due from the dried ether extract was treated with a saturated solution of picric acid in ethanol and the resultant deposit recrystallized from ethanol; yield 1.25 g. (10.8%), m.p. 164–166°. The picrate was converted, with aluminum oxide and benzene, to the indole IV, which was then recrystallized from a mixture of ethanol and water; m.p. 55–56°.

2,3-Dihydroxy-4H-5,6-dihydrobenzo(de)quinoline (V).— A solution of 554 mg. (0.002 mole) of the ethyl ester of 8-nitro-1,2,3,4-tetrahydro-1-naphthaleneglyoxylic acid (II) in 10 ml. of acetic acid was submitted to hydrogenation at 26°, at ordinary pressure, with 250 mg. of platinum oxide, prereduced with hydrogen. After 147 ml. of hydrogen had been absorbed during a period of 3 hours (theory for 0.006 mole, 149 ml.), the hydrogenation was interrupted, the catalyst removed by filtration, the acetic acid distilled under diminished pressure, and the residue maintained under reflux in ethanol solution in the presence of aqueous sodium hydroxide for a period of one hour. The ethanol was distilled *in vacuo*, water was added, and carbon dioxide was admitted into the solution until the base had been transformed completely to sodium bicarbonate. The precipitate which separated under these conditions was collected by filtration, washed with water, and recrystallized from acetone; yield 200 mg. (50%), m.p. 232–233°.

Anal. Calcd. for $C_{12}H_{11}NO_2$: C, 71.62; H, 5.51; N, 6.96. Found: C, 71.77; H, 5.72; N, 7.26.

Ultraviolet absorption spectrum in 95% ethanol, λ_{max} (log ϵ): 225 (4.57), 295 (3.96), 315 (4.00), 330 (3.90); $\lambda_{min.}$ (log ϵ): 265 (3.61), 310 (3.87), 325 (3.84).[12]

The substance was insoluble in dilute bicarbonate and ammonium hydroxide solutions, was soluble in dilute fixed alkali but formed a slightly soluble sodium salt. It gave a green color with dilute ferric chloride solution and failed to give a color with *p*-dimethylaminobenzaldehyde and sulfuric acid.[13]

The 3-acetate was formed when a solution of 100 mg. of the quinoline derivative V in 1 ml. of acetic anhydride was maintained under reflux for a period of one hour. After the reaction mixture had been kept for 24 hours at 0°, the crystalline precipitate was collected by filtration and recrystallized from ethanol. The substance gave no color with dilute ferric chloride solution; yield 90 mg. (75%), m.p. 256–259°.

Anal. Calcd. for $C_{14}H_{13}NO_3$: C, 69.12; H, 5.39; N, 5.76. Found: C, 69.26; H, 5.42; N, 5.99.

The potassium bicarbonate filtrate from the collection of V was acidified with dilute hydrochloric acid solution, the precipitate, which proved to be identical with 2-carboxy-1,3,4,5-tetrahydrobenz(cd)indole (III), collected by filtration and washed with water, yield 120 mg. (30%), m.p. 176–177°.

N-Formyl-1,2,3,4-tetrahydro-5-naphthylamine (VI).— An ether solution of 1,2,3,4-tetrahydro-5-naphthylamine,[8] prepared from 3.75 g. (0.02 mole) of the hydrochloride, was concentrated under reduced pressure and the residue maintained under reflux with 6.0 g. of formic acid for a period of 20 hours. The formic acid was distilled *in vacuo* and the residue recrystallized from ligroin; m.p. 101–102°.

Anal. Calcd. for $C_{11}H_{13}NO$: C, 75.38; H, 7.47; N, 8.06. Found: C, 75.11; H, 7.50; N, 7.97.

These studies were assisted by a grant from the National Science Foundation.

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[12] *Cf.* the curves displayed by 3-hydroxyquinoline and by carbostyril; G. W. Ewing and E. A. Steck, THIS JOURNAL, **68**, 2181 (1946).

[13] *Cf.* the properties of 2,3-dihydroxyquinoline as prepared from *o*-methyloxanilic acid, W. Madelung, *Ber.*, **46**, 3521 (1912), or from isatin with diazomethane, G. Heller, *ibid.*, **52**, 741 (1919); F. Arndt, B. Eistert and W. Ender, *ibid.*, **62**, 44 (1929).

BOSTON 15, MASS.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF COLUMBIA UNIVERSITY]

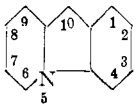
Studies on α-Pyridones. III. Ring-chain Tautomerism Involving the NH-Function. A Route to Benzo[b]pyrrocolines

BY FAUSTO RAMIREZ AND ALBERT P. PAUL[1]

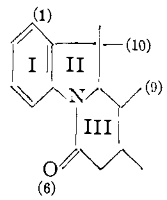
RECEIVED JANUARY 17, 1955

A route to benzo[b]pyrrocolines (A), based on a hitherto unobserved ring-chain tautomerism involving the NH-function of an α-pyridone and the CO-function of a ketone, has been developed. Alkaline hydrolysis of 2-(2′-oxocyclohexyl)-methyl-6-chloronicotinic acid (I) gave an α-pyridone whose infrared spectrum was consistent with the structure of 9-carboxy-4a-hydroxy-1,2,3,4,4a,10a-hexahydro-benzo[b]pyrrocolin-6(10H)one (IIb), the ring tautomer of 2-(2′-oxocyclohexyl)-methyl-6-oxynicotinic acid (IIa). The action of 2,4-dinitrophenylhydrazine on II gave a substance whose ultraviolet spectrum (λ_{max} 341 mμ) indicates also a ring tautomer of a hydrazone III. Concentrated sulfuric acid removed one mole of water from II, quantitatively, with formation of a tetrahydrobenzo[b]pyrrocoline derivative IV. IV absorbed one mole of hydrogen (Pd–C) and yielded 9-carboxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (VI). The action of mineral acids directly on the chloronicotinic acid derivative I has been shown to yield 6-(4′-carboxy)-butyl-2-hydroxy-5-oxo-6,7-dihydro-1,5H-pyrindine (VIII).

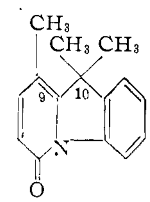
The benzo[b]pyrrocoline system A constitutes the I–II–III ring sequence of the heptacyclic alkaloid strychnine (B, part formula). The parent ring system itself (A, $C_{12}H_9N$) appears to have been obtained by Braun and Nelles[2] from the pyrolysis (300°, Cu) of 2-benzylpyridine. Robinson and Saxton[3] reported recently on an ingenious method for the construction of substituted derivatives of A. Thus, the hydrogen chloride-promoted condensation of acetonylacetone with (a) skatole (3-methylindole), (b) 3-ethylindole and (c) N-acetyltryptamine was found to give (a) 6,9,10-trimethylbenzo[b]pyrrocoline, (b) 10-ethyl-6,9-dimethylbenzo[b]pyrrocoline and (c) 10-(2-acetamidoethyl)-6,9-dimethylbenzo[b]pyrrocoline, respectively. The presence of a substituent at the 3-position of indole appears necessary for the formation of A.[4] By this



A, Ring Index No. 1647



B



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[1] David W. and Ellen A. Ferguson Fellow, 1953–1954. From part of the Ph.D. Thesis of A. P. Paul.

[2] J. von Braun and J. Nelles, *Ber.*, **70B**, 1767 (1937).

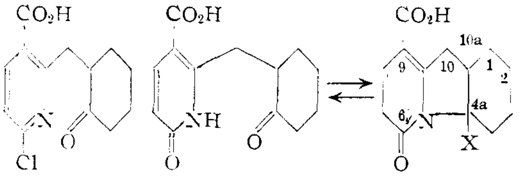
[3] (a) R. Robinson and J. E. Saxton, *J. Chem. Soc.*, 3136 (1950); (b) 976 (1952).

[4] In the recently announced total synthesis of strychnine (R. B. Woodward, M. P. Cava, W. D. Ollis, A. Hunger, H. U. Daenkier and K. Schenker, THIS JOURNAL, **76**, 4501 (1954)) the establishment of an α-pyridone derivative of benzo[b]pyrrocoline is carried out as one of the last synthetic steps.

method, Robinson and Saxton[3] obtained an α-pyridone derivative C, the ultraviolet absorption of which, was very similar to that of dehydrostrychninolone.[4]

In this paper we report on an approach to substituted α-pyridone derivatives of benzo[b]pyrrocoline, which is essentially based on a hitherto unobserved type of ring-chain tautomerism involving the NH-function of α-pyridones and the carbonyl function of ketones.

The alkaline hydrolysis of 2-(2′-oxocyclohexyl)-methyl-6-chloronicotinic acid (I)[5] gave a substance, m.p. 237–238°, the analysis of which disclosed the replacement of a chlorine atom by the elements of OH. The substance, m.p. 237–238°, is best formulated as 9-carboxy-4a-hydroxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (IIb), the ring tautomer of 2-(2′-oxocyclohexyl)-methyl-6-oxynicotinic acid (IIa), since it exhibited bands at 2.94-(OH), 5.95(COOH) and 6.12(pyridone) μ in the infrared. The model compound 2-methyl-6-oxynicotinic acid[5] presented altogether different features in the 2.9–4.0 μ region. The ultraviolet absorption spectrum (Fig. 1) is consistent with formulation IIb.



I IIa IIb, X = OH
III, X = —NH·NH·C_6H_3—2,4(NO_2)$_2$

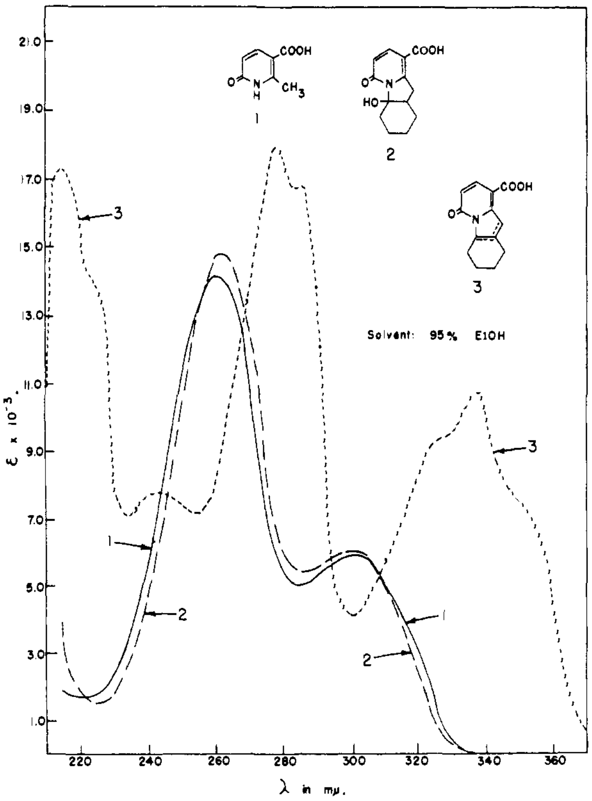
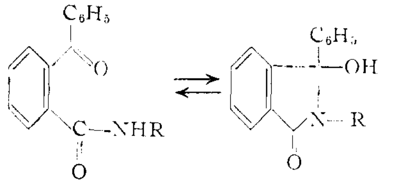


Fig. 1.

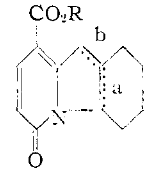
Of considerable interest is the behavior of the pyridone II with 2,4-dinitrophenylhydrazine. The yellow derivative which formed exhibited maxima at 265 and 341 mμ rather than at the expected 366 mμ characteristic[6] of simple cyclohexanone 2,4-dinitrophenylhydrazones. Since 2,4-dinitrophenylhydrazine itself absorbs at 260 and 343 mμ,[7] formulation III for the derivative appears indicated.[8]

Although the formal analogy between amides and pyridones is probably of little significance, it is of interest to note that amide-ketone ring-chain tautomerism of type

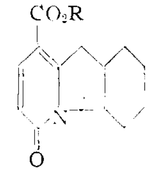


has been observed.[9] The existence of ring-chain tautomerism among sugar phenylhydrazones has been suggested.[10]

The action of concentrated sulfuric acid on the pyridone II resulted in the quantitative removal of the elements of water with formation of 9-carboxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(10H)-one (IVa) or 9-carboxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(4aH)-one(IVb); the position of the double bond in IV was not established, although the ultraviolet absorption spectrum (Fig. 1) suggests considerable conjugation best explained by formula IVb. The unsaturated pyridone IV absorbed one mole of hydrogen in the presence of palladium-on-carbon, with formation of 9-carboxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (VI), of which only one stereoisomer resulted in 93% yield. The ultraviolet absorption spectrum of VI was very similar to that of II and of 2-methyl-6-oxynicotinic acid.[5]



IV, R = H
V, R = CH_3



VI, R = H
VII, R = CH_3

In order to obtain additional spectral evidence in the infrared for the functional groups present in the compounds just described, methyl esters were prepared. Treatment of the unsaturated pyridone

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(5) (a) F. Ramirez and A. P. Paul, *J. Org. Chem.*, **19**, 183 (1954); (b) THIS JOURNAL, **77**, 1035 (1955).

(6) F. Ramirez and A. F. Kirby, *ibid.*, **76**, 1037 (1954).

(7) E. A. Braude and E. R. H. Jones, *J. Chem. Soc.*, 498 (1945).

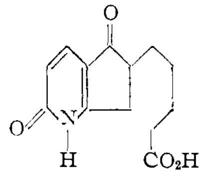
(8) Although no evidence is available concerning the mode of formation of III, the known properties of 2,4-dinitrophenylhydrazones suggests a replacement of the tertiary hydroxyl of IIb by the hydrazine in the acidic medium employed. The usual intermediate involved in the action of amine derivatives on carbonyls may be also considered. (*Cf.* F. Ramirez and A. F. Kirby, THIS JOURNAL, **74**, 4331 (1952); **75**, 6026 (1953)).

(9) S. Wawzonek, H. A. Laitinen and S. J. Kistiakowski, *ibid.*, **66**, 830 (1944).

(10) E. G. Percival, *Advances in Carbohydrate Chem.*, **3**, 23 (1948).

acid IV with diazomethane gave a non-crystalline methyl ester V, the infrared and ultraviolet absorption spectra of which were identical with those of the material obtained upon treatment of the pyridone acid II with methanolic hydrogen chloride. Catalytic hydrogenation (palladium-on-carbon) of the methyl ester V gave a saturated ester VII, identical with the product resulting from acid VI on treatment with diazomethane. It should be noted that ester VII was obtained from acid II utilizing conditions (methanolic hydrogen chloride) previously shown[5] to be without action on the NH-function of α-pyridones. The absence in VII of the characteristic broad band at 3.0–4.0 μ of α-pyridones with free NH-function substantiates the establishment of the N–C bond in VI and VII.[11]

It was shown recently[5] that the action of mineral acids on the chloronicotinic acid I led in good yield to a *pyrindine* derivative VIII, a result interpreted as involving an acid-catalyzed Claisen-type condensation. No pyridone II was obtained. It can be now concluded that rearrangement of I into VIII occurred prior to the hydrolysis of I to II.



VIII

Experimental[12]

9-Carboxy-4a-hydroxy-1,2,3,4,4a,10a-hexahydrobenzo-[b]pyrrocoline-6(10H)-one (IIb) or 2-(2′-Oxocyclohexyl)-methyl-6-oxynicotinic Acid (IIa).—A solution of 4.63 g. (0.0173 mole) of 2-(2′-oxocyclohexyl)-methyl-6-chloronicotinic acid (I)[5] in 82.5 ml. of 15% sodium hydroxide (12.4 g., 0.310 mole of sodium hydroxide) was refluxed for 14 hours. The cooled reaction mixture was diluted with ice-water, acidified with concentrated hydrochloric acid, and filtered. The crystalline product was recrystallized from ethanol (Norit) to give 3.74 g. (87%) of colorless crystals, m.p. 237–238°, which did not change on repeated recrystallization from ethanol. $\lambda^{EtOH}_{max.}$ 262 mμ, ϵ 14,800; 303 mμ, ϵ 6,000; band at 2.94, 5.95, 6.12 (strong), 6.36, and 6.45 (weak) μ, and broad band in the 3.2–4.0 μ region (Nujol mull).

Anal. Calcd. for $C_{13}H_{15}NO_4$: C, 62.6; H, 6.1; N, 5.6. Found: C, 62.3; H, 6.0; N, 5.7.

9-Carboxy-4a-[2′-(2″,4″-dinitrophenyl)-hydrazinyl]-1,2,-3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (III).—A solution of 9-carboxy-4a-hydroxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (IIb) (0.06 g.) in methanol (3 ml.) was treated with a solution of 2,4-dinitrophenylhydrazine sulfate in aqueous methanol and warmed 2 minutes on the steam-bath. The cooled reaction mixture was filtered to give 0.09 g. of yellow crystals, m.p. 178-180° dec. The analytical sample was obtained from propanol as bright yellow crystals, m.p. 182–183° dec., soluble in dilute sodium bicarbonate, retaining one mole of propanol of crystallization: $\lambda^{EtOH}_{max.}$ 265 mμ, ϵ 23,200; 310 mμ (shoulder); 340 mμ, ϵ 19,600.

Anal. Calcd. for $C_{19}H_{19}N_5O_7 \cdot C_3H_8O$: C, 54.0; H, 5.6; N, 14.3. Found: C, 54.0; H, 5.6; N, 14.3.

When the crude product, m.p. 178–180°, was recrystallized from anhydrous ethanol, the sample had m.p. 187-188° dec. and retained one mole of ethanol.

Anal. Calcd. for $C_{19}H_{19}N_5O_7 \cdot C_2H_6O$: C, 53.0; H, 5.3; N, 14.7. Found: C, 52.9; H, 5.4; N, 14.1.

9-Carboxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(10H)-one (IVa) or 9-Carboxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(4aH)-one (IVb).—A solution of the pyridone II (0.50 g.) in concentrated sulfuric acid (2.5 ml.) was heated on the steam-bath for 10 minutes. The cooled reaction mixture was poured onto 25 g. of crushed ice and filtered to give after drying in a vacuum desiccator 0.44 g. (96%) of yellow crystals, m.p. 202–207°. The analytical sample was obtained as yellow crystals, m.p. 190–191°, from ethanol: $\lambda^{EtOH}_{max.}$ 225 mμ, ϵ 13,900 (shoulder); 243 mμ, ϵ 7,800; 278 mμ, ϵ 17,900; 286 mμ, ϵ 16,800; 328 mμ, ϵ 9,400 (shoulder); 338 mμ, ϵ 10,700; 348 mμ, ϵ 7,700 (shoulder). Bands at 5.96, 6.14 and 6.22 μ, and broad band in the 3.0-4.0 μ region (Nujol mull).

Anal. Calcd. for $C_{13}H_{13}NO_3$: C, 67.5; H, 5.7; N, 6.1. Found: C, 67.7; H, 5.7; N, 6.0.

9-Carboxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (VI).—A solution of 9-carboxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(10H)-one (IVa) (or of IVb) (0.1205 g., 0.00052 mole) in anhydrous ethanol (20 ml.) was hydrogenated at atmospheric pressure, using 10% palladium-on-charcoal (0.0226 g.). A total of 13.5 ml. of hydrogen was absorbed at 33° over a 2-hour period. After filtering the mixture, the solvent was removed *in vacuo*, and the crystalline residue was recrystallized from nitromethane to give 0.113 g. (93%) of colorless crystals, m.p. 253–254° (dec., darkens at 247°), which did not improve on successive recrystallization: $\lambda^{EtOH}_{max.}$ 263 mμ, ϵ 14,700; 302 mμ, ϵ 5,900. Bands at 5.87, 6.12 (strong), 6.25, and 6.44 μ, and broad band in the 3.0–4.0 μ region (Nujol mull).

Anal. Calcd. for $C_{13}H_{15}NO_3$: C, 66.9; H, 6.5; N, 6.0. Found: C, 66.6; H, 6.5; N, 5.8.

2-Methyl-6-oxynicotinic Acid from Ethyl 2-Methyl-6-chloronicotinate.—A suspension of ethyl 2-methyl-6-chloronicotinate (0.50 g., 0.0025 mole) in 6.0 ml. of 10% sodium hydroxide (0.60 g., 0.015 mole of sodium hydroxide) was refluxed for 14 hours. The cooled reaction mixture was diluted with water, acidified with concentrated hydrochloric acid, and filtered to give 0.37 g. (97%) of colorless crystals, m.p. *ca.* 325° dec. A mixed melting point determination with authentic 2-methyl-6-oxynicotinic acid (previously prepared by acid hydrolysis of the chloronicotinate), as well as infrared comparison, established the nature of the product.

9-Carbomethoxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(10H)-one (Va) or 9-Carbomethoxy-1,2,3,4-tetrahydrobenzo[b]pyrrocolin-6(4aH)-one (Vb). (a) From IIb.—A mixture of 0.50 g. of IIb and 40 ml. of 5% methanolic hydrogen chloride was refluxed for 16 hours in a Soxhlet apparatus containing 4.0 g. of anhydrous magnesium sulfate in the thimble. The cooled reaction mixture was treated with 40 ml. of saturated sodium bicarbonate solution and extracted with chloroform. Removal of the chloroform *in vacuo* gave 0.42 g. of a yellow syrup: $\lambda^{EtOH}_{max.}$ 225, 277, 288, 325, 338 and 352 mμ; bands at 5.90, 6.07 (strong), 6.32 and 6.55 μ (chloroform).

(b) From IVa or IVb.—To a solution of 0.30 g. of IV in 10 ml. of anhydrous ether was added dropwise over a 30-minute period an excess of an ether solution of diazomethane. After 30 minutes longer at room temperature the solvent was removed in a current of dry air and finally *in vacuo* to give 0.30 g. of a clear yellow sirup. The infrared and ultraviolet absorption spectra of the product obtained were *identical* to those of the product from IIb.

9-Carbomethoxy-1,2,3,4,4a,10a-hexahydrobenzo[b]pyrrocolin-6(10H)-one (VII). (a) From Va or Vb.—A solution of 0.1264 g. (0.516 mmole) of V in 12 ml. of absolute ethanol was hydrogenated at atmospheric pressure in the presence of 0.0405 g. of 10% palladium-on-carbon. A total of 13.3 ml. of hydrogen was absorbed at 35° over a 55-minute period. The mixture was filtered and the solvent was removed *in vacuo* to give 0.13 g. of a faintly yellow sirup; $\lambda^{EtOH}_{max.}$ 267 and 300 mμ. Bands at 5.90, 6.08 (strong), 6.26 and 6.48 μ (chloroform).

(b) From VI.—A suspension of 0.024 g. of VI in anhydrous ether was treated with an excess of diazomethane dissolved in anhydrous ether. The dropwise addition was

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[11] A weak band at 6.20μ appeared in esters of unalkylated α-pyridones and was absent in esters of N-alkylated α-pyridones among compounds studied here. A band of medium strength at 6.5μ seemed to be present in N-alkylated and absent in unalkylated α-pyridones. The generality of these observations is not known.

[12] The microanalyses were carried out by Micro-Tech Laboratories, Skokie, Ill. The ultraviolet absorption spectra were taken in a Cary Recording Spectrophotometer, Model 11. The infrared absorption spectra were determined in a Baird Associates, Inc., spectrophotometer. Melting points are uncorrected.

carried out over a 4-hour period, the time required for the complete reaction and dissolution of VI. The solvent was removed in a current of dry air and finally *in vacuo* to give a colorless sirup, whose infrared spectrum was *identical* to that of the product obtained from V.

NEW YORK 27, N. Y.

[CONTRIBUTION FROM THE CHARLES F. KETTERING FOUNDATION FOR THE STUDY OF CHLOROPHYLL AND PHOTOSYNTHESIS AND THE DEPARTMENT OF CHEMISTRY, THE OHIO STATE UNIVERSITY]

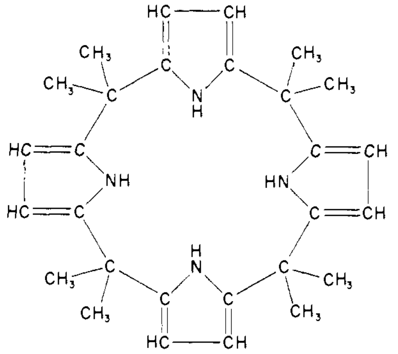
Concerning the Structure of "Acetonepyrrole"

BY PAUL ROTHEMUND AND CLARKE L. GAGE[1]

RECEIVED NOVEMBER 26, 1954

The structure of "acetonepyrrole" proposed by Chelintzev and Tronov has been partially confirmed. It is shown that at least three of the four bridge carbons are linked to the pyrrole nuclei in the α-positions.

The acid-catalyzed reaction of pyrrole and acetone yields "acetonepyrrole," $C_{28}H_{36}N_4$.[2] A structure has been proposed by Chelintzev and Tronov (I)[2d] and given the name $\alpha,\beta,\gamma,\delta$-octamethylporphinogen by Fischer.[3] This configuration is based on the isolation of maleimide by oxidation with chromic acid[3d] and pyrrole and 2-isopropylpyrrole by a pyrolytic reaction.[2b] The uncertainty of the linkage of the bridge carbons to the pyrrole nuclei, whether to the α- or β-positions, warranted further investigation because of the close similarity of the proposed structure of "acetonepyrrole" to the porphyrins and on account of the failure, thus far, to convert "acetonepyrrole" to a porphyrin.



High-pressure hydrogenation of "acetonepyrrole" with Nickel Pellet Catalyst (UOP)[4] at 265–270° and 204 atm. of hydrogen and copper chromite catalyst[5] at 215° and 204 atm. yielded pyrrole, 2-isopropylpyrrolidine, 2-isopropylpyrrole, 2,5-diisopropylpyrrolidine and 2,5-diisopropylpyrrole. Also, with the latter catalyst, a small amount of a crystalline product, $C_{14}H_{24}N_2$, was obtained. The nature and quantity of the products isolated from the above hydrogenolyses definitely establish that at least three of the four bridge carbons are bonded to the α-positions of the pyrrole nuclei. The remaining bridge carbon is probably bonded in a like manner since at no time in this investigation has a β-substituted pyrrole been isolated.

Of these reaction products only pyrrole and 2-isopropylpyrrole have been reported; therefore, the other reaction products were synthesized and compared with the product derived from the hydrogenolysis of "acetonepyrrole," and also with the products obtained from the zinc dust pyrolytic degradation of "acetonepyrrole." The latter yielded pyrrole, 2-isopropylpyrrole, 2-ethyl-5-isopropylpyrrole and two crystalline solids of unknown structure, $C_9H_{11}N$ and $C_{13}H_{17}N$. The latter two compounds appear to be pyrroles with unsaturated side-chains, and their structure will be further investigated.

The isolation of 2-ethyl-5-isopropylpyrrole was unexpected but not improbable considering the drastic pyrolytic conditions of the experiment. It is significant that the hydrogenolysis conducted at a temperature at least 100° below the pyrolytic degradation gave no 2-ethyl-5-isopropylpyrrole or corresponding pyrrolidine.

The synthetic pyrroles were prepared by the reaction of the appropriate pyrrole Grignard reagent with isopropyl bromide which yielded a mixture of mono- and poly-substituted pyrroles. Hydrogenation in dioxane with Raney Nickel W-4 catalyst[6] gave the corresponding pyrrolidines in 45–55% yield.

Experimental[7]

Pyrrole obtained from Eastman Kodak Company, white label, was distilled over sodium[8] from a Claisen flask just prior to use; boiling range 128–130°.

"Acetonepyrrole."—The procedure of Dennstedt[2b] was followed except that methanesulfonic acid[9] was used as the catalyst; yield 94 g., 88% of theory. Immediate extraction and recrystallization from acetone gave a white crystalline product, m.p.K. 296°, which kept for several months without discoloration.

Hydrogenolysis of "Acetonepyrrole."—A 500-ml. rocker-type autoclave[10] was charged with 55 g. of recrystallized "acetonepyrrole," 10 g. of pulverized Nickel Pellet Catalyst (UOP)[5] and 200 ml. of dry, peroxide-free dioxane. The contents of the bomb were brought to 157 atm. of hydrogen

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[1] Taken in part from a dissertation presented by Clarke L. Gage, to the Faculty of the Department of Chemistry, The Ohio State University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, December, 1951.

[2] (a) A. Baeyer, *Ber.*, **19**, 2184 (1886); (b) M. Dennstedt and J. Zimmermann, *ibid.*, **20**, 850, 2449 (1887); *ibid.*, **21**, 1478 (1888); (c) M. Dennstedt, *ibid.*, **23**, 1370 (1890); (d) V. V. Chelintzev and B. V. Tronov, *J. Russ. Phys. Chem. Soc.*, **48**, 105, 127 (1916); (e) Th. Sabalitschka and H. Haase, *Arch. Pharm.*, **226**, 484 (1928).

[3] H. Fischer and H. Orth, "Die Chemie des Pyrrols," Akademische Verlagsgesellschaft m.b.H., Leipzig, 1934, p. 20.

[4] Wilkens-Anderson Company, Chicago, Illinois.

[5] T. W. Riener, THIS JOURNAL, **71**, 1130 (1949).

[6] A. A. Pavlic and H. Adkins, *ibid.*, **68**, 1471 (1946).

[7] Boiling points are uncorrected. Melting points were taken either on a Fisher-Johns melting point block or on a Kofler hot stage mounted on a "Federal" microscope stand. The latter are designated m.p.K.

[8] R. Willstätter and D. Hatt, *Ber.*, **45**, 1477 (1912).

[9] Supplied by Indoil Chemical Company, Chicago, Illinois.

[10] American Instrument Company, Silver Springs, Maryland, Double Pedestal Rocking Type Autoclave.