390 (60)	1,940 (580)	610 (110)	>2,880	>2,880
180° Peel (oz/in)						
Initial mean (STDV)	83 (7)	89 (8)	83 (4)	63 (8)	66 (8)	73 (7)
Aged mean (STDV)	83 (5)	81 (3)	74 (7)	70 (5)	69 (5)	71 (6)
Loop Tack (oz/in)						
Initial mean (STDV)	87 (7)	88 (7)	86 (9)	48 (4)	77 (8)	57 (4)
Aged mean (STDV)	76 (4)	88 (7)	101 (5)	51 (5)	73 (6)	65 (5)

Conclusion

Eastman Chemical Company's water-white *Kristalex* and *Endex* pure monomer resins preferentially modify the styrene domains of an SBC adhesive. The lower molecular weight *Kristalex* end block resins reduce the 360°F adhesive viscosity, and increase room temperature and moderate temperature cohesive strength. In contrast, the higher molecular weight *Kristalex* 5140 and *Endex* 155 resins increase the adhesive viscosity and cohesive strength at 70°C. These resins can be used to balance the cohesion, viscosity, and temperature resistance of hot melt PSAs formulated using styrenic block copolymers.

For more information on formulation strategies using tackifiers from Eastman Chemical Company, contact us at 1-800-EASTMAN or visit us at www.eastman.com/adhesives.

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EASTMAN

NORTH AMERICA

Eastman Chemical Company
Corporate Headquarters
P.O. Box 431
Kingsport, TN 37662-5280 U.S.A.

Telephone:
U.S.A. and Canada, 800-EASTMAN (800-327-8626)
Other Locations, (1) 423-229-2000
Fax: (1) 423-229-1193

www.eastman.com

LATIN AMERICA

Eastman Chemical Latin America
9155 South Dadeland Blvd.
Suite 1116
Miami, FL 33156 U.S.A.

Telephone: (1) 305-671-2800
Fax: (1) 305-671-2805

EUROPE / MIDDLE EAST / AFRICA

Eastman Chemical B.V.
Fascinatio Boulevard 602-614
2909 VA Capelle aan den IJssel
The Netherlands

Telephone: (31) 10 2402 111
Fax: (31) 10 2402 100

ASIA PACIFIC

Eastman (Shanghai) Chemical
Commercial Company, Ltd. Jingan Branch
1206 CITIC Square
No. 1168 Nanjiing Road (W)
Shanghai 200041, P.R. China

Telephone: (86) 21-6120-8700
Fax: (86) 21-5213-5255

Eastman Chemical Japan Ltd.
AIG Aoyama Building 5F
2-11-16 Minami Aoyama
Minato-ku, Tokyo 107-0062 Japan

Telephone: (81) 3-3475-9510
Fax: (81) 3-3475-9515

Eastman Chemical Asia Pacific Pte. Ltd.
#05-04 Winsland House
3 Killiney Road
Singapore 239519

Telephone: (65) 6831-3100
Fax: (65) 6732-4930

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