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Application News

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Thermal Analysis

Measuring Polyethylene (PE)-Polypropylene (PP) Blend Samples

Polymeric materials are blends of two or more types of high molecular materials that are mixed to improve mechanical properties. Blends are often created to obtain properties that a single type cannot possess; however, this requires an understanding of component ratios. Unlike copolymers, mechanically blended polymeric materials exhibit the characteristics of each component, such as melting and crystallization, and multiple changes derived from each component can be observed through measurement with a DSC (differential scanning calorimeter). This research utilizes this process to introduce examples of determining the component ratios of blended high molecular materials by measuring the heat of fusion with a DSC.

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Measurement Example 1: Methods Using Individual Heats of Fusion

① Using the Heat of Fusion of Individual Components

The content of low density polyethylene (LDPE) and polypropylene (PP) was determined from the individual heat of fusion of each component, and the heat of fusion of each component in the blend sample.

The blend sample data in Fig. 1 shows a sufficient temperature difference between the melting peaks of LDPE and PP to allow for separate detection. In this case, the content can be determined by simply dividing the heat of fusion (mJ) of the unknown sample by the known heat of fusion (J/g) of a component.

We prepared a sample with a known blend ratio of LDPE:PP = 80:20 and verified the component ratio using this method. A satisfactory result of 79.1 %:20.9 % was obtained with respect to the 80:20 ratio of LDPE and PP.

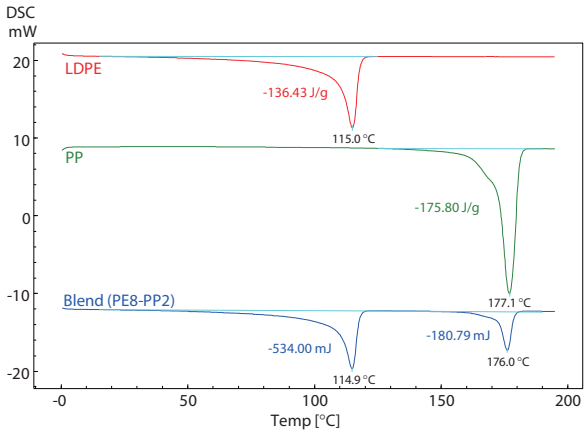

Fig. 1 DSC Curves of LDPE, PP, and Blend Sample

② Using an Approximated Heat of Fusion

The component ratio of a sample was determined from the measured melting peaks for high density polyethylene (HDPE) and PP, and a blend of these two components. (A different PP was used from that in the previous measurement.)

Since the melting peaks of HDPE and PP are detected at very close temperatures, the peaks overlap and cannot be completely separated. In this case, the peaks are divided laterally as shown in Fig. 2 and the heat quantity (approximated) of each peak is calculated as the heat of fusion of each component. (An optional partial area analysis program is required to perform this calculation.)

Fig. 3 shows the data obtained using this method. The heat of fusion of 100 % HDPE and PP, and the approximated heat of fusion of each component in the blend sample were used for the same calculation as in the previous section ①. Measurement results that provide a roughly close ratio of HDPE:PE = 85.1 %:14.9 % with respect to the actual blend ratio of HDPE:PE = 79.7 %:20.3 % were obtained. Note that significant overlapping of the two peaks reduces accuracy.

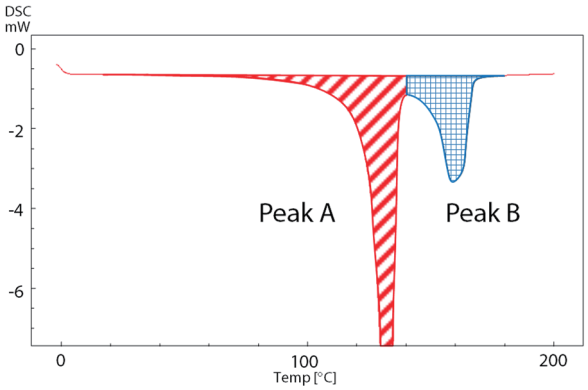

Fig. 2 Obtaining the Approximate Heat of Fusion

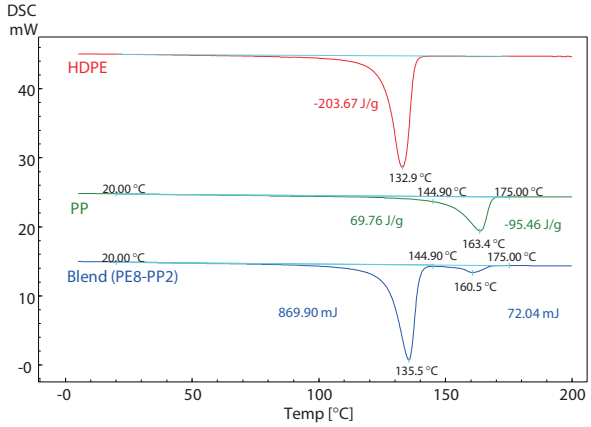

Fig. 3 DSC Curves of HDPE, PP, and Blend Sample

Measurement Example 2: Method Using the Total Heat of Fusion

In the case when peaks overlap, the content ratio can be determined from the total heat of fusion (value obtained through a single integration of the area of both peaks, as shown in Fig. 4) as an alternative to the method using an approximated heat of fusion as described in the previous section.

First, a calibration curve is created by plotting and joining the heats of fusion of the separate 100 % samples with a straight line, as shown in Fig. 5. This calibration curve expresses the relationship between the blend ratio and the total heat of fusion. The blend ratio can be determined from the measurement results for total heat of fusion by using this calibration curve.

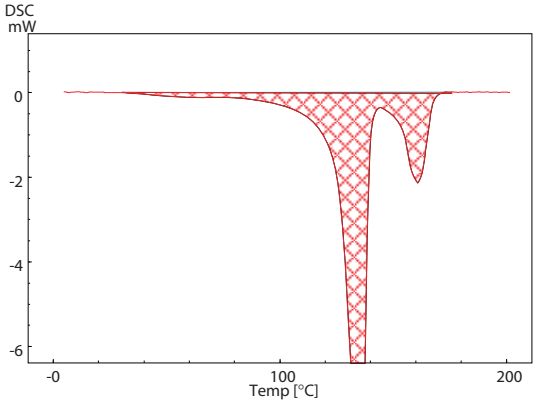

Fig. 4 Total Heat of Fusion of the Blend Sample

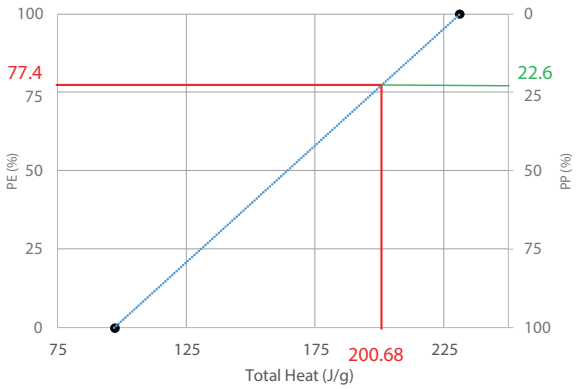

Fig. 5 Calibration Curve Determined from Separate HDPE and PP Samples

For example, a total heat of fusion of 200.68 (J/g) corresponds to a component ratio of PE:PP = 77.4 :22.6 . Table 1 compiles results of blend ratios determined from the total heat of fusion using this method with respect to samples A through E (which have known blend ratios).

This shows that an approximate blend ratio can be obtained from the total heat of fusion measured using a DSC and a calibration curve.

(Note that a calibration curve cannot be created unless there is a difference between the heat of fusion of each separate 100 % substance that comprises the blend.)

Table 1 Samples of Various Blend Ratios and Measurement Results

	Blend Ratio		Total Heat of Fusion (J/g)	Result Determined from Calibration Curve	
Sample	HDPE	PP		HDPE	PP
PP	0.00	100.00	97.07	0.00	100.00
A	19.72	80.28	122.11	18.70	81.30
B	40.64	59.36	151.95	40.99	59.01
C	49.90	50.10	159.98	46.99	53.01
D	60.16	39.84	174.53	57.86	42.14
E	79.88	20.12	200.68	77.40	22.60
HDPE	100.00	0.00	230.94	100.00	0.00

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