The Heats of Solution of Optically Active Amino Acids, the Corresponding Racemic Amino Acids, and Their Derivatives in Water

Masayuki MATSUMOTO† and Kazuo AMAYA*

National Chemical Laboratory for Industry, 1-1, Azuma, Yatabe-machi, Tsukuba, Ibaraki 305

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Synopsis. The heats of solution of normal and branched α-amino acids and of their derivatives in water were measured at 298.15 K. The experimental results show that the racemates are more stable than optically active compounds, except for glycylleucine, and that the differences in the heat of solution between the two species for branched compounds are nearly constant, about 2 kJ mol^{-1}, while those for the normal compounds are dependent on the number of carbon atoms in the alkyl chains.

In the previous papers,[1,2] measurements of the heat of solution of optically active α-amino acids and their corresponding racemic compounds in water were made at 298.15 K, and that the differences in the heat of solution between the two species were appreciably larger than the heats of mixing of concentrated aqueous solutions of *d*- and *l*-isomers.

In the present work, in order to obtain further information on the difference in crystal-lattice energy between optically active amino acid and the corresponding racemic amino acid, and on that between amino acid derivatives, solution calorimetry was undertaken.

Experimental

The apparatus and procedure were the same as have been described in a previous work.[2] The alanylalanine, norvaline, and norleucine were purchased from the Sigma Chemical Company. The glycylleucine, α-amino butyric acid (ABA), *N*-formylvaline, *N*-acetylvaline, and *N*-acetylleucine were purchased from the Tokyo Kasei Company, and the other, reagents were purchased from the Takara Kohsan Company. All the samples used were the purest reagents commercially. available. The purities of the amino acid crystals were certified by the above makers and were guaranteed to be more than 98%.

The acylamino acids and dipeptides were kept in a freezer before use. The other materials were also dried as previously has been described, and then used without further purification.

Results and Discussion

At first, the measurements of the heat of solution were made at various concentrations in order to confirm the concentration dependence. No concentration dependence of the molar enthalpy of solution was found within the limits of error of measurement in the range from 10^{-3} to 10^{-2} mol kg^{-1}.

The results obtained are given in Tables 1 and 2, and they are plotted in Fig. 1 alone with two data of the previous paper.[2] The values obtained are the means of three determinations. The ΔH_s values of L-leucine and glycyl-L-leucine are in approximate agreement with those of Kresheck and Benjamin.[3] Also, the ΔH_s value of the A-form in DL-α-amino butyric acid is in good agreement with that of Abraham *et al.*[4] The difference in the ΔH_s of alanylalanine is about 1.5 times that of Alanine.

The experimental results show that the differences in ΔH_s between the two species for branched α-amino

TABLE 1. HEATS OF SOLUTION OF α-AMINO ACIDS AND THEIR DERIVATIVES IN WATER AT 298.15 K

Substance	Molality range m / mol kg^{-1}	Heat of solution ΔH_s / kJ mol^{-1}
DL-α-Amino butyric acid (A-form)	$(0.96—1.00)\times10^{-2}$	1.50±0.01
L-α-Amino butyric acid	$(0.99—1.02)\times10^{-2}$	0.65±0.02
DL-Norvaline	$(0.87—1.08)\times10^{-2}$	0.50±0.10
L-Norvaline	0.89×10^{-2}	−2.29±0.03
DL-Norleucine	$(0.84—0.92)\times10^{-3}$	6.71±0.37
L-Norleucine	$(0.92—1.43)\times10^{-3}$	2.24±0.23
DL-Leucine	$(0.92—1.43)\times10^{-3}$	5.48±0.32
L-Leucine	$(1.07—1.17)\times10^{-3}$	3.41±0.22
N-Formyl-DL-valine	$(0.73—0.75)\times10^{-2}$	16.9 ±0.2
N-Formyl-L-valine	$(0.70—0.71)\times10^{-2}$	14.9 ±0.3
N-Acetyl-DL-valine	$(0.63—0.64)\times10^{-2}$	13.3 ±0.4
N-Acetyl-L-valine	$(0.64—0.65)\times10^{-2}$	12.3 ±0.2
N-Acetyl-DL-leucine	$(0.79—0.91)\times10^{-3}$	7.49±0.30
N-Acetyl-L-leucine	$(0.89—0.91)\times10^{-3}$	6.43±0.25
DL-Alanyl-DL-alanine	$(1.43—1.72)\times10^{-3}$	−7.82±0.14
L-Alanyl-L-alanine	$(1.14—1.50)\times10^{-3}$	−11.0 ±0.4
Glycyl-DL-leucine	$(0.64—0.72)\times10^{-3}$	−3.97±0.13
Glycyl-L-leucine	$(0.76—0.77)\times10^{-3}$	−2.86±0.09

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

Table 2. Differences in the heat of solution between optically active amino acids and their corresponding racemic compounds

Substance	Difference in the heat of solution at 298.15 K $\frac{\Delta\Delta H_s}{\text{kJ mol}^{-1}}$
α-Amino butyric acid	0.85±0.03
Norvaline	2.79±0.13
Norleucine	4.47±0.60
Leucine	2.07±0.54
N-Formylvaline	2.0 ±0.5
N-Acetylvaline	1.0 ±0.6
N-Acetylleucine	1.06±0.55
Alanylalanine	3.2 ±0.5
Glycylleucine	1.11±0.22

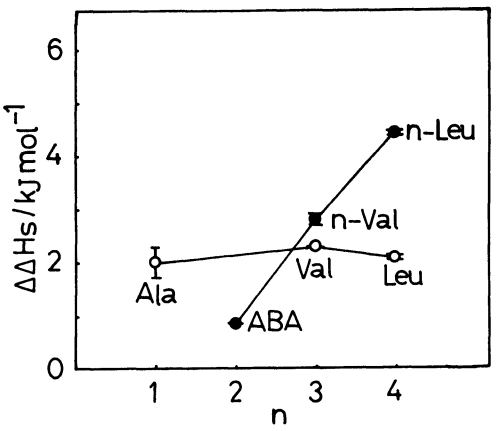

Fig. 1. The plots of the differences in the heat of solution against number of carbon atoms, *n*, in the alkyl chains of α-amino acids.

acids are nearly constant, about 2 kJ mol.$^{-1}$ In addition by replacing the hydrogen atom of the amino group in amino acids with an acyl group, the differences in ΔH_s for the series of acylamino acids become small.

On the other hand, the differences in ΔH_s for the normal compounds are dependent on the number of carbon atoms, *n*, in the alkyl chains, and they increase with the *n* value as is shown in Fig. 1.

It seems that, for the normal alkyl chain amino acids, the contribution of the intramolecular configuration is included in the heat of solution, whereas such contribution for the branched compounds is not included. It is known that rotational isomers exist for DL-α-amino butyric acid and DL-norleucine.[5-9] Therefore, the contribution of the intramolecular configuration is assumed to be proportional to the number of carbon-carbon bonds. Accordingly, the dependency of $\Delta\Delta H_s$ on the carbon number in the alkyl chains can reasonably be explained.

Finally, a further thermodynamic study of polymorphic forms in DL-α-amino butyric acid and DL-norleucine is now in progress.

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