CHEMISTRY LETTERS, pp. 1279 - 1282, 1984.

DSC STUDY OF POLYMORPHIC TRANSITIONS OF DL-2-AMINOBUTYRIC ACID AND DL-NORLEUCINE

Masayuki MATSUMOTO* † and Kazuko S. KUNIHISA

National Chemical Laboratory for Industry, Tsukuba Research Center, Yatabe, Ibaraki 305

The polymorphic transitions in DL-2-Aminobutyric acid and DL-norleucine were studied by differential scanning calorimetry(DSC). The experimental results show that the α-form of DL-norleucine is converted into a new γ-form at 390 K which is not the β-form or the superlattice deduced by Mathieson(Acta Crystallogr., 6, 399 (1953)) from crystal structures of α-and β-DL-methionine, and that the value of transition heat is about 5 kJ mol^{-1}, and is of the same order compared with that of the B-A transition in DL-2-Aminobutyric acid.

According to X-ray diffraction and IR spectra studies, many of crystalline aliphatic α-amino acids have polymorphic forms.[1-5] It has been found by Iitaka and coworkers that for example the B-form of DL-2-Aminobutyric acid(DL-ABA) is transformed into the A-form at 468 K, and that in crystal of the A-form of DL-ABA, the γ-carbon atom is distributed among 3 positions corresponding to trans, gauche I, and gauche II with respect to the nitrogen atom, whereas in the B-form, the γ-carbon atom is restricted to the trans position.[6] Then it is inferred that conformational change of molecule, and rearrangement of molecular layers due to intermolecular interactions between constituent molecules, occur simultaneously during the transition.

In this work, in order to obtain the information on polymorphic transitions of the α-form of DL-norleucine and the B-form of DL-ABA, DSC measurements were made. Differential scanning calorimeter used in this experiment is a model DSC-II with Thermal Analysis Data Station(TADS) manufactured by the Perkin-Elmer Corporation.

† Present address: M & A Laboratory, 428-12, Kami-asao, Asao-ku, Kawasaki 215.

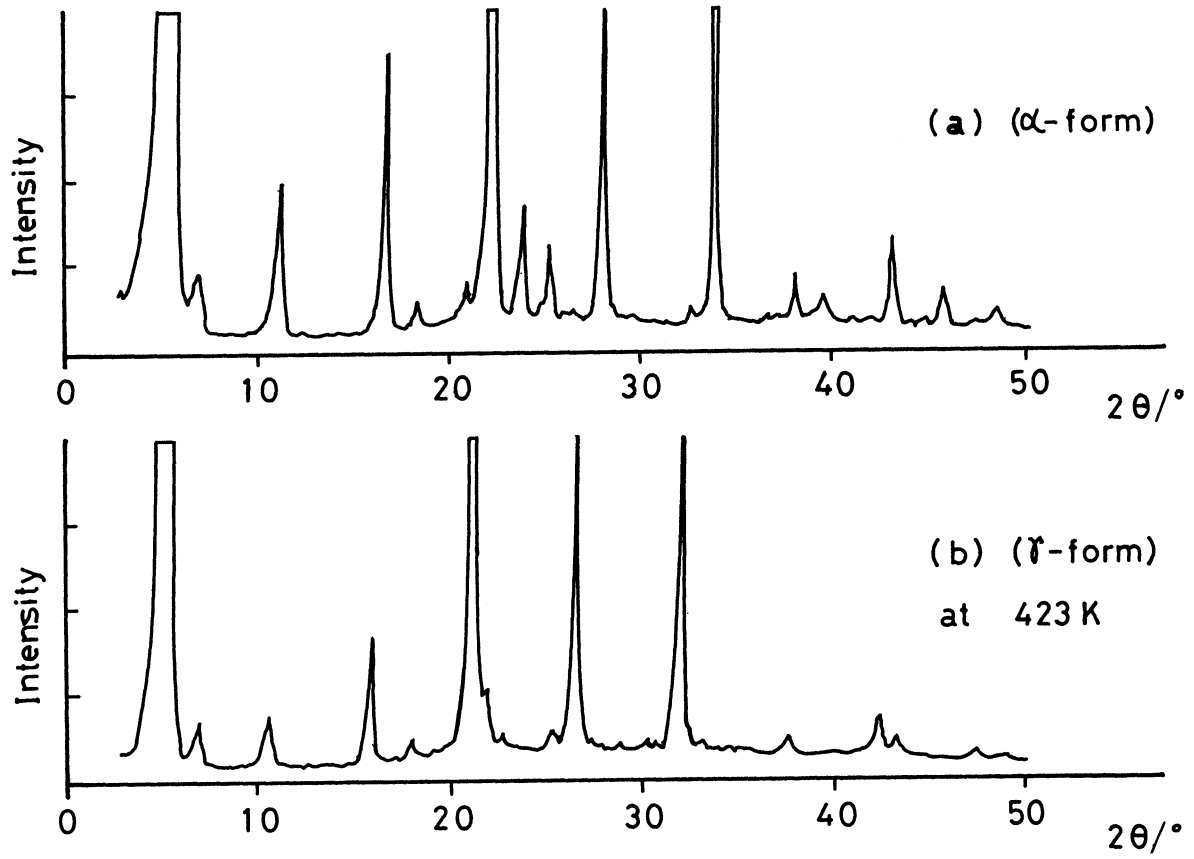

Fig. 1. X-Ray powder patterns of α- and new γ-forms in DL-norleucine. Radiation used: Cu Kα, 40 kV , 20 mA , Ni-filtered.

In each measurement, a few mg of sample was sealed in an aluminum pan, and the sample and the blank pans were set in the sample and the reference holders, respectively. The measurements of temperature and heat quantity were made in the ranges of heating rates between 0.63 and 10 K min^{-1}. The calorimeter was calibrated with Indium, m p = 429.78 K, H = 28.5 J g^{-1}, supplied by the Perkin-Elmer Co. The obtained values of melting point and heat of fusion of Indium which were extrapolated to the heating rate, zero, were 429.6 ± 0.1 K, 29.3 ± 0.4 J g^{-1}, respectively. The samples of DL-ABA and DL-norleucine were the Tokyo Kasei Co. G R grades, with a purity guaranteed to be more than 98%, and were recrystallized twice from the aqueous solution. The DL-norleucine was obtained as plate-like crystal by cooling at about 290 K for 24 h and the DL-ABA as fibrous crystal from the solution in water-ethanol mixture at about 283 K for 48 h. These samples were dried over silica-gels in a desiccator for two months, and before use, were again dried in vacuo for 6 h. The IR spectrum of DL-ABA obtained was identical with that

observed for the pure B-form.[3] Fig. 1(a) represents a X-ray powder pattern of DL-norleucine at room temperature. This X-ray pattern was identical with that of the α-form obtained by Dawson and Mathieson[7] (J.C.P.D.S. Powder Diffraction File, No. 7-717). Fig.1(b) shows a X-ray powder pattern at 423 K obtained by heating the α-form crystal. The existence of polymorphism of DL-norleucine was suggested by Mathieson, who deduced it to be the β-form or the superlattice from the dimorphs of DL-methionine.[8-10] It was confirmed that X-ray diffraction results in Fig.1(b) were different from the spacings calculated from the unit cell of the β-form or the superlattice either. Fig.2 represents the DSC curves. The measurements were repeated three times, but the shape of the DSC curve for the α-form of DL-norleucine was the same as that shown in Fig.2. Therefore, polymorphic transition of DL-norleucine was found to be enantiotropic. Furthermore, DSC measurements at different heating rate were made. As is shown in Fig.3, the values of peak temperature were dependent on the heating rate, but the heat quantity caused by the transition was nearly constant on any heating rate. The transition temperature of the α-form of DL-norleucine is estimated to be 390 K by the extrapolation of heating rate to zero. From X-ray diffraction and DSC measurements, it was found that the α-form of DL-norleucine was converted into a new form at 390 K which was called as γ-form. Since the rate of the B-A transition in DL-ABA was slow, as well as γ-α transition in glycine,[11] no polymorphic transition was observed at low heating rate. Accordingly, the values of heat of transition of DL-ABA and DL-norleucine were compared with those of heating rate at 5 K min^{-1}.

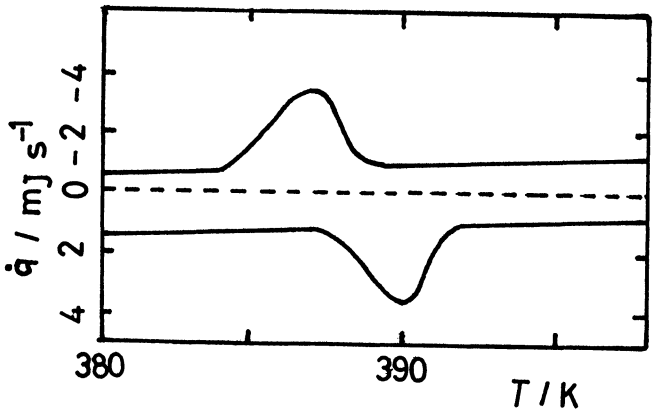

Fig. 2. DSC curves of DL-norleucine. Sample weight: 2.00 mg. Heating and cooling rates: 2.5 K min^{-1}

The results obtained are shown in Table 1. Here the values of heat of transition are the means of three runs. It is seen from Table 1 that the value of transition heat of DL-norleucine is about 5 kJ mol^{-1}, and is of the same order compared with that of the B-A transition in DL-ABA.

We would like to express our grateful thanks to Dr. M. Gotoh, and Dr. M. Mamiya of National Chemical Laboratory for Industry, for computation of X-ray diffraction data, and for advice of measurements of IR spectra, respectively.

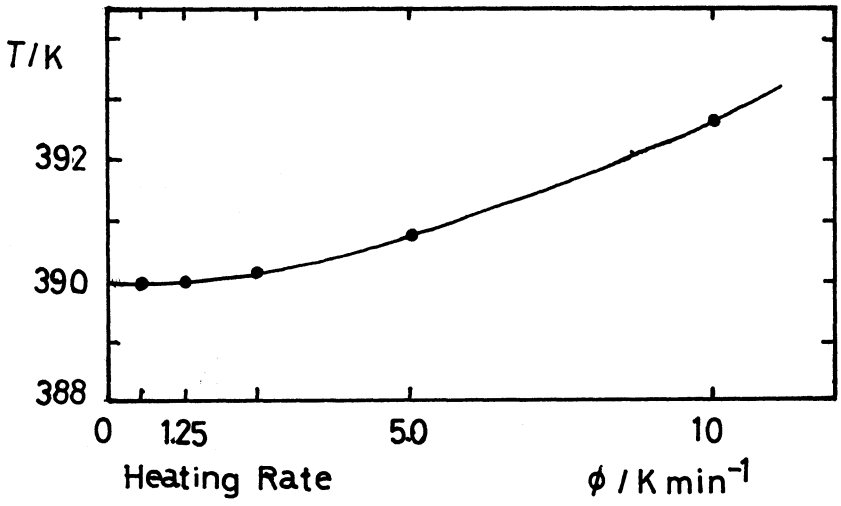

Fig. 3. Heating rate dependence of peak temperature in the case of transition of DL-norleucine.

Table 1. Heats of transition of DL-ABA and DL-norleucine

Substance	Transition temperature T / K	Heat of transition ΔH_t / kJ mol^{-1}
DL-ABA (B-A)	480-520	4.91 ± 0.29
DL-norleucine (α - γ)	390	4.92 ± 0.20

References

1) M. Tsuboi, T. Onishi, I. Nakagawa, T. Shimanouchi, and S. Mizushima, Spectrochim. Acta, 12, 253 (1958).
2) Y. Iitaka, Acta Crystallogr., 14, 1 (1960).
3) M. Tsuboi, Y. Iitaka, S. Suzuki, and S. Mizushima, Bull. Chem. Soc. Jpn., 32, 529 (1959).
4) T. Akimoto and Y. Iitaka, Acta Crystallogr., Sect. B. 28, 3106 (1972).
5) K. Nakata, Y. Takaki, and K. Sakurai, Acta Crystallogr., Sect. B. 36, 504 (1980).
6) T. Ichikawa and Y. Iitaka, Acta Crystallogr., Sect. B. 24, 1488 (1968).
7) B. Dawson and A. McL. Mathieson, Acta Crystallogr., 4, 476 (1951).
8) A. McL. Mathieson, Acta Crystallogr., 6, 399 (1953).
9) A. McL. Mathieson, Acta Crystallogr., 5, 332 (1952).
10) T. Taniguchi, Y. Takaki, and K. Sakurai, Bull. Chem. Soc. Jpn., 53, 803 (1980).
11) K. Sasaki, Rep. Nat. Chem. Lab. for Ind., 61, 54 (1966).

(Received April 7, 1984)