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CONDENSED 1,3,5-TRIAZEPINES—II†

THE SYNTHESIS OF 2,3-DIHYDRO-1*H*-IMIDAZO[1,2-*a*][1,3,5]BENZOTRIAZEPIN-5(6H)-ONES AND -THIONES

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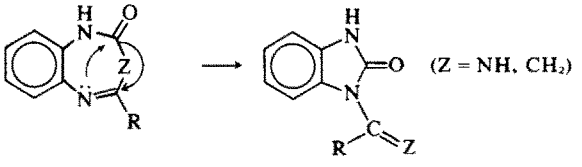
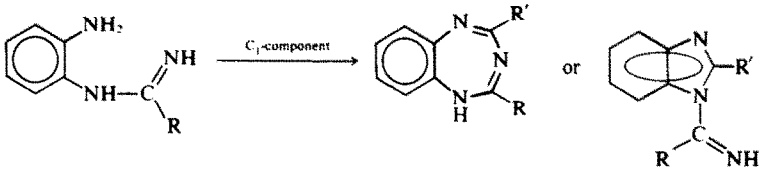
Abstract—A method, based on the reaction of 1-(2-aminoaryl)-2-iminoimidazolidines **8** with phosgen, 1,1'-carbonyldiimidazole and thiophosgene, carbon disulfide and 1,1'-thiocarbonyldiimidazole, respectively, has been devised for the synthesis of the title compounds. The compounds **8** are rearranged at elevated temperatures into the isomeric 2-amino-1-(2-amino-ethyl) benzimidazoles **11**.

The chemistry of the 1,3,5-benzotriazepine system has not been explored fully[2,3] and the assignment of this structure to a series of compounds[4,5] appears to be wrong or should, at least, be accepted with caution. This is probably partly the consequence of the expected easy ring contraction of the 1,3,5-benzotriazepines to the isomeric benzimidazoles (Scheme 1, Z = NH), and partly due to the fact that the most obvious syntheses of 1,3,5-benzotriazepines (see e.g. Scheme 2) may, as an alternative, lead directly to benzimidazoles (cf Ref. 6). Thermal ring contractions of the type mentioned have been observed in the related 1*H*-1,5-benzodiazepin-2(3*H*)-one series[7,8] (Scheme 1, Z = CH_2).



Scheme 1.



R = alkyl, NH_2 etc.

Scheme 2.

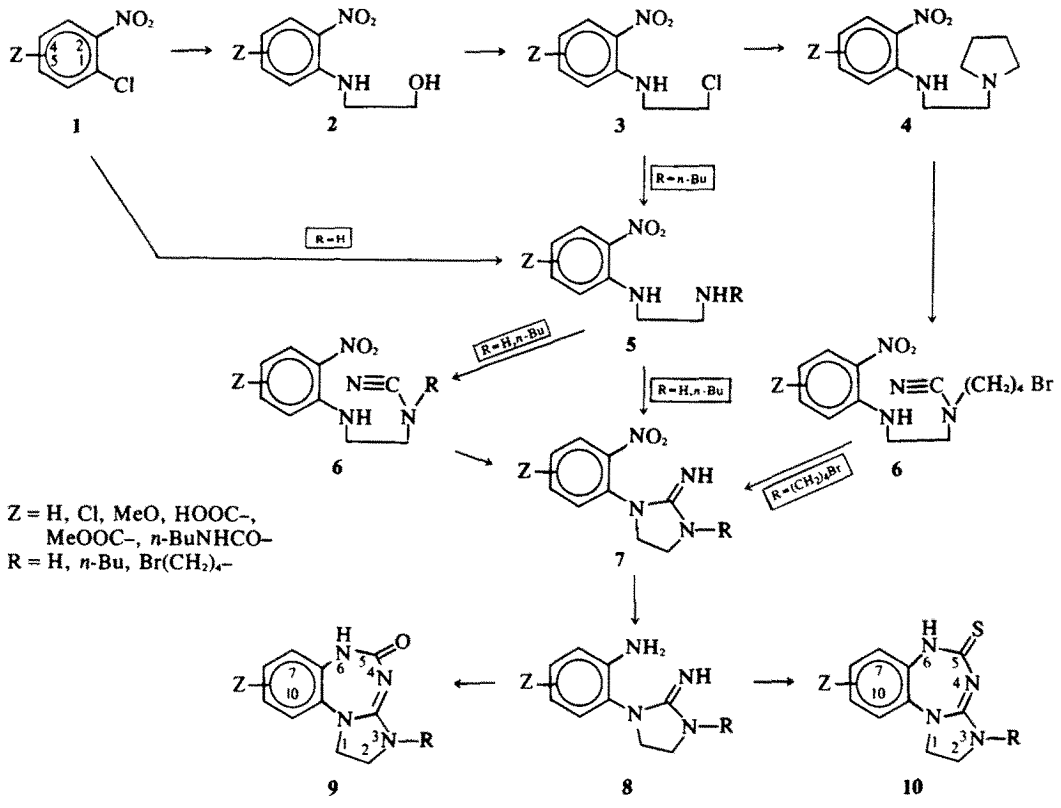
In order to restrict the number of those conformers of the starting compounds of the *o*-aminophenylguanidine type (R = NH_2 etc, Scheme 2) which are unfavourable for the formation of the 1,3,5-benzotriazepine system and, at the same time, to minimize the danger of subsequent ring contraction of the desired products,‡ 1-(2-aminophenyl)-2-iminoimidazolidines **8** were selected as the target compounds, and a general method for the synthesis of 2,3-dihydro-1*H*-imidazo[1,2-*a*][1,3,5]benzotriazepin-2(3*H*)-ones **9** and -thiones **10** has been developed by reacting compounds **8** with phosgene, thiophosgene, carbon disulfide, 1,1'-carbonyl- and 1,1'-thiocarbonyldiimidazole, respectively (Scheme 3).

The starting compounds **1**, most of which were either commercially available (Z = H, 4-Cl, 5-Cl, 4-MeO) or have been obtained as described in literature (Z = 4-COOH,[9,10] 4-COOMe[10]), were transformed into the N-(2-nitroaryl)-ethylenediamines **5** by three different methods, depending on the nature of the substituent R. Compounds **5** (R = H) were obtained by allowing to react the appropriate compounds **1** with excess ethylenediamine. The carboxyl group of **5** (R = H, Z = 4-COOH) was subsequently modified by known methods. For the synthesis of compounds **5** (R = n-Bu) a three step sequence **1** → **2** → **3** → **5** (R = n-Bu) was adopted, the first two steps being well documented in literature.[10-15] A limited number of the type **2** compounds has been obtained by methods which were different from those described in literature, see Experimental. When, in the last step of the above sequence, the butylamine was replaced by pyrrolidine, piperidine or dibutylamine, the corresponding compounds **4** and their piperidino and dibutylamino analogues were obtained, respectively.

The compounds **5** (R = H, n-Bu) were allowed to react with a slight excess of BrCN in boiling ethanol to yield the hydrobromides of the corresponding 2-imino-N-(2-nitroaryl)-imidazolidines **7** (see Table 1). When the reactions were performed in the presence of Na_2CO_3, the *N*-cyanoamine type intermediates **6** (R = H, n-Bu) could be isolated. Alternatively, **6** (R = n-Bu, Z = 4-Cl) was

†The preliminary communication[1] is considered as Part I of the series.

‡Compound **9** (Z = H, R = n-Bu) proved, according to DTA, to be stable at least up to 205°, in agreement with expectation.

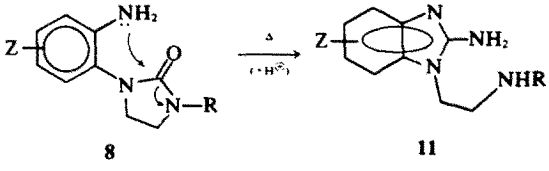


Scheme 3.

obtained by the von Braun degradation of the dibutylamino analogue of **4** (Z = 4-Cl; Bu_2N instead of the pyrrolidino group). Ring closure of the *N*-cyanoamines to salts of the corresponding compounds **7** was brought about by refluxing with aqueous acids.

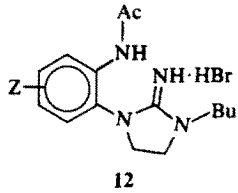
The hydrochlorides of the compounds **7** [R = $(CH_2)_4Br$ and $(CH_2)_5Br$] were obtained by the von Braun degradation of the corresponding compounds **4** and their piperidino analogues, respectively. Since the intermediate *N*-cyanoamines **6** [R = $(CH_2)_nBr$] proved to be oils, they were immediately subjected to cyclization with HCl.

The hydrobromides and hydrochlorides of the compounds **7** were catalytically (Pd/C) reduced in aq MeOH or EtOH. To avoid rearrangement of **8** into benzimidazole derivatives **11** (Scheme 4) the reductions were performed in the presence of excess aq HBr and HCl, respectively, and the free bases **8**, used for transformation into compounds **9** and **10**, were freshly liberated from their salts.



Scheme 4.

At elevated temperatures **8** (Z = H, R = n-Bu) indeed rearranged into **11** (Z = H, R = n-Bu) but, at ordinary temperatures, the free bases **8** proved stable. That rearrangements of the above type did not take place in the course of the ring closures of compounds **8** to **9** and **10** either, is proven by the non-identity of the latter with the analogous cyclization products of the compounds **11** which will be described in Part III.



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Conversion of the compounds **8** into 2,3-dihydro-1*H*-imidazo[1,2-a][1,3,5]benzotriazepin-5(6*H*)-ones **9** and -thiones **10** was performed by treating them with phosgene and 1,1'-carbonyldiimidazole, and carbon disulfide, thiophosgen and 1,1'-thiocarbonyldiimidazole, respectively, the yields being rather low (even in the presence of K_2CO_3), when phosgene and thiophosgene were applied as reagents (see Tables 3 and 4). The compounds **9** form colorless crystals, while the compounds **10** are light yellow to yellow.

The compounds **7**, **9** and **10** (R = H) are potentially tautomeric and could exist as the tautomers with the C=N bond located in the imidazole cycle as well. That this is probaly not the case in EtOH and DMSO may be inferred from the similarity of the UV spectra of pairs of otherwise identical compounds with R = H and R = n-Bu or $(CH_2)_4Br$, respectively. A similar conclusion may be drawn for the compounds **9** (R = H) in the crystalline state from the positions of the C=O bands in the IR spectra.

The results of the biological screening of the compounds described in the present paper will be published by Dr. L. Petöcz elsewhere.

EXPERIMENTAL

2-Diethylaminoethyl 4-chloro-3-nitrobenzoate, HCl salt

A mixture of 4-chloro-3-nitrobenzoic acid[9] (2·0 g; 10 mmoles) and $SOCl_2$ (20 ml) was refluxed for 1 hr. The excess $SOCl_2$ was distilled off, and the residue was dissolved in anhydrous benzene (20 ml). *N,N*-Diethyl-*N*-(2-hydroxyethyl)ammonium chloride (1·6 g; 10 mmole) was added, and the mixture was refluxed for 8 hr. An oily precipitate was formed which gradually turned crystalline. The mixture was allowed to cool, and the product was filtered and recrystallized from ethanol to yield 2·3–2·5 g (68–74%) of the title compound, m.p. 143–144°. (Found: C, 46·15; H, 5·57; N, 8·01. Calc. for $C_{13}H_{18}Cl_2N_2O_4$: C, 46·30; H, 5·38; N, 8·30%). UV (EtOH): 228 (4·32); 294 (3·04); ~330 sh (~2·5).

N-Butyl-4-chloro-3-nitrobenzamide

4-Chloro-3-nitrobenzoic acid[9] (5·0 g; 25 mmoles) was converted with $SOCl_2$ into the acid chloride as described above. The crude product was dissolved in dry ether (30 ml). An ethereal (30 ml) solution of butylamine (7·5 ml; 75 mmoles) was added, and the mixture was refluxed for 8 hr. The solvent and excess amine were distilled off, and the residue was triturated with water to yield 5·4 g (84%) of the crystalline product, m.p. 72–74°, from benzene-light petroleum. (Found: C, 51·54; H, 5·07; Cl, 13·79; N, 10·52. Calc. for $C_{11}H_{13}ClN_2O_3$: C, 51·47; H, 5·11; Cl, 13·81; N, 10·71%).

2-(o-Nitroanilino)-ethanol **2**

Compounds **2** with Z = H,[11–14] Z = 4-Cl,[15] Z = 5-Cl,[10] Z = 4-COOH[10] and Z = 4-COOMe[10] were obtained by allowing the appropriate compounds **1** to react with 2-aminoethanol. By prolonging the reaction time from 6 to 14 hr, the yield could be raised from 66[10] to 84% in the case of **2** (Z = 4-COOH). An alternative mode of preparation of **2** (Z = 4-COOMe) consists in treating **2** (Z = 4-COOH) consecutively with $SOCl_2$ and methanol as described below (in the absence of pyridine, $SOCl_2$ does *not* react with the alcoholic OH group the starting compound). UV (EtOH), Z = H: 232 (4·29); 280 (3·60); 410 (3·80), Z = 4-COOH: 263 (4·28); 290 (4·27); 417 (3·72).

Methyl 3-(2-hydroxyethyl)-3-nitrobenzoate (**2**, Z = 4-COOMe)

2 (Z = 4-COOH) was refluxed with $SOCl_2$ (5 ml/g) for 2 hr. The reagent was distilled off. Methanol (4 ml/g of initially introduced **2**) was added, and the mixture was refluxed for 1·5 hr. The cool mixture was filtered and poured into water (100 ml) to yield yellow crystals of the title compound, m.p. 103–104° (from CCl_4), lit.[10] m.p. 104°, identical m.p. and IR with an authentic sample.

N-Butyl-[4-(2-hydroxyethyl)-3-nitrobenzamide] (**2**, Z = 4-BuNHCO–)

A mixture of **2** (Z = 4-COOMe) (7·8 g; 32 mmoles) and butylamine (20 ml) was refluxed for 16 hr. The solvent was distilled off, and the purple oily residue was triturated with water until it gradually turned into a light brown crystalline product (7·7 g; 84%) m.p. 110–111°C (from $CHCl_3$–petrol or aqueous EtOH). (Found: C, 55·59; H, 6·76; N, 15·16. Calc. for $C_{13}H_{19}N_3O_4$: C, 55·51; H, 6·81; N, 14·94%).

N-(2-Chloroethyl)-o-nitranilines **3**

The compounds **3** with Z = H,[11,13] Z = 5-Cl,[10] Z = 4-HOOC[10] and Z = 4-MeOOC[10] have been prepared by allowing compounds **2** to react with $POCl_3$, $SOCl_2$ and $SOCl_2$/pyridine, respectively, as described in literature. Where comparisons were made with $POCl_3$ and $SOCl_2$, the latter reagent was found to be superior. For the reaction of **2** (Z = 4-HOOC) with $SOCl_2$ in the *absence* of pyridine see above. **3** (Z = 4-Cl) is new and has been obtained in 79 and 73% yields, respectively, by allowing **2** (Z = 4-Cl) to react with excess PCl_5 in refluxing $CHCl_3$ (cf Ref. 13) or with refluxing excess $SOCl_2$. M.p. 94°C (petrol or CCl_4). (Found: Cl, 30·23; N, 11·74. Calc. for $C_8H_8Cl_2N_2O_2$ (235·1): Cl, 30·16; N, 11·92%). UV (EtOH): Z = H: 232 (4·32); 279 (3·66); 418 (3·76). Z = 4-Cl: 239 (4·41); 270 (3·75), sh; 431 (3·75). Z = 4-COOH: 263 (4·35); 286 (4·28); 410 (3·74).

N-(2-Nitrophenyl)-ethylenediamines (**5**, R = H)

The unsubstituted compound **5** (R = Z = H) is known from literature.[16†] The 4-chloro and 4-methoxy derivatives (**5**, R = H, Z = 4-Cl and 4-MeO, respectively) were obtained similarly by allowing the appropriate chloronitrobenzene **1** to react with excess ethylenediamine at 110–120°. No attempt was made to purify the crude products (obtained in 88–98% yield by distilling off the excess of the reagent *in vacuo*,‡ taking up the residue in 10% aqueous NaOH and $CHCl_3$, and working up the $CHCl_3$ layer in the usual manner). Instead, they were directly reacted upon with BrCN (see below). UV (EtOH): Z = R = H, HBr-salt: 230 (4·30); 280 (3·66); 417 (3·73); HCl-salt: 231 (4·24); 279 (3·60); 416 (3·86).

4-(2-Ammonioethylamino)-3-nitrobenzoate (betaine of **5**, R = H, Z = 4-COOH)

A mixture of 4-chloro-3-nitrobenzoic acid (6·0 g; 30 mmoles) and ethylenediamine (50 ml) was stirred for 6 hr at 100°. The excess diamine was stilled off *in vacuo*, and the solid residue was triturated and subsequently refluxed with an aqueous (50 ml) solution of $NaHCO_3$ (2·5 g; 30 mmoles). The resulting suspension was allowed to cool to yield 6·0 g (89%) of a yellow crystalline product which was purified by reprecipitating it with acetic acid from its 5% aqueous NaOH solution. M.p. 300° (dec.). (Found: C, 44·24; H, 5·25; H_2O, 7·59. Calc. for $C_9H_{11}N_3O_4 \cdot H_2O$: C, 44·45; H, 5·39; H_2O, 7·32%). IR (KBr): *no* νC=O band. The crude product proved sufficiently pure for esterification.

Methyl 4-(2-aminoethylamino)-3-nitrobenzoate hydrochloride (HCl salt of **5**, R = H, Z = 4-COOMe)

The above crude betaine (20·1 g; 89 mmoles) was refluxed with anhydrous MeOH (1500 ml) for 18 hr. The soln was allowed to cool, and the resulting crystalline product was filtered off and recrystallized from MeOH to yield 15·6 g (73%) of yellow needles, m.p. 264° (dec.) from MeOH. (Found: C, 43·56; H, 5·01; N, 15·43. Calc. for $C_{10}H_{13}N_3O_4 \cdot HCl$: C, 43·45; H, 5·12; N, 15·24%). IR (KBr): νC=O 1720 cm^{-1}. The corresponding ethyl ester hydrochloride, m.p. 272–274°C (dec.), was obtained by treating 4-chloro-3-nitrobenzoic acid successively with refluxing $SOCl_2$, refluxing EtOH and refluxing ethanolic ethylenediamine, and treating the oily product with ethanolic HCl. (Found: C, 45·65; H 5·26; N 14·24. Calc. for $C_{11}H_{15}N_3O_4 \cdot HCl$: C, 45·60; H, 5·57; N, 14·50%). UV (EtOH): 263 (4·32); 287 (4·31); 412 (3·70).

2-Diethylaminoethyl 4-(2-aminoethylamino)-3-nitrobenzoate dihydrochloride (Di-HCl salt of **5**, R = H, Z = $Et_2NCH_2CH_2OOC$–)

A mixture of the HCl salt of 2- diethylaminoethyl 4-chloro-3-nitrobenzoate (13·3 g; 39·5 mmole), ethylenediamine (25 ml) and anhydrous dioxane was refluxed for 6 hr and evaporated to dryness *in vacuo*. The oily residue was taken up in water (100 ml) and ether (50 ml), and the aqueous layer was extracted with two further portions of ether (50 ml, each). The combined ether solutions were dried over $MgSO_4$, and dry HCl gas was introduced to yield a crystalline product which was recrystallised from 95% EtOH to yield orange coloured crystals of m.p. 141–142°. (Found: C, 43·14; H, 7·11; N, 12·85. Calc. for $C_{15}H_{24}N_4O_4 \cdot 2HCl \cdot H_2O$: C, 43·38; H, 6·80; N, 13·49%).

N-Butyl-4-(2-aminoethylamino)-3-nitrobenzamide hydrochloride (HCl salt of **5**, R = H, Z = n-BuNH–CO–)

A mixture of *N*-butyl-4-chloro-3-nitrobenzamide (9·9 g; 39 mmole), ethylenediamine (10 ml) and EtOH (50 ml) was refluxed for 10 hr and evaporated to dryness *in vacuo*. The oily residue turned crystalline when triturated with water. The product was filtered off and taken up in EtOH (50 ml). The product was only partly dissolved. Dry HCl gas was introduced, and the hydrochloride thus formed was filtered off and washed with a small amount of ice cold ethanol to yield 9·65 g (79%) of the HCl salt, m.p. 261–262° from EtOH. (Found: C, 49·20; H, 6·53; Cl, 11·58; N, 17·37. Calc. for $C_{13}H_{20}N_4O_3 \cdot HCl$: C, 49·29; H, 6·68; Cl, 11·19; N, 17·96%). The same product was obtained (in lower yield)

†The b.p. stated in Ref. 16 appears to be erroneous. We have found b.p. 200° at 0·6 torr.

‡Caution! Compounds (**5**, R = H) tend to explode on heating. The distillations should be performed at lowest possible pressures.

when the betaine of **5** (R = H, Z = COOH) was treated successively with $SOCl_2$ and n-$BuNH_2$.

N-Butyl-N-(2-nitrophenyl)-ethylenediamines (**5**, R = n-Bu)

Compounds **5** (R = n-Bu, Z = H, 4-Cl and 5-Cl) were obtained from **3** (0·1 mole) by refluxing for 8 hr with n-$BuNH_2$ (100 ml); the excess amine was distilled off *in vacuo*, and the residue was triturated with 10% aqueous NaOH (200 ml) to yield a red oily product which was taken up in ether (200 ml). The aqueous layer was extracted with ether (100 ml) and the combined ether solutions were washed with water (100 ml) and dried over $MgSO_4$. Evaporation of the solvent furnished the crude bases in the form of red oils. Since considerable decomposition takes place on attempted distillation of larger quantities of the bases, the crude products were used for the subsequent steps. Z = H, 75%, b.p. 200°/0·6 torr; HCl salt: m.p. 169° (EtOH) (Found: Cl, 12·89; N, 15·40. Calc. for $C_{12}H_{19}N_3O_2$·HCl: Cl, 12·89; N, 15·40%). Z = 4-Cl, 90–95%, b.p. 186–188°/0·5 torr; HBr salt: m.p. 206–208°C (EtOH); HCl salt: m.p. 212–213° (EtOH) (Found: Cl, 23·08; N, 13·68. Calc. for $C_{12}H_{18}ClN_3O_2$·HCl: Cl, 23·01; N, 13·63%); Z = 5-Cl, 97%.

N-Butyl-4-(2-butylaminoethylamino)-3-nitrobenzamide (**5**, R = n-Bu, Z = n-BuNH–CO–)

(a) A mixture of 4-(2-hydroxyethylamino)-3-nitrobenzoic acid[10] (**2**, Z = 4-COOH), (4·5 g; 20 mmoles), $SOCl_2$ (40 ml) and 3 drops of pyridine were refluxed for 6 hr. The excess $SOCl_2$ was distilled off *in vacuo*, and the resulting oil was dissolved in ether (100 ml). The ethereal solution was added by drops to a mixture of n-$BuNH_2$ and ether (40 ml each). The ether was distilled off, and the resulting solution was refluxed for 8 hr. The excess n-$BuNH_2$ was distilled off *in vacuo* and the solid residue was triturated with cold 20% aq NaOH to yield 5·0 g (75%) of the yellow crystalline plates m.p. 147–148° from aqueous MeOH.

(b) A mixture of methyl 4-(2-chloroethylamino)-3-nitrobenzoate[10] (**3**, Z = COOMe) (9·0 g; 34 mmoles) and n-$BuNH_2$ (18·5 g; 250 mmoles) was refluxed for 8 hr. The excess amine was distilled off *in vacuo*, and the residue was worked up as described under (a) to yield 10·8 g (92%) of the same product as obtained under (a) above. (Found: C, 60·68; H, 8·36; N, 16·44. Calc. for $C_{17}H_{28}N_4O_3$: C, 60·69; H, 8·39; N, 16·66%). IR (KBr): Amide I 1640 cm^{-1}.

N-[2-(2-Nitranilino)ethyl]-pyrrolidines **4**

(a) A mixture of **3** (Z = 4-Cl) (23·5 g; 100 mmoles) and pyrrolidine (100 ml) was refluxed for 6 hr. The bulk of the excess amine was removed by distillation *in vacuo*. The residue was triturated with water (100 ml), the aqueous phase was decanted, another portion of water (200 ml) was added, and 100 ml of the latter was distilled off. The oily residue gradually solidified on cooling to yield 24 g of a crude product which was washed with water and dissolved in ether (500 ml). The insoluble dark tars were filtered off, and the filtrate was evaporated to dryness to yield 22 g (80%) of crystalline (**4**; Z = 4-Cl), m.p. 72° from petrol or MeOH. (Found: Cl, 13·15; N, 15·20. Calc. for $C_{12}H_{16}ClN_3O_2$ Cl, 13·15; N, 15·58%). UV (EtOH): 240 (4·44); ~270 sh (~3·8); 440 (3·79).

The HCl salt was obtained by treating an ethereal solution of the base with dry HCl and recrystallizing the product from EtOH. M.p. 231°; (Found: Cl, 23·29; N, 13·45. Calc. for $C_{12}H_{16}ClN_3O_2$·HCl: Cl, 23·23; N, 13·77%). UV (EtOH): 237 (4·42); ~270 sh (~3·75); 425 (3·72).

(b) A mixture of **3** (Z = 4-COOH),[10] (28·5 g; 116 mmoles) and pyrrolidine (130 ml) was refluxed for 8 hr. The excess pyrrolidine was distilled off *in vacuo*, and the residue was dissolved in water (300 ml). The solution was boiled up, acidified with conc HCl and allowed to cool slowly to yield 24·2 g (53%) of **4**·HCl·H_2O (Z = 4-COOH), m.p. 249–250° (dec.) from H_2O. (Found: C, 47·06; H, 6·14; N, 12·49. Calc. for $C_{13}H_{17}N_3O_4$·HCl·H_2O: C, 46·78; H, 6·04; N, 12·59%). UV (EtOH): 261 (4·30); 285 (4·19); 402 (3·64).

(c) The ethyl ester of the above product was obtained by refluxing the latter (4·0 g; 12 mmole) for 1 hr with $SOCl_2$ (80 ml), removing the excess reagent and refluxing the residual oil for 1 hr with EtOH (30 ml). The crystalline product, **4**·HCl (Z = EtOOC) was precipitated by the addition of ether. 3·9 g (95%), m.p. 153–155°. (Found: C, 52·32; H, 6·39; N, 11·99. Calc. for $C_{15}H_{21}N_3O_4$·HCl: C, 52·40; H, 6·45; N, 12·22%). UV (EtOH): 262 (4·26); 286 (4·24); 401 (3·67).

(d) **4**·HCl·H_2O (Z = 4-COOH) (55·5 g; 175 mmole) was refluxed for 1 hr with $SOCl_2$ (400 ml). The residue, obtained after removing the excess $SOCl_2$, was triturated with $CHCl_3$ (200 ml) to yield a yellow crystalline product. This was filtered off and mixed with anhydrous $CHCl_3$. n-Butylamine (55 ml) was added to the suspension which subsequently was refluxed for 13 hr and evaporated to dryness. The residue was triturated with N/1 NaOH solution (200 ml) to yield an oily product which was dissolved in benzene (400 ml). The aqueous layer was extracted with another portion of benzene (100 ml). The combined benzene solutions were dried ($MgSO_4$) and concentrated to about 1/3 of the original volume. Light petroleum was added to yield **4** (Z = n-BuNH–CO–) (42·8 g; 73%), m.p. 108–110° from benzene—light petroleum. (Found: C, 61·05; H, 7·94; N, 16·70. Calc. for $C_{17}H_{26}N_4O_3$: C, 61·06; H, 7·84; N, 16·75%).

N-[2-(4-Chloro-2-nitranilino)ethyl]-piperidine

This compound was prepared in 65% yield similarly to its lower ring homologue (**4**; Z = 4-Cl); the steam distillation step was unnecessary, since the product crystallised when triturated with water. M.p. 115–116° from MeOH. (Found: C, 55·59; H, 6·09; Cl, 12·61; N, 14·61. Calc. for $C_{13}H_{18}ClN_3O_2$: C, 55·03; H, 6·39; Cl, 12·50; N, 14·81%).

N,N-Dibutyl-N'-(4-chloro-2-nitrophenyl)-ethylenediamine

3, Z = 4-Cl (7·05 g; 30 mmoles) was stirred with dibutylamine (50 ml; 300 mmoles) for 6 hr at 130°. The excess amine was distilled off *in vacuo*, and the residue was triturated with water (50 ml). The aqueous phase was decanted, and the oily product was dissolved in ether (150 ml). The ethereal solution was washed with three portions of water (50 ml, each) and dried ($MgSO_4$). The solvent was distilled off to yield 9·0 g (91%) of a red oil which proved pure according to TLC (Kieselgel G; benzene–MeOH, 10:1). The oily base was characterized in form of its crystalline hydrochloride, m.p. 273°, which was obtained by introducing dry HCl gas into an ethereal solution of the base and recrystallizing the product from 2-propanol. (Found: Cl, 19·75; N, 11·85. Calc. for $C_{16}H_{26}ClN_3O_2$·HCl: Cl, 19·44; N, 11·53%).

2-Imino-N-(2-nitrophenyl)imidazolidine hydrobromides (·*HBr*)

(a) Mixtures of the N-(2-nitroaryl)ethylenediamines **5** (0·1 mole), BrCN (0·12 mole) and EtOH (80–100 ml) were refluxed for 3 hr. Crystallization of the products started on cooling and was completed by the addition of ether (150–200 ml). The products form faint yellow crystals.

(b) The N-cyano-N'-(2-nitroaryl)-ethylenediamines **6** (see below) (5 mmoles) were refluxed for 45–60 min with 48% aqueous HBr (15 ml). The crystalline products sepearated on cooling. Ring closure (to yield the corresponding HCl salts) could be effected also with the aid of 20% aqueous HCl.

(c) Mixtures of the pyrrolidines **4** (90 mmoles), BrCN (100 mmoles) and EtOH (200 ml) were stirred at room temp. for 30 min and then refluxed for another 30 min. Dry HCl gas was passed for 1·5 hr through the refluxing soln. The mixture was allowed to stand overnight, the solvent was evaporated *in vacuo*, the crystalline residue was triturated with cold acetone, filtered off and washed with ether. For the yields, m.ps and analytical data of the products see Table 1.

Methyl 4-(2-imino-1-imidazoldinyl)-3-nitrobenzoate hydrobromide (*HBr salt of* **7**, *R = H, Z = 4-COOMe*)

Methyl 4-(2-aminoethylamino)-3-nitrobenzoate hydrochloride (HCl salt of **5**, R = H, Z = 4-COOMe) (29·4 g; 107 mmoles) was triturated with 10% aqueous Na_2CO_3 soln (200 ml). The resulting crystalline free base was dried and refluxed for 4 hr with a methanolic (200 ml) soln of BrCN (12·7 g; 120 mmoles), until a clear soln was obtained. About 2/3 of the solvent was distilled off, and ether was added to the soln, until crystallization of the product started. The mixture was allowed to cool, and the resulting faint yellow HBr salt (27 g; 73·5%) was thoroughly washed with ether in order ro remove the excess BrCN. For the m.p. and analytical results see Table 1.

Table 1. 2-Imino-N-(2-nitroaryl)imidazolidine hydrobromides (7·HBr)

Z	R	Method of synthesis[a]	Yield %	M.p. (Recryst. from)	Formula (Mol. wt)	Calc./Found C%	H%	Br%	N%
H	H	A[b]	80–90	239°	$C_9H_{10}N_4O_2$·HBr			27·83	19·51
		B[c]	92[f,g]	(EtOH)	(287·7)			27·53	19·81
H	n-Bu	A	85	262–4° (dec.)	$C_{13}H_{18}N_4O_2$·HBr	45·49	5·58		16·33
				(EtOH)	(343·3)	45·83	5·50		16·55
4-Cl	H	A[b]		260–2° (dec)	$C_9H_9ClN_4O_2$·HBr	33·61	3·14	24·85	17·42
				(EtOH)	(321·57)	33·97	3·62	24·32	17·00
4-Cl	n-Bu	A	70–75	269–70° (dec.)	$C_{13}H_{17}ClN_4O_2$·HBr	[c]		21·16	14·83
		B[d]	72	(*i*-PrOH)	(377·7)			20·95	14·78
		B[e]	72	285–7°	[f,g]				
				(EtOH–Et_2O)					
4-Cl	$-(CH_2)_4Br$	C	65	265–6° (dec.)	$C_{13}H_{16}BrClN_4O_2$·HCl	[h]			13·29
				(MeOH–Et_2O)	(412·1)[f]				13·48
4-Cl	$-(CH_2)_5Br$	C'	50	226–8°	$C_{14}H_{18}BrClN_4O_2$·HCl	40·80	4·65		
				(EtOH–Et_2O)	(426·1)[f]	40·48	4·93		
5-Cl	n-Bu	A	70	247°	$C_{13}H_{17}ClN_4O_2$·HBr			21·16	14·83
				(i-PrOH)	(377·7)			21·41	14·59
4-MeO	H	A[b]	70–75	235° (dec.)	$C_{10}H_{12}N_4O_3$·HBr	37·84	4·13		17·67
				(EtOH)	(317·15)	37·71	4·23		17·70
4-MeOOC	H	A'	74	195° (dec.)	$C_{11}H_{12}N_4O_4$·HBr	38·28	3·79		16·24
				(MeOH–Et_2O)	(344·2)	38·63	4·00		16·25
4-EtOOC	$-(CH_2)_4Br$	C'	46	229–30° (dec.)	$C_{16}H_{21}BrN_4O_4$·HCl	42·73	4·93		[k]
				(EtOH)	(449·7)[f]	42·62	5·03		
4-BuNHCO	H	A'	35	223–4°	$C_{14}H_{19}N_5O_3$·HBr	43·53	5·22	20·69	
				(EtOH–Et_2O)	(386·26)	43·61	5·20	20·70	
4-BuNHCO	n-Bu	A'	89%	242°	$C_{18}H_{27}N_5O_3$·HBr	48·87	6·38	18·07	15·83
				(EtOH–Et_2O)	(442·4)	48·65	6·30	17·40	15·62
4-BuNHCO	$-(CH_2)_4Br$	C'	52	215–6°	$C_{18}H_{26}BrN_5O_3$·HCl	45·34	5·71	[l]	14·69
				(EtOH–Et_2O)	(476·81)[f]	44·90	6·13		14·48

[a] Method A: Ring closure of N-(2-nitroaryl)-ethylenediamines (5) with BrCN; Method B: Acid catalysed ring closure of N-cyanoamines 6; Method C: Reaction of pyrrolidines 4 with BrCN. [b] The starting 5 (R = H) was used in crude form. [c] Cl, Calc.: 9·39, Found: 9·32%. [d] Catalyst: aqueous HBr. [e] Catalyst: aqueous HCl. [f] HCl salt. [g] The IR spectra of the HCl and HBr salts were identical. [h] Ionic Cl, calc. 8·60; found 8·97%. Total halogen, expressed as Cl, calc 28·93; found 28·74%. [i] Starting compound: piperidinoanalogue of 4 (Z = 4-Cl). [j] See text for the detailed description. [k] Ionic Cl, Calc.: 7·88, Found: 7·65%. [l] Ionic Cl, Calc.: 7·44, Found: 7·20%. Total halogen, expressed as Br, Calc.: 33·52, Found: 33·90%.

Ethyl 4-[3-(4-*bromobutyl*)-1-*imidazolidinyl*]-3-*nitrobenzoate hydrochloride* (*HCl salt of* 7, R = $-(CH_2)_4Br$, Z = 4-COOEt)

A solution of ethyl 4-(2-pyrrolidinoethylamino)-3-nitrobenzoate hydrochloride (HCl salt of 4, Z = 4-COOEt) (14·9 g; 46·7 mmoles) in EtOH (100 ml), in which sodium (1·1 g; 48 mmoles) has been dissolved, was treated with BrCN (6·3 g; 60 mmoles) and refluxed for 0·5 hr. The mixture was allowed to cool, the NaCl was filtered off, and dry HCl gas was introduced for 0·5 hr into the soln. Heat was evolved. The warm soln was treated with Norite and allowed to stand overnight in a refrigerator to yield 9·6 g (46%) of the title compound. For the m.p. and analytical results see Table 1.

N-Butyl-4-(2-*imino*-1-*imidazolidinyl*)-3-*nitrobenzamide hydrobromide* (*HBr salt of* 7, Z = 4-BuNHCO, R = H)

Sodium (1·8 g; 79 mmoles) and N-butyl-4-(2-aminoethylamino)-3-nitrobenzamide hydrochloride (HCl salt of 5, Z = 4-BuNHCO, R = H) (23·4 g; 74 mmoles) were dissolved in this order in anhydrous EtOH (100 ml). The mixture was heated to its b.p. and allowed to cool. The crystalline precipitate was filtered off, and the ethanolic filtrate was treated with BrCN (12·0 g; 113 mmoles) and refluxed for 6 hr. The solvent was distilled off. The crystalline residue was triturated with acetone (50 ml) to yield 9·9 g of the title compound (35%, corrected for unreacted starting material recovered in form of the free base). For the m.p. and analytical results see Table 1.

N-Butyl-4-(3-*butyl*-2-*imino*-1-*imidazolidinyl*)-3-*nitrobenzamide hydrobromide* (*HBr salt of* 7, Z = 4-BuNHCO, R = n-Bu).

A mixture of N-butyl-4-(2-butylaminoethylamino)-3-nitrobenzamide (5, Z = 4-BuNHCO, R = n-Bu) (25·2 g; 75 mmoles), BrCN (8·75 g; 82·5 mmoles), and EtOH (150 ml) was refluxed for 6 hr. About one half of the solvent was distilled off, and ether was added until crystallization of the product started. The mixture was allowed to cool, and the resulting thick crystalline paste was filtered off and thoroughly washed with ether in order to remove any unreacted BrCN. 29·6 g (89%) of the faint yellow crystals of the title compound were obtained. For the m.p. and analytical results see Table 1.

4-[3-(4-*Bromobutyl*)-2-*imino*-1-*imidazolidinyl*]-*N-butyl*-3-*nitrobenzamide hydrochloride* [*HCl salt of* 7, Z = 4-BuNHCO, R = $Br(CH_2)_4$]

A mixture of the pyrrolidine (4; Z = 4-BuNHCO) (5·0 g; 15 mmoles), BrCN (2·0 g; 19 mmoles) and anhydrous EtOH (40 ml) was refluxed for 1 hr. Dry HCl gas was introduced for 0·5 hr into the hot soln which subsequently was refluxed for 1 hr. Dry HCl gas was introduced for another 10 min, and the soln was evaporated to dryness *in vacuo*. The oily residue was triturated with acetone (50 ml) whereby it first dissolved, but precipitation of the product soon started. The mixture was kept in a refrigerator overnight to yield 3·7 g (52%) of the HCl salt. For the m.p. and analytical results see Table 1.

N-Cyano-N'-(2-nitrophenyl)-ethylenediamines 6

(a) Ethereal solns (50 ml) of BrCN (5·3 g; 50 mmole) were added by drops under continuous stirring to the mixture of ethereal solns (50 ml) of (5; R = Z = H and R = n-Bu, Z = 4-Cl, respectively) (50 mmole) and 5% aq Na_2CO_3 (10 ml). Stirring was continued for 30 min to yield, in the R = Z = H series, 10·2 g (100%) of a crystalline product, m.p. 103° from benzene. (Found: C, 52·75; H, 4·86; N, 27·41. Calc. for $C_9H_{10}N_4O_2$: C, 52·42; H, 4·89; N, 27·17%). UV (EtOH): 231 (4·31); 281 (3·66); 425 (3·74) IR (KBr): $\nu C \equiv N$ 2240 cm^{-1}. In the R = n-Bu, Z = 4-Cl series the ethereal layer was separated, dried ($MgSO_4$) and evaporated to dryness *in vacuo*. Recrystallization of the dry residue from CCl_4 furnished 10·2 g (68%) of 6, m.p. 60°. (Found: C, 53·07; H, 5·91; Cl, 11·80; N, 18·71.

Table 2. N-(2-Aminoaryl)-2-iminoimidazolidine dihydrobromides (8; di-HBr)

Z	R	Yield %	M.p. (Recryst. from)	Formula (Mol. wt)	Calc./found C%	H%	Br%	N%	UV (EtOH)
H	H	92	268°	$C_9H_{12}N_4 \cdot 2\,HBr$	31·97	4·17	47·38	16·56	211 sh (4·19); 240
			(MeOH–Et_2O)	(338·1)	32·40	4·63	46·67	16·41	(3·99); 296 (3·53)
H	n-Bu	68	291–2°	$C_{13}H_{20}N_4 \cdot 2\,HBr$			32·35	11·34	216 sh (4·22); 238
			(MeOH–Et_2O)	(394·1)			32·84	11·18	(4·04); 296 (3·59)
		78[a]	101–2°[a]	$C_{13}H_{20}N_4$[a]	67·21	8·68		24·12	
			(CCl_4-gasoline)	(232·3)	66·80	8·74		24·87	
4-Cl	n-Bu	84	263–5°	$C_{13}H_{19}ClN_4 \cdot 2\,HBr$		[b]	37·29	13·07	210 (4·55); 245
			(MeOH–Et_2O)	(428·6)			36·78	12·55	(4·04); 305 (3·64)
		66[c]	185–6°[c]	$C_{13}H_{19}ClN_4 \cdot HBr \cdot H_2O$	42·69	6·06	21·85	15·32	210 (4·53); 246
			(H_2O)	(365·7)[d]	42·77	5·63	21·96	15·61	(4·02); 304 (3·64)
4-Cl	$-(CH_2)_4Br$	60	203–5°[e]	$C_{13}H_{18}ClN_4Br \cdot 2\,HCl$			[f]	13·70	
			(MeOH–Et_2O)	(418·6)				14·16	
5-Cl	n-Bu	65[g]	256–8°[g]	$C_{13}H_{19}ClN_4 \cdot 2\,HBr$					
				(428·6)					
4-MeO	H	90	225°	$C_{10}H_{14}N_4O \cdot 2\,HBr$			43·30	15·18	206 (4·65); 230
			(MeOH–Et_2O)	(368·1)			43·82	14·83	(3·98), sh; 287 (3·47)[h]
4-MeOOC–	H	70	196° (dec.)	$C_{11}H_{14}N_4O_2 \cdot 2\,HBr$	33·35	4·07			222 (4·26); 330
			(MeOH–Et_2O)	(396·1)	33·40	4·59			(3·47)
4-(n-BuNHCO)–	H	71	153–5° (dec.)	$C_{14}H_{21}N_5O \cdot 2\,HBr$	38·46	5·30	35·56		220 (4·20), sh; 318
			(EtOH–Et_2O)	(437·2)	38·03	5·46	35·98		(3·58)
4-(n-BuNHCO)–	n-Bu	89	190° (dec.)	$C_{18}H_{29}N_5O \cdot 2\,HBr$	43·82	6·33	32·40	14·20	~210 (~4·3); 319
			(EtOH–Et_2O)	(493·3)	43·74	6·70	31·39	14·27	(3·51)
4-(n-BuNHCO)–	$-(CH_2)_4Br$	79	88–90°[e]	$C_{18}H_{28}BrN_5O \cdot 2\,HCl$	44·74	6·26		14·49	211 (4·42); 225
			(EtOH–Et_2O)	(483·3)	44·04	6·54		14·10	(4·36), sh; 320 (3·57)

[a] Free base, obtained by treatment of the dihydrobromide with 40% aqu. NaOH at room temp. The yield stated is the overall yield of the reduction step and liberation of the base. [b] Total halogen, expressed as Cl, Found: 24·50, Calc.: 24·81%. [c] Monohydrobromide-monohydrate, obtained by treatment of the dihydrobromide with 15% aq NaOH at room temp. [d] H_2O loss at 100° 5·02, Calc.: 4·93%. [e] Dihydrochloride. [f] Ionic Cl, Found: 17·43, Calc.: 16·94%. [g] Crude product which was used without purification in the subsequent step. [h] Solvent H_2O.

Calc. for $C_{15}H_{17}ClN_4O_2$ (296·8): C, 52·61; H, 5·78; Cl, 11·95; N, 18·88%). IR (KBr): $\nu C \equiv N$ 2200 cm^{-1}. UV (EtOH): 238 (4·44); ~270 (~3·8), sh; 430 (3·77).

(b) An ethereal soln (10 ml) of BrCN (0·7 g; 6·5 mmole) was added by drops under continuous stirring to the ethereal soln (10 ml) of N,N-dibutyl-N'-(4-chloro-2-nitrophenyl)-ethylenediamine (see above) (1·64 g; 5 mmole). Stirring was continued for 30 min. The soln was filtered, the filtrate was evaporated to dryness, and the dry residue was recrystallized from CCl_4 to yield 0·9 g (60%) of **6** (R = n-Bu, Z = 4-Cl), identical according to m.p., IR spectra and TLC with the product obtained as described under (a).

N-(2-Aminoaryl)-2-iminoimidazolidine dihydrobromides (**8** *di*-HBr).

(a) *General procedure.* **7**·HBr (0·1 mole) was dissolved in mixtures (500–600 ml) of MeOH and H_2O (1:0·7–1:3, v/v); 48% aq HBr (20–40 ml) was added, and the soln was reduced at room temp and normal pressure in the presence of 7–8% Pd/C catalysts (5–10 g) until 0·3 mole of H_2 was absorbed. The catalyst was removed, and the dry residue of the filtrate was recrystallized from EtOH–Et_2O. For the yields, m.ps and analytical data see Table 2.

8, di-HBr (Z = 4-Cl, R = H) resisted all attempts at crystallization, and the crude product was therefore directly converted into the corresponding compound **10** (see below).

Owing to its very poor solubility, **7**·HBr [Z = 4-(n-BuNHCO), R = H] was reduced in aq ethanolic HBr (300 ml EtOH and 180 ml 48% HBr for 0·1 mole of the starting substance). In two cases, where the hydrochlorides rather than the hydrobromides of **7** were available as starting materials, the reductions were performed (under otherwise identical conditions) in the presence of 37% aq HCl, and furnished the corresponding compounds **8** di-HCl. The resulting salts (as well as the free base isolated in a single case) are colourless crystalline compounds.

(b) **8** di-HBr (Z = 4-Cl, R = n-Bu) (35·8 g; 84 mmole) was treated with 15% aq NaOH (200 ml) at 10° to yield, after transient formation of a clear soln, 20 g (66%) of **8**·HBr·H_2O (Z, R as above). For the m.p. and microanalytical data see Table 2.

Acetylation. The soln of **8**·HBr·H_2O (Z = 4-Cl, R = n-Bu) (2·0 g; 5·5 mmole) in Ac_2O (20 ml) was heated for 30 min at 70°. The solvent was distilled off *in vacuo*, and the residue was triturated with Et_2O to yield 2·1 g (98%) of **12** (Z = 4-Cl), m.p. 237–8° (Found: Br, 20·63; N, 14·21. Calc. for $C_{15}H_{21}ClN_4O$·HBr (389·7): Br, 20·51; N, 14·38; $\nu C{=}O$ 1665 cm^{-1}.

Rearrangement of **8** (Z = H, R = n-Bu). A soln of the title compound (6·0 g; 26 mmole; freshly liberated from the dihydrobromide as described below) in diethyl carbonate (15 ml) was refluxed for 1 hr. On cooling, 2·1 g (35%) of (**11**; Z = H, R = n-Bu), colourless plates, m.p. 171° (from EtOAc), separated which, according to m.p. and IR spectra, proved identical with an authentic sample, obtained as will be described in Part III.

2,3-Dihydro-1H-imidazo[1,2-a][1,3,5]benzotriazepin-5(6H)-ones **9**

(a) The dihydrobromides or dihydrochlorides (10 mmole) of the compounds **8** were stirred for 10 min with the methanolic (20 ml) soln of Na (0·52 g; 22·6 mmole). The solvent was distilled off *in vacuo* (bath temperature below 30°), the residue was taken up in $CHCl_3$ (30 ml), the NaBr was filtered off, and the solvent was again distilled off as described above to yield the free bases **8** mostly as oils.

(b) The compounds **8** were dissolved in $CHCl_3$ (50 ml for the amount of base obtained from 10 mmole of the dihydrobromide or dihydrochloride). Solns of $COCl_2$ (1·8 g; 18 mmole) in $CHCl_3$ (5 ml) were added, and the mixtures were allowed to stand overnight at room temp. The solvent was filtered off, and the residues were triturated with 10% aq Na_2CO_3 (30 ml) to yield the corresponding compounds **9** which were filtered off and washed with water until neutral. For the yields etc. see Table 3.

(c) **8** (Z = R = H) obtained .from 10 mmole of the dihydrobromide was dissolved in a mixture of anhydrous dioxane (20 ml) and $CHCl_3$ (5 ml). 1,1'-Carbonyldiimidazole (3·6 g; 22 mmole) was added; the mixture was stirred for 20 min at room temp and gently refluxed for 5 min to yield 1·60–1·76 g (82–90%) of **9** (Z = R = H), identical according to IR with the $COCl_2$ cyclization product.

2,3-Dihydro-1H-imidazo[1,2-a][1,3,5]benzotriazepin-5(6H)-thiones **10**

(a) The dihydrobromides or dihydrochlorides (10 mmole) of the compounds **8** were dissolved in methanolic (50 ml) solns of Na (0·50 g; 23 mmole) at room temp. CS_2 (6 ml) was added, and the mixtures were refluxed for 6–10 hr and evaporated to dryness *in vacuo*. The residues were triturated with water (100 ml) to yield the title compounds. For the yields, etc. see Table 4.

(b) The compounds **8** (obtained from 10 mmole of their salts) were treated with $CSCl_2$ (purity 95%; 0·95 ml; 11 mmole) in $CHCl_3$ soln as described above for the preparation of the oxo analogues. For the yields, etc. see Table 4.

(c) The compounds **8** (obtained from 10 mmole of their salts) were dissolved in anhydrous acetone (20 ml). 1,1'-Thiocarbonyldiimidazole (1·8 g; 10 mmole) was added, and the mixtures were refluxed for 30 min and evaporated to dryness. The residues were triturated and washed with three portions (20 ml, each) of water. For the yields, etc. see Table 4.

Hydrolysis of **9** (Z = 8-Cl, R = n-Bu). A mixture of the title compound (293 mg; 1·0 mmole), EtOH (1 ml) and 24% aq HBr (4 ml) was refluxed for 8 h and evaporated to dryness *in vacuo* to yield 392 mg (92%) of **8**, di-HBr (Z = 4-Cl, R = n-Bu), m.p. 263–4° (from MeOH–Et_2O).

IR and UV spectra were obtained with Hungarian Optical Works (Budapest) Type Spectromom 2000 IR and Type Spectromom 201 UV spectrometers. The UV spectra will be published in Ref. 17.

Table 3. 2,3-Dihydro-1*H*-imidazo[1,2-*a*][1,3,5]benzotriazepin-5(6*H*)-ones **9**

Z	R	Yield[a] %	M.p. (Recryst. from)	Formula (Mol. wt)	Calc./found C%	H%	N%	UV (EtOH)	$\nu C{=}O$ (KBr)
H	H	A: 30 B: 82–90	255–7° (DMF)	$C_{10}H_{10}N_4$ (202·2)	59·40 59·13	4·98 5·14	27·71 27·82	209 (4·31); 235 (4·58); 273 (3·33), sh	1650/45[d]
H	n-Bu	A: 41	205–7° (MeOH)	$C_{14}H_{18}N_4O$ (258·3)	65·09 64·81	7·02 6·90	21·69 21·86	212 (4·14), sh; 239 (4·51); 292 (3·19)	1645
8-Cl	n-Bu	A: 27	220° (EtOH)	$C_{14}H_{17}ClN_4O$ (292·8)	57·43 57·74	5·85 5·78	[b]	218 (4·30), sh; 239 (4·51); 305 (3·40)	1645
9-Cl	n-Bu	A: 12	197–8° (EtOH)	$C_{14}H_{17}ClN_4O$ (292·8)	[c]		19·01 19·24	241 (4·66); 304 (3·38)	1640
8-MeOOC-	H	A: 27	272° (dec.) (DMF)	$C_{12}H_{12}N_4O_3$ (260·3)	55·38 55·65	4·65 4·52	21·53 21·87	224 (4·42); 232 (4·40), 293 (3·62); 318 (3·60)	1655[d]
8-(n-BuNHCO)-	n-Bu	A: 21	244–5° (aq EtOH)	$C_{19}H_{27}N_5O_2$ (357·5)	63·84 63·51	7·62 7·34	19·60 19·41	242 (4·36); 261 (4·42); 320 (3·40)	1640[d]

[a] Ring closure A with phosgen, B with 1,1'-carbonyldiimidazole; [b] Cl: Calc.: 12·03, Found: 12·39%; [c] Cl, Calc.: 12·03, Found: 12·13%; [d] Ring carbonyl.

Table 4. 2,3-Dihydro-1*H*-imidazo[1,2-*a*][1,3,5]benzotriazepin-5(6*H*)-thiones **10**

Z	R	Yield[a] %	M.p. (Recryst. from)	Formula (Mol. wt)	Calc./found C%	H%	N%	S%	UV (EtOH)
H	H	A: 82 B: 46	264–5° (dec.) (DMF)	$C_{10}H_{10}N_4S$ (218·3)	55·04 55·12	4·62 4·62		14·70 14·24	204 (4·38); 264 (4·40); 312 (4·22); ~360 (~3·2), sh
H	n-Bu	A: 95	187–8° (dec.) (MeOH)	$C_{14}H_{18}N_4S$ (274·4)	61·28 61·55	6·61 6·82	20·42 20·20	11·69 12·31	<200 (~4·6); 270 (4·50); 312 (4·34); ~375 (~3·1), sh
8-Cl	H	A: 60	257–8° (dec.) (DMSO)	$C_{10}H_9ClN_4S$ (252·7)	47·52 47·68	3·59 3·82	22·17 21·82	12·69 12·40	272 (4·44); 324 (4·26); ~380 (~3·0), sh[d]
8-Cl	n-Bu	A: 90 B: 16 C: 82	214–6° (acetone)	$C_{14}H_{17}ClN_4S$ (308·8)	[b]		18·14 18·47	10·38 10·56	<200 (~4·6); 275 (4·50); 315 (4·30); ~370 (~3·2), sh
9-Cl	n-Bu	A: 64 B: 20 C: 70	217–8° (acetone)	$C_{14}H_{17}ClN_4S$ (308·8)	[c]		18·14 18·73	10·38 10·28	212 (4·28); 275 (4·46); 314 (4·32); ~365 (~3·3), sh
8-MeO	H	A: 95	260–1° (dec.) (DMSO)	$C_{11}H_{12}N_4OS$ (248·3)	53·21 53·27	4·87 5·01	22·56 22·64	12·92 12·87	276 (4·46); 313 (4·36); ~3·7 (~3·1), sh[d]
8-MeOOC-	H	A: 89	>300° (dec.) (aq. DMF)	$C_{12}H_{12}N_4O_2S$ (276·3)			20·28 20·49	11·60 11·59	
8-(n-BuNHCO)-	H	A: 73	248–9° (DMF)	$C_{15}H_{19}N_5OS$ (317·4)	56·76 57·13	6·03 6·12		10·10 10·03	263 (4·52); 284 (4·55); 312 (4·12), sh[d]
8-(n-BuNHCO)-	n-Bu	A: 92 B: 20	207–8° (EtOH)	$C_{19}H_{27}N_5OS$ (373·5)	61·09 61·05	7·29 7·38		8·58 8·65	220 (4·33); 279 (4·63); 316 (4·30); ~389 (~3·2), sh

[a] Ring closure A with CS_2, B with $CSCl_2$, C with 1,1'-thiocarbonyldiimidazole; [b] Cl, calc.: 11·48, Found: 12·02%; [c] Cl, calc.: 11·48, Found: 11·56%; [d] Solvent DMSO.

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