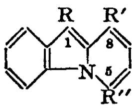
174. *Experiments on the Synthesis of the Ring Systems of Strychnine and Allied Alkaloids. Part II.**

By Sir Robert Robinson and J. E. Saxton.

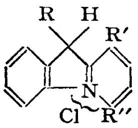
The " ethiodide " of 1 : 5 : 8-trimethyl-2 : 3-benzopyrrocoline (Robinson and Saxton, *J.*, 1950, 3136) is identical with the " methiodide " of 1-ethyl-5 : 8-dimethyl-2 : 3-benzopyrrocoline (*loc. cit.*) which proves that in the formation of these salts the β-carbon of the indole nucleus is ethylated, and methylated, respectively. It is apparent that these salts and also the hydracid salts of the benzopyrrocolines are pyridinium salts. Several new condensations of indole or its derivatives with 1 : 4-dicarbonyl compounds are described and in the case of a keto-aldehyde, namely lævulaldehyde (as its dimethyl acetal), it is found that the aldehyde group attacks position 1 (>NH). Thus with skatole the product is 1 : 8-dimethyl-2 : 3-benzopyrrocoline. An observation, which is of importance in further work in the direction of the strychnine skeleton, is that 2-methylfuran can replace the lævulaldehyde dimethyl acetal; a condensation with 3-ethylindole is mentioned as an example.

The condensation of indole with acetonylacetone has been re-examined; the products include 1 : 4-dimethylcarbazole.

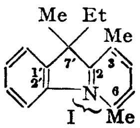
In our first paper on these topics (*J.*, 1950, 3136) we drew attention to the fact that the hydrochloride of 1 : 5 : 8-trimethyl-2 : 3-benzopyrrocoline (I; R = R′ = R″ = Me) must possess an entirely different constitution from the base, the substances not being in readily mobile equilibrium with each other in all usual circumstances. For example, ether does not extract the base from a dilute acid solution of the salt and the same acid (*e.g.*, 1% aqueous hydrochloric acid) does not extract the base from ethereal solution. Hence the base was considered to be markedly pseudomeric.



(I)



(II)



(III)

In the month which saw the publication of our communication an opportunity was taken to point out that the salt should be a pyridinium derivative of the structure (II)

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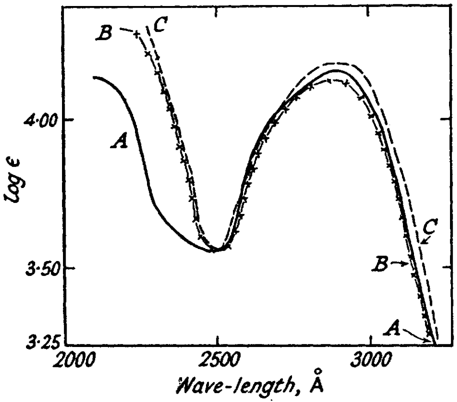
* Part I, *J.*, 1950, 3136, has not hitherto been designated as such, but it is now seen to be the starting point of a series of investigations.

($R = R' = R'' = Me$) (Anniversary Address of the President of the Royal Society, November 30th, 1950; *Proc. Roy. Soc.*, *A*, 1951, **205**, 1). The correctness of this suggestion has now been proved unequivocally.

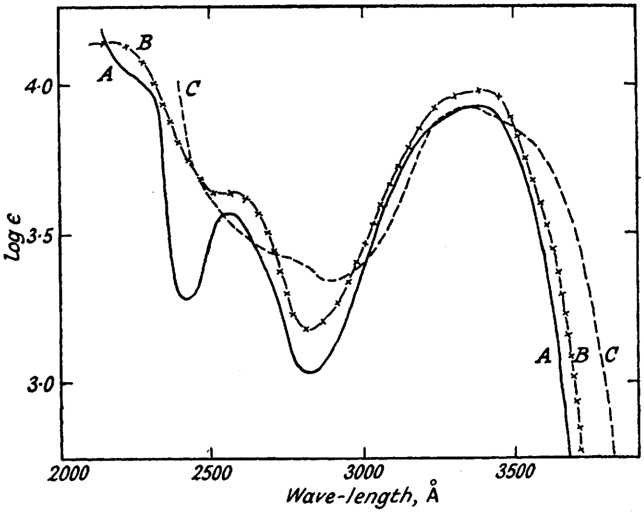
The benzopyrrocolines are feeble bases and react sluggishly with alkyl halides. Combination with methyl or ethyl iodide was effected in sealed tubes at 100°. It transpired, as was expected, that the "ethiodide" of 1 : 5 : 8-trimethyl-2 : 3-benzopyrrocoline was identical with the "methiodide" of 1-ethyl-5 : 8-dimethyl-2 : 3-benzopyrrocoline. This salt must therefore be (III), and the hydrochloride is (II) because of the close similarity of the ultra-violet absorption spectra (see Fig. 1). These spectra have no resemblance to those characteristic of the bases (*loc. cit.*) but, apart from a higher log ε, they are remarkably like those shown by 5 : 6 : 7 : 8-tetrahydro-1 : 5 : 8-trimethyl-2 : 3-benzopyrrocoline and by 9-ethyl-1 : 2 : 3 : 4-tetrahydrocarbazole. It is perhaps permissible to conclude from this correspondence that the constant factors are predominant and these are the unsaturation of the benzene ring and an unsaturated group in the five-membered ring fused with

FIG. 1.



A, 1 : 5 : 8-*Trimethyl*-2 : 3-*benzopyrrocoline in dilute hydrochloric acid.*
B, 1 : 5 : 8-*Trimethyl*-2 : 3-*benzopyrrocoline "methiodide" in water.*
C, 1 : 5 : 8-*Trimethyl*-2 : 3-*benzopyrrocoline "ethiodide" in water.*

FIG. 2.



A, *Perchlorate of trimethylbenzylenepyridone in alkaline methanol.*
B, *Trimethylbenzylenepyridone in methanol.*
C, *Dehydrostrychninolone* (*Prelog, Kocòr, and Taylor*, loc. cit.).

it. Surprisingly it seems to be less important that to achieve this comparison we need to take –CMeEt–, –NEt–, and –NR– (where R is in $\cdot CHMe\cdot CH_2\cdot CH_2\cdot CHMe\cdot$) as the equivalent saturated groups of the said five-membered ring.

The formation of salts such as (III) is a typical *C*-alkylation of a hetero-enoid system (cf. Hamilton and Robinson, *J.*, 1916, **109**, 1029) and the products can only be termed " alkyl halides " if it is desired to indicate a relation to their generators.

In this sense, (III) is both a " methiodide " and an " ethiodide," but in fact it is neither. We suggest that these substances should be named as pyridinium derivatives and the most important substituent is benzylene $\cdot C_6H_4\cdot CH_2\cdot$ in which the side-chain carbon atom is numbered 7′ (for convenience of avoidance of α in the resulting nomenclature), and the *ortho*-carbon atom is numbered 2′.

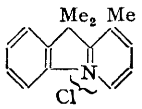
Inspection of the structure (III) shows that it includes certain characteristics of the strychnine molecule namely the ββ-disubstitution in the indole nucleus and three of the rings of the heptacyclic system of the alkaloid.

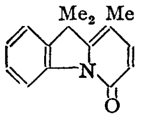
In order to make possible a nearer approach we desired to omit the substituent in the 5-position (cf. I). A methyl group in this position can be readily diagnosed by the formation of coloured salts on condensation with *p*-dimethylaminobenzaldehyde. One such dye has been analysed and is described in the Experimental portion.

On replacement of acetonylacetone in the condensation with skatole by lævulaldehyde dimethyl acetal, a dimethyl-2 : 3-benzopyrrocoline was produced. This must have the constitution (I; R = R′ = Me; R″ = H), rather than the alternative with H at 8 and Me at 5 because its " methiodide " did not exhibit the above-mentioned reaction with *p*-dimethylaminobenzaldehyde.

In an analogous synthesis with 3-ethylindole we found that the lævulaldehyde acetal could be replaced by 2-methylfuran, an observation which greatly enlarges the scope of our method. In the case of skatole itself, competing polymerisation renders the more reactive lævulaldehyde acetal the better starting point.

(IV)





(V)

The constitution of 5 : 8-dimethyl-2 : 3-benzopyrrocoline was confirmed by oxidation of its " methochloride " (IV) to a pyridone (V); this could be effected by alkaline ferricyanide. This substance contains the chromophore of the so-called colourless benzylidene derivatives in the strychnine series (for example, that of *iso*dihydrostrychnine) to which one of us has frequently referred,* and more simply of dehydrostrychninolone (Prelog, Kocòr, and Taylor, *Helv. Chim. Acta*, 1949, **32**, 1052). The ultra-violet absorption spectrum of (V) (Fig. 2) is very like that of dehydrostrychninolone.

An interesting feature is that the spectrum in methanol is altered by the addition of sodium hydroxide. There is no hydroxyl group or other source of active hydrogen in the molecule and the only explanation of the result that we can envisage is based on electrostriction of the dipole or associated dipole by hydroxyl (or methoxyl) ions.

A related phenomenon is the formation of an abnormal perchlorate, $2B,HClO_4$. This we might formulate as $[H(-\ +)(-\ +)]^+ClO_4^-$. In that case both the dipoles included would be of pyridinium structure, or at least an intermediate form between neutral pyridone and full pyridinium dipole. An alternative hypothesis based on hydrogen bonding is expressed in the symbol $[(+\ -)H(-\ +)]^+ClO_4^-$.

The condensation of indole with acetonylacetone in ethanolic hydrogen chloride is now found to yield 1 : 4-dimethylcarbazole (Anderson and Campbell, *J.*, 1950, 2856), a new synthesis of which is described herein, and a substance, presumably $C_{14}H_{15}ON$, isolated

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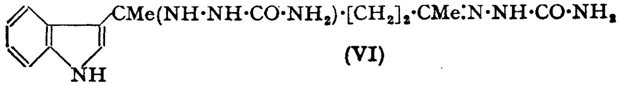
* Dr. A. M. Stephen (D. Phil. Thesis, Oxford Univ., 1949) and one of us found that the ultra-violet absorption of these substances resembled that of 1-phenyl-2-pyridone and accumulated other evidence of this type of structure. We were in correspondence with Professor V. Prelog who was cognisant of our work and very courteously acknowledged this in the communication of Prelog, Kocòr, and Taylor (*loc. cit.*).

as a semicarbazido-semicarbazone (VI). The latter forms a complex with two molecules of semicarbazide (cf. *J.*, 1950, 3137, 3139).



(VI)

Two further examples of the synthesis of carbazole derivatives from indole and 1 : 4-diketones are described in the Experimental section.

EXPERIMENTAL

Condensation of Indole with Acetonylacetone.—The mixture (1 g.) obtained from the interaction of indole and acetonylacetone under the conditions previously described (*J.*, 1950, 3139) was dissolved in aqueous ethanol (1 : 1), and excess of semicarbazide hydrochloride and sodium acetate in aqueous ethanol (1 : 1) added. The solution was gently heated for 5 minutes on the steam-bath and allowed to cool. The crystals that separated were collected, washed with water, ethanol, and ether, and dried at 100° *in vacuo*. This substance (0·4 g.), decomp. 242°, so obtained as dense, colourless rhombs, was insoluble in all ordinary organic solvents (Found : C, 43·5, 43·2; H, 6·5, 6·9; N, 36·9, 35·8. $C_{18}H_{33}O_4N_{13}$ requires C, 43·7; H, 6·7; N, 36·8%). These remarkable analytical results may be interpreted as follows. Condensation of 1 mol. of C_8H_7N with 1 mol. of $C_6H_{10}O_2$, with loss of $1H_2O$, gives $C_{14}H_{15}ON$, the semicarbazone of which is $C_{15}H_{18}ON_4$. The difference to be accounted for is $C_3H_{15}O_3N_9$, that is 3 mols. of semicarbazide. We are able (see below) to remove two molecules of semicarbazide and hence this substance is regarded as $C_{16}H_{23}O_2N_7,2CH_5ON_3$.

The complex (0·2 g.) was mixed with aqueous oxalic acid (10 c.c. of 30%) and heat applied until dissolution was complete. After cooling, the mixture was extracted with ether several times, and the combined extracts were washed with sodium carbonate solution and water, and evaporated. The residue separated from ethanol as colourless prisms, m. p. 240° (Found : C, 55·4; H, 7·0; N, 27·4. $C_{16}H_{23}O_2N_7$ requires C, 55·7; H, 6·8; N, 28·4%). This substance is thought to be the *semicarbazone* (VI) of 5-3′-indolyl-5-semicarbazidohexan-2-one.

The mother-liquors from the semicarbazone preparation described above were diluted with much water, and the product collected, and crystallised from aqueous ethanol. 1 : 4-Dimethylcarbazole (0·7 g.) was obtained as long, colourless needles, m. p. 97—98° (Found : C, 86·0; H, 6·7; N, 7·3. Calc. for $C_{14}H_{13}N$: C, 86·2; H, 6·7; N, 7·2%). Dr. N. Campbell kindly provided a specimen of his 1 : 4-dimethylcarbazole which had m. p. 82—86° (Anderson and Campbell, *loc. cit.*, m. p. 79—82°); on admixture with our specimen the m. p. was 82—91°. The picrate crystallised from ethanol or benzene as red needles, m. p. 151—152° (decomp.) (Anderson and Campbell, *loc. cit.*, give m. p. 142—143°) (Found : C, 56·7; H, 3·8; N, 13·2, 13·5. Calc. for $C_{14}H_{13}N,C_6H_3O_7N_3$: C, 56·6; H, 3·8; N, 13·2%).

Synthesis of 1 : 4-*Dimethylcarbazole.*—A mixture of *p*-xylylhydrazine (2 g.) and *cyclo*hexanone (1·5 g.) was heated on the steam-bath for a few minutes—until hydrazone formation appeared to be complete. In an earlier experiment the derivative was isolated and crystallised from ethanol in orange prisms, which when kept overnight in an evacuated desiccator decomposed to a brown tar. Hence the substance was not completely purified in this synthesis. The mixture was cooled and, when no further crystallisation occurred, the product was collected and washed with a little cold ethanol. This *cyclo*hexanone *p*-xylylhydrazone was added to 10% sulphuric acid (100 c.c.), and the mixture boiled for 30 minutes. The product was isolated by means of ether and crystallised from light petroleum (b. p. 40—60°). After one crystallisation 5 : 6 : 7 : 8-tetrahydro-1 : 4-dimethylcarbazole (1 g.) was obtained as colourless needles, m. p. 86—88°; Anderson and Campbell, *loc. cit.*, give m. p. 88—89°. A solution of the tetrahydrodimethylcarbazole (0·75 g.) and chloranil (2 g.) in the minimum volume of sulphur-free xylene was refluxed until a few drops of the liquid developed no red colour with hot aqueous sodium hydroxide (4 hours). The solution was cooled, separated from tetrachloroquinol, diluted with ether, shaken with sodium hydroxide solution, and dried. The solvents were removed, and the product was dissolved in light petroleum (b. p. 80—100°). Purification was effected by adsorption on an alumina column, the product being eluted with light petroleum (b. p. 60—80°)–benzene (3 : 1). 1 : 4-Dimethylcarbazole (0·25 g.) separated from light petroleum (b. p. 40—60°) as colourless needles or prisms, m. p. 96—97°, alone or when mixed with the specimen obtained from indole and acetonylacetone (Found : C, 86·3; H, 6·7; N, 7·3. Calc. for $C_{14}H_{13}N$: C, 86·2; H, 6·7; N, 7·2%). The picrate crystallised from ethanol as red needles,

m. p. 152° (decomp.), alone or mixed with the picrate of the product from indole and acetonylacetone.

The absorption of 1 : 4-dimethylcarbazole in the ultra-violet closely resembles that of carbazole as the following data show (values of $\log_{10} \varepsilon$ in parentheses). Carbazole: Maxima, 2350 (4·26), 2550 (4·20), 2930 (4·18), 3220 (3·53), 3350 (3·47); minima, 2500 (4·12), 2700 (3·52), 3080 (3·41), 3310 Å (3·40). 1 : 4-Dimethylcarbazole: Maxima, 2350 (4·30), 2600 (4·04), 2890 (4·15), 3220 (3·6), 3350 (3·6); minima, 2550 (3·95), 2740 (3·75), 3000 (3·21), 3310 Å (3·51).

7′-Ethyl-3 : 6 : 7′-trimethyl-1 : 2(2′ : 7′)-benzylenepyridinium Iodide (III).—A mixture of 1 : 5 : 8-trimethyl-2 : 3-benzopyrrocoline (1 g.) and ethyl iodide (5 c.c.) was heated at 100° for 3—4 hours in a sealed tube. The product was collected, washed with ether, and crystallised from water or ethanol. *7′-Ethyl-3 : 6 : 7′-trimethyl-1 : 2(2′ : 7′)benzylenepyridinium iodide* was obtained as colourless or very pale yellow prisms, m. p. 247—249° (decomp.) (Found: C, 56·2; H, 5·6; I, 35·3. $C_{17}H_{20}NI$ requires C, 55·9; H, 5·5; I, 34·8%). This quaternary salt furnished a deep red dye on being heated with *p*-dimethylaminobenzaldehyde or *p*-nitrosodimethylaniline in ethanol in the presence of a trace of piperidine (see below).

Interaction of 1-ethyl-5 : 8-dimethyl-2 : 3-benzopyrrocoline and methyl iodide was effected in the same manner and the resulting salt crystallised from water or ethanol as colourless or pale yellow prisms, m. p. 247—249° (decomp.) (Found: C, 55·9; H, 5·4; I, 35·0%). A mixture with the 7′-ethyl-3 : 6 : 7′-trimethyl-1 : 2-(2′ : 7′)benzylenepyridinium iodide obtained from trimethylbenzopyrrocoline and ethyl iodide had m. p. 247—249° (decomp.). The two specimens were compared by means of *X*-ray single-crystal photographs, for which we are greatly indebted to Mrs. D. Crowfoot Hodgkin and Miss P. M. Cowan. The identity of the two specimens was fully confirmed by their report.

3 : 6 : 7′ : 7′-Tetramethyl-1 : 2(2′ : 7′)benzylenepyridinium iodide was similarly prepared from the base and methyl iodide and crystallised from water as colourless prisms, with a slight yellow or green tinge, m. p. 239—241° (decomp.) (Found: C, 54·9; H, 5·1; I, 36·3. $C_{16}H_{18}NI$ requires C, 54·7; H, 5·1; I, 36·2%).

The ultra-violet absorption spectra (Fig. 1) show clearly the nuclear-skeletal identity of the three salts studied.

Condensation of Tetramethylbenzylenepyridinium Iodide with p-*Dimethylaminobenzaldehyde.*—An alcoholic solution of the quaternary iodide (1 g.), *p*-dimethylaminobenzaldehyde (0·5 g.), and piperidine (2 drops) was refluxed for an hour. The solvent was then removed and the product crystallised from ethanol or ethanol–ether. *3 : 7 : 7′-Trimethyl-6-*p-*dimethylaminostyryl-1 : 2(2′ : 7′)benzylenepyridinium iodide* was obtained as red, hexagonal prisms, decomp. 209—210° (Found: C, 62·5; H, 6·3; I, 24·3. $C_{26}H_{29}N_2I,\frac{1}{2}C_2H_5\cdot OH$ requires C, 62·4; H, 6·2; I, 24·5%).

The quaternary iodide also gave a deep red dye with *p*-nitrosodimethylaniline under the same conditions. The product was obtained as greenish-black plates with a metallic lustre, decomp. 215—216°. When heated in pyridine solution with hydroxylamine hydrochloride the dye was decomposed and an almost colourless solution resulted.

1 : 8-Dimethyl-2 : 3-benzopyrrocoline (I; R = R′ = Me, R″ = H).—A solution of skatole (3·6 g.) and lævulaldehyde dimethyl acetal (3·6 g.) in ethanol (10 c.c.) was saturated with dry hydrogen chloride at 0°; it was then poured into water (50 c.c.) and shaken with ether. The aqueous layer was basified with sodium hydroxide and kept in the refrigerator. Next day the product was collected and crystallised from light petroleum (b. p. 60—80°) and then twice from ethanol. *1 : 8-Dimethyl-2 : 3-benzopyrrocoline* (2 g.) was obtained as yellow needles, m. p. 86—87° (Found: C, 86·0; H, 6·7; N, 7·0. $C_{14}H_{13}N$ requires C, 86·2; H, 6·7; N, 7·2%).

The *perchlorate* was prepared in acetone and crystallised from methanol as colourless prisms, m. p. 173—176° (Found: C, 56·7; H, 4·8; N, 4·6; Cl, 12·2. $C_{14}H_{13}N,HClO_4$ requires C, 56·9; H, 4·8; N, 4·7; Cl, 12·0%). The "*methiodide*" [*3 : 7′ : 7′-trimethyl-1 : 2(2′ : 7′)benzylenepyridinium iodide*] was obtained from water as very pale yellow needles, m. p. 252° (decomp.) (Found: C, 53·6; H, 4·9; I, 38·2. $C_{15}H_{16}NI$ requires C, 53·4; H, 4·8; I, 37·7%). This salt gave no colour when heated in ethanol solution with *p*-dimethylaminobenzaldehyde, showing that there can be no methyl group in the α-position to the nitrogen atom of the pyridine ring.

1-Ethyl-8-methyl-2 : 3-benzopyrrocoline (I; R = Et; R′ = Me; R″ = H).—A solution of 3-ethylindole (2 g.) in methanol (20 c.c.) was saturated with hydrogen chloride. 2-Methylfuran (2 c.c.) was added and the mixture kept for 12 hours. Water (100 c.c.) was added and the neutral material extracted with ether. The base was then isolated as before and purified by way of the perchlorate. *1-Ethyl-8-methyl-2 : 3-benzopyrrocoline* (1 g.) was obtained from methanol as golden flakes, m. p. 71—73° (Found: C, 85·8; H, 7·2; N, 6·7. $C_{15}H_{15}N$ requires

C, 86·1; H, 7·2; N, 6·7%). The *perchlorate* was crystallised from water or methanol containing a trace of perchloric acid, and obtained as colourless prisms, m. p. 166—168° (Found: C, 58·0, 58·3; H, 4·9, 5·3; N, 4·7; Cl, 11·4. $C_{15}H_{15}N,HClO_4$ requires C, 58·2; H, 5·2; N, 4·5; Cl, 11·5%). The "*methiodide*" [*7′-ethyl-*3 : *7′-dimethyl-*1 : 2(2′ : 7′)-*benzylenepyridinium iodide*] was obtained from water as very pale yellow rhombs, m. p. 219—221° (Found: C, 54·8; H, 5·0; I, 36·5. $C_{16}H_{18}NI$ requires C, 54·7; H, 5·1; I, 36·2%). This salt gave no colour on being heated in ethanol solution with *p*-dimethylaminobenzaldehyde and a trace of piperidine.

1-*Methyl-*2 : 3-*benzopyrrocoline* (I; R = Me; R′ = R″ = H).—Hydrogen chloride was led into a suspension of succindialdoxime (1 g.) in ethanol (20 c.c.) until all the solid had dissolved. A solution of skatole (1 g.) in ethanol (10 c.c.) was then added, and the mixture again saturated with hydrogen chloride and then kept overnight. Water (100 c.c.) was added and the neutral material extracted with ether. The aqueous solution was basified and the product isolated by means of ether and crystallised from methanol. 1-*Methyl-*2 : 3-*benzopyrrocoline* (0·2 g.) was obtained as golden plates, m. p. 67—68° (Found: C, 85·7; H, 6·2; N, 7·7. $C_{13}H_{11}N$ requires C, 86·2; H, 6·1; N, 7·7%).

3 : 7′ : *7′-Trimethyl-*1 : 2(2′ : 7′)-*benzylenepyrid-*6-*one* (V).—Attempts to oxidize 7′-ethyl-3 : 6 : 7′-trimethyl-1 : 2-benzylenepyridinium chloride, as also its condensation product with *p*-dimethylaminobenzaldehyde, were made using alkaline ferricyanide, potassium permanganate, or hydrogen peroxide. No crystalline product could be isolated. A successful result was achieved only when position 6 was unsubstituted.

An aqueous solution of 3 : 7′ : 7′-trimethylbenzylenepyridinium iodide (5·0 g.) was heated with an excess of freshly precipitated silver chloride for an hour on the steam-bath. Potassium ferricyanide (15 g.) in a little water was added to the cooled and filtered solution which was stirred mechanically, and 2N-sodium hydroxide (50 c.c.) added dropwise until the reaction mixture was strongly alkaline. Ether was added, and the stirring continued for another hour. The ethereal layer was separated, the aqueous layer was again extracted with ether, and the combined extracts were dried and evaporated, leaving a pale yellow semi-solid mass (150 mg.). The pyridone could not be crystallised directly; it was triturated with perchloric acid; the *perchlorate* crystallised, from methanol or water containing a little perchloric acid, as colourless prisms (from methanol) or long, colourless needles (from water), m. p. 202—204° when heated moderately rapidly; when slowly heated it decomposed from 185° to 205° (Found: C, 65·3, 65·4; H, 5·4, 5·7; Cl, 6·5, 6·7. $2C_{15}H_{15}ON,HClO_4$ requires C, 65·4; H, 5·6; Cl, 6·5%). The base (1·0 g.) was regenerated from the perchlorate, and crystallised by the careful addition of light petroleum to its solution in dry ether. 3 : 7′ : *7′-Trimethyl-*1 : 2(2′ : 7′)-*benzylenepyrid-*6-*one* was so obtained in colourless needles, m. p. 82—83° (Found: C, 80·2; H, 6·6; N, 6·0, 6·2. $C_{15}H_{15}ON$ requires C, 80·0; H, 6·7; N, 6·2%). This substance is readily soluble in most organic solvents; its solution in ethanol fluoresces blue.

N-*Chloroacetyl-*3-*methylindole*.—A solution of skatole (5 g.) in ether (50 c.c.) was added to the Grignard reagent from magnesium (2 g.) and ethyl bromide (10 g.) in ether (200 c.c.), and the mixture warmed on the steam-bath until evolution of ethane ceased. The solution was then cooled in ethanol and solid carbon dioxide, and a solution of chloroacetyl chloride (9 g.) in ether (50 c.c.) was added dropwise with vigorous stirring. Stirring was continued while the reaction mixture was allowed to reach room temperature. Water (50 c.c.) was then added, followed by dilute acetic acid (50 c.c.), and mixture stirred until the intermediate had been decomposed. The ethereal layer was separated, washed with sodium hydrogen carbonate solution, and dried ($MgSO_4$), and the solvent removed without heating. The product was crystallised from ethanol or light petroleum (b. p. 60—80°), and N-*chloroacetyl-*3-*methylindole* (5 g.) obtained as long, colourless needles, m. p. 105° (Found: C, 63·5; H, 4·7. $C_{11}H_{10}ONCl$ requires C, 63·6; H, 4·8%).

This substance gives a magenta Ehrlich reaction, and a deep brown colour with sulphuric acid and sodium dichromate. It is very susceptible to alkaline hydrolysis and an attempt to condense it with ethyl sodioacetoacetate in alcoholic solution led only to the formation of skatole (m. p. 95°; picrate, m. p. 170°).

Condensation of Indole with Lævulaldehyde Dimethyl Acetal.—An alcoholic solution of indole (2 g.) and lævulaldehyde dimethyl acetal (2·5 g.) was saturated with hydrogen chloride at 0° and then kept overnight. The dark amorphous mass, precipitated by addition of water, was dried and extracted with boiling benzene (1 × 50 c.c.; 2 × 25 c.c.), and the benzene solution treated with charcoal and filtered, yielding a pale yellow solution with a green fluorescence. The solvent was removed *in vacuo*, and the product crystallised from benzene. 1-Methylcarbazole was obtained as colourless rhombs, m. p. 121° alone, and 119—121° when mixed with authentic 1-methylcarbazole of m. p. 119—120°. When it was mixed with 4-methylcarbazole of m. p. 115—116°, the m. p. was 100—105°. The picrate crystallised from benzene as red prisms, m. p. 151—153°, alone and when mixed with the picrate of authentic 1-methylcarbazole (Found: C, 55·6; H, 3·7; N, 13·3. Calc. for $C_{13}H_{11}N,C_6H_3O_7N_3$: C, 55·6; H, 3·4; N, 13·7%).

4-*Methyl*-1-*phenylcarbazole*.—A solution of indole (2 g.) and phenacylacetone (3 g.) in ethanol (20 c.c.) was cooled in ice, saturated with hydrogen chloride, and set aside overnight. The solution was then diluted with water and extracted with ether, and the ethereal extracts were dried and evaporated. The residue was dissolved in benzene and purified by adsorption on alumina. Evaporation of the benzene eluate gave a colourless oil, a solution of which in light petroleum (b. p. 40—60°) deposited crystals. 4-*Methyl*-1-*phenylcarbazole* was so obtained as colourless rhombs, m. p. 114—115° (Found: C, 88·3; H, 5·9; N, 5·5. $C_{19}H_{15}N$ requires C, 88·7; H, 5·9; N, 5·5%). The *picrate* separated from methanol as red needles, m. p. 148° (Found: C, 62·0; H, 3·9; N, 11·4. $C_{19}H_{15}N,C_6H_3O_7N_3$ requires C, 61·7; H, 3·7; N, 11·5%).

Some Further Notes.—Skatole does not condense with 1 : 2-dibenzoylethane in cold ethanolic hydrogen chloride. When the mixture was heated, the diketone was dehydrated to diphenylfuran (Perkin and Schloesser, *J.*, 1890, **57**, 954), m. p. 89° (Found: C, 87·3; H, 5·6. Calc. for $C_{16}H_{12}O$: C, 87·3; H, 5·5%). The yield of diphenylfuran was quantitative when hydrogen chloride was passed into a hot saturated solution of dibenzoylethane.

Under the usual conditions skatole and succinonitrile afforded ethyl succinate and diskatole hydrochloride, m. p. 180° (Found: C, 72·9, 72·9; H, 6·6, 6·5; N, 9·8, 9·3; Cl, 12·1, 11·6. Calc. for $C_{18}H_{18}N_2,HCl$: C, 72·4; H, 6·4; N, 9·4; Cl, 11·9%). Oddo and Crippa (*Atti R. Accad. Lincei*, 1924, [v], **33**, I, 51) give m. p. 173°.

An attempted condensation of ethyl indole-3-carboxylate with acetonylacetone in ethanolic hydrogen chloride led to the formation of intractable tar, and no benzopyrrocoline derivative could be isolated.

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DYSON PERRINS LABORATORY, OXFORD UNIVERSITY. [*Received, November* 1*st*, 1951.]