SII NanoTechnology Inc.

DSC AS PROBLEM-SOLVING TOOL: DETERMINATION OF COMPOSITION OF EVA POLYMERS

Problem

A scientist working with EVA (ethylene - vinyl acetate) copolymers desires an easy-to-use, yet sensitive and precise test for determining the composition of the materials.

EVA copolymers include a broad range of thermoplastic materials with variable vinyl acetate contents (ranging from 5 to 50%). Applications of EVA copolymers include packaging, wire and cable insulations, coatings and adhesives. By far, the most commonly used application of EVA is for various types of packaging films.

The end-use properties of the EVA products, including the packaging films, is very much dependent upon the level of the vinyl acetate (VA) component contained in the polymer. Low levels of VA (e.g., 5%) result in a material which is more rigid. The lower levels of vinyl acetate produce a packaging film which has good optical clarity, but only moderate toughness, and such films are used as meat wrappers, cereal liners and ice bags. Higher levels of VA result in more flexible films with a higher degree of toughness and better stretching performance. Higher levels of VA (15 to 18%) produce a polymer which is utilized as heat-seal layers in coextruded films.

Solution

Since the level of the vinyl acetate component in EVA copolymers is very critical to the product's mechanical properties and end-use performance, it is important to have an easy means to quantitatively identify the amount of VA component in the polymer system. The best means of assessing the composition of EVA copolymers is with differential scanning calorimetry (DSC). DSC is an easy to use technique which provides a high degree of sensitivity and precision for compositional analysis of copolymers, such as EVA. In particular the Seiko EXSTAR DSC6100 instrument provides extremely flexible operation and gives the highest sensitivity of any commercially available DSC device.

Three ethylene - vinyl acetate copolymers (Elvax from the Dupont Corporation) containing varying levels of vinyl acetate were analyzed using the Seiko DSC. Sample 150 contained 33% VA, while sample 450 had 18% VA and sample 750 contained 9% VA. The samples were heated at a rate of 10°C/min from -130 to 165°C.

Displayed in Figure 1 are the DSC results obtained on Elvax sample 150 (33% VA). This material exhibits a glass transition event (Tg) at -24.2°C, and the Tg is associated with

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the VA component. The change in heat capacity at Tg is 0.94 J/g deg. An endothermic transition is obtained at 52.9°C and this represents the melting of the ethylene crystalline component in the EVA copolymer. The heat of melting of the ethylene component is 32.8 J/g.

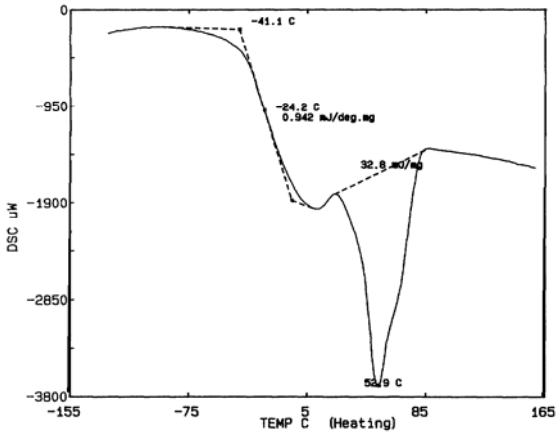

Figure 1

The DSC results on the intermediate VA sample (450 with 18% VA) are displayed in Figure 2. The Tg of this sample is -26.2°C and the change in heat capacity at Tg is significantly lower (0.60 J/g deg) as compared to sample 150. The decrease in the change in Cp is directly due to the lower concentration of the vinyl acetate component. The melting endotherm for sample 450 now exhibits two peaks with the main peak occurring at 87°C. The measured heat of melting increases to 74.1 J/g, which directly reflects the increase in the ethylene crystalline component.

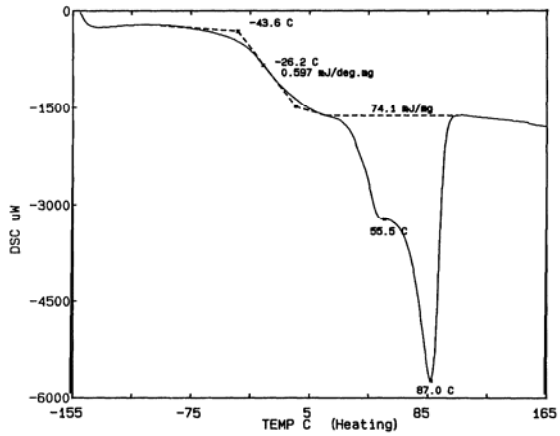

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Figure 2

Displayed in Figure 3 are the DSC results generated on sample 750 which contains the

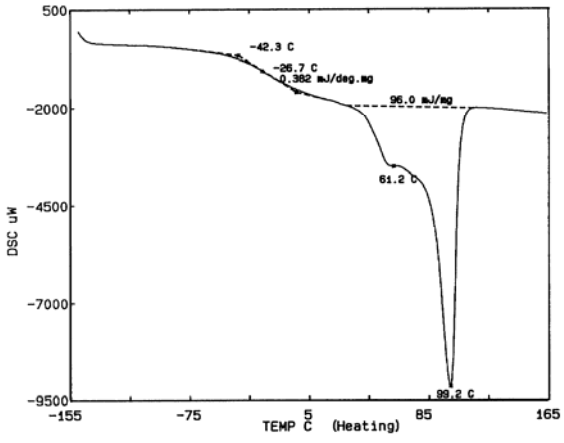

Figure 3

least amount of VA (9%). The Tg is observed at -26.7°C and one unique aspect of EVA copolymers is that the Tg does not shift significantly despite large changes in the composition of the polymer. The change in Cp at Tg is 0.38 J/g deg which is consistent with the fact that this sample has the lowest concentration of VA. The melting endotherm for this material has increased to 99.2°C and the heat of melting has also increased to 96.0 J/g.

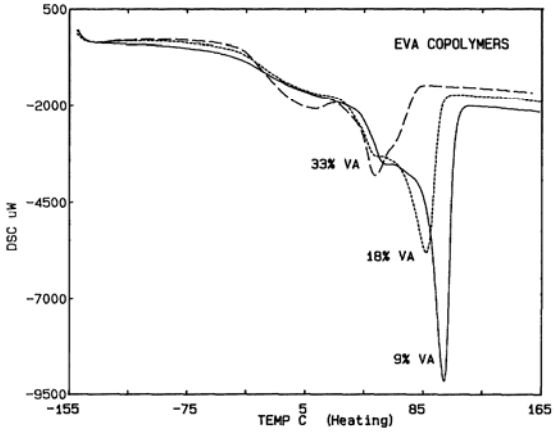

Figure 4

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Shown in Figure 4 is a direct comparison of the DSC data obtained on the three EVA copolymers. The effects of the changing levels of VA are clearly evident in these results.

The DSC results obtained on the three EVA copolymers are summarized as follows:

		Cp	**Tm**	**Heat of Melting**
%VA	(J/d deg)	(°C)		(J/g)
33	0.94	52.9		32.8
18	0.60	87.0		74.1
9	0.38	99.2		96.0

Summary

The Seiko DSC provides a sensitive, yet easy to use, means of assessing the composition of EVA copolymers. It was found that the Tg of the EVA materials was insensitive to changes in the change in heat capacity at Tg increased with increasing levels of the VA component while the heat of melting of the ethylene component decreased with increasing levels of VA.

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