

# Kristalex™ and Endex™ hydrocarbon resins for improved PSA performance

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 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.

**Table 1. Typical physical properties**

Hydrocarbon resin	RBSP <sup>a</sup> °C	T <sub>g</sub> °C	OMSCP <sup>b</sup> °C	MMAp <sup>c</sup> °C	Molecular weight distribution		
					M <sub>n</sub>	M <sub>w</sub>	M <sub>z</sub>
Kristalex 3070	70	32	4	1	600	900	1,330
Kristalex 3085	85	39	35	2	650	1,200	1,900
Kristalex 3100	100	51	65	6	900	1,500	2,500
Kristalex 5140	140	90	>180	10	1,750	4,900	9,800
Endex 155	153	105	117	15	2,500	6,900	12,900

<sup>a</sup>Ring-and-ball softening point

<sup>b</sup>Odorless mineral spirits cloud point

<sup>c</sup>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 publication ADH-7669, "Eastman's Spectrum of Hydrocarbon Resins."

## 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° and 40°C, 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 (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. End-block resins preferentially enter the styrene domains

**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 <sup>a</sup>	100	100	100	100	100	100	100	100	100	100	100
Piccotac 1095 <sup>b</sup>	110	110	110	110	110	110	110	110	110	110	110
Kristalex 3070 <sup>b</sup>	—	20	50	—	—	—	—	—	—	—	—
Kristalex 3085 <sup>b</sup>	—	—	—	20	50	—	—	—	—	—	—
Kristalex 3100 <sup>b</sup>	—	—	—	—	—	20	50	—	—	—	—
Kristalex 5140 <sup>b</sup>	—	—	—	—	—	—	—	10	20	—	—
Endex 155 <sup>b</sup>	—	—	—	—	—	—	—	—	—	10	20
Calsol 5550 <sup>c</sup>	10	10	10	10	10	10	10	10	10	10	10
Irganox® 1010 <sup>d</sup>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

<sup>a</sup>KRATON Polymers LLC

<sup>b</sup>Eastman

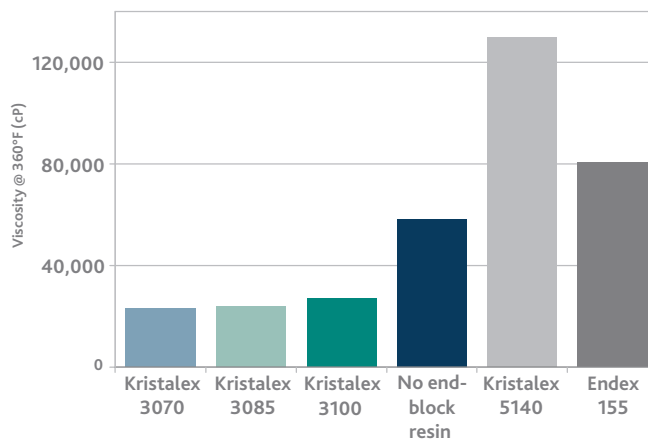
<sup>c</sup>Calumet Specialty Products

<sup>d</sup>BASF

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.

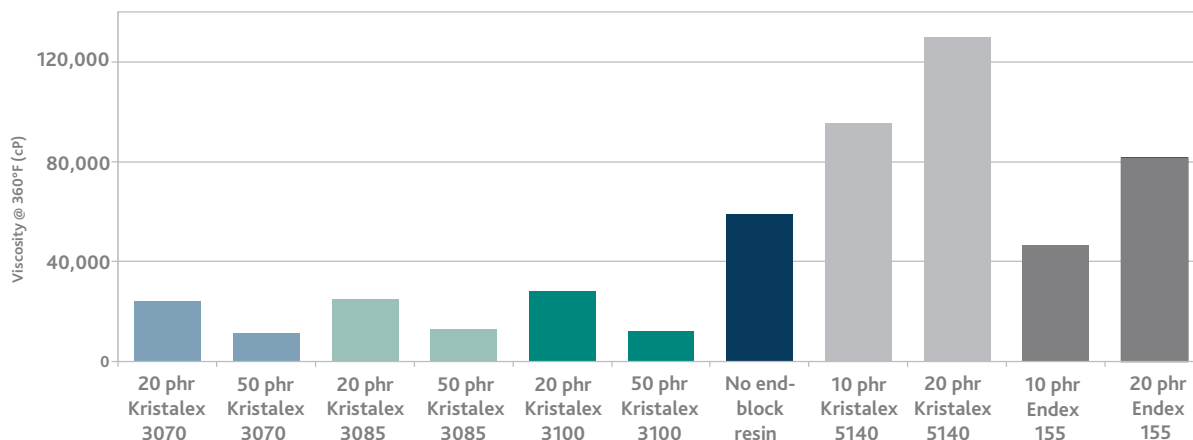
**Figure 1. Effect on adhesive viscosity with 20 phr end-block resins**

Formulated with KRATON D1126 radial block copolymer



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

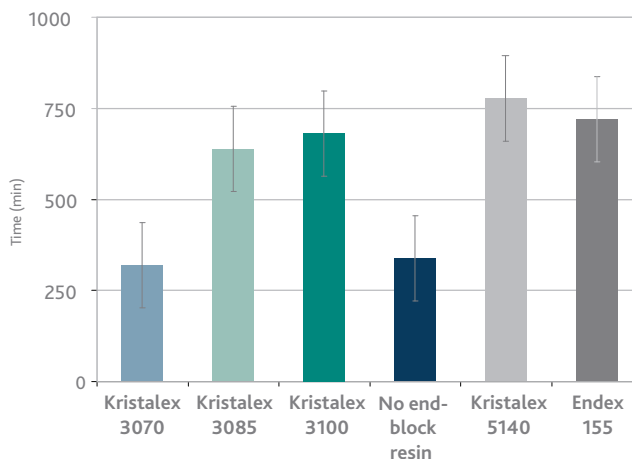
**Figure 2. Effect on adhesive viscosity relative to the amount of end-block resin**



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. However, it is important to note the addition of these resins also affects the RBSP and SAFT of the adhesive. Kristalex 3070, 3035, 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 KRATON D1161 and radial KRATON 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**

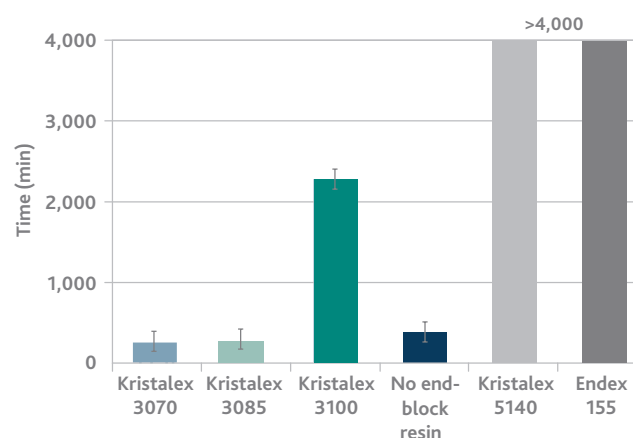
Ingredient	Kristalex 3070		Kristalex 3085		Kristalex 3100		No end-block resin	Kristalex 5140		Endex 155	
	20 phr	50 phr	20 phr	50 phr	20 phr	50 phr		10 phr	20 phr	10 phr	20 phr
RBSP (°C, STDV = 3)	122	118	135	122	133	121	140	142	161	147	156
SAFT (°C, STDV = 3)	99	90	100	96	104	98	105	110	113	113	112

Adjusting adhesive viscosity must be balanced with the cohesive strength requirements for the adhesive. All 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 more than 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 are maintained after aging the tapes at 40°C for two weeks.

**Figure 4. 70°C hold power for tapes with 20 phr end-block resin**

Formulated with KRATON D1126 radial block copolymer



In addition to allowing the formulator to adjust the viscosity and cohesive strength of SBC-based PSAs, the lower-molecular-weight end-block 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
<b>RT hold power (min)</b>						
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
<b>40°C hold power (min)</b>						
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)
<b>70°C hold power (min)</b>						
Initial mean (STDV)	300 (40)	330 (80)	2,700 (300)	440 (290)	>4,000	>4,000
Aged mean (STDV)	320 (60)	390 (60)	1,940 (580)	610 (110)	>4,000	>4,000
<b>180° peel (oz/in.)</b>						
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)
<b>Loop tack (oz/in.)</b>						
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'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, contact us at 1-800-EASTMAN or visit us at [eastman.com/adhesives](http://eastman.com/adhesives).



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