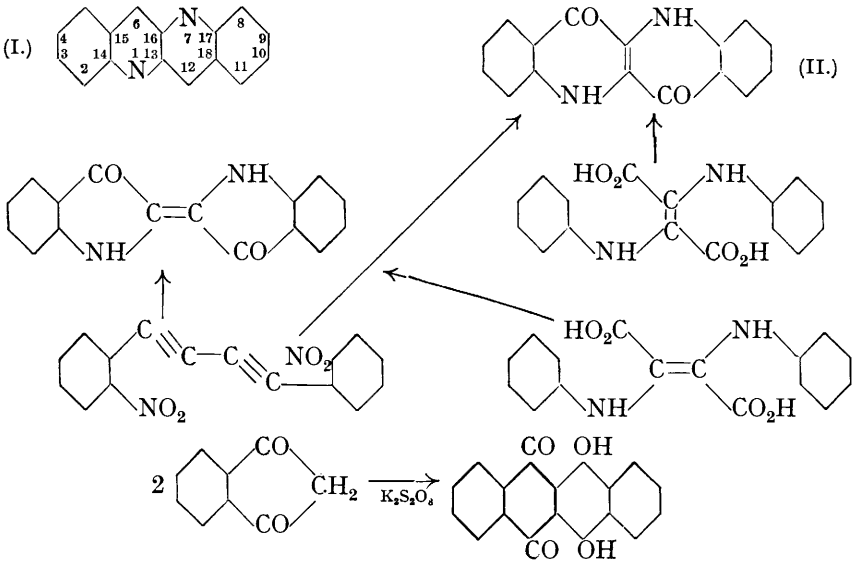
328. *The Epindoline Group. Part I. Trial of Various Methods for the Synthesis of Epindolidiones.*

By A. D. Ainley and Robert Robinson.

By epindoline (I) we denote a tetranuclear base, the dihydroxy-derivative of which in its γ-pyridone form (II) (epindolidione) is not only isomeric with indigotin but might well be a congener of that pigment in many of its processes of preparation.

This becomes clear on inspection of the annexed schemes, and it was desired to synthesise (II) by an unambiguous method in order to compare the properties of the substance with those of indigotin.

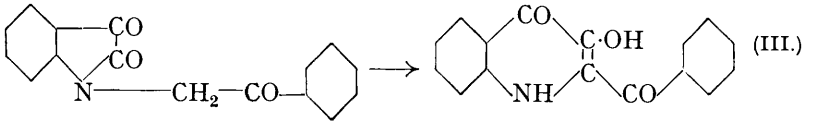


The last-cited reaction provides an analogy for the possible oxidation of indoxyl to epindolidione.

The name epindoline is proposed partly in order to recall this transposition relationship with the indigotin series and partly by analogy to quindoline.

The outcome of the series of experiments herein described is that, although we have had to travel a long road, the synthesis of **4 : 10-*dimethylepindolidione*** (XXII) has been effected and this very sparingly soluble substance is in no respect similar to indigotin in its properties. We now intend to review some of the indigo syntheses in order to find out whether epindolidione is a by-product.

The first main method of attack of the problem was based on the idea that *N*-phenacylisatin should, under the influence of basic catalysts, be capable of isomeric change with formation of 2-benzoyl-**3 : 4**-dihydroxyquinoline (III). Working then with the *N*-*o*-nitrophenacylisatin, we should obtain a product which on reduction ought to furnish epindolidione by dehydration.



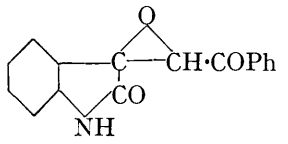
We have incidentally examined members of the isatinacetic acid series (see p. 1512) and, as the condensation of sodio-isatin with ethyl chloroacetate proceeded normally, we were disposed to think that the product from sodio-isatin and phenacyl bromide was *N*-phenacylisatin.

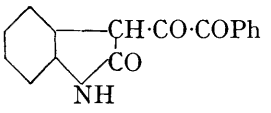
As expected, it was easily changed to a pseudo-acidic isomeride by treatment with alkalis and actually the transformation occurs in aqueous solution.

But when the supposed *N*-*o*-nitrophenacylisatin was isomerised and reduced, a red vat-dye was produced, and this was recognised as indirubin. This observation gave a valuable clue and we now regard " phenacylisatin " as an ethylene oxide derivative (IV) which is changed by alkalis to *benzoylformyloxindole* (V).

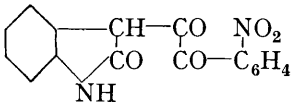
The reactions are analogous to those described by Bodforss (*Ber.*, 1918, **51**, 192), who condensed benzaldehyde and substituted derivatives with phenacyl bromide in the presence

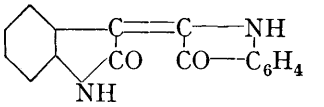
of sodium ethoxide and obtained glycides which could be transposed with the formation of diketones.

(IV.) 

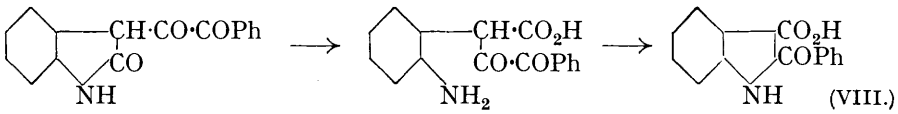
 (V.)

The formation of indirubin (VII) from the o-*nitrobenzoylformyloxindole* (VI) is then readily explicable and is an interesting novel synthesis of the colouring matter.

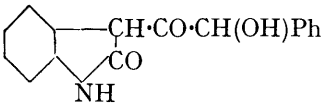
(VI.) 

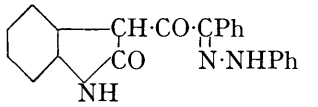
 (VII.)

Nevertheless, it was difficult to get direct confirmation of this theory by the examination of (V). It is rather stable to hydrolytic agents and remarkably resistant towards hydrogen peroxide; boiling aqueous sodium hydroxide led to the formation of benzoylformic acid and an acid, $C_{16}H_{11}O_3N$, isomeric with the initial material. This is probably 2-*benzoylindole*-3-*carboxylic acid* (VIII), formed in the following manner :

 (VIII.)

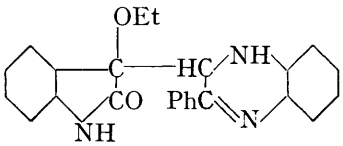
Oxindole was not isolated in these experiments, but it was obtained as the result of hydrolysis of (V) with a mixture of acetic and hydrochloric acids. On reduction with zinc dust and aqueous sodium hydroxide, benzoylformyloxindole yields a dihydro-derivative which must be *mandeloyloxindole* (IX) because it gives a ferric reaction. Some simple processes of degradation of this substance to benzaldehyde are mentioned in the experimental section and are difficult to understand.

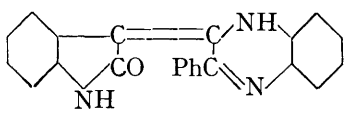
(IX.) 

 (X.)

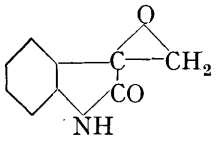
The *phenylhydrazone* of benzoylformyloxindole is an extraordinary substance; it is provisionally formulated as (X) partly because the carbonyl of the benzoyl group appears to be the more active (compare the reduction already mentioned) and partly because this structure contains a tautomeric system which seems to be required for the explanation of the remarkable colour changes in various solutions (see p. 1514). The alternative with the phenylhydrazone group in the β-position to the phenyl group possesses, however, one advantage in the formal constitutional analogy with the violurates; a further study of this problem is contemplated.

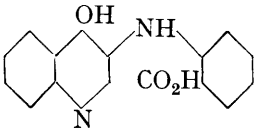
An addition compound of (IV) and alcohol has been isolated, and condensation of (IV) with *o*-phenylenediamine in alcoholic acetic acid solution furnished a substance of the probable constitution (XI). Benzoylformyloxindole and *o*-phenylenediamine gave a base (XII) having the expected composition, but the properties of this quinoxaline (?) are unusual; the formula suggests a possible explanation.

(XI.) 

 (XII.)

The parent compound (XIII) of the group to which the substance (IV) belongs has been prepared by Arndt, Eistert, and Ender (*Ber.*, 1929, **62**, 44) from isatin by interaction with diazomethane.

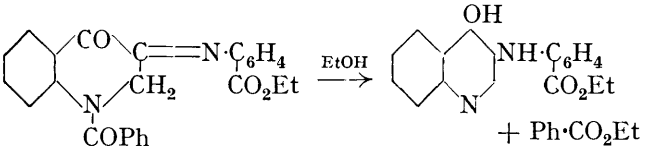
(XIII.) 

 (XIV.)

Other products of this reaction, previously studied by Heller (*Ber.*, 1919, **52**, 741; compare also *Ber.*, 1926, **59**, 704) are 2 : 3-dihydroxyquinoline and its 3-methyl ether.

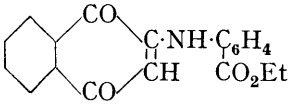
The next projected line of synthesis was by way of the acid (XIV), which we hoped to be able to dehydrate in the desired direction. It seemed possible that *o*-nitrosobenzoic acid or an ester thereof could be condensed with γ-ketotetrahydroquinoline and that the product might undergo isomeric change.

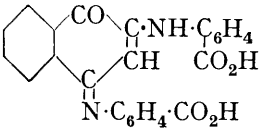
This was realised in the condensation of ethyl *o*-nitrosobenzoate with *N*-benzoyl-4-ketotetrahydroquinoline in alcoholic solution in the presence of potassium carbonate, whereby the ester of (XIV) and ethyl benzoate were produced.



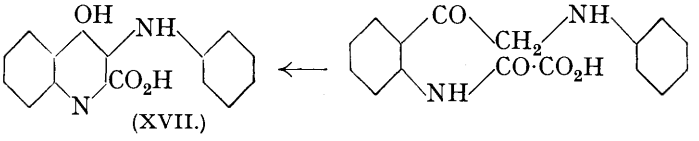
Unfortunately the ring-closure of (XIV) could not be brought about, a result undoubtedly due to the feeble reactivity of the pyridine nucleus. We had anticipated this, but thought that the activating substituents might overcome the effect.

Incidentally the condensation of *o*-nitrosobenzoic acid and its ester with α-tetralone was studied and the naphthaquinone derivatives (XV) and (XVI) were obtained.

(XV.) 

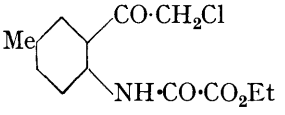
 (XVI.)

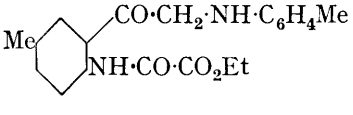
Finally we directed attention to the synthesis of an acid of the type (XVII) and placed reliance on the synthetic method illustrated.



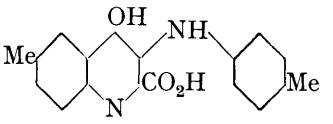
An attempt to enter this route by way of ω-anilino-*o*-nitroacetophenone failed because we were unable to condense ω-bromo-*o*-nitroacetophenone with aniline.

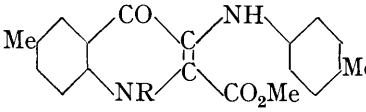
The successful method started with ω-chloro-2-amino-5-methylacetophenone (Kunckel, *Ber.*, 1900, **33**, 2647), which was condensed with ethoxalyl chloride, yielding (XVIII). After replacement of the chlorine atom by iodine, a *p*-toluidine residue could be introduced (we used *p*-toluidine in the interests of symmetry).

(XVIII.) 

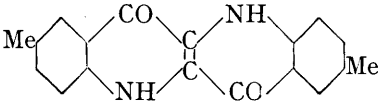
 (XIX.)

The ring closure of (XIX) (Camp's synthesis) occurred under the influence of boiling aqueous alcoholic sodium hydroxide and the *acid* (XX) was isolated.

(XX.) 

 (XXI.)

Esterification of this colourless acid by means of methyl-alcoholic sulphuric acid or by means of diazomethane in ethereal solution afforded the yellow *methyl* ester (probably XXI, R = H). Diazomethane acting on a methyl-alcoholic solution of the acid gave a yellow *dimethyl* derivative (probably XXI, R = Me) in which the occurrence of NMe was demonstrated. The *diacetyl* derivative of (XX) is a colourless substance. The ring closure of (XX) was first accomplished by successive treatment of the diacetyl derivative with thionyl chloride and aluminium chloride, and dimethylepindolidione (XXII) was obtained in the course of these experiments. The most satisfactory method is, however, to boil the acid (XXI), its methyl ester or its diacetyl derivative with 60% sulphuric acid ; the change then proceeds smoothly.

 (XXII.)

4 : 10-Dimethylepindolidione is an infusible crystalline yellow substance, best purified by sublimation, possessing weakly basic and acidic properties. It resembles a complex acridone and is more closely characterised in the experimental section.

Experimental.

Ethyl Isatin-N-*acetate*.—A suspension of isatin (24 g.) in absolute ethyl alcohol (96 c.c.) was added to a solution of sodium ethoxide prepared from sodium (3·2 g.) and absolute ethyl alcohol (64 c.c.). After filtration, the residue was washed with benzene and added to a solution of ethyl bromoacetate (22·5 g.) in dry benzene (140 c.c.). The reaction mixture was frequently shaken and kept for 12 hours. The residue, after filtration, was washed with water; it crystallised from ethyl alcohol in golden-yellow needles (11·7 g.), m. p. 129—130° (Found : C, 62·0; H, 4·8; N, 6·0. Calc. for $C_{12}H_{11}O_4N$: C, 61·8; H, 4·9; N, 6·0%).

Putochin (*J. Russ. Phys. Chem. Soc.*, 1928, **60**, 1179; *Centralblatt*, 1929, I, 998) obtained isatin-*N*-acetic ester by treating sodio-isatin with ethyl chloroacetate in dry benzene solution and described this substance as orange-coloured needles, m. p. 114°. We have been unable to reproduce these results, probably through some variation in the conditions employed.

Several attempts were made to effect the isomerisation of isatin-*N*-acetic ester with formation of 2-carbethoxy-3 : 4-dihydroxyquinoline by treatment with alcoholic sodium ethoxide but without success. None of the products obtained gave a positive ferric reaction.

Isatin-N-*acetic Acid*.—The dark reddish-brown solution of isatin-*N*-acetic ester (6·4 g.) in ethyl alcohol (70 c.c.) and aqueous sodium hydroxide (60 c.c. of 10%) became pale yellow in about 2 minutes. After acidification with hydrochloric acid, the reaction mixture was cooled and the product collected (5·7 g.) ; it crystallised from hot water in long reddish-orange needles, m. p. 206—207° (Found : C, 53·5; H, 4·2; N, 6·0; loss at 110°, 9·0. Calc. for $C_{10}H_7O_4N,H_2O$: C, 53·8; H, 4·0; N, 6·3; H_2O, 8·0%. Found in dried material : C, 58·8; H, 3·6; N, 7·0. Calc. for $C_{10}H_7O_4N$: C, 58·5; H, 3·4; N, 6·8%).

This product was found to be identical with that obtained by Langenbeck (*Ber.*, 1928, **61**, 942) by the interaction of chloroacetic acid and isatin in the presence of sodium carbonate (m. p. and mixed m. p. 206—207°).

Isatin-*N*-acetic acid (1 g.) and thionyl chloride (10 c.c.) were refluxed for 3 hours, giving an orange-red solution. The excess of thionyl chloride was removed and, on cooling, an orange solid was obtained, m. p. 139—140° with previous softening. This isatin-*N*-acetyl chloride was condensed with aceto-*p*-toluidide in carbon disulphide solution in the presence of aluminium chloride, but no satisfactory product of the reaction other than unchanged isatin-*N*-acetic acid could be isolated.

Isatylideneacetophenone Oxide (IV).—(A) A solution of sodium (0·8 g.) in ethyl alcohol (16 c.c.) was added to isatin (6 g.) suspended in ethyl alcohol (24 c.c.) and the mixture was well

shaken and kept for 30 minutes; the alcoholic liquors were then decanted, and the residue washed twice with alcohol by decantation. A solution of phenacyl bromide (7·3 g.) in benzene (70 c.c.) was added to the alcohol-moist sodio-isatin and the reaction mixture was well shaken for 30 minutes at room temperature, its colour gradually changing to buff-brown and sodium bromide separating. After 12 hours, the solution was filtered and mixed with a large excess of light petroleum (b. p. 40—60°), precipitating a thick oily paste which slowly solidified.

Crystallisation of this material from alcohol afforded clusters of fine colourless needles, m. p. 205° (decomp.) (Found : C, 75·6; H, 5·0; N, 3·4%). These analytical figures do not correspond to any anticipated product of the reaction; they indicate the composition $C_{16}H_{14}O_2,2C_{16}H_{11}O_3N$, which requires C, 75·0; H, 4·7; N, 3·6%.

The benzene–light petroleum mother-liquors were concentrated, and the residual varnish rubbed with aqueous alcohol; a solid substance then separated. Many recrystallisations from light petroleum (b. p. 100—120°)–ethyl alcohol gave a product, m. p. 161—162°, which occurred in almost colourless, hexagonal plates (Found : C, 69·8; H, 5·3; N, 4·9. $C_{16}H_{11}O_3N,C_2H_5{\cdot}OH$ requires C, 69·5; H, 5·5; N, 4·5%). The alcohol cannot be removed by drying and is probably added to the oxide ring of (IV). Treatment with aqueous sodium hydroxide gave benzoylformyloxindole (below) and ethyl alcohol (recognised).

(B) A solution of sodium (3·2 g.) in absolute alcohol (64 c.c.) was added to isatin (24 g.) suspended in absolute ethyl alcohol (96 c.c.), the mixture being well shaken to avoid caking. The violet-black sodio-isatin was collected, well washed with alcohol and finally with benzene until the washings were colourless, and added to a solution of phenacyl bromide (28 g.) in benzene (200 c.c.); the solution became warm. The whole was shaken vigorously for 30 minutes and kept for 23 hours at room temperature; sodium bromide then slowly separated together with a pale yellow crystalline solid.

The residue obtained after filtration was thoroughly washed with water; it crystallised from benzene in thick, pale yellow prisms (14 g.), m. p. 161·5—162° (Found : C, 72·3; H, 4·4; N, 5·0. $C_{16}H_{11}O_3N$ requires C, 72·5; H, 4·2; N, 5·3%). A further quantity was isolated from the benzene mother-liquors in the form of the compound with ethyl alcohol. This substance (or the alcohol addition compound) is reduced by zinc dust, in alkaline solution or in presence of dilute hydrochloric acid, with the formation of acetophenone in larger relative amount than from benzoylformyloxindole under similar conditions. The reduction and formation of acetophenone may also be accomplished by alkaline hydrosulphite. The ferric reaction in alcoholic solution is entirely negative.

Benzoylformyloxindole (IV).—A solution of sodium hydroxide (50 c.c. of 10%) was added to a suspension of isatylideneacetophenone oxide (5·7 g.) in alcohol (100 c.c.); the solid rapidly dissolved to a dark brown solution, which was boiled for 30 seconds, cooled, diluted with an equal volume of water, and acidified with hydrochloric acid. A bright yellow crystalline precipitate separated (5·05 g.), and this crystallised from glacial acetic acid in yellow-orange clusters of chisel-shaped prisms, m. p. 178·5—179·5° (Found : C, 72·5; H, 4·3; N, 5·4. $C_{16}H_{11}O_3N$ requires C, 72·5; H, 4·2; N, 5·3%). This substance is insoluble in cold aqueous sodium carbonate but dissolves on heating to a pale yellow solution; its solution in cold aqueous sodium hydroxide is paler yellow than the intensely yellow alcoholic solution. Addition of ferric chloride to an alcoholic solution gives a deep green coloration which rapidly darkens to an opaque greenish-black colour; on addition of water a greenish-black precipitate is thrown down. The pale yellow solution in sulphuric acid becomes orange and then bright red on heating.

On coupling with *p*-nitrobenzenediazonium or *p*-toluenediazonium salts in alkaline solution, orange and yellow alkali-insoluble azo-compounds were produced respectively. The substance was not readily oxidised by hydrogen peroxide in acetic acid or aqueous alkaline solution, and when heated with concentrated aqueous potassium or sodium hydroxide it was unchanged in a short time; sparingly soluble salts separated.

The oxime was prepared for comparison with the phenylhydrazone; it is pale yellow and soluble in aqueous sodium carbonate.

The *phenylhydrazone* (X ?) was prepared by gently warming a solution of the components in acetic acid for a few minutes until the orange-red tone of the solution had given place to a pure permanganate red. Alcohol was then added, and the derivative separated in reddish-mauve plates which were recrystallised from acetic acid–alcohol in the same form (Found : C, 74·2; H, 4·8; N, 11·9. $C_{22}H_{17}O_2N_3$ requires C, 74·4; H, 4·8; N, 11·8%). On heating, the substance shrinks at 160° and at 165° collapses with decomposition to an opaque viscous tar which even appears to harden on further heating and eventually softens above 240° but is not

transparent at 340°. The remarkable properties mentioned in the introduction are connected with the existence of differently coloured modifications, of which there must be at least three, namely yellow, blue or violet, and colourless. Solutions in benzene are almost colourless when hot (pale greenish-yellow if concentrated) and become pale bluish-green on cooling; the mauve-red substance then crystallises from the solution.

Solutions in carbon tetrachloride or ethyl ether are also nearly colourless. Solutions in methyl alcohol are violet-red; in ethyl alcohol, reddish-violet; in *iso*amyl alcohol, much bluer-violet; in *cyclo*hexanol, almost blue. These colorations are very intense and are produced on the addition of the appropriate solvent to one of the nearly colourless solutions, for example, in benzene. The solution in pyridine is yellow and on dilution with the alcohols the series is moved to the red; thus pyridine–*iso*amyl alcohol is similar to ethyl alcohol alone. Ethyl amyl ether and anisole give pale yellow solutions and addition of water or dilute mineral acid to any solution (miscible solvent) gives a yellow coloration. The solution in hot ethyl acetate is yellowish-green and becomes bluer and more intense on cooling; crystallisation then occurs and the solution becomes pale yellow as the mauve-red substance separates. The cold solution in ethyl acetoacetate is greenish-blue and it seems possible that the new phenylhydrazone may be of utility in the future as a reagent for the study of tautomerism. The solution in benzene exhibits a violet-blue fluorescence. Analogous substances are being prepared and an attempt will be made to determine the constitution of the compound now described as well as to elucidate the cause of its curious behaviour.

Condensation of Isatylideneacetophenone Oxide with o-*Phenylenediamine.*—A mixture of isatylideneacetophenone oxide (1 g.), *o*-phenylenediamine (0·9 g.), acetic acid (15 c.c.), and alcohol (10 c.c.) was heated on the steam-bath (reflux) for 10 hours and then cooled. A buff-yellow solid, precipitated by the addition of water, crystallised from ethyl alcohol in pale brownish-yellow, long, thin, rectangular plates, m. p. 200—201° (Found : C, 75·1; H, 5·4; N, 11·1. $C_{24}H_{21}O_2N_3$ requires C, 75·2; H, 5·5; N, 10·9%). The constitution (XI) suggested for this substance is based on the analytical results and the qualitative recognition of the presence of an ethoxyl group.

Condensation of Benzoylformyloxindole and o-*Phenylenediamine.*—A mixture of benzoylformyloxindole (0·5 g.), *o*-phenylenediamine (0·4 g.), acetic acid (7 c.c.), and alcohol (7 c.c.) was gently boiled; the colour gradually changed to crimson and dark maroon-brown needles separated. The substance crystallised from *iso*amyl alcohol in a similar form, m. p. 255° (Found : C, 78·0; H, 4·5; N, 12·5. $C_{22}H_{15}ON_3$ requires C, 78·3; H, 4·4; N, 12·5%). This derivative is evidently formed from its generators with the elimination of $2H_2O$ and it has therefore the composition of the expected oxindylphenylquinoxaline. The variation (XII) is suggested in order to account for the colour of the base and its other somewhat anomalous behaviour. The solution in concentrated hydrochloric acid is deep bluish-green (artificial light) and on dilution with water the colour is discharged; on neutralisation the unchanged base is precipitated. The solution in *iso*amyl alcohol is dark maroon in colour.

Mandeloyloxindole (IX).—When isatylideneacetophenone oxide was reduced by zinc dust and hot aqueous sodium hydroxide, acetophenone was liberated; acidification of the alkaline solution gave a voluminous crystalline precipitate. This substance crystallised from benzene in clusters of colourless needles, m. p. 164—165° (Found in material dried at 105° : C, 71·7; H, 5·0; N, 5·0. $C_{16}H_{13}O_3N$ requires C, 71·9; H, 4·9; N, 5·2%). The same substance was obtained in somewhat improved yield (0·65 g.) and with formation of much less of the by-product, acetophenone, from benzoylformyloxindole (1·0 g.), aqueous sodium hydroxide (25 c.c. of 10%), and zinc dust (1·0 g.) after boiling for 15 minutes.

Like benzoylformyloxindole, this substance is very stable towards hot 40% aqueous sodium hydroxide; it is not decomposed in a short time at the boiling point and a sparingly soluble sodium salt separates. On the addition of ferric chloride to an alcoholic solution an intense bluish ivy-green coloration is developed; in aqueous solution the ferric reaction is blackish-violet. On boiling with concentrated hydrochloric acid and acetic acid, decomposition occurs with the formation of amorphous, sparingly soluble material.

The evidence for the existence of the tautomeric enolisable system is strengthened by the observation that the substance couples with diazonium salts, including diazobenzenesulphonic acid, to yellow, orange or red azo-compounds which give benzaldehyde on heating in alkaline solution. Another reaction of a similar kind is the following. Bromine, added to a weakly alkaline solution of the substance, gives a colourless precipitate; on the addition of sodium hydroxide the odour of benzaldehyde is perceptible and becomes strong on heating.

It is remarkable that this substance is stable to Fehling's reagent even on boiling; at first

this was held to be evidence against the suggested formula, but there appears to be no plausible alternative and owing to enolisation the characteristic reducing group may be absent.

Hydrolysis of Benzoylformyloxindole by Aqueous Sodium Hydroxide.—A solution of benzoylformyloxindole (3·5 g.) in aqueous sodium hydroxide (35 c.c. of 10%) was refluxed for 6 hours; the ferric reaction of a neutralised sample was then found to be negative. The yellow solution was acidified with hydrochloric acid and extracted with ether. The ethereal solution was washed with water and then with aqueous sodium carbonate, causing the separation of a considerable amount of a sparingly soluble sodium salt in pale yellow leaflets. This was collected and the aqueous alkaline filtrate was acidified with hydrochloric acid; a small amount of oil then separated, but nothing of a crystalline nature could be isolated (in preliminary experiments). Accordingly phenylhydrazine was added, giving a rapid crystallisation of the phenylhydrazone of benzoylformic acid; this crystallised from aqueous alcohol and from benzene in pale yellow needles, m. p. 164—164·5° with evolution of gas (Found : C, 69·9; H, 5·1; N, 11·9. Calc. for $C_{14}H_{12}O_2N_2$: C, 70·0; H, 5·0; N, 11·7%). A specimen prepared from benzoylformic acid had the same m. p. and mixed m. p. A very small quantity of an unidentified crystalline substance, possibly a hydroxyquinoline derivative, remained in the ethereal solution. The sparingly soluble sodium salt was converted into an acid, which crystallised from acetic acid in almost colourless prismatic needles, m. p. 230—231° (decomp.) (Found : C, 72·3; H, 4·2; N, 5·3. $C_{16}H_{11}O_3N$ requires C, 72·5; H, 4·1; N, 5·3%). This acid is sparingly soluble in most organic solvents and it gives no ferric reaction in alcoholic solution.

The composition suggested a hydroxyphenylquinolinecarboxylic acid, and Dr. R. C. Shah kindly gave us a specimen of 4-hydroxy-2-phenylquinoline-3-carboxylic acid which did not prove to be identical with our acid. An isomeride, namely, 3-hydroxy-2-phenylquinoline-4-carboxylic acid, has been obtained by John (*J. pr. Chem.*, 1932, **133**, 259) from the initial materials of the present investigation, namely, from isatin and phenacyl bromide, by the agency of aqueous potassium hydroxide at 100°. The process has only a superficial resemblance to our series, as it is essentially a Pfitzinger reaction and the isatin is surely converted into potassium isatinate at an early stage. The same acid has been obtained by Bargellini and Berlingozzi (*Gazzetta*, 1923, **53**, 3, 369) starting with isatin and phenacylphthalimide; it has m. p. 207° and is not identical with our substance. The most probable constitutions on the quinoline basis were thus excluded and it then occurred to us that the substance might be 2-benzoylindole-3-carboxylic acid (VIII). Although we are unable to prove this rigidly, yet the formation of indole on fusion with potassium hydroxide may be accepted as strong confirmatory evidence; the indole was recognised by odour and by the usual unmistakable colour reactions.

Hydrolysis of Benzoylformyloxindole by Acids.—Benzoylformyloxindole (2 g.) was refluxed with a mixture of acetic acid (20 c.c.) and concentrated hydrochloric acid (20 c.c.) for 2 hours. The product was diluted, neutralised with ammonia, and extracted with ether. The ethereal solution was washed successively with dilute aqueous sodium carbonate, aqueous sodium hydroxide, dilute hydrochloric acid and water, then dried and evaporated. The oily residue soon crystallised (0·6 g.) and was identified with oxindole, m. p. 120° after recrystallisation from water (Found : C, 72·1; H, 5·3. Calc. for C_8H_7ON : C, 72·2; H, 5·3%). The m. p. was not depressed on admixture with an authentic specimen.

Isatylidene-o-nitroacetophenone Oxide.—(It may be mentioned here that various attempts to condense *o*-nitrophenacyl bromide with methyl anthranilate and even with aniline met with no success.) A suspension of isatin (12 g.) in absolute ethyl alcohol (48 c.c.) was added to a solution of sodium ethoxide prepared from sodium (1·6 g.) and absolute ethyl alcohol (32 c.c.). The whole was vigorously shaken, filtered, and the residue washed twice with alcohol and finally with dry benzene until the washings were colourless. Whilst still moist with benzene, the sodio-isatin was added to a solution of *o*-nitrophenacyl bromide (15 g.) in dry benzene (100 c.c.), and the mixture well shaken and kept for 22 hours at room temperature. The residue obtained after filtration was extracted with water to remove sodium bromide and any unchanged isatin and sodio-isatin, and the insoluble portion crystallised from a mixture of equal volumes of benzene and ethyl alcohol (yield, 10·1 g.). The pale yellow prisms had m. p. 207—208° (decomp.) with slight previous softening; the actual decomposition point depended, to some extent, on the rate of heating (Found : C, 62·0; H, 3·4; N, 9·1. $C_{16}H_{10}O_5N_2$ requires C, 61·9; H, 3·2; N, 9·0%).

o-*Nitrobenzoylformyloxindole* (VI).—Aqueous sodium hydroxide (15 c.c. of 10%) was added to a suspension of isatylidene-*o*-nitroacetophenone oxide (3 g.) in ethyl alcohol (15 c.c.). The resulting dark brown solution was boiled for 30 seconds, cooled, diluted with water (50 c.c.), and acidified with hydrochloric acid. A bright orange-yellow solid, m. p. 237° (decomp.), separated, and this crystallised readily from acetic acid in orange-yellow prismatic needles, m. p. 239°

(decomp.), varying with the rate of heating. The yield was almost quantitative (Found: C, 62·0; H, 3·4; N, 9·0. $C_{16}H_{10}O_5N_2$ requires C, 62·0; H, 3·2; N, 9·0%). The substance is sparingly soluble in hot alcohol to a deep orange-yellow solution; in cold dilute alcohol solution the ferric reaction is an intense greenish-brown, blackish-brown on dilution with water. The orange-red solution in concentrated sulphuric acid becomes orange-yellow on gentle heating.

Indirubin (VII).—Without a clear understanding of the true mechanism of the formation of this substance a number of experiments were performed on the reduction of isatylidene-*o*-nitroacetophenone oxide which leads to the formation of indirubin under several sets of conditions. The yield is better when *o*-nitrobenzoylformyloxindole is reduced.

(A) Isatylidene-*o*-nitroacetophenone oxide (5 g.) was suspended in ethyl alcohol (50 c.c.), and concentrated aqueous ammonia (25 c.c., *d* 0·88) added, giving a dark brown solution, which was saturated with hydrogen sulphide at room temperature and kept for 12 hours prior to heating on the steam-bath for 15 minutes. A crystalline solid separated (0·6 g.), which crystallised from boiling nitrobenzene in dark reddish-purple needles, m. p. 345—347°. Sublimation commences at 330—335°, giving a red vapour (Found in material dried at 110° in a high vacuum over phosphoric oxide: C, 73·1; H, 3·7; N, 11·1. Calc. for $C_{16}H_{10}O_2N_2$: C, 73·3; H, 4·0; N, 10·7%).

The filtrate was diluted with water, reheated, and then cooled; amorphous flocks separated and on crystallisation from nitrobenzene gave a further crop of indirubin and, on long standing, a blue (? microcrystalline) solid which was not further examined.

(B) On gently heating a suspension of isatylidene-*o*-nitroacetophenone oxide with a mixture of zinc dust and aqueous ammonium chloride a gradual conversion into a crimson-purple precipitate occurred, but this was not indirubin.

Concentrated aqueous ammonia (*d* 0·88) was added drop by drop to a boiling suspension of isatylidene-*o*-nitroacetophenone oxide in aqueous ferrous sulphate. There was very little immediate reaction as shown by the green precipitate of ferrous hydroxide, but prolonged boiling gradually converted the green precipitate into a black deposit. Acidification with hydrochloric acid gave a suspension of a dark red-purple powder, which crystallised from nitrobenzene in very small needles, identical in appearance with the product previously obtained and showing the reactions of indirubin.

(C) *o*-Nitrobenzoylformyloxindole on reduction by a variety of methods furnishes indirubin. A hot alcoholic solution containing a few drops of concentrated hydrochloric acid was treated with an excess of zinc dust, boiled for a few seconds, and the clear liquid decanted. On distillation of the alcohol indirubin was formed (yield, 70%) and recognised by comparison with an authentic specimen.

In connection with the recognition of indirubin, the gradual formation of indigotin in the vat is useful; it may be added that its dilute amyl-alcoholic solution is permanganate-red and that characteristically coloured zones are produced when this solution is allowed to rest on concentrated sulphuric acid.

3-(o-*Carboxyphenylamino*)-4-*hydroxyquinoline* (XIV).—Condensation of *N*-benzoyl-4-ketotetrahydroquinoline (Clemo and Perkin, J., 1924, **125**, 1617) with *o*-nitrosobenzoic acid did not occur in acetic anhydride or hot acetic acid solution, but under the influence of aqueous alcoholic sodium hydroxide a small amount of the product described below was obtained. Better results followed from the employment of ethyl *o*-nitrosobenzoate, but here again a mixture of acetic acid and acetic anhydride was useless as a medium for the condensation.

(A) A mixture of ethyl *o*-nitrosobenzoate (1·0 g.) and *N*-benzoyl-4-ketotetrahydroquinoline (1·5 g.; 1 mol.) was heated at 100° for 25 minutes; it fused to a green liquid which gradually became brown. After cooling, the reaction product was stirred with alcohol; the solid obtained (1·2 g.) crystallised from ethyl alcohol in needles, m. p. 99·5—100·5° (depressed on admixture with either of the reactants) (Found: C, 67·3; H, 5·3; N, 7·2. $C_{22}H_{20}O_5N_2$ requires C, 67·3; H, 5·1; N, 7·1%). The formula cited does not conform with anticipated products.

This substance is freely soluble in benzene, sparingly soluble in light petroleum, insoluble in aqueous acids and alkalis; it dissolves in boiling water, a white solid, m. p. 106—109°, separating on cooling, the m. p. being only a little depressed on admixture with ethyl *o*-nitrosobenzoate. On solution in benzene and addition of light petroleum (b. p. 40—60°) a pale buff crystalline solid was deposited, m. p. 99—100° to a green liquid. This substance gave an intense green coloration with concentrated sulphuric acid and phenol and apparently contains a nitroso-group.

(B) A mixture of *N*-benzoyl-4-ketotetrahydroquinoline (2 g.), ethyl *o*-nitrosobenzoate (1·4 g.), ethyl alcohol (40 c.c.), and sodium carbonate (2 g.) was refluxed for 11 hours and kept at room temperature overnight. The separated solid product was washed with dilute hydro-

chloric acid in order to remove sodium carbonate; it then crystallised from acetic acid in colourless prismatic needles (0·3 g.), m. p. 253·5—254° (Found: C, 69·5; H, 4·4; N, 9·5. $C_{18}H_{16}O_3N_2$,$C_{16}H_{12}O_3N_2$ requires C, 69·4; H, 4·7; N, 9·5%). This substance is evidently a *compound* of the acid and its ester described below.

The acetic acid mother-liquors were diluted with water and the precipitate was stirred with sodium carbonate solution and filtered. The insoluble neutral portion crystallised from ethyl alcohol in clusters of colourless prismatic needles, m. p. 274·5—275°, and consisted of 3-o-*carbethoxyphenylamino*-4-*hydroxyquinoline* (Found: C, 70·1; H, 5·2; N, 8·8. $C_{18}H_{16}O_3N_2$ requires C, 70·1; H, 5·2; N, 9·1%).

Acidification of the sodium carbonate extract with acetic acid precipitated 3-o-*carboxyphenylamino*-4-*hydroxyquinoline*, which crystallised from ethyl alcohol in long thin plates, m. p. 255° (decomp.) (Found: C, 68·5; H, 4·6; N, 9·9. $C_{16}H_{12}O_3N_2$ requires C, 68·6; H, 4·3; N, 10·0%).

The formation of ethyl benzoate was confirmed under the following conditions. A mixture of *N*-benzoyl-4-ketotetrahydroquinoline (2 g.), *o*-nitrosobenzoic ester (1·4 g.), absolute alcohol (40 c.c.), and anhydrous potassium carbonate (2 g.) was refluxed for 2½ hours, although the reaction appeared to be completed in a few minutes as indicated by the immediate separation of a yellow solid and the development of an orange-brown solution and no detectable subsequent change. The alcoholic filtrate had a strong odour of ethyl benzoate, and this substance was isolated by means of ether and later by extraction with light petroleum. On hydrolysis it afforded benzoic acid (0·2 g.). The ring closure of the acid (XIV) was attempted under varied conditions such as heating at 260°, boiling with acetic anhydride, heating with acetic anhydride and sulphuric acid, keeping a mixture with fuming sulphuric acid (20% oleum) at room temperature, successive treatment with thionyl chloride and stannic chloride, heating with stannic chloride, heating with zinc chloride and heating with phosphoryl chloride, but in no case did the reaction succeed. In the light of our later acquired knowledge of the properties of dimethylepindolidione, some of these experiments were repeated, but no trace of epindolidione was isolated. On boiling with 60% sulphuric acid the yellow solution became crimson (green in thin layers) and then dull, intense green.

2-o-*Carbethoxyphenylamino*-α-*naphthaquinone* (XV).—A mixture of α-tetralone (2 g.), ethyl *o*-nitrosobenzoate (2·45 g.), potassium carbonate (2 g.), and ethyl alcohol (40 c.c.) was refluxed for 2 hours. The solids were collected, shaken with water (20 c.c.), then filtered (A), and washed until the filtrate was colourless. The dark green residue (0·7 g.) dissolved partly in hot acetic acid, and the solution deposited dark green needles, m. p. above 280° (Found: C, 69·4; H, 4·5; N, 4·3. $C_{19}H_{15}O_4N$,0·5H_2O requires C, 69·1; H, 4·8; N, 4·2%). Acidification of the filtrate (A) with hydrochloric acid gave a dark red-purple precipitate (0·5 g.), which crystallised from acetic acid in slender maroon needles, m. p. 244° (decomp.). This was identical with the main product of a previous experiment in which sodium carbonate was used as condensing agent (Found: C, 64·6; H, 4·4; N, 6·5. $C_{24}H_{16}O_5N_2$,2H_2O requires C, 64·3; H, 4·5; N, 6·3%). The substance is acidic and gives a yellow vat with alkaline sodium hydrosulphite. Its alkaline solutions are blood-red and the solution in sulphuric acid is intense dull crimson.

ω-*Chloro*-2-*ethoxalylamino*-5-*methylacetophenone* (XVIII).—ω-Chloro-2-amino-5-methylacetophenone (Kunckel, *Ber.*, 1900, **33**, 2647) (13·6 g.) was dissolved in boiling ether (1 l.), and ethoxalyl chloride (11·6 g.; 1 mol.) slowly added in small amounts at a time and with good shaking. The mixture was kept for 1 hour and filtered, and the ether distilled. The residue of ω-*chloro*-2-*ethoxalylamino*-5-*methylacetophenone* (16·4 g.) crystallised from ethyl alcohol in long, thin, monoclinic plates, m. p. 144—144·5° (Found: C, 54·9; H, 5·1; N, 5·1. $C_{13}H_{14}O_4NCl$ requires C, 55·0; H, 5·0; N, 5·0%).

p-*Tolylamino*-2-*ethoxalylamino*-5-*methylacetophenone* (XIX).—Sodium iodide (4 g.; 1 mol.) was dissolved in acetone (70 c.c.), ω-chloro-2-ethoxalylamino-5-methylacetophenone (6·4 g.) added, and the mixture shaken until the separation of sodium chloride appeared to be complete. After the addition of *p*-toluidine (5·0 g.; 2 mols.), the mixture was refluxed for 10 minutes, the liquid becoming brown with the separation of an orange-yellow solid. The brown oil which separated on pouring into water (200 c.c.) gradually solidified; crystallisation of this product from ethyl alcohol gave ω-p-*tolylamino*-2-*ethoxalylamino*-5-*methylacetophenone* (2·5 g.), which crystallised from ethyl alcohol in clusters of yellow needles, m. p. 140·5—141° (Found: C, 67·9; H, 6·4; N, 7·7. $C_{20}H_{22}O_4N_2$ requires C, 67·8; H, 6·2; N, 7·9%).

2-*Carboxy*-3-p-*tolylamino*-4-*hydroxy*-6-*methylquinoline* (XX).—Aqueous sodium hydroxide (6·0 c.c. of 40%) was added to a suspension of ω-*p*-tolylamino-2-ethoxalylamino-5-methylacetophenone (2·4 g.) in a boiling mixture of ethyl alcohol (70 c.c.) and water (35 c.c.), and the mixture was refluxed for 2 hours. Addition of the caustic soda solution caused the production of an

orange-red tinge which rapidly disappeared with the development of a yellowish-green colour. After evaporation of the alcohol the residue was cooled, a little tar removed, and the filtrate just acidified with hydrochloric acid; a bright yellow solid was first precipitated, but this soon became pale yellowish-grey (1·9 g.). 2-*Carboxy*-3-p-*tolylamino*-4-*hydroxy*-6-*methylquinoline* crystallised from aqueous acetic acid in long, thin, colourless plates, m. p. 237—238° (decomp.) (Found : C, 70·1; H, 5·2; N, 9·4. $C_{18}H_{16}O_3N_2$ requires C, 70·1; H, 5·2; N, 9·1%). A brown coloration is developed on the addition of ferric chloride to an alcoholic solution.

2-*Carbomethoxy*-3-p-*tolylamino*-4-*keto*-6-*methyl*-1 : 4-*dihydroquinoline* (XXI, R = H).—(A) 2-Carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline (0·5 g.) along with methyl alcohol (20 c.c.) containing 10% by weight of concentrated sulphuric acid was refluxed for 1¼ hours; it then dissolved rapidly to a dark brown solution. The greater part of the methyl alcohol was evaporated, the residue cooled, and water (2 vols.) added, a yellowish-brown solid being deposited. Crystallisation from methyl alcohol afforded small, bright yellow plates, m. p. 230° (decomp.) (0·3 g.) (Found : C, 71·0; H, 5·6. $C_{19}H_{18}O_3N_2$ requires C, 70·8; H, 5·6%).

The m. p. of this ester was not depressed in a mixture with the product obtained from the action of diazomethane on the acid in ethereal solution (see below), but was depressed to 215° in a mixture with the product obtained from the action of diazomethane in methyl alcohol.

Hydrolysis of the ester (0·1 g.) with boiling methyl alcohol (5 c.c.) and aqueous sodium hydroxide (5 c.c. of 10%) caused almost complete loss of the bright yellow colour; acidification of the cooled liquid with hydrochloric acid precipitated 2-carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline, m. p. and mixed m. p. 237—238° (decomp.).

(B) An ethereal solution of diazomethane (15 c.c. containing 0·35 g. CH_2N_2; 3 mols.) was added to a suspension of 2-carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline (0·75 g.) in dry ether (10 c.c.) with cooling in melting ice. Evolution of nitrogen occurred slowly and orange-coloured crystals were deposited; the reaction was complete after 22 hours. 2-*Carbomethoxy*-3-p-*tolylamino*-4-*keto*-6-*methyl*-1 : 4-*dihydroquinoline* (0·57 g.) was obtained; it crystallised from aqueous methyl alcohol in long, thin, bright orange, monoclinic prisms, m. p. 227—228° (decomp.) (Found : C, 70·2; H, 5·7; N, 8·6; MeO, 10·3; MeN, 0·0. $C_{19}H_{18}O_3N_2$ requires C, 70·8; H, 5·6; N, 8·7; MeO, 9·9%). This ester was insoluble in dilute aqueous sodium hydroxide and gave no ferric reaction in alcoholic solution.

(C) A solution of diazomethane (from 2 g. of nitrosomethylurethane; *ca.* 3 mols.) in ether was slowly added to a suspension of 2-carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline (1 g.) in absolute methyl alcohol (25 c.c.). Vigorous evolution of nitrogen occurred during the addition, together with almost complete solution of the acid. After keeping for 3½ hours at room temperature the yellow solid (0·35 g.) was collected and after crystallisation from methyl alcohol proved to be identical with the ester obtained in the previous preparations. The ethereal methyl-alcoholic filtrate was concentrated to a small bulk; small ochre-yellow prisms then separated (*ca.* 0·05 g.). This substance was freely soluble in methyl and ethyl alcohols and in chloroform; it was soluble in hot benzene but sparingly soluble in the cold solvent, crystallising in short, thick, ochre-yellow prisms, m. p. 246° (Found: C, 71·2; H, 6·1. $C_{20}H_{20}O_3N_2$ requires C, 71·4; H, 6·0%). The presence of both methoxyl and methylimino-groups was demonstrated and thus it appears that this substance is 2-*carbomethoxy*-3-p-*tolylamino*-4-*keto*-1 : 6-*dimethyl*-1 : 4-*dihydroquinoline* (XXI, R=Me). It is insoluble in aqueous alkalis and gives no ferric reaction in alcoholic solution.

2-*Carboxy*-3-p-*tolylacetamido*-4-*acetoxy*-6-*methylquinoline*.—Acetyl chloride (2 c.c.) was gradually added to 2-carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline (2 g.) in pyridine (12 c.c.) with cooling when necessary; a pale brown solid separated. After keeping for 30 minutes at room temperature the mixture was added to an excess of dilute hydrochloric acid, the pale cream solid was collected, shaken for 3 hours with aqueous sodium carbonate solution, in which it dissolved very slowly, and filtered from a little brown insoluble material, and the filtrate acidified with dilute hydrochloric acid. The almost white solid which was precipitated was moderately readily soluble in hot ethyl alcohol and acetic acid and very sparingly soluble in the cold, but showed a tendency to separate in an amorphous form. Slow cooling of a solution in hot acetic acid furnished very small, short, colourless prisms (1·9 g.), m. p. 217° (decomp.) (Found : C, 65·8, 65·8; H, 5·4, 5·3; N, 7·2. $C_{22}H_{20}O_5N_2$,0·5H_2O requires C, 65·8; H, 5·5; N, 7·0%).

4 : 10-*Dimethylepindolidione* (XXII).—(A) Thionyl chloride (2 c.c.) was added to a suspension of 2-carboxy-3-*p*-tolylacetamido-4-acetoxy-6-methylquinoline (0·2 g.) in chloroform (5 c.c.); almost complete solution occurred in the cold and a small amount of a brown flocculent solid was formed. Gentle heating under reflux for 3 hours produced an intense green colour, which

gradually changed to dark brown. The excess of chloroform and thionyl chloride was evaporated in a vacuum, leaving a brown glassy residue which contained chlorine. This was dissolved in nitrobenzene (10 c.c.), aluminium chloride (0·5 g.) added, and the whole kept at room temperature for 24 hours, an intense red-brown coloration developing. Decomposition of the reaction mixture with ice and hydrochloric acid and removal of the nitrobenzene in steam left a dark brown, somewhat tarry residue, which, after extraction with warm ethyl alcohol, afforded a brick-red, nearly insoluble and infusible product. This material sublimed to give a dark brick-red microcrystalline sublimate (vapour also brick-red) with some decomposition (Found : C, 70·8; H, 4·8. $C_{22}H_{18}O_4N_2$ requires C, 70·6; H, 4·8%). It would appear that this substance is a *diacetyl* derivative of dimethylepindolidione.

(B) 2-Carboxy-3-*p*-tolylacetamido-4-acetoxy-6-methylquinoline (1·85 g.) was suspended in chloroform (30 c.c.), thionyl chloride (2 c.c.) added, and the whole heated on the steam-bath for 4 hours. Removal of the excess of thionyl chloride and chloroform in a vacuum gave a dark brown residue, which was dissolved in nitrobenzene (20 c.c.), aluminium chloride (1·5 g.) added, and the whole kept at room temperature for 18 hours. Decomposition of the reaction mixture with ice and hydrochloric acid and removal of the nitrobenzene in steam left an almost black, somewhat tarry, product which became brittle when cold. A brown product (0·95 g.), obtained after extraction of the tarry matter with hot ethyl alcohol, was completely insoluble in aqueous sodium carbonate and very sparingly soluble in the ordinary organic solvents, but it sublimed in brown plates (red tinge absent from this specimen). The greater part was sublimed at 270—300°/0·001 mm., giving a dark brown sublimate, maroon-red with a green reflex by transmitted light, which was not definitely crystalline under the microscope (Found : C, 68·4; H, 5·1; N, 8·6. $C_{20}H_{16}O_3N_2,H_2O$ requires C, 68·6; H, 5·1; N, 8·0%). The analyses in this case point to a hydrated *monoacetyl* derivative and it is reasonable to suppose that during the steam distillation an acetoxy-group suffered hydrolysis.

(C) The alcohol-insoluble residue obtained in (B) was suspended in 60% sulphuric acid (5 c.c.) and heated at 130° for 2 hours, the mixture diluted with water and filtered, and the product dried and sublimed under atmospheric pressure. This substance gave an orange-green vapour and sublimed in long, thin, rectangular plates, which were orange-brown by transmitted light and red-brown by reflected light (Found : C, 75·1; H, 5·0. $C_{18}H_{14}O_2N_2$ requires C, 74·5; H, 4·8%). The properties of this specimen agree closely with those of the specimens obtained as in (D), which we regard as the standard preparation. The slightly high value for the carbon content is doubtless due to carbonisation which cannot be entirely avoided at the high temperature required for sublimation.

(D) A mixture of 2-carboxy-3-*p*-tolylamino-4-hydroxy-6-methylquinoline (0·5 g.) and 60% sulphuric acid (10 c.c.) was boiled gently for 2—3 minutes and cooled. Bright yellow, minute, rectangular plates separated (0·35 g.) and the acid filtrate, diluted with water, deposited a brown precipitate (0·1 g.) which on sublimation gave pale yellow crystals identical with those that separated directly. The sublimed product was orange when hot and yellow when cold (Found : C, 74·9; H, 4·9; N, 9·8. $C_{18}H_{14}O_2N_2$ requires C, 74·5; H, 4·8; N, 9·7%).

(E) A mixture of 2-carboxy-3-*p*-tolylacetamido-4-acetoxy-6-methylquinoline (0·5 g.), sulphuric acid (5 c.c.), and water (5 c.c.) was boiled gently for 2—3 minutes. The almost colourless solution slowly became red with a green fluorescence and the odour of acetic acid was observed. The crystalline deposit that separated on cooling was collected and well washed with water and alcohol (yield, 0·34 g., and 0·1 g. on dilution of the mother-liquor) (Found : C, 72·6; H, 4·9; N, 9·4, 9·4. $C_{18}H_{14}O_2N_2,0{\cdot}5H_2O$ requires C, 72·3; H, 5·0; N, 9·3%). On sublimation in a high vacuum the yellowish-green vapour condensed in rectangular plates, which were orange when hot and bright yellow when cold (Found : C, 74·7; H, 5·0%). This sublimed product is identical with the similarly purified substance obtained as in (D), but the original material may contain some monoacetyl derivative. Thus the crude specimen obtained in this way showed one small divergence from that derived from the unacetylated acid; from acetic acid containing sulphuric acid it crystallised more readily and completely in clusters of microscopic prismatic needles. The question as to the content of acetylated substance must be left open.

4 : 10-*Dimethylepindolidione* is insoluble in boiling alcohol, *iso*amyl alcohol, ethyl acetate, benzene, acetic acid, acetone, nitrobenzene, and chlorobenzene and very sparingly soluble in boiling pyridine. It may be crystallised in yellow, fibrous, microscopic, prismatic needles by extraction with pyridine in a Soxhlet apparatus. It is sparingly soluble in boiling quinoline and separates on cooling in minute, brownish-yellow, thin, rectangular plates that show characteristic twinning with the formation of paddle-shaped aggregates.

The solution in alcoholic potassium hydroxide is yellow and exhibits an intense yellowish-green fluorescence; the potassium salt separates as a crimson powder when a hot saturated solution is cooled. On the addition of water the salt is completely hydrolysed and the original substance separates as a yellow precipitate. The salmon-red solution in sulphuric acid exhibits an intense green fluorescence. The basic properties are shown by increased solubility in acetic acid in the presence of sulphuric acid; the salt is at once decomposed on the addition of sufficient water. By using a little sulphuric acid, the mixed solvent may be employed for purposes of recrystallisation, the orange-yellow microscopic plates being washed with acetic acid and alcohol and dried at 130° (Found : C, 74·6; H, 5·0%). The substance cannot be reduced by means of alkaline hydrosulphite even in the presence of pyridine or alcohol.

The addition of zinc dust to a boiling suspension in pyridine–acetic acid induces solution and decolorisation; the liquid quickly becomes brownish-orange with a green fluorescence on exposure to air and acidification with hydrochloric acid produces a bright red coloration. If the liquid is acidified before aeration, no such coloration is produced.

Further experiments in this field are in progress.

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