



Thermal Properties of Elvax® Measured by Differential Scanning Calorimeter (DSC)

Summary

The melting and freezing points of various Elvax® ethylene vinyl acetate (EVA) polymers were measured using a DSC. As the percent vinyl acetate (VA) increases, the melting and freezing points of the EVA copolymer decrease. When used in hot-melt adhesive formulations, the melting point predicts high-temperature performance, and the freezing point predicts set speed.

Discussion

Elvax® Background

Elvax® is a copolymer of ethylene and vinyl acetate. The two key parameters for EVA copolymers are the percent vinyl acetate and melt index (MI). At low comonomer levels, the EVA copolymer has a high degree of polyethylene (PE) crystallinity. As the percent VA increases, the VA disrupts the PE crystallinity. This is reflected in a lower melting and freezing point along with a lower heat of fusion (energy needed to change from solid to liquid).

The MI is an indication of the molecular weight (MW) and viscosity of the polymer. The MI is measured by the grams of polymer that come out of a narrow orifice held at 190°C (374°F) with a specified weight. If the MI is low, the MW and viscosity are high. If the MI is high, the MW and viscosity are low.

DSC Background

DSC is a standard tool for measuring the melting and freezing points of polymers and other solids. One way to describe how a DSC works is to think about what happens when you heat a solid with a constant heat input. Initially, the solid polymer is heated from room temperature to its melting point. As it melts from a solid to a molten liquid, the temperature is constant. After the phase change is complete, the temperature starts to rise again (Figure 1).

Instead of having a constant heat input, the DSC is based on the temperature increasing at a constant rising rate. This means more or less heat energy is put into the sample to make the temperature increase at a constant rate. When a phase change occurs, much higher than normal levels of heat are needed. The point of the maximum heat input is called the melting point. This can be seen in Figure 2. The area under the melting point curve represents the total energy needed for the phase change. This is called the heat of fusion.

Figure 1. Temperature Change for Constant Heat Input

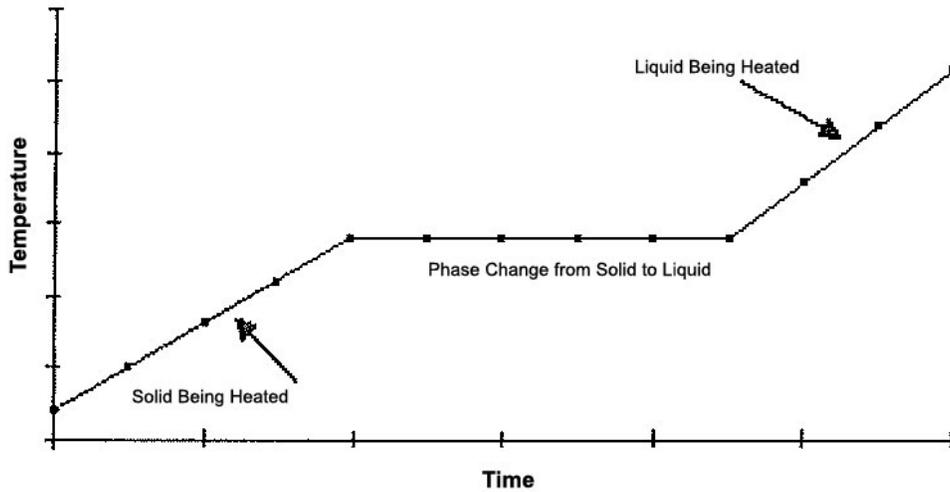
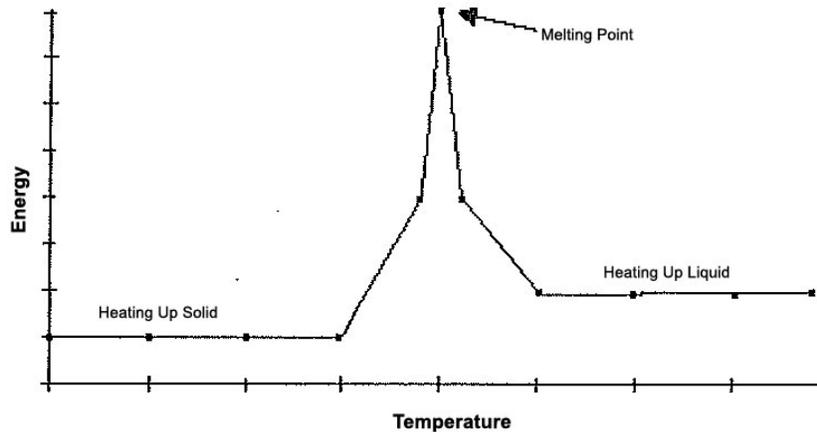


Figure 2. Energy Needed for Constant Temperature Rise



DSC Background Results for Elvax®

DSC was used to measure the melting and freezing points of EVA copolymers. For this process, a small sample is placed in a container, and energy is added to raise the temperature to a constant rate of 10°C/min. The sample is cooled and then reheated at 10°C/min. The information from the first heating cycle reflects the thermal history of the previous processing of the polymers, such as orienting or annealing, so the information should be used with caution. For this work, the melting point is taken from the second heat.

The results for Elvax® copolymers are shown in Table 1. As the percent VA increases, the melting and freezing points decrease. Low-density polyethylene (LDPE) containing 0% VA has a melting point of about 110°C (230°F). Elvax® 40W has 40% VA and a freezing temperature of 27°C (81°F). An EVA copolymer with VA concentrations higher than 40% would have an even lower freezing point. There are commercially available grades of EVA resins with very high (>40%) VA levels, but special handling techniques must be utilized before they can be pelletized.

Table 1
Thermal Properties of EVA Copolymers Measured by DSC

Elvax® Guide	% VA	MI	Melt Pt., °C (°F)	Freeze Pt., °C (°F)	Heat Fusion J/g	Ring and Ball, °C (°F)
40W	40	57	47 (117)	27 (81)	23	104 (219)
150, 150W	32	43	63 (145)	41 (106)	34	110 (230)
265	28	3	75 (167)	51 (124)	44	171 (340)
240W	28	43	74 (165)	48 (118)	--	110 (230)
360	25	2	78 (172)	58 (136)	53	188 (370)
460	18	2.5	88 (190)	67 (153)	65	199 (390)
660	12	2.5	96 (205)	74 (165)	78	193 (379)
760Q	9	2	100 (212)	81 (178)	82	--
LDPE	0	--	110 (230)	89 (192)	98	--

Tests run on a DuPont 9900 Instrument.

Sample Size about 10mg

First Heat -30° to 180°C (-22° to 356°F) at 10°C/min.

Cool Down 180° to -30°C at 10°C/min.

Second Heat -30° to 180°C at 10°C/min.

Melting Point from Second Heat - Not from First Heat

Heat of Fusion is average of heating and cooling curves.

Specific Heat of all grades is about 0.75 cal/g °C.

This is calculated from DSC cooling curve.

Ring and Ball Softening Point Compared to DSC

Ring and ball softening point is often used by the adhesive industry to predict high-temperature properties. The ring and ball softening points for waxes and tackifiers are easy to interpret, but the ring and ball results for polymers are more difficult to understand. When a wax or tackifier starts to soften, the ball will drop quickly because the wax or tackifier has very little melt strength.

The ring and ball number for Elvax® resins is a reflection of the DSC melt point and the polymer viscosity. It is possible to have a low-melting polymer as measured by DSC, which has a high ring and ball number. Elvax® 265 melts at 75°C (167°F), but due to its high melt strength, it has a ring and ball of 171°C (340°F). Elvax® 205W has a melt point of 72°C (162°F) and relatively low melt strength, so the ring and ball is only 80°C (176°F).

Table 2
Thermal Properties of High Melt Index (Low Viscosity) Elvax®

Elvax® Guide	% VA	MI	Melt Pt. °C (°F)	Freeze Pt. °C (°F)	Ring and Ball, °C (°F)
Standard Process					
210W	28	400	60 (140)	39 (102)	82 (180)
410	18	500	73 (163)	53 (127)	88 (190)

Low-viscosity polymers are made using standard polymerization and an improved polymerization process.

Changing the melt index does not change the melting point. This can be seen in the 200 series of polymers in Table 1. For these 28% VA resins, the MI varies from 3 to 500, and the melting point only drops by a few degrees.

For many years, it was thought that as the MI increased, the melting point dropped. Table 2 shows the DSC results for high MI (low viscosity) polymers. For the same VA level, there was a dropoff in melting point versus the low MI (high viscosity) counterparts.

The melting point of the polymer reflects the upper end-use temperature for an adhesive. Above the melting point, the polymer is a viscous liquid and will eventually creep or fail. However, other components in the adhesive or wax blend formulation contribute to the upper end-use temperature as well. In some cases, the formulation may still work above the polymer melt point.

The freezing point of the polymer will affect the set speed. If one polymer freezes at 80°C (176°F) and another at 40°C (104°F), the polymer with the higher freezing point will set up faster. As with the melting point, other components in the formulation can play a major role in determining set speed.

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K-27274 (09/13) Printed in the U.S.A.



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