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DSC Measurements of Polyamide

Relationship between Amide Group Density and Melting Temperature

1. Introduction

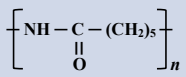
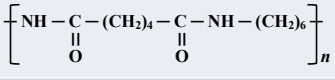
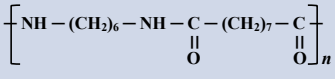
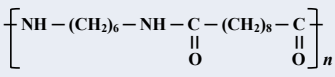
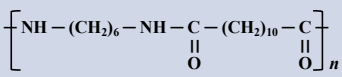
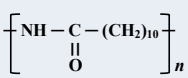
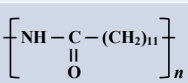
Polyamide is a general term for linear polymers whose main chains are regularly linked by amide bonds, -NH-CO-, and is generally known as “Nylon”. Polyamides are a typical engineering plastic, and mainly nylon 6 (N6) and nylon 66 (N6-6) are used in a wide range of applications, including automobiles, machinery, electronics, sporting goods, and convenience goods[1].

Polyamides are classified according to the number of carbon atoms in the amide bond of the repeating structural unit, as shown in Table 1. In addition, it is generally known that the various properties of polyamides depend on the ratio of a number of the amide groups to a number of the atoms in the main chain, the amide group density. Here, the amide group density is as follows, and the amide group density of each polyamide are shown in Table 1.

$$\text{Amide grope density} = \frac{-\text{NH} - \text{CO} -}{\text{Number of atoms in the main chain}} \times 100 \quad \cdots\cdots (1)$$

This report introduces the results of DSC measurements for each of the polyamides listed in Table 1, as well as the results of a study of the relationship between the amide group density and the melting temperature for these polyamides.

Table 1 Molecular Structure and Amide Group Density of Typical Polyamides

Polyamide	Molecular structure	Amide group density
N6 Poly(caprolactam)		14.3
N6-6 Poly(hexametylene adipamide)		14.3
N6-9 Poly(hexametylene nonanediamide)		11.8
N6-10 Poly(hexametylene sebacamide)		11.1
N6-12 Poly(hexametylene dodecanediamide)		10.0
N11 Poly(undecanoamide)		8.3
N12 Poly(lauryllactam)		7.7

2. Measurements

The samples were made of polyamide manufactured by SCIENTIFIC POLYMER PRODUCTS. All the samples were melted once and then quenched to be used as measurement samples.

DSC measurements was carried out by the NEXTA DSC600 High Sensitivity Differential Scanning Calorimeter. Measurements were taken over a temperature range of 0 to 280 °C at a heating rate of 10 °C/min using 10 mg of sample.

3. Measurement Results

Figure 1 shows the DSC measurement results for each polyamide. Depending on the type of polyamide, the glass transition temperature (glass transition initiation temperature T_{ig}) and the melting temperature (T_m) depends on the type of polyamide.

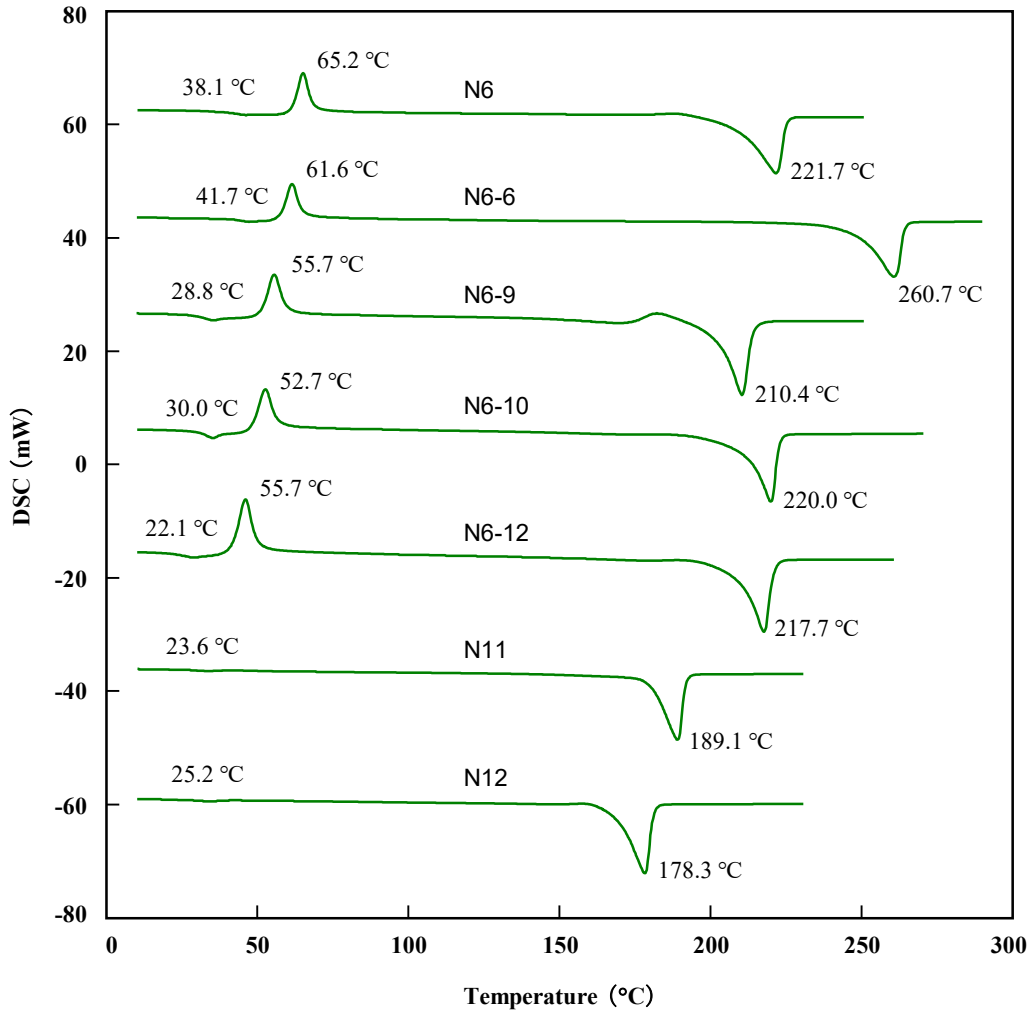


Figure 1 DSC curves for each polyamide

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The melting temperature of polyamides is related to the amide group density, and it is known that the melting temperature rises with an increase in the amido group density in the groups with even number of amide bond cycles (N6 and N12 in Table 1 and Figure 1), odd numbered groups, even-even groups (N6-6, N6-10, and N6-12 in Table 1 and Figure 1), and even-odd groups[2].

Figure 2 shows the relationship between the amide group density and melting temperature for N6 and N12 in the even-numbered group, and for N6-6, N6-10, and N6-12 in the even-even group. In all cases, the higher the amide group density, the higher the melting temperature are observed, and this tendency can be confirmed in the results shown in Figure 2.

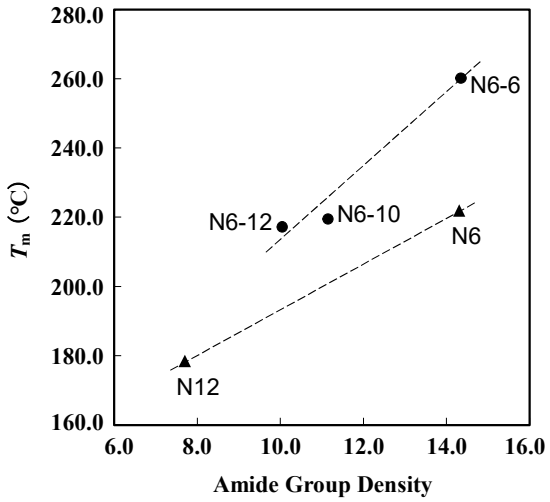

Figure 2 Relationship between the amide group density and melting temperature

Reference

1) Industrial Materials, **44**, No.7, Nikkan Kogyo Shimbun (1996)
2) Encyclopedia of Polymer Science and Technology, Vol.10, Jhon Wiley & Sons Inc., New York (1970)