23. *αγ-Diaminobutyric Acid.*

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αγ-Diaminobutyric acid has certain properties distinct from those of the higher homologues, ornithine and lysine : (*a*) this diamino-acid forms three characteristic hydrochlorides, (*b*) treatment of αγ-dicarbobenzyloxyamino-butyric acid with phosphorus pentachloride gives 1-carbobenzyloxy-3-(carbobenzyloxyamino)pyrrolid-2-one and not γ-(carbobenzyloxyamino)-α-carboxyaminobutyric acid anhydride, which one might expect by analogy with ornithine and lysine.

Our present interest in αγ-diaminobutyric acid arises from its presence in acid hydrolysates of the antibiotic polypeptides, the polymyxins, from which both the dl-form (Catch and Jones, *Biochem. J.*, 1948, **42**, lii) and the l-form (Catch, Jones, and Wilkinson, *Ann. N.Y. Acad. Sci.*, 1949, **51**, 917) have been isolated. We now report some reactions of αγ-diaminobutyric acid which differ from those of the higher homologues, ornithine and lysine.

It was found that αγ-diaminobutyric acid gave not only the expected mono- and di-hydrochlorides, but also formed a third, stable hydrochloride of characteristic crystalline form, in which the amino-acid and hydrogen chloride were present in the molecular ratio, 2 : 3. This corresponds to Synge's observations (*Biochem. J.*, 1939, **33**, 671) that αγ-diaminobutyric acid forms three crystalline oxalates in which the proportions of oxalic acid are 0·5, 1·0, and 1·5 moles to each mole of amino-acid, whilst Carter, Abeele, and Rothrock's findings (*J. Biol. Chem.*, 1949, **178**, 325) that dl-αγ-diaminobutyric acid dihydrochloride, on repeated crystallisation from alcohol–water, was converted into the monohydrochloride, confirm, in part, our experiments.

The polypeptide structure of the polymyxins, and the presence of a new, naturally-occurring amino-acid, stimulated attempts to prepare polypeptides containing αγ-diaminobutyric acid residues. It was intended to polymerise γ-(carbobenzyloxyamino)-α-carboxyaminobutyric acid anhydride following the procedures described for the preparation of polylysine (Katchalski, Grossfeld, and Frankel, *J. Amer. Chem. Soc.*, 1947, **69**, 2565; 1948, **70**, 2095) and polyornithine (Katchalski and Spitnik, *Nature*, 1949, **164**, 1092).

Following the method for the synthesis of ε-carbobenzyloxy-α-carboxy-l-lysine anhydride (Bergmann, Zervas, and Ross, *J. Biol. Chem.*, 1935, **111**, 245), l-αγ-diaminobutyric acid (I) was converted into the dicarbobenzyloxy-derivative and treated in cold ethereal solution with

phosphorus pentachloride. On storage, a crystalline, optically active solid separated. This was apparently not the required anhydride but 1-carbobenzyloxy-3-(carbobenzyloxyamino)-

(I.) $CH_2 \cdot CH_2 \cdot CH \cdot CO_2H$ (NH_2, NH_2)

(II.) $CH_2—CH_2$; RN; $CH \cdot NHR'$; CO

pyrrolid-2-one (II; R = R′ = $CO_2 \cdot CH_2Ph$). Hydrogenation of the product in ethanol in the presence of platinum oxide gave a product to which the 3-carbobenzyloxyamino-structure (II; R = H, R′ = $CO_2 \cdot CH_2Ph$) rather than the 1-carbobenzyloxyamino-structure (II; R = $CO_2 \cdot CH_2Ph$, R′ = H) was assigned, because of its inability to react with acetic anhydride and of the non-production of colour with ninhydrin. Both (II; R = R′ = $CO_2 \cdot CH_2Ph$) and (II; R = H, R′ = $CO_2 \cdot CH_2Ph$) were hydrogenated in glacial acetic acid in the presence of platinum oxide to 3-aminopyrrolid-2-one (II; R = R′ = H), which was isolated as a crystalline solid, m. p. 98—99°, by sublimation *in vacuo*. The product was optically active ($[\alpha]_D^{21}$ = −64·4° in water), gave a strong purplish-blue with ninhydrin, and was readily hydrolysed by hydrochloric acid to L-αγ-diaminobutyric acid. 3-Aminopyrrolid-2-one gave a picrate, m. p. 180—184°, and a mono-acetyl derivative, m. p. 191°, $[\alpha]_D^{21}$ = −97·3° in water. These physical constants were obviously different from those recorded by Adamson (*J.*, 1943, 39); the explanation was found in the partial racemisation which occurred under the relatively drastic condition employed by Adamson [cf. the racemisation when 2-ketopyrrolidine-4-carboxylic acid is prepared by heating glutamic acid (Arnew and Opsahl, *J. Biol. Chem.*, 1940, **134**, 649)]. L-αγ-Diaminobutyric acid was therefore converted into the ethyl ester dihydrochloride by Akabori and Numano's method (*Bull. Chem. Soc. Japan*, 1936, **11**, 214). The free ester on liberation in the cold cyclised on being kept, even at room temperature to give L-3-amino-pyrrolid-2-one, identical with that obtained by hydrogenation of the dicarbobenzyloxy-pyrrolidone (II; R = R′ = $CO_2 \cdot CH_2Ph$). Further proof of identity was shown by its conversion into L-3-acetamidopyrrolid-2-one, m. p. 191°, $[\alpha]_D^{21}$ = −97·3° in water. The ease of racemisation of L-3-aminopyrrolid-2-one was shown by heating a sample in a sealed tube at 155—160° for five hours (shorter times of heating caused only partial racemisation), whereupon DL-3-amino-pyrrolid-2-one was isolated; this gave DL-3-acetamidopyrrolid-2-one, hydrolysed by hydrochloric acid to DL-αγ-diaminobutyric acid. On the paper chromatogram the behaviour of DL- and L-3-aminopyrrolid-2-one was identical.

The course of the cyclisation of αγ-di(carbobenzyloxyamino)butyric acid has an analogy in Berenbom and White's observation (*J. Amer. Chem. Soc.*, 1949, **71**, 2246) that, unless the phosphorus oxychloride formed during the conversion of α-benzyl hydrogen *N*-carbobenzyl-

(III.) $CO_2 \cdot CH_2Ph$; $CH \cdot NH \cdot CO_2 \cdot CH_2Ph$; $CH_2 \cdot CH_2 \cdot COCl$ —$POCl_3$, NH_3→ $CH_2—CH_2$; CO; $CH \cdot CO_2 \cdot CH_2Ph$; N; $CO_2 \cdot CH_2Ph$ (IV.)

oxyglutamate into the acid chloride (III) was removed, treatment of (III) with ammonia did not give the desired amide but intramolecular cyclisation occurred to give 1 : 5-dicarbo-benzyloxypyrrolid-2-one (IV).

The ease of cyclisation of ethyl αγ-diaminobutyrate led to an investigation of the cyclisation of the acid itself. When L-αγ-diaminobutyric acid (V; n = 1) monohydrochloride, acetic anhydride, and anhydrous sodium acetate were heated on the steam-bath racemisation occurred and from the reaction mixture DL-1-acetyl-3-acetamidopyrrolid-2-one (VII; n = 1) was isolated.

$CH_2—[CH_2]_n$; $Ac \cdot N$; $CH \cdot NHAc$; CO (VII.) ←Ac_2O, NaOAc— $CH \cdot NH_2$; $[CH_2]_n$; CO_2H; $CH_2 \cdot NH_2$ (V.) —AcCl, AcOH→ C—N; C—O; $C \cdot CH_3$; $[CH_2]_n$; $CH_2 \cdot N \cdot Ac$ (VI.)

This is in contrast to Wrede's observation (*Z. physiol. Chem.*, 1932, **206**, 146) that treatment of lysine (V; n = 3) or ornithine (V; n = 2) with acetyl chloride and acetic acid at 100° caused racemisation and gave a compound, formulated as (VI; n = 3) or (VI; n = 2), respectively.

Experimental.

Hydrochlorides of αγ-Diaminobutyric Acid.—The *dihydrochlorides* were prepared by recrystallisation from concentrated hydrochloric acid or glacial acetic acid–concentrated hydrochloric acid. The DL-salt, m. p. 202—205° (decomp.), was isolated as beautiful hexagonal prisms (Found : N, 14·6; Cl, 37·1. $C_4H_{10}O_2N_2,2HCl$ requires N, 14·7; Cl, 37·2%), whilst the L-form gave unsymmetrical quadrilateral prisms, m. p. 197—198° (decomp.), $[\alpha]_D^{21}$ +13·3° (*c* = 0·25 in water), $[\alpha]_{5461}^{21}$ +16·2° (*c* = 0·8 in water) (Found : C, 25·2; H, 6·3; N, 14·5; Cl, 37·2. $C_4H_{10}O_2N_2,2HCl$ requires C, 25·1; H, 6·3; N, 14·7; Cl, 37·2%).

On careful crystallisation of the dihydrochlorides from aqueous alcohol, the respective *sesquihydrochlorides* were obtained in rosettes of slender prisms. The sesquihydrochlorides were also obtained on drying the dihydrochlorides *in vacuo* at 100°. The DL-salt had m. p. 194—196° (decomp.) (Found : N, 16·4; Cl, 30·5. $C_4H_{10}O_2N_2,1\frac{1}{2}HCl$ requires N, 16·2; Cl, 30·8%); the L-form had m. p. 211—212° (decomp.), $[\alpha]_D^{21}$ +13·5° (*c* = 0·8 in water), $[\alpha]_{5461}^{21}$ +16·2° (*c* = 0·8 in water), $[\alpha]_{5461}^{21}$ +26·9° (*c* = 0·8 in 5N-hydrochloric acid) (Found : C, 27·8; H, 6·4; N, 15·9; Cl, 30·8. $C_4H_{10}O_2N_2,1\frac{1}{2}HCl$ requires C, 27·8; H, 6·6; N, 16·2; Cl, 30·8%).

The *monohydrochlorides* were prepared from the dihydrochlorides on treatment with pyridine in aqueous alcohol. Recrystallisation from aqueous alcohol gave shallow rectangular prisms : DL-form, m. p. 229° (decomp.) (Found : C, 31·3; H, 7·0; N, 17·9; Cl, 22·7. $C_4H_{10}O_2N_2,HCl$ requires C, 31·1; H, 7·1; N, 18·1; Cl, 23·0%); L-form, m. p. 225° (decomp.), $[\alpha]_D^{21}$ +23·8° (*c* = 1·2 in 6N-hydrochloric acid), $[\alpha]_{5461}^{21}$ +28·6° (*c* = 1·2 in water), $[\alpha]_{5461}^{21}$ +10·0° (*c* = 1·7 in N-KOH) (Found : N, 18·2; Cl, 23·0); D-form, m. p. 223—224°, $[\alpha]_D^{21}$ −11·4° (*c* = 0·25 in water) (Found : N, 18·0; Cl, 22·8%).

Dipicrates of αγ-Diaminobutyric Acid.—The *dipicrates* were isolated as yellow, long fine prisms by crystallisation from water : DL-form, m. p. 189° (decomp.) (Found : C, 33·1; H, 2·5; N, 19·5. $C_4H_{10}O_2N_2,2C_6H_4O_7N_3$ requires C, 33·3; H, 2·8; N, 19·5%); L-form, m. p. 187° (decomp.) (Found : C, 33·7; H, 2·6; N, 19·5%); D-form, m. p. 187° (Found : N, 19·6%).

The D-glutamic acid used in the synthesis of D-αγ-diaminobutyric acid was prepared by hydrolysis of the D-glutamylpeptide from the capsule of *Bacillus anthracis* (cf. Bruckner and Ivanovics, *Z. physiol. Chem.*, 1937, **247**, 281).

L-αγ-*Di(carbobenzyloxyamino)butyric Acid.*—To a solution of L-αγ-diaminobutyric acid monohydrochloride (18·9 g.) in sodium hydroxide solution (122·4 ml.; 2N.) maintained at 0°, benzyl chloroformate (41·7 g.) and sodium hydroxide solution (183·6 ml.; 2N.) were added in four equal portions at intervals of thirty minutes and with vigorous stirring. After being stirred for a further two hours the mixture was acidified with hydrochloric acid and extracted with chloroform. The chloroform solution was washed with water, dried (Na_2SO_4), and concentrated under reduced pressure. The residue crystallised from ethyl acetate–light petroleum (b. p. 60—80°) in micro-needles, m. p. 91—92° (33 g.) (Found : C, 62·2; H, 5·7; N, 7·2. $C_{20}H_{22}O_6N_2$ requires C, 62·2; H, 5·7; N, 7·25%). The acid was insoluble in water, readily soluble in alcohol, somewhat soluble in ether, and did not produce any characteristic colour with ninhydrin.

L-1-*Carbobenzyloxy*-3-(*carbobenzyloxyamino*)*pyrrolid*-2-*one.*—αγ-Di(carbobenzyloxyamino)butyric acid (73·9 g.) was dissolved in dry ether (500 ml.), cooled to −5° and phosphorus pentachloride (44 g.) added, with stirring. After a further twenty minutes a clear solution was obtained and then on more prolonged cooling a crystalline mass separated, which was filtered off and washed several times with cold ether. Recrystallisation from ethyl acetate–light petroleum (b. p. 60—80°) or ethyl acetate–ether gave prisms, m. p. 113—114° (45 g.) [Found : C, 65·2; H, 5·3; N, 7·7%; *M* (Rast), 358. $C_{20}H_{20}O_5N_2$ requires C, 65·2; H, 5·4; N, 7·6%; *M*, 350]. The *pyrrolidone* was optically active, $[\alpha]_{5461}^{21}$ = −35·1° (*c* = 0·8 in ethyl acetate), and did not produce any characteristic colour with ninhydrin, A further crop (12 g.) was isolated from the original ether solution by concentration *in vacuo*, trituration with light petroleum, and crystallisation from ethyl acetate–ether.

Ethyl L-αγ-*Diaminobutyrate Dihydrochloride.*—L-αγ-Diaminobutyric acid monohydrochloride (35 g.) was suspended in dry absolute ethanol (1000 ml.) and dry hydrogen chloride passed into the boiling mixture until a clear solution was obtained. The solution was refluxed for 6 hours and concentrated to dryness *in vacuo*, and any residual hydrochloric acid removed by reconcentration *in vacuo* after the addition of ethanol and then benzene. The resinous mass slowly crystallised after prolonged drying in a vacuum desiccator over phosphoric oxide and was twice recrystallised, first from ethanol–benzene and then from ethanol–ether, giving prisms, m. p. 172° (decomp.) (29 g.), very soluble in water and ethanol and somewhat hygroscopic (Found : N, 12·6. $C_6H_{16}O_2N_2Cl_2$ requires N, 12·7%). The product gave a purplish-blue colour with ninhydrin.

L-3-*Aminopyrrolid*-2-*one.*—The ester dihydrochloride (28 g.) was dissolved in absolute ethanol (100 ml.), cooled to −5°, and a solution of sodium ethoxide [from sodium (5·9 g.)] in absolute alcohol (100 ml.) added, with vigorous stirring. After a few minutes the mixture was diluted with twice the volume of dry ether, the precipitated sodium chloride filtered off, and the filtrate concentrated to dryness *in vacuo*. On being set aside at *ca.* 0° the residue crystallised, and was recrystallised from benzene–acetone giving plates, m. p. 98—99° (18 g.). The product could also be purified by sublimation at 80°/10^{-2} mm. giving needles, m. p. 99°, $[\alpha]_D^{21}$ = −64° (*c* = 1·8 in water) [Found : C, 48·0; H, 7·9; N, 27·9%; *M* (Rast), 105. $C_4H_8ON_2$ requires C, 48·0; H, 8·0; N, 28·0%; *M*, 100].

The *pyrrolidone* was very soluble in water, ethanol, and acetone, very hygroscopic, and gave a strong purplish-blue colour with ninhydrin; it did not give the deep-red coloration characteristic of a diketopiperazine on being warmed with an alkaline solution of picric acid (Abderhalden, *Z. physiol. Chem.*, 1924, **139**, 181). Acetylation by means of acetic anhydride gave L-3-*acetamidopyrrolid*-2-*one*, crystallising from acetone in needles, m. p. 191°, $[\alpha]_D^{21}$ = −97·3° (*c* = 1·8 in water) [Found : C, 51·0; H, 7·0; N,

19·6%; *M* (Rast), 119. $C_6H_{10}O_2N_2$ requires C, 50·7; H, 7·0; N, 19·7%; *M*, 142]. The *hydrochloride*, precipitated when dry hydrogen chloride was passed through an alcoholic solution of the pyrrolidone, crystallised from ethanol–ether in needles, m. p. 186° (Found : C, 35·0; H, 6·6; N, 20·3; Cl, 25·9. $C_4H_9ON_2Cl$ requires C, 35·2; H, 6·6; N, 20·5; Cl, 26·0%). The *hydrogen oxalate* crystallised from moist alcohol in needles, softening at 120° and decomposing vigorously at 140° (Found : N, 14·8. $C_6H_{10}O_5N_2$ requires N, 14·7%). The *picrate* crystallised from aqueous alcohol in yellow prisms, m. p. 180—184° (decomp.) after darkening, softening at 170° (Found : C, 36·8; H, 3·4; N, 21·0. $C_{10}H_{11}O_8N_5$ requires C, 36·48; H, 3·3; N, 21·3%).

Hydrolysis with 6N-hydrochloric acid gave L-αγ-diaminobutyric acid, which was isolated as its monohydrochloride, m. p. 225° (decomp.), $[\alpha]_{5461}^{21} = +27{\cdot}0°$ ($c = 2{\cdot}6$ in N-hydrochloric acid), and also identified by conversion into the dipicrate, which crystallised from water in yellow prisms, m. p. 187° (decomp.).

L-3-(*Carbobenzyloxyamino*)*pyrrolid*-2-*one*.—L-1-Carbobenzyloxy-3-(carbobenzyloxyamino)pyrrolid-2-one (2·6 g.) was dissolved in absolute alcohol (60 ml.) and hydrogenated in the presence of Adams's catalyst (0·8 g.). After the adsorption of 1 mol. of hydrogen the rate of hydrogenation was negligible. The catalyst was filtered off and, after evaporation of the alcohol *in vacuo*, the residue crystallised from ethanol–light petroleum (b. p. 60—80°) as plates, m. p. 178° (1·9 g.), $[\alpha]_{5461}^{21} = -52{\cdot}3°$ ($c = 0{\cdot}9$ in ethanol). (Alternatively the alcohol solution was concentrated *in vacuo* and the solid residue extracted with warm water, and filtered. When the filtrate was cooled a crystalline mass of L-3-(*carbobenzyloxyamino*)-*pyrrolid*-2-*one* separated.) [Found : C, 61·3; H, 5·9; N, 11·9%; *M* (Rast), 270. $C_{12}H_{14}O_3N_2$ requires C, 61·55; H, 6·0; N, 12·0%; *M*, 234]. The product was sparingly soluble in cold water but readily soluble in hot water; it did not produce any characteristic colour with ninhydrin.

The product was warmed on the steam-bath for 15 minutes with acetic anhydride; the mixture was concentrated to dryness *in vacuo* and the residue crystallised from acetone giving plates, m. p. 177° (undepressed on admixture with the starting material).

L-3-*Aminopyrrolidone*.—(a) *By catalytic hydrogenation of* L-1-*carbobenzyloxy*-3-(*carbobenzyloxyamino*)-*pyrrolid*-2-*one in glacial acetic acid*. The dicarbobenzyloxypyrrolidone (2·85 g.) was hydrogenated in glacial acetic acid (50 ml.) in the presence of platinum oxide (1 g.). After the absorption of 2 mols. of hydrogen the reaction ceased. The catalyst was filtered off, the solvent removed *in vacuo*, the residue triturated several times with warm dry ether, and dried in a vacuum-desiccator over phosphoric oxide. A sample of the dried resinous material was dissolved in cold ethanol, and the solution made faintly alkaline with sodium methoxide and concentrated to dryness *in vacuo*. The residue was extracted with acetone and filtered, and the filtrate sublimed *in vacuo* at 90°/10^{-2} mm. to give a crystalline sublimate, m. p. 98—99° not depressed on admixture with L-3-aminopyrrolid-2-one prepared as described previously (Found : N, 28·0. Calc. for $C_4H_8ON_2$: N, 28·0%). The product was optically active, $[\alpha]_D^{21} = -64{\cdot}4°$ ($c = 1{\cdot}8$ in water), and gave a purplish-blue colour with ninhydrin but none with alkaline sodium picrate.

The hydrochloride crystallised from ethanol–ether in needles, m. p. 186° (undepressed on admixture with the pyrrolidone hydrochloride obtained previously) (Found : C, 35·2; H, 6·5. Calc. for $C_4H_9ON_2Cl$: C, 35·2; H, 6·6%). The hydrogen oxalate crystallised from ethanol in platelets which decomposed at 140° after softening at 120°.

The 2 : 4-*dinitrophenyl* derivative crystallised from aqueous alcohol in yellow needles, m. p. 205—206° (not depressed on admixture with a sample prepared from the 3-aminopyrrolidone obtained previously) (Found : N, 18·8. $C_{10}H_{11}N_4O_7$ requires N, 18·7%).

The resin (0·6 g.) was gently warmed for a few minutes with acetic anhydride (2 ml.); the solution was cooled and diluted with ether, and the crystalline precipitate was filtered off and crystallised from acetone giving L-3-acetamidopyrrolidone (0·6 g.) as plates, m. p. 192° (alone or on admixture with the previous sample), $[\alpha]_D^{21} = -96{\cdot}5°$ ($c = 0{\cdot}8$ in water) (Found : C, 51·0; H, 6·9; N, 20·0. Calc. for $C_6H_{10}O_2N_2$: C, 50·7; H, 7·0; N, 19·7%). The product may also be purified by sublimation at 140°/10^{-2} mm.

The resin (0·5 g.) was also heated on the steam-bath for 30 minutes with hydrochloric acid (25 ml.; 6N.). After being concentrated *in vacuo*, the residue was dried and dissolved in alcohol, and pyridine slowly added. The precipitate was filtered off and recrystallised from moist alcohol to give L-αγ-diaminobutyric acid monohydrochloride, m. p. 225° (decomp.), $[\alpha]_{5461}^{21} = +26{\cdot}8°$ ($c = 2{\cdot}5$ in N-hydrochloric acid).

(b) *By catalytic hydrogenation of* L-3-(*carbobenzyloxyamino*)*pyrrolid*-2-*one in glacial acetic acid*. L-3-(Carbobenzyloxyamino)pyrrolid-2-one (0·15 g.) in glacial acetic acid (15 ml.) was hydrogenated in the presence of platinum oxide (0·13 g.); after the absorption of 1 mol. of hydrogen, the reaction ceased. The catalyst was filtered off and the solvent removed *in vacuo*. The residual resin, after treatment as described above, was sublimed at 80—90°/10^{-2} mm. to yield a crystalline sublimate, m. p. 98° (0·08 g.).

L-3-Acetamidopyrrolidone, prepared in the usual manner, was isolated as plates, m. p. 191—192°, $[\alpha]_D^{21} = -96°$ ($c = 1$ in water).

The resin was distilled from a small distillation flask, and had b. p. 120—130°/10^{-2} (oil-bath at 160—180°). The main bulk rapidly darkened in colour but a clear distillate (*ca.* 50%) was obtained which set to a crystalline mass, m. p. *ca.* 98—100°, $[\alpha]_D^{21} = -27°$ ($c = 0{\cdot}7$ in water).

The partially racemised *acetyl* derivative, prepared from the above distillate, crystallised from acetone in needles, m. p. 176—177° (after some preliminary softening at 172°), $[\alpha]_D^{21} = -62{\cdot}0°$ ($c = 0{\cdot}64$ in water) [Found : C, 50·9; H, 6·8; N, 20·1%; *M* (Rast), 117. $C_6H_{10}O_2N_2$ requires C, 50·7; H, 7·0; N, 19·7%; *M*, 142]. Hydrolysis with 6N-hydrochloric acid gave a partially racemised L-αγ-diaminobutyric acid monohydrochloride, $[\alpha]_{5461}^{21} = +21{\cdot}8°$ ($c = 2{\cdot}7$ in N-hydrochloric acid).

The *picrate* crystallised from aqueous alcohol in yellow needles, m. p. 198—200° (decomp.) (Found: C, 36·8; H, 3·1. $C_4H_8ON_2,C_6H_3O_7N_3$ requires C, 36·48; H, 3·3%).

The Racemisation of L-3-*Aminopyrrolidone.*—A sample of L-3-aminopyrrolidone (0·7 g.) was heated in a sealed tube in an atmosphere of nitrogen at 150° for 30 minutes, then at 170° for 15 minutes. The melt darkened and on cooling solidified; sublimation at $90/°10^{-2}$ mm. gave a crystalline solid (0·48 g.), m. p. 93—96° (after softening at 92°), $[\alpha]_D^{21} = -54·7°$ ($c = 1·8$ in water). The acetyl derivative, m. p. 177—178° (after softening at 168°), $[\alpha]_D^{21} = -59°$ ($c = 1·1$ in water), on hydrolysis with 6N-hydrochloric acid gave a partially racemised L-$\alpha\gamma$-diaminobutyric acid, $[\alpha]_{5461}^{21} = +21·8°$ ($c = 2·6$ in water).

A sample of L-3-aminopyrrolidone (0·8 g.) was heated in a sealed tube in an atmosphere of nitrogen for 5 hours at 155—160°. The resulting brown solid was sublimed at $100°/10^{-1}$ mm. to give DL-3-*aminopyrrolidone* (0·5 g.) [Found: N, 27·8%; *M* (Rast), 119. $C_4H_8ON_2$ requires N, 28·0%; *M*, 100].

DL-3-*Acetamidopyrrolidone*, prepared from the above, crystallised from acetone in needles, m. p. 174—175°, $[\alpha]_{5461}^{21} = 0·00°$ ($c = 0·8$ in water) [Found: C, 51·0; H, 7·0; N, 19·6%; *M* (Rast), 145. $C_6H_{10}O_2N_2$ requires C, 50·7; H, 7·0; N, 19·7%; *M*, 142]. Hydrolysis of the DL-3-acetamidopyrrolidone with 6N-hydrochloric acid gave DL-$\alpha\gamma$-diaminobutyric acid monohydrochloride, m. p. 228—229° (decomp.), $[\alpha]_{5461}^{21} = 0·00°$ ($c = 1·2$ in N-hydrochloric acid).

DL-3-*Acetamido*-1-*acetylpyrrolidone.* L-$\alpha\gamma$-Diaminobutyric acid monohydrochloride (4 g.) was heated on the steam-bath for 3 hours with acetic anhydride (25 ml.) and anhydrous sodium acetate (1 g.). The mixture was cooled, filtered, and concentrated to dryness *in vacuo*. The residue was extracted with hot acetone, and the solution filtered from the insoluble solid and concentrated *in vacuo*. The residual resin crystallised from acetone–ether in rosettes of prisms (2·8 g.), m. p. 132°, $[\alpha]_{5461}^{21} = 0·00°$ ($c = 1·3$ in water) [Found: C, 52·2; H, 6·6; N, 15·3%; *M* (Rast), 220. $C_8H_{12}O_3N_2$ requires C, 52·2; H, 6·5; N, 15·2%; *M*, 184]. The product was readily soluble in water and did not give any characteristic colour with ninhydrin.

Distillation in a micro-molecular still gave a clear resin, b. p. $120°/10^{-3}$ mm., which set to a hard crystalline mass on being kept.

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