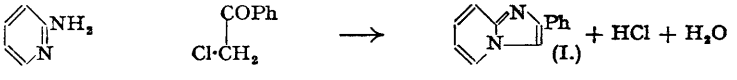
533. *Preparation of Pyridinobenziminazole and its Derivatives.*

By Neil Campbell and E. B. McCall.

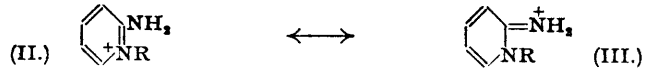
2-Aminopyridine and its 3- and 5-substituted derivatives condense with 2-chloro*cyclo*hexanone to form 4 : 5 : 6 : 7-tetrahydropyridino(1′ : 2′-1 : 2)-benziminazoles. The unsubstituted tetrahydro-compound on dehydrogenation yields pyridino(1′ : 2′-1 : 2)benziminazole.

Tschitschibabin (*Ber.*, 1924, **57**, 2092; 1925, **58**, 1704) showed that 2-aminopyridine combines with α-halogenated ketones or esters to give pyridino(1′ : 2′-1 : 2)glyoxalines, the halogen attacking the ring-nitrogen atom rather than the primary amino-group. In agreement with this and of relevance to the present work is the observation that ω-chloroacetophenone and 2-aminopyridine yield 4-phenylpyridino(1′ : 2′-1 : 2)glyoxaline (I) whose structure was determined by Schmid and Bangler (*Ber.*, 1925, **58**, 1971; 1926, **59**, 1360). It is doubtful if such

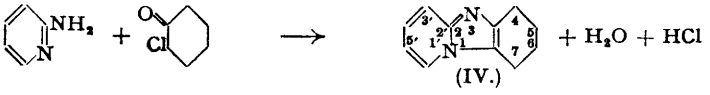


reactions are as simple as represented, and it is pertinent to mention that the long-chain alkyl iodides give with 2-aminopyridine in cymene a mixture containing 75—85% of the strongly basic 1-alkyl-2-pyridone imine and 15—25% of the isomeric 2-alkylaminopyridine (Sharp, *J.*, 1939, 1855). Even here, however, the ring nitrogen is the main centre of attack. Theoretically this is to be expected since the cation (II; R = CH_2·COPh, etc.) resulting from the quaternary-salt formation can resonate with the form (III) (cf. Mann and Watson, *J. Org.*

Chem., 1948, **13**, 502). Attack at the primary amino-group would give rise to products without such resonance stabilisation.

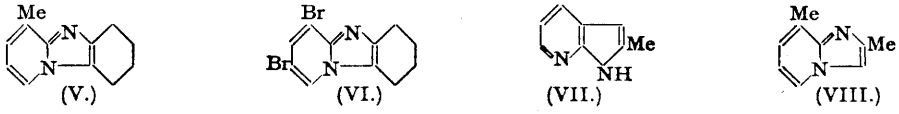


It would be expected from such considerations that 2-aminopyridine and 2-chloro*cyclo*hexanone would give 4 : 5 : 6 : 7-tetrahydropyridino(1′ : 2′-1 : 2)benziminazole (IV) and not 6 : 7 : 8 : 9-tetrahydro-2-carboline as claimed in an I.G. Farbenindustrie patent (B.P. 360,027;



cf. *Chem. Abstracts*, 1932, **26**, 3514). It was therefore decided to reinvestigate the reaction, employing not only 2-aminopyridine but also suitably substituted derivatives.

2-Aminopyridine and 2-chloro*cyclo*hexanone condense to give a product apparently identical with that obtained by the German workers except that it crystallises from organic solvents as the monohydrate, $C_{11}H_{12}N_2,H_2O$, m. p. 56—58°, a fact not mentioned in the patent. The hydrate



is readily dehydrated *in vacuo* to give the anhydrous base, m. p. 95—96° (*A*). 2-Amino-3-methylpyridine and 2-amino-3 : 5-dibromopyridine in the same way give respectively 4 : 5 : 6 : 7-tetrahydro-3′-methyl- (V; as dihydrate) and -3′ : 5′-dibromo-pyridino(1′ : 2′-1 : 2)benziminazole (VI) the structures of which are thus unambiguously determined.

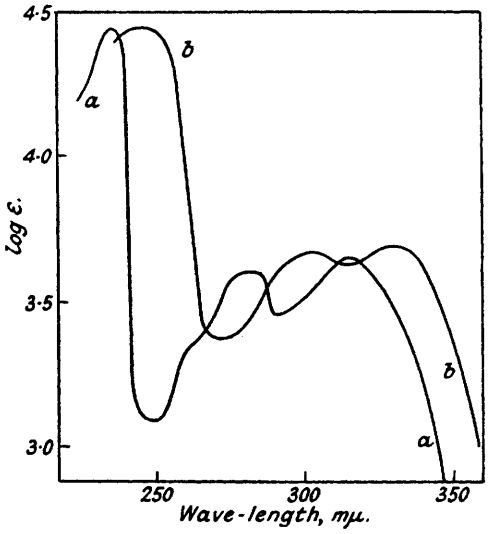
Comparison of the ultra-violet absorption spectra of the 3′ : 5′-dibromo-compound and the product *A* shows great similarity (Fig. 1) and provides evidence that the cyclisation of 2-aminopyridine and 2-chloro*cyclo*hexanone occurs at the two nitrogen atoms to give a pyridinobenziminazole derivative. The two absorption curves show that in the wave-length region 230—400 mμ. the two substances exhibit almost identical absorption, the only difference being the expected displacement of 10—20 mμ. towards the longer wave-lengths by the bromine auxochromes (see Braude, *Ann. Reports*, 1945, **42**, 124). The condensation product of 2-amino-5-bromopyridine and 2-chloro*cyclo*hexanone likewise has a similar absorption curve with maxima at 245 mμ. (log ε 4·36), 290 mμ. (log ε 3·63), and 325 mμ. (log ε 3·70), suggesting that it is 5′-bromo-4 : 5 : 6 : 7-tetrahydropyridino(1′ : 2′-1 : 2)benziminazole. Here also displacement of the absorption maxima by bromine is obvious. Final conclusions cannot be drawn unless these absorption spectra are shown to be distinctly different from those of 6 : 7 : 8 : 9-tetrahydro-2-carboline. This compound not having been prepared, its absorption curve is not known but,

since the methylene groups of the reduced ring contribute little or nothing to the absorption (see R. N. Jones, *Chem. Reviews*, 1943, **32**, 21), the absorption of the tetrahydrocarboline will probably be essentially the same as that of pyridino(2′ : 3′-2 : 3)pyrrole or its alkyl derivatives. Fig. 2 shows that the spectra of tetrahydropyridino(1′ : 2′-1 : 2)benziminazole and 5-methylpyridino(2′ : 3′-2 : 3)pyrrole (VII) are different, but it is not legitimate to draw structural conclusions from these data since control experiments showed that the absorption spectrum of 4 : 3′-dimethylpyridino(1′ : 2′-1 : 2)glyoxaline (VIII) differs more from that of the tetrahydropyridinobenziminazole than from that of the methylpyridinopyrrole. Chemical evidence, however, was more conclusive. The product *A* was dehydrogenated by means of palladised charcoal at 300° (cf. Horning, Horning, and Walker, *J. Amer. Chem. Soc.*, 1948, **70**, 3935) to give a product with properties similar to those of pyridino(1′ : 2′-1 : 2)benziminazole previously synthesised by Morgan and Stewart (*J.*, 1938, 1292; 1939, 1057).

2-2′-Pyridylamino*cyclo*hexanone (IX) is stated to be prepared from 2-sodioaminopyridine and 2-chloro*cyclo*hexanone (B.P. 360,027). We have found that it is more conveniently obtained by boiling 2-aminopyridine and 2-chloro*cyclo*hexanone in ethanol containing sodium

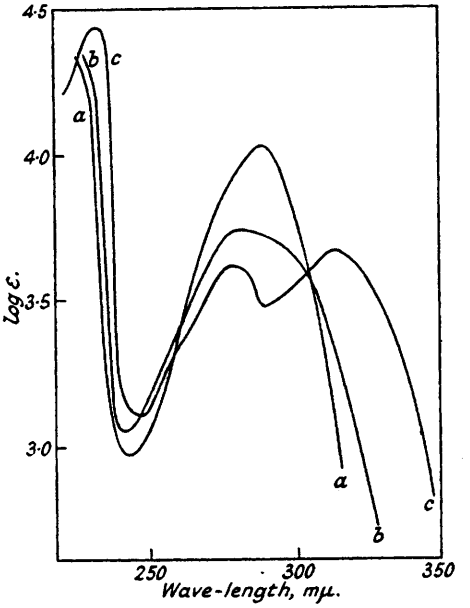
carbonate although the yields are only 30%. To ensure that the product is not 1-2′-keto*cyclo*hexyl-2-pyridone imine (X), its ultra-violet absorption spectrum was measured and compared with those of 2-methylaminopyridine and 1-methyl-2-pyridone imine, recently measured by Anderson and Seeger (*J. Amer. Chem. Soc.*, 1949, **71**, 340). Fig. 3 shows that in the above

FIG. 1.



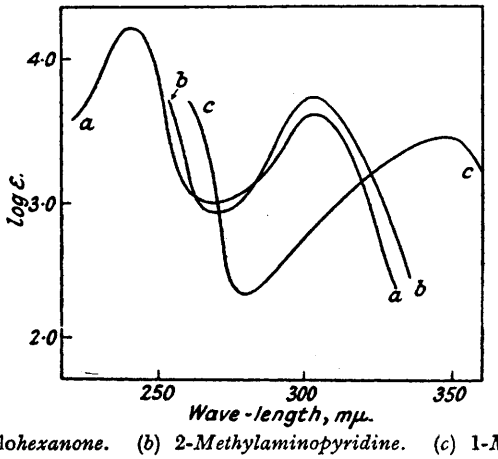
(*a*) *Compound A.* (*b*) 3′ : 5′-*Dibromo*-4 : 5 : 6 : 7-*tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole.*

FIG. 2.



(*a*) 5-*Methylpyridino*(2′ : 3′-2 : 3)*pyrrole.* (*b*) 4 : 3′-*Dimethylpyridino*(1′ : 2′-1 : 2)*glyoxaline.* (*c*) 4 : 5 : 6 : 7-*Tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole.*

FIG. 3.

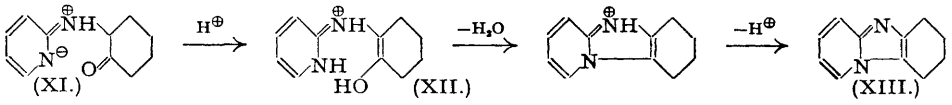


(*a*) 2-2′-*Pyridylamino*cyclo*hexanone.* (*b*) 2-*Methylaminopyridine.* (*c*) 1-*Methyl*-2-*pyridone imine.*

reaction the halogen atom has reacted with the amino-group of 2-aminopyridine to give the pyridylamino*cyclo*hexanone. This was confirmed by the chemical properties of the product. With boiling ethanolic sodium hydroxide it gave no ammonia, thus showing the absence of an imino-group; the only product isolated was 2-2′-pyridylamino*cyclo*hexanol, which was also formed when aluminium *iso*propoxide in *iso*propanol was used. Presumably in the first instance some sodium ethoxide was formed and this catalysed a hydrogen transfer of the Meerwein–Ponndorf type. Reduction by Huang-Minlon's modification of the Wolff–Kishner

method (*J. Amer. Chem. Soc.*, 1946, **68**, 2487) gave 2-*cyclo*hexylaminopyridine, identical with the product formed by condensation of 2-bromopyridine and *cyclo*hexylamine. Clemmensen reduction cleaved the molecule, and 2-aminopyridine was identified as one of the products. Similar cleavages of amino-ketones by the Clemmensen method have been reported (von Braun and Weissbach, *Ber.*, 1929, **62**, 2416).

2-2′-Pyridylamino*cyclo*hexanone in the presence of hydrogen ions readily yields the tetrahydropyridinobenziminazole. Since protons add preferentially to the ring-nitrogen atom, a plausible mechanism is outlined below in which proton adds to the polar form (XI). The product (XII) undergoes ring-closure by dehydration, and the free base (XIII) is liberated by alkali. It is somewhat difficult to account for the observation that some of the substituted 2-aminopyridines with 2-chloro*cyclo*hexanone in the presence of sodium carbonate undergo ring-closure and no pyridylamino*cyclo*hexanone can be isolated.



It would appear from the above results that 2-aminopyridine and 2-chloro-ketones can yield pyridino(1′ : 2′-1 : 2)glyoxalines either by attack at the ring-nitrogen atom (see p. 2411) or at the 2-amino-group. The course taken evidently depends *inter alia* on the pH of the reaction mixture, but further work is necessary before a full assessment can be made.

Experimental.

All ultra-violet absorption spectra measurements were made on a Hilger Barfit medium quartz spectrograph.

4 : 5 : 6 : 7-*Tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole*.—The patented method (*loc. cit.*) gave a 33% yield of the product, and the following modified procedure is preferable. 2-Chloro*cyclo*hexanone (8 g.) was added dropwise to boiling 2-aminopyridine (11·4 g., 2 mols.), and the mixture was boiled gently for a further 15 minutes. The solution was made alkaline with sodium hydroxide and steam-dstilled until the distillate was free from aminopyridine. The residue was extracted with benzene, and the dried extract (Na_2SO_4) on evaporation gave a syrup which distilled at 170—180°/12 mm. and slowly crystallised, m. p. 45—65° (yield 7·4 g., 65%). Recrystallisation from ether–light petroleum gave 4 : 5 : 6 : 7-*tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole monohydrate*, m. p. 56—58° (Found: C, 69·7; H, 7·3; N, 15·2%; *M*, 174. $C_{11}H_{12}N_2,H_2O$ requires C, 69·5; H, 7·4; N, 14·7%; *M*, 190), with absorption maxima at 235 mμ. (log ε 4·45), 281 mμ. (log ε 3·62), and 316 mμ. (log ε 3·66). It gives a *picrate* (yellow needles from ethanol–acetic acid), m. p. 260—261° (Found: N, 17·4. $C_{17}H_{15}O_7N_5$ requires N, 17·5%), and a methiodide (colourless needles), m. p. 256—258°. When dried over phosphoric oxide for 48—72 hours and finally in a high vacuum, it loses the theoretical weight of water to form the anhydrous substance, m. p. 95—96°, which on exposure to air rapidly reverts to the monohydrate. Examination on the heating-stage microscope showed that the hydrate melts to a cloudy liquid which does not clear until the water of crystallisation distils off at 120°; the clear liquid on cooling crystallises in the anhydrous form.

4 : 5 : 6 : 7-*Tetrahydro-3′-methylpyridino*(1′ : 2′-1 : 2)*benziminazole*.—2-Amino-3-methylpyridine (5 g.) and 2-chloro*cyclo*hexanone (7·7 g., 1·25 mols.) were boiled in ethanol (30 ml.) for 28 hours, and the solvents distilled off until crystallisation of the hydrochloride, m. p. 235—237°, commenced. The free base was obtained by addition of sodium hydroxide and separated in long needles from water as the *dihydrate*, m. p. 60—61° (Found: C, 64·3; H, 8·0; N, 12·7. $C_{12}H_{14}N_2,2H_2O$ requires C, 64·8; H, 8·2; N, 12·6%). It forms a *picrate* (yellow plates from ethanol), m. p. 155—158° (Found: N, 16·9. $C_{18}H_{17}O_7N_5$ requires N, 17·1%). The substance is also obtained in 48% yield by boiling the reactants without a solvent. Distillation *in vacuo* gave the anhydrous compound, m. p. 85—87°, b. p. 230—240°/13 mm., which when crystallised from water gave the dihydrate, m. p. 52—54°.

5′-*Bromo- and* 3′ : 5′-*Dibromo*-4 : 5 : 6 : 7-*tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole*.—2-Amino-3 : 5-dibromopyridine (5 g.) and 2-chloro*cyclo*hexanone (4 g., 1·5 mols.) were boiled in ethanol (30 ml.) for 26 hours and worked up as above to give 3′ : 5′-*dibromo*-4 : 5 : 6 : 7-*tetrahydropyridino*(1′ : 2′-1 : 2)-*benziminazole*, which crystallised from light petroleum (b. p. 100—120°) in needles (2·4 g., 37%), m. p. 159—160° (Found: C, 40·5; H, 3·45; N, 8·4; Br, 47·9. $C_{11}H_{10}N_2Br_2$ requires C, 40·0; H, 3·1; N, 8·5; Br, 48·4%). It shows absorption maxima at 245 mμ. (log ε 4·45), 290 mμ. (log ε 3·68), and 325 mμ. (log ε 3·70), and forms a *picrate* (yellow needles from ethanol–acetic acid), m. p. 167—169° (Found: N, 12·5. $C_{11}H_{10}N_2Br_2,C_6H_3O_7N_3$ requires N, 12·4%). 2-Amino-5-bromopyridine similarly gave 5′-*bromo*-4 : 5 : 6 : 7-*tetrahydropyridino*(1′ : 2′-1 : 2)*benziminazole* [prisms from light petroleum (b. p. 100—120°)] (73%), m. p. 148—149° (Found: C, 52·8; H, 4·4; N, 10·3; Br, 31·2. $C_{11}H_{11}N_2Br$ requires C, 52·6; H, 4·40; N, 11·2; Br, 31·8%), which has absorption maxima at 245 mμ. (log ε 4·45), 302 mμ. (log ε 3·68), and 332 mμ. (log ε 3·70). It forms a hydrochloride, m. p. 260—262°, and a *picrate* (yellow needles from glacial acetic acid), m. p. 264—265° (decomp.) (Found: N, 13·7. $C_{11}H_{11}N_2Br,C_6H_3O_7N_3$ requires N, 14·6%). The monobromo-compound was also obtained in 73% yield without the use of a solvent.

4 : 5 : 6 : 7-*Tetrahydro-5′-nitropyridino*(1′ : 2′-1 : 2)*benziminazole*.—2-Amino-5-nitropyridine (3·0 g.) and 2-chloro*cyclo*hexanone (2·9 g., 1 mol.) were mixed and the temperature was gradually raised until at 120—130° a vigorous reaction commenced. After this had subsided the mixture was kept at 130° for 2 hours. The black product was dissolved in boiling dilute hydrochloric acid (25 ml.) (charcoal), and the solution filtered. Neutralisation with sodium hydroxide gave the *nitro*-compound, which crystallised in orange-yellow needles from ethanol (charcoal) (1·4 g., 30%), m. p. 214—215° (Found: C, 60·6; H, 5·1; N, 18·5. $C_{11}H_{11}O_2N_3$ requires C, 60·8; H, 5·1; N, 19·3%). Its *picrate* formed yellow needles (ethanol–acetic acid), m. p. 216—219° (decomp.) (Found: N, 18·2. $C_{11}H_{11}O_2N_3,C_6H_3O_7N_3$ requires N, 18·8%).

Preparation of Pyridino(1′ : 2′-1 : 2)*benziminazole*.—4 : 5 : 6 : 7-Tetrahydropyridino(1′ : 2′-1 : 2)benziminazole (1 g.) and palladised charcoal (0·5 g.) were heated in a metal-bath at 300° for 6 hours and the residue was thoroughly extracted with boiling acetone. Evaporation of the solvent gave a solid (0·9 g.) which was dissolved in benzene (40 ml.), and the solution was passed down a column of alumina (24″ × 1″). Development of the column with benzene gave two zones: a lower, strongly fluorescent band of unchanged material, and an upper, pale green band which on extraction yielded pyridino(1′ : 2′-1 : 2)benziminazole (elongated prisms from benzene), m. p. 176—177° (lit., 178°) (Found: C, 78·5; H, 4·6; N, 17·1. Calc. for $C_{11}H_8N_2$: C, 78·5; H, 4·8; N, 16·7%).

Preparation of Substituted Pyridino(1′ : 2′-1 : 2)*glyoxalines*.—Bromoacetone and 2-aminopyridine gave a 10% yield of 4-methylpyridino(1′ : 2′-1 : 2)glyoxaline (Tschitschibabin, *Ber.*, 1926, **59**, 2054), b. p. 134—136°/15 mm. (Found: C, 71·9; H, 6·8; N, 21·3. Calc. for $C_8H_8N_2$: C, 72·7; H, 6·1; N, 21·2%). In view of the small yield the following modified procedure was adopted for the substituted derivatives. 2-Amino-3-methylpyridine (5 g.), bromoacetone (6·3 g., 1 mol.), and ethanol (30 ml.) were boiled until the smell of the bromoacetone could scarcely be detected (*ca.* 25 hours). Evaporation of the ethanol and addition of ether gave the 4 : 3′-dimethylpyridinoglyoxaline hydrobromide as a pale yellow mass, m. p. 248—250° (8·4 g.), which with sodium hydroxide gave the free *base* (needles from water or light petroleum) (4 g.), m. p. 42—45° (Found: C, 61·7; H, 7·5; N, 16·4. $C_9H_{10}N_2,1\frac{1}{2}H_2O$ requires C, 62·4; H, 7·6; N, 16·2%). It forms a *picrate* (yellow prisms from ethanol–acetic acid), m. p. 192—194° (Found: N, 18·8. $C_{15}H_{13}O_7N_5$ requires N, 18·7%).

2-Amino-3 : 5-dibromopyridine (5 g.) and bromoacetone (2·8 g.) in ethanol (30 ml.), when boiled for 40 hours, gave 3′ : 5′-dibromo-4-methylpyridino(1′ : 2′-1 : 2)glyoxaline hydrobromide, m. p. >300°, which with alkali afforded the *base* [needles from light petroleum (b. p. 100—120°)] (3·9 g.), m. p. 144—145° (Found: N, 9·7; Br, 55·0. $C_8H_6N_2Br_2$ requires N, 9·7; Br, 55·1%). This forms a *picrate* (yellow prisms from ethanol–acetic acid), m. p. 198—200° (Found: N, 13·3. $C_8H_6N_2Br_2,C_6H_3O_7N_3$ requires N, 13·5%). 2-Amino-5-bromopyridine (5 g.) similarly gave 5′-bromo-4-methylpyridinoglyoxaline hydrobromide (4·9 g.), m. p. 210—220°, 2·3 g. of which gave the *base* (1·2 g.) as needles [from light petroleum (b. p. 60—80°)], m. p. 102—103° (Found: C, 45·3; H, 3·6; N, 12·4; Br, 38·6. $C_8H_7N_2Br$ requires C, 45·5; H, 3·3; N, 13·3; Br, 37·9%); the *picrate* formed yellow needles (from ethanol–acetic acid), m. p. 226—228° (decomp.) (Found: N, 16·2. $C_8H_7N_2Br,C_6H_3O_7N_3$ requires N, 15·9%). 2-Amino-5-nitropyridine (3 g.) gave 4-methyl-5′-nitropyridinoglyoxaline hydrobromide (3 g.), m. p. >300°, which quantitatively gave the *base* (yellow needles from ethanol), m. p. 197—199° (slight decomp.) (Found: C, 54·0; H, 3·8; N, 23·2. $C_8H_7O_2N_3$ requires C, 54·2; H, 4·0; N, 23·7%). This gave a *picrate* as yellow plates (ethanol–acetic acid), m. p. 181—184° (decomp.) (Found: N, 20·2. $C_{14}H_{10}O_9N_6$ requires N, 20·7%).

2-Aminopyridine (3·1 g.) and ω-chloroacetophenone (5 g.) were boiled in ethanol (30 ml.) for 28 hours (cf. Tschitschibabin, *Ber.*, 1926, **59**, 2051; Schmid and Bangler, *loc. cit.*). Evaporation of the solvent gave an oil and a small quantity of slender needles, m. p. 114—116°, probably the 4-*phenylpyridinoglyoxaline hydrochloride* (Found: C, 58·2; H, 5·1; N, 10·2; Cl, 13·1. $C_{13}H_{10}N_2,HCl,2H_2O$ requires C, 58·5; H, 5·7; N, 10·2; Cl, 13·3%). The oil, with sodium hydroxide, gave the 4-phenyl-base as a brown oil which slowly solidified and was crystallised from ethanol; it had m. p. 134—136° (lit., 135·5° and 140°) (Found: C, 80·0; H, 5·3. Calc. for $C_{13}H_{10}N_2$: C, 80·4; H, 5·2%). It gives a *picrate* as yellow needles (from glacial acetic acid), m. p. 228—229° (decomp.) after sintering at 200° (Found: N, 17·6, 15·4. $C_{19}H_{13}O_7N_5$ requires N, 16·6%).

2-Amino-3-methylpyridine (3 g.) and ω-chloroacetophenone (7·5 g.) were fused together, and the melt temperature gradually raised to 130°, whereupon a vigorous reaction commenced. The mixture was kept for 2 hours at this temperature, and the resulting yellow syrup dissolved in dilute hydrochloric acid. Addition of sodium hydroxide gave the 3′-*methyl*-4-*phenylpyridinoglyoxaline*, which formed, from light petroleum (b. p. 100—120°), elongated prisms (4·8 g.), m. p. 108—110° (Found: C, 80·4; H, 5·9; N, 13·5. $C_{14}H_{12}N_2$ requires C, 80·7; H, 5·8; N, 13·5%). It forms a *picrate* (yellow needles from ethanol–acetic acid), m. p. 240—241° (decomp.) after sintering at 210° (Found: N, 15·9. $C_{20}H_{15}O_7N_5$ requires N, 16·0%).

2-2′-*Pyridylamino*cyclo*hexanone*.—2-Chloro*cyclo*hexanone (5 g.), 2-aminopyridine (4·5 g.), and sodium carbonate (3 g.) were boiled in ethanol for 3 hours. Trituration followed by evaporation of the solvent gave 2-2′-*pyridylamino*cyclo*hexanone* (2·1 g.) (needles from ethanol), m. p. 147—149° (Found: C, 69·1; H, 7·5; N, 15·2. $C_{11}H_{14}ON_2$ requires C, 69·5; H, 7·4; N, 14·7%). 2 : 4-Dinitrophenylhydrazine and sulphuric acid gave by Brady's method the impure 2 : 4-dinitrophenylhydrazone sulphate (orange needles from ethanol–acetic acid), m. p. 164—165° (decomp.) (Found: N, 16·4; S, 6·2. $C_{17}H_{20}O_8N_6S$ requires N, 18·0; S, 6·8%). The pyridylamino*cyclo*hexanone (0·7 g.), sodium hydroxide (3 g.), and water (5 ml.) were boiled, and enough ethanol added to give a homogeneous solution. Boiling was continued for 9 hours and the solution was diluted with water. Extraction with ether and subsequent evaporation gave a brown oil which solidified on trituration with ethanol to give 2-2′-*pyridylamino*cyclo*hexanol* (rhombic plates from ethanol), m. p. 159—160° (Found: C, 68·3; H, 8·4; N, 14·4. $C_{11}H_{16}ON_2$ requires C, 68·7; H, 8·4; N, 14·6%). The same product was obtained by

reduction with aluminium *iso*propoxide in the usual way ("Organic Reactions," ed. Roger Adams, Vol. II, p. 197) except that methanol instead of ethanol was used in the Hahn partial condenser. Boiling of the pyridylamino*cyclo*hexanone (2·3 g.) in water (25 ml.) and concentrated hydrochloric acid (35 ml.) with amalgamated zinc (*ca.* 25 ml.) for 10 hours, with concentrated hydrochloric acid (25 ml.) added every 3 hours, gave 2-aminopyridine (1·5 g.), identified as the picrate, m. p. 218—221° (decomp.), and as the dibenzoyl derivative (needles from ethanol), m. p. 167—169° (Found: C, 75·5; H, 4·7; N, 9·8. Calc. for $C_{19}H_{14}O_2N_2$: C, 75·5; H, 4·7; N, 9·3%), giving no m. p. depression when mixed with an authentic sample of 2-dibenzoylaminopyridine.

2-Pyridylamino*cyclo*hexanone (2·8 g.), sodium hydroxide (2 g.), and 90% hydrazine hydrate (5 ml.) were boiled in trimethylene glycol (40 ml.) for 1 hour, and the excess of hydrazine and water were distilled off until the temperature of the boiling liquid reached 200°. The solution was then boiled for 4 hours and diluted with water, whereupon 2-2′-pyridylamino*cyclo*hexane crystallised out as a mass of colourless plates (0·9 g.), m. p. 125—126° (lit., 123—124°). It gave no m. p. depression when mixed with the compound prepared as follows (cf. Bergstrom, *J. Org. Chem.*, 1946, **11**, 244). 2-Bromopyridine (5 g.) and *cyclo*hexylamine (9·5 g.) were boiled for 6 hours, and the cooled mixture dissolved in pyridine. Powdered sodium hydroxide was added, the pyridine and excess of *cyclo*hexylamine removed by evaporation, and the residue distilled. 2-Bromopyridine (b. p. 105—110°/44 mm.) distilled over and 2-2′-pyridylamino*cyclo*hexane separated on the side-arm of the distillation flask; the latter formed needles (from light petroleum), m. p. 125—126° (Found: C, 74·8; H, 8·8. Calc. for $C_{11}H_{16}N_2$: C, 75·0; H, 9·1%). It gave a *benzoyl* derivative (needles from ethanol), m. p. 129—130° (Found: C, 77·0; H, 7·1; N, 9·8. $C_{18}H_{20}ON_2$ requires C, 77·1; H, 7·2; N, 9·9%), and a *picrate* (yellow needles from ethanol–acetic acid), m. p. 185—187° (Found: N, 17·2. $C_{17}H_{19}O_7N_5$ requires N, 17·3%).

2-2′-Pyridylamino*cyclo*hexanone (0·9 g.) was boiled with acetic anhydride (1·6 g.) for 3 hours and then poured into water. Neutralisation with sodium carbonate gave a brown oil which slowly crystallised and on extraction with light petroleum gave 4 : 5 : 6 : 7-tetrahydropyridino(1′ : 2′-1 : 2)-benziminazole as colourless cubes, m. p. and mixed m. p. with a specimen prepared as above 56—58°. A product insoluble in light petroleum was also obtained as yellow prisms (from ethanol), m. p. 158—160° (Found: C, 73·1; H, 6·5; N, 7·3%).

2-2′-Pyridylamino*cyclo*hexanone (2·5 g.) was dissolved in glacial acetic acid and dry hydrogen bromide was led through the cold solution for 1 hour. From the solution an 80% yield of tetrahydropyridino-benziminazole, m. p. 54—58°, was obtained.

Other Cyclisations.—2-Amino-3-methylpyridine (2·5 g.), 2-chloro*cyclo*hexanone (4·6 g.), and sodium carbonate (1·9 g.) were boiled in ethanol (20 ml.) for 3 hours. Chromatographic purification of the product gave unchanged 2-amino-3-methylpyridine, a product, possibly *cyclo*hex-2-enone, and tetrahydro-3′-methylpyridinobenziminazole (46% yield), m. p. 59—61°. Similar experiments with 2-amino-5-bromopyridine (reflux time 12 hours) and 2-amino-3 : 5-dibromopyridine (reflux period 18 hours) yielded the corresponding 5′-bromo- (17% yield), m. p. 147—148°, and 3′ : 5′-dibromo-compounds (30% yield), m. p. 159—160°, respectively.

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