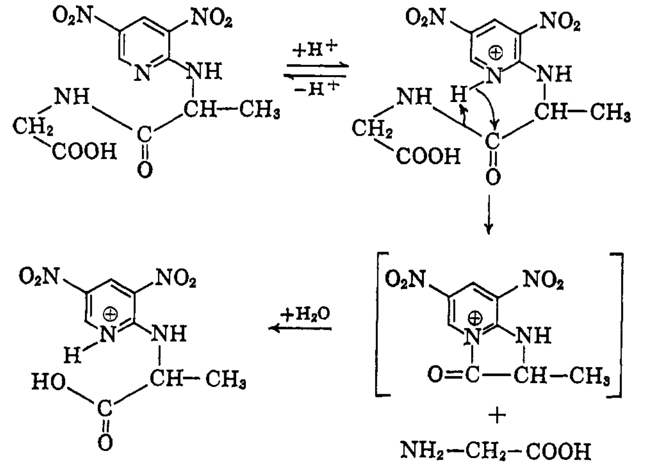
On the other hand, the concept that catalysis solely by a nucleophile or by an electrophile can be surpassed in efficiency by the concerted catalysis of a nucleophile and an electrophile has received much attention in recent years. For example the amide of γ-(4-imidazolyl)butyric acid is hydrolyzed at a rate which indicates that the imidazolyl group participates in the reaction in its protonated form.[16] The specific rate for the participation of protonated imidazolyl group in the hydrolysis of γ-(4-imidazolyl)butyramide is greater than that of the participation of the imidazolyl group in the hydrolysis of the corresponding ester. These results lend credence to the concerted electrophilic-nucleophilic mechanism proposed for the intramolecular catalysis of amide hydrolysis.

Therefore, we strongly favor the proposition that A is the form reactive in hydrolysis and that pyridinium ion performs both functions of a bifunctional catalyst, attacking the carbonyl carbon of the amide and simultaneously donating a proton to the departing glycine molecule, with the formation of a cyclic acylpyridinium ion. The water molecule then adds in a following fast reaction. Although the reaction involving proton transfer in a fast pre-equilibrium followed by reaction of the conjugate base with the protonated substrate in the rate-determining step is kinetically a general acid catalysis, we think that mechanistically it is not a general acid catalysis at all but rather a electrophilic-nucleophilic catalysis.



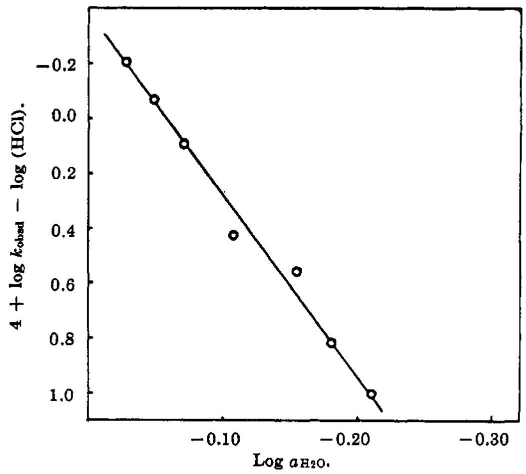


Figure 5.—Hydrolysis of dinitro-2-pyridylalanylglycine in hydrochloric acid solutions; plot of (log k_{obsd} − log [HCl]) against log a_{H_2O}. The slope ω^* is −6.37.

A comparison of rate constants of hydrolysis of dinitro-2-pyridylalanylglycine (I) and dinitro-4-pyridylalanylglycine is instructive in considering the extraordinary behavior of I; the rate of hydrolysis of dinitro-4-pyridylalanylglycine is even smaller than that of dinitrophenylalanylglycine (II), indicating a neighboring-group participation in the case of I.

Further evidence for a favored intramolecular process for the acid hydrolysis of I is provided by the small, negative entropy of activation.[17]

Acknowledgment.—The authors wish to thank Professor E. Scoffone and D. U. Miotti for helpful discussion and Mr. E. De Menego for his technical assistance.

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(16) T. C. Bruice and J. M. Sturtevant, *J. Am. Chem. Soc.*, **81**, 2860 (1959).

(17) M. L. Bender and M. C. Neveu, *ibid.*, **80**, 5388 (1958).

The Synthesis and Reactions of 1-(Dimethylamino)-3-phenyloxindole

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The reaction of α-chlorodiphenylacetyl chloride with 1,1-dimethylhydrazine was found to give 1-(dimethylamino)-3-phenyloxindole in high yield under very mild conditions. A mechanism involving an α-lactam intermediate was proposed. The title compound was subjected to various reactions, mainly substitutions at the 3 position and variations of the carbonyl function.

In recent years there has been in increasing interest in reactions of α-haloamides which culminated in the isolation of the first α-lactams by Baumgarten[1] and Sheehan.[2] Sarel[3] studied the sodamide-promoted rearrangement of α-chloro-α,α-diphenylacetanilide to afford mainly N-phenyl-N-benzhydrylurea. Earlier, Sheehan[4] investigated in detail the reaction of α-chloro-α,α-diphenylacetanilide with sodium hydride and identified "three compounds of the oxindole and indoxyl type."

The reaction of α-chlorodiphenylacetyl chloride with acylhydrazines is reported to give oxadiazinones.[5] Bird[6] obtained a diazetidinone by reaction of α-

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(1) H. E. Baumgarten, J. F. Fuerholzer, R. D. Clark, and R. D. Thompson, *J. Am. Chem. Soc.*, **85**, 3303 (1963).

(2) J. C. Sheehan and T. Lengyel, *ibid.*, **86**, 1356 (1964).

(3) S. Sarel, F. D'Angeli, J. T. Klug, and Aviva Taube, *Israel J. Chem.*, **2**, 167 (1964).

(4) J. C. Sheehan and J. W. Frankenfeld, *J. Am. Chem. Soc.*, **83**, 4792 (1961).

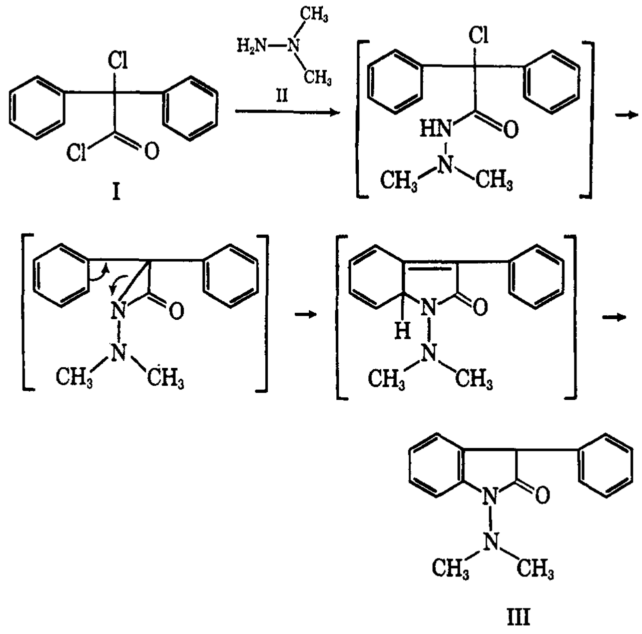
(5) J. Van Alphen, *Rec. trav. chim.*, **48**, 163 (1929).

(6) C. W. Bird, *J. Chem. Soc.*, 674 (1963).

chlorodiphenylacetyl chloride with ethyl N′-phenylhydrazine-N-carboxylate in refluxing toluene. He was able to rearrange this diazetidinone by treatment with hydrochloric acid to 1-ethoxycarbonylamino-3,3-diphenyloxindole.

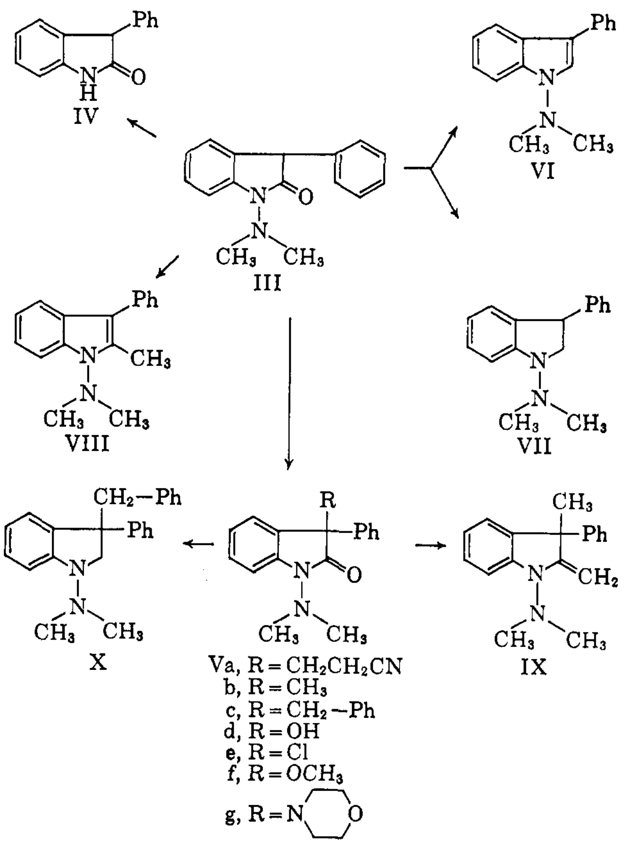
In view of this background the reaction of α-chlorodiphenylacetyl chloride (I) with 1,1-dimethylhydrazine (II) seemed of interest. None of the expected 1-(α-chlorodiphenylacetyl)-2,2-dimethylhydrazine could be isolated after addition of 2 equiv. of II to an ice-cold ether solution of I. Instead, the still-acid reaction mixture after being washed with ice-cold dilute sodium hydroxide gave 1-(dimethylamino)-3-phenyloxindole (III). In subsequent experiments an ether solution of I was treated with at least 3 equiv. of II to give purified III in yields consistently better than 70%. The low temperature at which the formation of III takes place, in presence of no other base than 1,1-dimethylhydrazine, is somewhat surprising and indicates the tremendous reactivity of the expected intermediate, 1-(α-chlorodiphenylacetyl)-2,2-dimethylhydrazine, compared with α-chloro-α,α-diphenylacetanilide,[4] where no reaction was observed below 40° even in presence of sodium hydride. Assuming a similar α-lactam intermediate, the mechanism shown in Scheme I seems reasonable.

SCHEME I



The structure of III was established by spectral data and by Raney nickel degradation to the known 3-phenyloxindole (IV). The oxindole III was very weakly basic. On titration in 50% methanol the pK_a' was found by extrapolation to be less than 2. A hydrochloride was formed in 2-propanol with anhydrous hydrogen chloride, but dissociated on attempted recrystallization from 2-propanol. The oxindole III was also recovered unchanged after 16 hr. at reflux temperature with a severalfold excess of methyl iodide in acetonitrile solution or after treatment with phosgene under the conditions used with other 1-acyl-2,2-dialkylhydrazines.[7] The proton in 3 position of III was quite reactive, enabling cyanoethylation to give Va or smooth alkylation with alkyl halides to give Vb and Vc (see Scheme II). Air oxidation of the alkaline solution, as in the preparation of other dioxindole derivatives,[8] gave an 82% yield of the dioxindole Vd. This provided an easy source of the chloro compound Ve which was obtained by chlorination with thionyl chloride in presence of pyridine under mild conditions. The methoxy derivative Vf was accessible either from the chloro compound Ve by reaction with sodium methoxide or from the dioxindole Vd on treatment with methyl iodide and base. The chlorine in Ve may be replaced readily with amines, as shown in the preparation of Vg. The reduction of III gave a mixture of the indole VI and the basic indoline VII which formed a hydrochloride. The reactivity of the carbonyl toward Grignard reagents was demonstrated by the formation of the indole VIII from III and of the 2-methyleneindoline derivative IX from Vb. IX being an enamine of a substituted hydrazine exhibited considerable basic strength. It was readily soluble in dilute mineral acids and its pK_a' was found to be 5.5 by titration. Lithium aluminum hydride reduction of Vc gave the indoline X, which was very soluble in all organic solvents and was therefore converted to the hydrochloride.

SCHEME II



Experimental Section[9]

1-Dimethylamino-3-phenyloxindole (III).—To a solution of 350 g. (1.32 moles) of α-chlorodiphenylacetyl chloride[10] in 3 l. of absolute ether was slowly added, with stirring at about −20°, 300 g. (5 moles) of 1,1-dimethylhydrazine. The suspension,

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[7] R. F. Meyer and B. L. Cummings, *J. Heterocyclic Chem.*, **1**, 186 (1964).

[8] P. L. Julian and J. Pikl, *J. Am. Chem. Soc.*, **57**, 539 (1935).

[9] Melting points were observed on a Fisher-Johns block with a calibrated thermometer.

[10] C. L. Stevens and J. C. French, *J. Am. Chem. Soc.*, **75**, 657 (1953).

after standing at room temperature for 16 hr., was treated with about 1 l. of water. The organic layer was separated, washed with water, dried (K_2CO_3), and evaporated. The solid residue was crystallized from about 300 ml. of cyclohexane to give 251 g. (75%) of product: m.p. 90–91°; $\lambda_{\max}^{\mathrm{KBr}}$ 5.79 μ (C═O); $\lambda_{\max}^{\mathrm{MeOH}}$ 253 mμ (ϵ 6930); n.m.r. in $CDCl_3$ showed nine aromatic protons at 7.1–7.3, one proton (3 position) at 4.5, and six methyl protons at 3.0 p.p.m.

Anal. Calcd. for $C_{16}H_{16}N_2O$: C, 76.16; H, 6.39; N, 11.10. Found: C, 76.32; H, 6.40; N, 11.19.

3-Phenyloxindole (IV).—A solution of 3.3 g. of III in 300 ml. of alcohol was heated to reflux for 5 hr. with 50 g. of wet Raney nickel (Raney Catalyst Co., Chattanooga, Tenn.). The filtrate was evaporated and the resulting semisolid was crystallized from aqueous 2-propanol to give 2.5 g. of crude product, m.p. 80–85°. The dried product was washed with 250 ml. of boiling hexane. The residue, m.p. 181–183°, 0.4 g., was recrystallized from ethanol: m.p. 187–188° (lit.[11] 185–187°); infrared and ultraviolet spectra were identical with reported data.[12]

1-(Dimethylamino)-2-oxo-3-phenyl-3-indolinepropionitrile (Va).—To a solution of 25.2 g. (0.1 mole) of III in 400 ml. of absolute ether was added 0.5 g. of sodium methoxide followed by 10 g. (0.19 mole) of acrylonitrile. It was stirred at room temperature for 5 hr. After standing for 16 hr. it was filtered, and the filtrate washed with water and evaporated. The product was recrystallized from 2-propanol to give a white crystalline solid, m.p. 119–120°, 26.5 g. (87%).

Anal. Calcd. for $C_{19}H_{19}N_3O$: C, 74.73; H, 6.27; N, 13.76. Found: C, 75.06; H, 6.21; N, 14.03.

1-(Dimethylamino)-3-methyl-3-phenyloxindole (Vb).—The sodium salt of III was prepared by careful addition of 5 g. (0.11 mole) of a 53.8% sodium hydride dispersion in mineral oil to a solution of 25.2 g. (0.1 mole) of III in 100 ml. of dimethylformamide. The suspension was heated with stirring for 3 hr., at 50° and cooled to room temperature; 21.3 g. (0.15 mole) of methyl iodide was added. It was stirred at room temperature for 10 hr., then heated on the steam bath for 3 hr. The solvent was evaporated under reduced pressure, and the residue was taken up in ether and washed with water. The crude product, m.p. 60–65°, was recrystallized from hexane to give a white crystalline product: m.p. 70–72°; 19.7 g. (74%); $\lambda_{\max}^{\mathrm{MeOH}}$ 253 mμ (ϵ 7000); n.m.r. (CCl_4) showed nine aromatic protons at 7.1–7.2, six N-methyl protons at 2.9, and three C-methyl protons at 1.65 p.p.m.

Anal. Calcd. for $C_{17}H_{18}N_2O$: C, 76.67; H, 6.81; N, 10.52. Found: C, 76.43; H, 6.85; N, 10.34.

1-(Dimethylamino)-3-benzyl-3-phenyloxindole (Vc) was prepared in analogy to the previous experiment, using benzyl chloride, 13.9 g. (0.11 mole). The product was recrystallized from 2-propanol to give 24.7 g. (72%), m.p. 128–129°, $\lambda_{\max}^{\mathrm{MeOH}}$ 257 mμ (ϵ 6120).

Anal. Calcd. for $C_{23}H_{22}N_2O$: C, 80.60; H, 6.48; N, 8.19. Found: C, 80.48; H, 6.49; N, 8.18.

1-(Dimethylamino)-3-hydroxy-3-phenyloxindole (Vd).—To a solution of 252 g. (1 mole) of III in absolute methanol was added 57 g. (1.05 moles) of sodium methoxide. The solution was stirred and a rapid air stream was introduced for 18 hr. The reaction mixture was evaporated on the rotary evaporator under reduced pressure, the residue was slurried with water and neutralized with glacial acetic acid. The white solid, m.p. 164–166°, was recrystallized from 2-propanol to give 220.3 g. (82%) of VII, m.p. 170–171°, $\lambda_{\max}^{\mathrm{KBr}}$ 2.95 (OH) and 5.84 μ (C═O), $\lambda_{\max}^{\mathrm{MeOH}}$ 259 mμ (ϵ 5660).

Anal. Calcd. for $C_{16}H_{16}N_2O_2$: C, 71.63; H, 6.01; N, 10.45. Found: C, 71.63; H, 6.01; N, 10.42.

3-Chloro-1-(dimethylamino)-3-phenyloxindole (Ve).—To a solution of 107 g. (0.4 mole) of Vd in 1000 ml. of absolute ether was added 53.7 g. (0.68 mole) of pyridine followed by the dropwise addition of 71.3 g. (0.6 mole) of thionyl chloride. The suspension was stirred for 6 hr. Ice–water, 300 ml., was added, and the ether layer was washed with water, dried ($MgSO_4$), and evaporated. The residue, m.p. 56–58°, was recrystallized from isopropyl ether to give 92.4 g. (81%) of a pale yellow crystalline solid, m.p. 59–60°, $\lambda_{\max}^{\mathrm{KBr}}$ 5.79 μ (C═O).

Anal. Calcd. for $C_{16}H_{15}ClN_2O$: C, 67.08; H, 5.27; N, 9.77. Found: C, 67.23; H, 5.31; N, 9.91.

1-(Dimethylamino)-3-methoxy-3-phenyloxindole (Vf). **A. From Ve.**—A solution of 3 g. (0.055 mole) of sodium methoxide in 50 ml. of methanol was added to a solution of 14.3 g. (0.05 mole) of Ve in 100 ml. of absolute methanol. The solution was heated at reflux for 3 hr., the solvent was evaporated under reduced pressure, and the residue taken up in ether and washed with water. The pale yellow solid obtained after evaporation of ether was recrystallized from hexane to give 9.2 g. (65%) of a white crystalline solid: m.p. 73–74°; $\lambda_{\max}^{\mathrm{KBr}}$ 579 (C═O) and 9.02 μ (C–O–C); $\lambda_{\max}^{\mathrm{MeOH}}$ 259 mμ (ϵ 5360); n.m.r. showed nine aromatic protons at 7.1–7.25, three aliphatic protons (OCH_3) at 3.2, and six protons [$N(CH_3)_2$] at 2.9 p.p.m.

Anal. Calcd. for $C_{17}H_{18}N_2O_2$: C, 72.33; H, 6.43; N, 9.92. Found: C, 72.27; H, 6.34; N, 9.98.

B. Vf from Vd.—To a solution of 2.68 g. (0.01 mole) of Vd in 10 ml. of dimethylformamide was added 0.5 g. (0.011 mole) of a 53.8% sodium hydride dispersion in mineral oil. After stirring 1 hr., 4.25 g. (0.03 mole) of methyl iodide was added. It was heated on the steam bath for 16 hr., the solvent was evaporated, and the residue was worked up as above to give 1.35 g. of product, m.p. 73–74°, identical with Vf in every respect.

1-(Dimethylamino)-3-morpholino-3-phenyloxindole (Vg).—To 50 ml. of morpholine was added 28.6 g. (0.1 mole) of Ve with stirring. After a few minutes morpholine hydrochloride started precipitating from the solution and the temperature rose to about 50°. It was allowed to stand for 16 hr., the excess morpholine was evaporated under reduced pressure, and the residue was taken up in ether and water. The organic layer was washed with dilute hydrochloric acid, followed by water, dried (K_2CO_3), and evaporated to give a white product, m.p. 133–135°. Two recrystallizations from 2-propanol gave 27.2 g. (81%) of white crystals, m.p. 138–139°, $\lambda_{\max}^{\mathrm{KBr}}$ 5.82 μ (C═O), $\lambda_{\max}^{\mathrm{MeOH}}$ 259 mμ (ϵ 6000), $\lambda_{\max}^{\mathrm{MeOH\text{-}HCl}}$ 259 mμ (ϵ 4650) and 302 mμ (ϵ 1150).

Anal. Calcd. for $C_{20}H_{23}N_3O_2$: C, 71.20; H, 6.87; N, 12.46. Found: C, 71.21; H, 7.10; N, 12.44.

1-(Dimethylamino)-3-phenylindole (VI).—An ether solution of 25.2 g. (0.1 mole) of III was added to a solution of 9.5 g. (0.25 mole) of lithium aluminum hydride in 500 ml. of absolute ether. It was heated at reflux temperature with stirring for 4 hr. The reaction mixture was cooled in ice and excess $LiAlH_4$ was decomposed by dropwise addition of 10 ml. of water, 7.5 ml. of 20% sodium hydroxide solution, and 35 ml. of water in that order. The ether filtrate was dried (K_2CO_3) and evaporated to give 22.2 g. of a pale yellow oil, b.p. 140–147° (0.35 mm.). Crystallization from hexane gave 5.1 g. (21.6%) of a white crystalline solid: m.p. 76–77°; $\lambda_{\max}^{\mathrm{KBr}}$ 6.49 μ (C═C); $\lambda_{\max}^{\mathrm{MeOH}}$ 267 mμ (ϵ 13,100) and 224 mμ (ϵ 28,800); no shift was observed in acidic or basic medium; n.m.r. showed 10 aromatic protons at 7–8 and six aliphatic protons at 2.85 p.p.m.

Anal. Calcd. for $C_{16}H_{16}N_2$: C, 81.32; H, 6.83; N, 11.86. Found: C, 81.39; H, 6.90; N, 11.96.

1-(Dimethylamino)-3-phenylindole (VII).—The hexane filtrate from the above experiment was evaporated and the resulting yellow oil was redistilled to give 14.5 g. (61%) of product, b.p. 120° (0.1 mm.), $\lambda_{\max}^{\mathrm{MeOH}}$ 298 mμ (ϵ 3620) and 253 mμ (ϵ 7710). In presence of 1 drop of 5 *N* HCl the $\lambda_{\max}$ was shifted to 280 mμ (ϵ 3200).

Anal. Calcd. for $C_{16}H_{18}N_2$: C, 80.63; H, 7.61; N, 11.75. Found: C, 80.56; N, 7.46; N, 11.59.

Hydrochloride.—The hydrochloride was formed by introducing excess HCl gas into a solution of 2 g. of VII in 50 ml. of benzene. The benzene solution on concentration and cooling deposited a compact crystalline solid, 1.5 g., m.p. 145–148° dec. Recrystallization from benzene did not change the melting point.

Anal. Calcd. for $C_{16}H_{19}ClN_2$: C, 69.92; H, 6.97; N, 10.20. Found: C, 70.21; H, 6.97; N, 10.07.

1-(Dimethylamino)-2-methyl-3-phenylindole (VIII).—A solution of 25.2 g. (0.1 mole) of III in 100 ml. of absolute ether was added to a Grignard solution prepared from 12 g. (0.5 g.-atom) of magnesium turnings and 71 g. (0.5 mole) of methyl iodide in 300 ml. of ether. After standing for 20 hr., a sample, after work-up, indicated unreacted III. Therefore, 500 ml. of benzene was added to the reaction mixture, and the ether was removed by distillation. The benzene solution was heated at reflux for 3 hr. Water, 100 ml., was added with cooling, and the organic layer was washed with water and evaporated to give 19.8 g. of an oil, the infrared spectrum of which still indicated some unreacted carbonyl compound. Repeated crystallization from hexane yielded a white crystalline solid: 3.75 g. (15%);

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[11] J. Meisenheimer and H. Meis, *Chem. Ber.*, **57**, 289 (1924).

[12] H. E. Zaugg and R. W. De Net, *J. Am. Chem. Soc.*, **84**, 4576 (1962).

m.p. 91–92°; $\lambda_{\max}^{\mathrm{KBr}}$ 6.39 μ (C=C): $\lambda_{\max}^{\mathrm{MeOH}}$ 282 mμ (ε 13,100), 277 (13,100), and 229 (25,900); no shift was observed after addition of a drop of 5 *N* HCl; n.m.r. (CCl_4) indicated nine aromatic protons at 6.8–7.7, six protons [$N(CH_3)_2$] at 3.06, and three protons (CCH_3) at 2.4 p.p.m.

Anal. Calcd. for $C_{17}H_{18}N_2$: C, 81.56; H, 7.25; N, 11.19. Found: C, 81.77; H, 7.33; N, 11.23.

1-(Dimethylamino)-3-methyl-2-methylene-3-phenylindoline (IX).—A solution of 53.2 g. (0.2 mole) of Vb in 200 ml. of absolute ether was added to a Grignard solution prepared from 14.4 g. (0.6 g.-atom) of magnesium turnings and 85 g. (0.6 mole) of methyl iodide in 600 ml. of ether. The reaction mixture was heated at reflux temperature for 2 hr. With cooling, 300 ml. of a saturated ammonium chloride solution was added. The organic layer was washed with water, dried (K_2CO_3), and evaporated to give a pale yellow solid. Recrystallization from 2-propanol gave yellow crystals: 40.2 g. (76%); m.p. 68–69°; $\lambda_{\max}^{\mathrm{MeOH}}$ 6.03 μ (C=C); $\lambda_{\max}^{\mathrm{MeOH}}$ 273 mμ (ε 15,800); n.m.r. showed nine aromatic protons at 6.4–7.3, two protons at 3.8 and 4.2 (=CH_2), six protons at 2.9 [$N(CH_3)_2$], and three protons at 1.65 p.p.m. (CH_3).

Anal. Calcd. for $C_{18}H_{20}N_2$: C, 81.78; H, 7.62; N, 10.59. Found: C, 81.60; H, 7.50; N, 10.48.

3-Benzyl-1-(dimethylamino)-3-phenylindoline Hydrochloride (X).—The reduction of 14.5 g. of Vc was carried out with 8 g. of lithium aluminum hydride in 500 ml. of absolute ether at reflux temperature for 16 hr. It was worked up as in the preparation of VI. The crude product, m.p. 40–45°, was very soluble in every organic solvent. It was dissolved in 100 ml. of cyclohexane and an excess of HCl gas was introduced. The hydrochloride was recrystallized from acetone to give 11.3 g. (73%) of a white crystalline product, m.p. 196–198°. There was no absorption in the carbonyl region of the infrared spectrum.

Anal. Calcd. for $C_{23}H_{25}ClN_2$: C, 75.61; H, 6.90; N, 7.67. Found: C, 75.53; H, 6.83; N, 7.69.

Acknowledgment.—The author wishes to thank Mrs. B. L. Cummings and Miss M. J. Weaver for technical assistance, Mr. C. E. Childs and staff for microanalytical data, and Dr. J. M. Vandenbelt, Mr. R. B. Scott, and Mr. E. J. Schoeb for spectral data.

4,7-Diazaindole Derivatives

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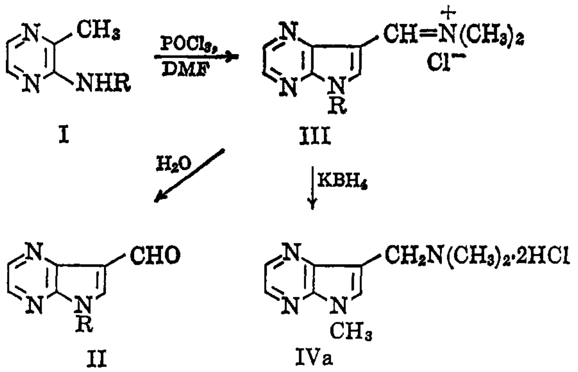
Received May 18, 1965

Condensation of 2-amino-3-methylpyrazine or its N-methyl analog with the Vilsmeier reagent furnished the corresponding 4,7-diazaindole-3-carboxaldehydes. Various transformations of these compounds, including the elaboration of 4,7-diaza analogs of gramine, tryptophane, and tryptamine, are reported.

While numerous examples of indole analogs containing one or more nitrogen atoms in the benzenoid ring have been recorded in the literature, the 4,7-diazaindole ring system has not been previously reported. In connection with our interest in certain phases of pyrazine chemistry,[1] we discovered a convenient synthetic route to aldehyde derivatives of this new heterocyclic nucleus. The reaction involves treatment of 2-amino-3-methylpyrazines with the Vilsmeier reagent.

Recently, Arnold[2] reported the reaction of 4-picoline with the Vilsmeier reagent to give either 2-(4-pyridyl)-malonaldehyde or 3-dimethylamino-2-(4-pyridyl)acrolein, depending on work-up conditions. Subsequently, Bredereck and Simchen[3] described the preparation of 2-(4-pyrimidyl)malonaldehyde from 4-methylpyrimidine under similar conditions.

Treatment of 2-methylamino-3-methylpyrazine (Ia) with the preformed phosphorus oxychloride–dimethylformamide complex furnished an immonium salt, IIIa, which, after hydrolysis, afforded a new crystalline compound with empirical formula, $C_8H_7N_3O$, indicating the incorporation of two additional carbon atoms. This was assigned the structure, 1-methyl-4,7-diazaindole-3-carboxaldehyde[4] (IIa), on the basis of the following evidence. Spectral data indicated the formation of a new chromophoric system, including a carbonyl function generated from the immonium salt; this could be confirmed by the formation of aldehyde derivatives. Further verification of the assigned structure was provided by the n.m.r. spectrum which showed, in addition to the three N-methyl protons (4.02 p.p.m.) and protons on positions 5 and 6 (quartet centered at 8.50 p.p.m.), two one-proton singlets at 10.23 and 8.28 p.p.m., ascribed to the aldehyde and C-2 protons, respectively.



a, R = CH_3
b, R = H

It was also found that 2-amino-3-methylpyrazine[5] (Ib) condensed with the Vilsmeier reagent to furnish the high-melting 4,7-diazaindole-3-carboxaldehyde (IIb), although no immonium derivative, analogous to IIIa, could be isolated in this case. The N-unsubstituted aldehyde (IIb) was converted to IIa on treatment with dimethyl sulfate.

While the formation of the aldehydes (II) might be rationalized in terms of an intermediate such as V,

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(1) W. B. Lutz, S. Lazarus, S. Klutchko, and R. I. Meltzer, *J. Org. Chem.*, **29**, 1645 (1964).

(2) Z. Arnold, *Collection Czech. Chem. Commun.*, **28**, 863 (1963).

(3) H. Bredereck and G. Simchen, *Angew. Chem. Intern. Ed. Engl.*, **2**, 738 (1963).

(4) According to the systematic *Chemical Abstracts* nomenclature, compound IIa is 5-methyl-5H-pyrrolo[2,3-*b*]pyrazine-7-carboxaldehyde. Because of greater clarity and conciseness, the designation of these compounds as diazaindoles is preferred by the authors.

(5) H. Gainer, M. Kokorudz, and W. K. Langdon, *J. Org. Chem.*, **26**, 2360 (1961).