APPLICATION NOTE

Material Characterization

Author:

Yan Ji

PerkinElmer Inc.,
Shanghai, China

DSC 4000 Differential Scanning Calorimetry of Solar Battery Active Layer Material

Introduction

Organic solar cells (OSCs) are a new type of photovoltaic technology for converting solar energy into electrical energy. The technology generally uses a sandwich structure of transparent electrodes / photoactive layers / metal electrodes. Among them, the active layer (which one has not been defined properly according to the sandwich structure above) is the most important and core component of the organic solar cell, which is one of the important factors that determine the conversion efficiency of the battery, usually given by the p-type conjugated polymer and n-type semiconductor acceptor materials are blended and prepared. Organic polymer solar cells use organic polymer materials as the active layer, which can be well combined with flexible substrates. They have excellent characteristics such as wide material sources, light weight, simple preparation process, and flexibility.

Polymer / fullerene solar cells using conjugated polymers as electron donors and fullerene and its derivatives as electron acceptors are currently important research topics. Through molecular design strategies, the basic properties of polymers and fullerenes and their derivatives are optimized. These properties include the absorption spectrum, molecular energy level and mobility of the two, and the degree of crystallinity. Among them, the crystallinity of the active layer material is also closely related to the energy conversion efficiency of the battery. Differential scanning calorimetry (DSC) can directly measure the melting enthalpy of the active layer material and infer the level of crystallinity of the material. This allows the user to estimate energy conversion efficiency and therefore infer the best ratio of electron donor and electron donor in the active material.

PerkinElmer®
For the Better

In accordance with the above test requirements, this article uses PerkinElmer's DSC 4000 differential scanning calorimeter (Figure 1) to test the polymer (DBT) and fullerene (PCBM) The heating curve of the four active materials with different ratios, the melting enthalpy of the four active materials with different ratios is calculated from the melting absorption peak, and then the crystallinity of the active layer materials and the regularity of the molecular arrangement.

Experimental Methods

The initial temperature of the experiment is 30 °C, the temperature scanning range is 30-300 °C, the carrier gas is N_2, the flow rate is 20 mL/min, the temperature rise and fall phases are 20 °C/min, in order to stabilize the sample temperature, the initial and final temperatures were placed in isothermal for 1 min, as shown in Figure 2. In order to eliminate the thermal history of the sample itself to get an accurate heat flow curve and the enthalpy of melt of the sample, the sample is warmed twice, and the second warming curve is taken to calculate the enthalpy of melt of the sample. Prior to the experiment, four different mass fractions of polymer (DBT) and fullerene (PCBM) active layer materials were configured, with 10%, 20%, 40%, and 50% mass fractions of polymer (DBT), respectively.

Experimental Results

The second warming curves of four active layer materials with different ratios of intercepted polymers (DBT) and fullerenes (PCBM) are shown in Figure 3. The peak melting enthalpy of the four samples was around 223 °C, and the melting enthalpy of the samples increased with the increase of DBT mass fraction. With the increase of DBT mass fraction, the melting enthalpy of the active layer material of the battery continues to increase, the internal compatibility of the material is better and the molecular arrangement is more regular. However, a high DBT mass fraction in the active material may affect the electron transfer efficiency, which in turn may affect the conversion efficiency of the battery. Subsequently, the optimal ratio of polymer (DBT) to fullerene (PCBM) in the active material needs to be deduced by taking into account the magnitude of the cell's energy conversion efficiency.

Figure 1. PerkinElmer DSC 4000 differential scanning calorimeter.

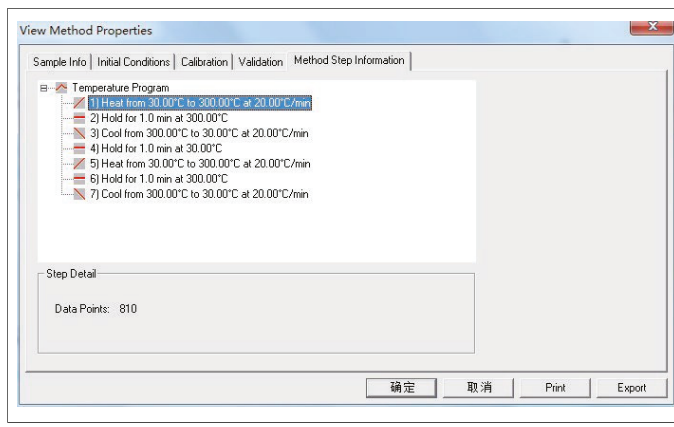

Figure 2. Experimental conditions for sample testing.

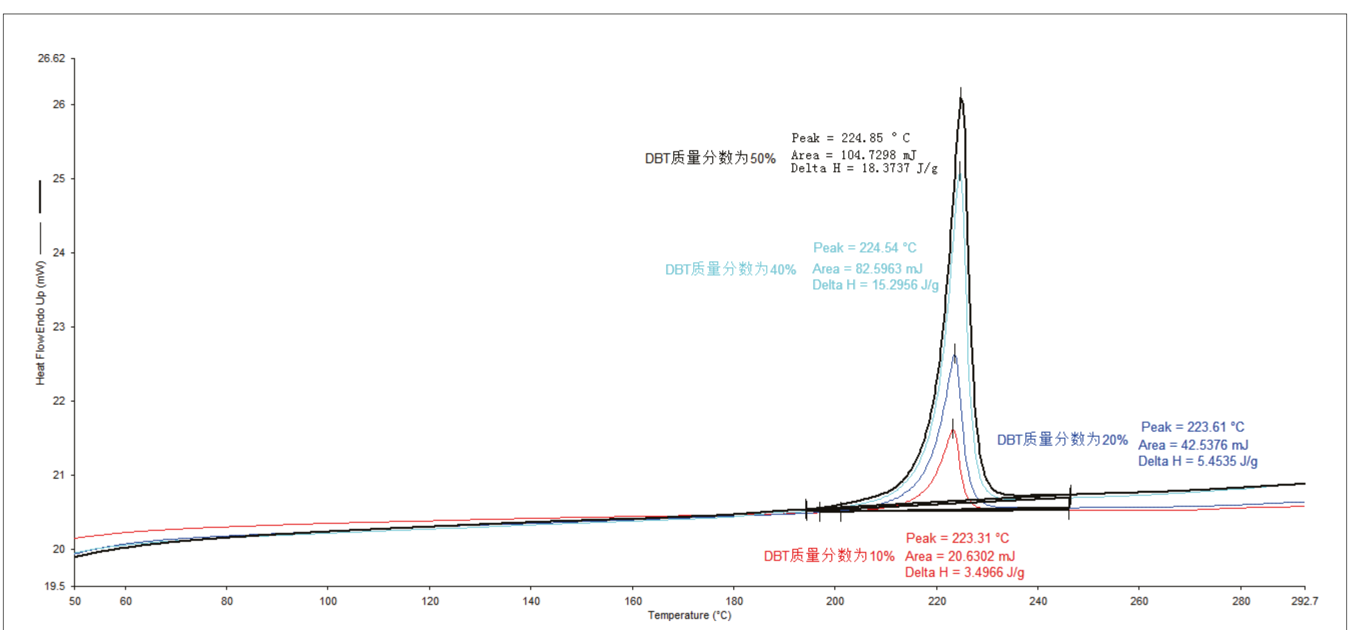

Figure 3. Melting curves and enthalpy of melting for the second warming of four different ratios of active materials.

Conclusion

In this paper, a DSC 4000 differential scanning calorimeter is used to test the heat flow curve of active layer materials in an organic solar cell, and the enthalpy of melting is calculated based on the melting peak to determine the molecular alignment and compatibility of the material. The Peak Area calculation function in the software simplifies the data processing steps and improves the experimental efficiency.

PerkinElmer, Inc.
940 Winter Street
Waltham, MA 02451 USA
P: (800) 762-4000 or
(+1) 203-925-4602
www.perkinelmer.com

171525 PKI