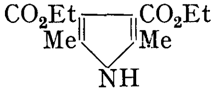
188. *Phthalocyanines. Part X. Experiments in the Pyrrole,* iso*Oxazole, Pyridazine, Furan, and Triazole Series.*

By J. A. Bilton and R. P. Linstead.

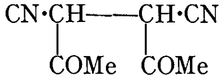
The object of this investigation and the theoretical ideas underlying it are outlined in the preceding paper. Its general result was that no phthalocyanine-like pigment was obtained in any of the five series investigated. In some cases this appears to be a genuine negative and in agreement with theory; in others the result is inconclusive, as suitably close intermediates could not be prepared. In the course of the work a striking difference was observed between the ease with which various heterocyclic *o*-dicarboxylic esters could be converted into the corresponding amides. Amides were readily formed from esters derived from pyridine (preceding paper; Engler, *Ber.*, 1894, **27**, 1788; compare Blumenfeld, *Monatsh.*, 1895, **16**, 700), pyrazine (Gabriel and Sonn, *Ber.*, 1907, **40**, 4850), pyridazine and *iso*oxazole (this paper), but not from the corresponding derivatives of pyrrole, and the conditions necessary for the formation of amides from furan esters are extremely drastic (p. 928). The explanation for this is not apparent.

Derivatives of 2 : 5-*Dimethylpyrrole*-3 : 4-*dicarboxylic Acid.*—Attempts to prepare the diamide of this acid from the corresponding readily accessible ethyl ester (I), with the object of dehydrating it to the dinitrile by the usual methods, were frustrated by the remarkable inertia of the ester towards ammonia; the diamide also could not be obtained through the acid chloride. Preparation through the imide was out of the question, as anhydrides of pyrrole-*o*-dicarboxylic acids are difficult to prepare, owing to the ease of decarboxylation, and imides are apparently unknown. The methods successful in the aromatic and in other heterocyclic series (Part IX) were thus useless.

It appeared possible that diacetylsuccinonitrile (II) might be easily prepared from cyanoacetone in the same way as diacetylsuccinic ester from acetoacetic ester. It was then hoped to convert it, by condensation with ammonia in the usual Paal–Knorr manner, into 3 : 4-dicyano-2 : 5-dimethylpyrrole (III).

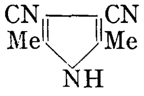


(I.)



$$\begin{matrix} \mathrm{CN\cdot CH} & \text{——} & \mathrm{CH\cdot CN} \\ | & & | \\ \mathrm{COMe} & & \mathrm{COMe} \end{matrix}$$

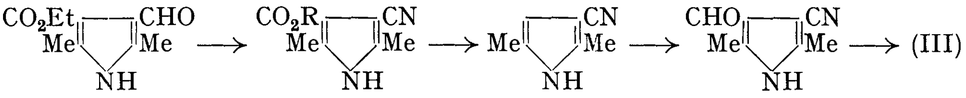
(II.)



(III.)

We were unable, however, to prepare (II) by the interaction of the sodio-compound of cyanoacetone with either iodine or *bromocyanoacetone.* Neither could the pyrrole derivative be obtained by direct condensation of cyanoacetone, bromocyanoacetone, and ammonia.

Finally we found that the method used by Fischer and Rothemund (*Ber.*, 1930, **63**, 2255) for the preparation of 3 : 5-dicyano-2 : 4-dimethylpyrrole could be successfully applied to the formation of the isomeric compound (III), in which the cyano-groups are adjacent. The method is outlined in the scheme :

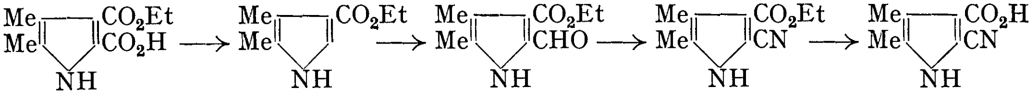


(IV.) (V.) (VI.) (VII.)

Ethyl 3-formyl-2 : 5-dimethylpyrrole-4-carboxylate (IV) and its oxime were prepared from Hantzsch's ethyl 2 : 5-dimethylpyrrole-3-carboxylate by Fischer and Zerweck's method (*Ber.*, 1922, **55**, 1947; 1923, **56**, 524). Dehydration of the oxime yielded ethyl 3-cyano-2 : 5-dimethylpyrrole-4-carboxylate (V, R = Et), which, like the corresponding diester (I), failed to yield an amide when heated under pressure with ammonia. Decarboxylation of the *acid* obtained by hydrolysis (V, R = H) readily yielded 3-*cyano*-2 : 5-*dimethylpyrrole* (VI). This, by the Fischer–Zerweck modification of Gattermann's method, gave 4-*formyl*-3-*cyano*-2 : 5-*dimethylpyrrole* (VII). The yield of the latter was good and the 3-cyano-group thus has no inhibiting effect on the reaction. It is shown later that a 2-cyano-group, on the other hand, inhibits the introduction of a 3-formyl group by the same method. The *oxime* of the aldehyde (VII) gave an excellent yield of 3 : *4-dicyano-2 : 5-dimethylpyrrole* (III) on dehydration.

This dinitrile yielded no phthalocyanine-like pigment when treated with metallic reagents under the usual conditions. Its constitution was confirmed by conversion into the cyano-ester (V, R = Et) by alcoholic acid.

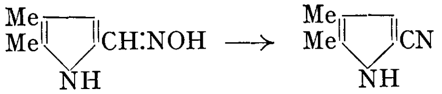
Derivatives of 2 : *3-Dimethylpyrrole-4* : *5-dicarboxylic Acid.*—For the preparation of the dinitrile of this acid, the most suitable method appeared to be the introduction of a formyl group into 2 : 3-dimethyl-4- or -5-cyanopyrrole, followed by dehydration of the corresponding oxime. The first method attempted is outlined below :



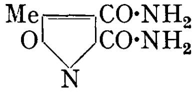
(VIII.) (IX.) (X.) (XI.) (XII.)

Ethyl hydrogen 2 : 3-dimethylpyrrole-4 : 5-dicarboxylate (VIII) (Piloty and Wilke, *Ber.*, 1912, **45**, 2586) was decarboxylated to (IX), and this was converted into the 5-aldehyde (X) and 5-aldoxime (Fischer and Beller, *Annalen*, 1925, **444**, 244). The latter on dehydration yielded the *cyano-ester* (XI) and thence by hydrolysis *5-cyano-2 : 3-dimethylpyrrole-4-carboxylic acid* (XII). At this stage the method broke down unexpectedly, as it was not found possible to decarboxylate (XII) to the corresponding mononitrile (XIII).

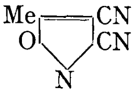
The mononitrile was, however, successfully prepared by converting the acid ester (VIII) into 2 : 3-dimethylpyrrole by Fischer and Nüssler's method (*Annalen*, 1931, **491**, 168), an α-formyl group being introduced in the usual way, and the corresponding oxime (XIV) dehydrated. We were unable to effect the introduction of the β-formyl group by Gattermann's reaction into either the nitrile (XIII), the oxime (XIV), or the corresponding 5-aldehyde.



(XIV.) (XIII.)



(XV.)

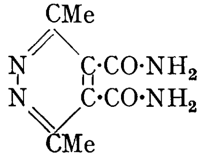


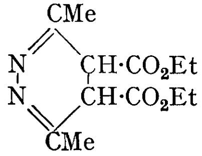
(XVI.)

iso*Oxazole Group.*—The researches of various Italian workers indicated that amides and nitriles of the *iso*oxazole series, unlike their pyrrole analogues, could be prepared by conventional methods (*Gazzetta*, 1915, **45**, i, 362; 1921, **51**, ii, 229; 1929, **59**, 930; 1932, **62**, 436). No diamides or dinitriles were known, but ethyl 5-methyl*iso*oxazole-3 : 4-dicarboxylate, which can be obtained from diacetylsuccinic ester, was a convenient starting material. This ester readily gave the corresponding *diamide* (XV) on treatment with ammonia, and thence by fusion with phosphoric oxide 3 : *4-dicyano-5-methyl*iso*oxazole* (XVI). The structure of this followed from its reconversion into the original diester with alcoholic hydrogen chloride. The dinitrile was hydrolysed by cold aqueous alkali with extraordinary ease into the corresponding *cyanoamide* (either 3 : 4- or 4 : 3-). Quilico and Frori (*Gazzetta*, 1932, **62**, 436) found that 5-cyano*iso*oxazole was readily hydrolysed to the corresponding amide under similar conditions. They also observed that alcoholic alkali led to ring fission with the formation of potassium cyanoacetate. In the present work it was shown that no ring fission had occurred by dehydrating the cyanoamide to the parent dinitrile (XVI). Neither the cyanoamide nor the dinitrile yielded pigments when treated with the usual metallic reagents.

Pyridazine Group.—Here again a convenient starting material in 3 : 6-dimethylpyridazine-4 : 5-dicarboxylic ester could be obtained from diacetylsuccinic ester (Paal and Ubber, *Ber.*, 1903, **36**, 497). This was converted into the *diamide* (XVII) by aqueous ammonia in the cold. The corresponding 4 : 5-dihydro-ester (XVIII), the primary product of the interaction of hydrazine and diacetylsuccinic ester, yielded no diamide under the same conditions. The diamide (XVII) yielded the corresponding *imide* at its melting point and the imide re-formed the diamide with cold aqueous ammonia. This behaviour paralleled that of the corresponding derivatives of phthalic and quinolinic acids. All attempts to dehydrate the diamide to dinitrile were unsuccessful.

(XVII.)





(XVIII.)

Furan Group.—Reichstein (*Helv. Chim. Acta*, 1930, **13**, 345; 1931, **14**, 1277) has observed that the Gattermann aldehyde synthesis can only be applied to the α-positions of the furan ring. Hence the synthesis of dinitriles through aldoximes appeared difficult. Seka has found (*Ber.*, 1924, **57**, 1864) that 2 : 5-dimethylfuran-3 : 4-dicarboxylic ester only yields the corresponding diamide with great difficulty. We can confirm this; the yields obtained in our experiments were so small that dehydration of the diamide could not be investigated. This resistance to amide formation appears to be a general property of furan esters, for another promising line of attack was held up by the fact that the *methyl* ester of 5-cyano-3-methylfuran-4-carboxylic acid (Rinkes, *Rec. trav. chim.*, 1931, **50**, 1127) failed to yield a cyanoamide on treatment with aqueous or alcoholic ammonia.

Triazole Group.—Grischkevitsch-Trochimovski (*Rocz. Chem.*, 1921, **1**, 468) and Fialkov (*Bull. Soc. chim.*, 1927, **41**, 1209) have shown that the tetra-amide of hydrogen cyanide, reacting as diaminomaleinitrile (XIX), yields dicyanotriazole (XX) on treatment with nitrous acid.

(XIX.)

(XX.)

This substance failed to yield pigments of the phthalocyanine type when heated with metallic reagents. This was not surprising, as it is among the strongest of organic acids (Fialkov, *loc. cit.*). The *N*-methyl ether also yielded no pigments, possibly owing to the difficulty of forming an ortho-ring.

Grischkevitsch-Trochimovski (*loc. cit.*; *J. Russ. Phys. Chem. Soc.*, 1924, **55**, 548) states that dicyanotriazole is first formed in a yellow modification, which yields a colourless form on sublimation. Our yellow reaction product yielded a practically colourless dinitrile on crystallisation and it appears probable that the original colour is due to the presence of a trace of impurity. The evidence adduced by Grischkevitsch-Trochimovski and by Fialkov (*locc. cit.*) for the existence of two distinct forms of the dinitrile is very slight.

EXPERIMENTAL.

3 : 4-*Dicyanopyrrole Series.*

Method 1.—*Diacetylsuccinic ester.* In the routine preparation of this ester by Knorr's reaction (*Ber.*, 1894, **27**, 1155) "molecular" sodium was found preferable to sodium wire. 260 G. of ethyl acetoacetate were gradually added to 48 g. of "molecular" sodium under 3 l. of anhydrous ether, the mixture being shaken and cooled in ice when necessary. The nearly solid paste was treated with shaking with 210 g. of iodine dissolved in dry ether. After an hour's standing, the ethereal solution was filtered and evaporated. Diacetylsuccinic ester, which crystallised from the residue, was pressed on a tile and crystallised from 50% acetic acid. Yield, 119 g. (46%); m. p. 82—85°, raised to 88° by recrystallisation. In larger batches it was found advisable to add solid iodine with only enough ether to keep the mixture mobile. When sodium wire was used, the above quantities give 100 g. of ester, in agreement with Knorr.

2 : 5-Dimethylpyrrole-3 : 4-dicarboxylic ester (I), m. p. 91°, was prepared from this in quantitative yield by treatment with aqueous ammonia (*d* 0·880) or, better, with a solution of ammonium acetate in acetic acid (Knorr, *Ber.*, 1885, **18**, 299). Hydrolysis of the ester was troublesome; the following procedure, modified from that of Knorr (*ibid.*, p. 1561), was used: A solution of 20 g. of the ester in the minimum amount of hot alcohol was treated with 100 c.c. of 12% aqueous caustic potash and enough alcohol to effect solution. The alcohol was boiled off

during 2 hours, and the solution cooled in ice and acidified with mineral acid. The mixture of diacid and acid ester was taken up in the minimum quantity of caustic soda solution, and the acid ester precipitated by adding acetic acid to the ice-cold solution until it was acid to litmus. The diacid was then precipitated from the ice-cold filtrate by the addition of dilute sulphuric acid until it was acid to Congo-red. The diacid formed needles from dilute alcohol, m. p. 250°; yield, 20%. No diamide could be obtained by treating the diacid successively with thionyl chloride or phosphorus pentachloride and ammonia under a variety of conditions.

2 : 5-Dimethylpyrrole-3 : 4-dicarboxylic ester was unchanged after being heated at 100° for 2 days with aqueous ammonia (*d* 0·880), or after 3½ days' treatment under pressure at 100° with methyl-alcoholic ammonia, saturated at 0°.

Methyl acetoacetate (Komnenos, *Monatsh.*, 1910, **31**, 687) was converted into *methyl* 1 : 2-*diacetylsuccinate* by the method described above for the ethyl ester. The methyl ester only solidified after distillation, b. p. 120°/20 mm., and separated from dilute alcohol in small white crystals, m. p. 113·5° (Found : C, 52·3; H, 6·0. $C_{10}H_{14}O_6$ requires C, 52·2; H, 6·2%). Treatment of this ester with aqueous ammonia yielded only a brown oil and the reaction was not further investigated.

Method 2.—Cyanoacetone (Holtzwart, *J. pr. Chem.*, 1889, **39**, 238) was prepared from β-iminobutyronitrile (Moir, J., 1902, **81**, 101) immediately before use and was kept in ethereal solution, as evaporation led to the formation of a substance, m. p. 265°, apparently the dimeride (compare Moir, *loc. cit.*). The ethereal solution from 2 g. of iminobutyronitrile was treated with an excess of sodium in flat, freshly cut plates. The white sodio-compound was filtered off and separated mechanically from the excess of sodium; yield, 26%. When it was treated with phenylhydrazine in dilute acetic acid solution, it yielded the hydrazone, m. p. 96°, reported by Holtzwart (*loc. cit.*). When an ethereal suspension of the sodio-compound was left overnight with iodine, dissolved in ether, no reaction occurred.

The ethereal solution of cyanoacetone from 2 g. of iminobutyronitrile was treated with 4 g. of bromine (1 mol.) and kept overnight. A yellow oil separated, which was distilled after removal of solvent. *α-Bromocyanoacetone* boiled at 43°/12 mm. (Found : Br, 51·7, 50·1. C_4H_4ONBr requires Br, 49·4%); a fraction, b. p. 99°/12 mm., was also obtained. Bromocyanoacetone was soluble in light petroleum and was precipitated from such solutions by the addition of ether. On standing, it decomposed with the formation of ammonium bromide. An attempt to condense cyanoacetone with bromocyanoacetone and aqueous ammonia directly to a pyrrole derivative was fruitless. Attempted condensation of the sodio- and the bromo-derivative of cyanoacetone to diacetylsuccinonitrile was also unsuccessful.

Method 3.—Ethyl 2 : 5-dimethylpyrrole-3-carboxylate was prepared in consistent yields of 43% by Hantzsch's reaction (*Ber.*, 1890, **23**, 1474), and converted successively into the 4-formyl derivative (IV) (yield 77%, m. p. 151°), and the 4-aldoxime (theoretical yield, m. p. 223°) by the methods of Fischer and Zerweck (*locc. cit.*). The aldoxime was dehydrated by ½ hour's boiling with acetic anhydride and dry sodium acetate (Fischer and Zerweck, *loc. cit.*, 1923). The product was added to hot water, the solution evaporated nearly to dryness and diluted with hot water, and the separated ethyl 4-cyano-2 : 5-dimethylpyrrole-3-carboxylate (V, R = Et) crystallised from water to a m. p. of 152°. For large batches it was convenient to reduce the proportion of anhydride from that used by the previous workers, although the yield was slightly depressed. Thus, 85 g. of oxime, 85 g. of sodium acetate, and 800 g. of acetic anhydride gave 61 g. of the cyano-ester (78%). This cyano-ester was not converted into the corresponding cyano-amide on treatment at room temperature with aqueous ammonia, saturated at 0°, or by heating in an autoclave with methyl-alcoholic ammonia (saturated at − 20°) for 6 hours at 135° and 200 lb./sq. in. pressure. It was recovered unchanged from both experiments, m. p. and mixed m. p. 152°.

10 G. of the cyano-ester were heated to boiling with 100 c.c. of 25% aqueous caustic soda and just sufficient ethyl alcohol to effect solution. The solution was boiled for 30 minutes, water being added from time to time to dissolve the precipitate; alcohol was removed, and the product acidified at 0° with dilute hydrochloric acid. The flocculent precipitate of 3-*cyano*-2 : 5-*dimethylpyrrole*-4-*carboxylic acid* (V, R = H) was crystallised from water. Yield, theoretical; m. p. 288° (decomp.) (Found : C, 58·4; H, 5·0. $C_8H_8O_2N_2$ requires C, 58·5; H, 4·9%). The sodium salt appeared to be rather sparingly soluble in water. 26 G. of this acid were decarboxylated in an oil-bath at 200°/13 mm., 3-*cyano*-2 : 5-*dimethylpyrrole* (VI) distilling as a brownish-red product, which crystallised from water (charcoal) in white needles, m. p. 89°; yield, 73% (Found : N, 23·5. $C_7H_8N_2$ requires N, 23·3%).

A solution of 13·1 g. of 3-cyano-2 : 5-dimethylpyrrole in 45 c.c. of dry chloroform and 45 c.c.

of dry ether was treated with 40 c.c. of dry ice-cold liquid hydrogen cyanide, and a current of dry hydrogen chloride was passed through the solution at 0°. The red imine hydrochloride soon separated from the green-fluorescing solution. After an hour's passage of the gas, the product was left overnight at 0°, and the precipitate collected and washed with dry ether. The imine hydrochloride was decomposed first with ice-water and finally by warming on the water-bath. The yellow flocculent precipitate of 4-*formyl*-3-*cyano*-2 : 5-*dimethylpyrrole* (VII) was filtered off, washed with water, and crystallised from 50% alcohol, forming yellow needles, m. p. 207°; yield, 81% (Found: C, 64·8; H, 5·5. $C_8H_8ON_2$ requires C, 64·9; H, 5·4%). 10 G. of this aldehyde were dissolved in warm alcohol, and water added to give a faint turbidity. A concentrated aqueous solution of 10 g. of hydroxylamine hydrochloride, neutralised with caustic soda, was added and the mixture heated gently on a water-bath. After 15 minutes, the solution was cooled, and the *oxime* collected; it crystallised from dilute alcohol in long white needles, which softened at 214°, turned brown at 220°, and melted at 223°; yield, theoretical (Found: N, 26·0. $C_8H_9ON_3$ requires N, 25·8%).

10 G. of this aldoxime were refluxed for ½ hour with 500 c.c. of acetic anhydride and 10 g. of sodium acetate, and the product worked up as in the previous similar dehydration. 3 : 4-*Dicyano*-2 : 5-*dimethylpyrrole* (III) formed white needles from dilute alcohol, m. p. 239° (brown at 200°); yield, 89% (Found: C, 65·9; H, 4·9; N, 29·2. $C_8H_7N_3$ requires C, 66·2; H, 4·8; N, 29·0%).

Dry hydrogen chloride was passed through a solution of 3 g. of the dinitrile in 100 c.c. of absolute alcohol for 8 hours at room temperature. The solution soon turned deep red and deposited a white precipitate. Filtration and evaporation of the alcohol then yielded long white needles of ethyl 4-cyano-2 : 5-dimethylpyrrole-3-carboxylate, m. p. and mixed m. p. 148°. This was further identified by conversion successively into 4-cyano-2 : 5-dimethylpyrrole-3-carboxylic acid, m. p. and mixed m. p. 286°, and 4-cyano-2 : 5-dimethylpyrrole, m. p. and mixed m. p. 89°.

3 : 4-Dicyano-2 : 5-dimethylpyrrole was heated with the following reagents from 200° to 280° during 1 hour: Sodium amyloxide, stannous chloride, copper-bronze, cuprous chloride, zinc and magnesium. In each case there was charring and no sign of the formation of a pigment of the phthalocyanine type. Negative results were also obtained by heating the dinitrile at 200° for 7 hours with the following: β-naphthol, acetamide, glycerol, copper-bronze, etched magnesium, calcium oxide.

2 : 3-*Dicyanopyrrole Series.*

Methyl α-iso*Nitrosoethyl Ketone* (cf. Diels and Jost, *Ber.*, 1932, **65**, 3292).—A mixture of 834 g. of methyl ethyl ketone and 28 c.c. of concentrated hydrochloric acid was treated during 2½ hours with 1333 g. of amyl nitrite, the temperature being kept at 50—60°. The product was treated with 1 kg. of powdered ice and 1008 g. of 33% caustic soda solution and stirred for 2 hours, and the *iso*nitroso-compound isolated following the directions of Fischer and Orth ("Die Chemie des Pyrrols," p. 408). Yield, 680 g.; thorough extraction with ether was essential.

The *iso*nitroso-compound was reduced on a large scale as follows (cf. Diels and Jost, *loc. cit.*; Künne, *Ber.*, 1895, **28**, 2036). 300 G. of methyl *iso*nitrosoethyl ketone were added slowly to a rapidly stirred solution of 1985 g. of stannous chloride dihydrate in 1666 c.c. of concentrated hydrochloric acid, the reaction being controlled by cooling in ice-water. The cold solution was diluted with 12 l. of water, hydrogen sulphide passed in, tin sulphide allowed to settle, and the liquid filtered. The treatment with hydrogen sulphide was repeated to ensure complete removal of the tin. The final filtrate was evaporated to 2 l., and the removal of water completed under reduced pressure at 50—60°. The residual black oil was dissolved at 30° in 22 parts of absolute alcohol, the ammonium chloride filtered off, and dry ether added until the turbidity produced just dissolved on shaking. On standing overnight at 0° in a closed vessel, fine white crystals of aminobutanone hydrochloride (135 g., 37%) separated, which were filtered off and washed with an anhydrous mixture of alcohol and ether. This process, although tedious, was found more convenient than that involving electrolytic removal of the tin (Fischer and Orth, *op. cit.*, p. 410).

Ethyl hydrogen 2 : 3-dimethylpyrrole-4 : 5-dicarboxylate (VIII), m. p. 201°, was prepared in 26% yield by condensing this hydrochloride with oxalacetic ester in aqueous alkali (Piloty and Wilke, *loc. cit.*; *Ber.*, 1913, **46**, 1597; Fischer and Kutscher, *Annalen*, 1930, **481**, 199).

Attempted Preparations of 4 : 5-*Dicyano*-2 : 3-*dimethylpyrrole.*—(1) Via 5-*cyano*-2 : 3-*dimethylpyrrole*-4-*carboxylic acid.* Ethyl hydrogen 2 : 3-dimethylpyrrole-4 : 5-dicarboxylate was decarboxylated to ethyl 2 : 3-dimethylpyrrole-4-carboxylate (IX) at 225° in a stream of carbon dioxide. Yield, nearly theoretical; m. p. 110° (cf. Piloty and Wilke, *Ber.*, 1912, **45**, 2588). The 5-formyl group was introduced and the corresponding aldoxime prepared following Fischer and Beller (*loc. cit.*).

3 G. of 4-carbethoxy-2 : 3-dimethylpyrrole-5-aldoxime were refluxed for ½ hour with 150 c.c. of acetic anhydride and 3 g. of sodium acetate. *Ethyl* 5-*cyano*-2 : 3-*dimethylpyrrole*-4-*carboxylate* (XI) was isolated in fine powdery crystals, m. p. 180°, from the product by the usual procedure; yield, 81% (Found : C, 62·4; H, 6·1. $C_{10}H_{12}O_2N_2$ requires C, 62·5; H, 6·3%). 3·7 G. of this cyano-ester were hydrolysed by 1 hour's boiling with 44 c.c. of 25% aqueous caustic potash and sufficient alcohol for solution. After removal of the alcohol, 5-*cyano*-2 : 3-*dimethylpyrrole*-4-*carboxylic acid* (XII) was precipitated by the addition of mineral acid; it crystallised from 50% alcohol (charcoal) in stout shining crystals, m. p. 242°, decomp. 250°; yield, 94% (Found : C, 58·3; H, 4·8. $C_8H_8O_2N_2$ requires C, 58·5; H, 4·9%). This cyano-acid was very stable. No carbon dioxide was evolved when it was liberated from aqueous solutions of its salts at room temperature. Heated at 4 mm., it charred without decarboxylation. Heated in glycerol at 280° for 30 minutes, it yielded an unidentified solid, m. p. 176°, which was not the corresponding cyanodimethylpyrrole (m. p. 121·5°). It yielded no phthalocyanine-like pigment when heated with copper and ammonium aminosulphonate.

(2) Via 2 : 3-*dimethylpyrrole*. 2 : 3-Dimethylpyrrole was prepared from ethyl hydrogen 2 : 3-dimethylpyrrole-4 : 5-dicarboxylate following Fischer and Nüssler (*loc. cit.*). The 5-formyl group was introduced (Fischer and Orth, *op. cit.*, p. 154) and thence the 5-aldoxime (XIV), m. p. 121°, was prepared. 1 G. of this oxime was dehydrated in the usual way with an equal weight of sodium acetate in 50 c.c. of acetic anhydride to 5-*cyano*-2 : 3-*dimethylpyrrole* (XIII), which formed long glistening needles from water (charcoal), m. p. 121·5°; yield, 66% (Found : C, 70·3; H, 6·7; N, 23·2. $C_7H_8N_2$ requires C, 70·0; H, 6·7; N, 23·3%). This failed to react with hydrogen cyanide and hydrogen chloride under the usual conditions either in a mixture of ether and chloroform at 0° or in chloroform alone at room temperature. The corresponding 5-aldoxime and 5-aldehyde also failed to react under these conditions.

iso*Oxazole Series.*

5 G. of ethyl 5-methyl*iso*oxazole-3 : 4-dicarboxylate, m. p. 56° (Schmidt and Widman, *Ber.*, 1908, **41**, 1252), were shaken for several hours in a closed flask with an excess of aqueous ammonia (*d* 0·880). The long white needles of 5-*methyl*iso*oxazole*-3 : 4-*dicarboxyamide* (XV) were filtered off, washed with water, and crystallised from alcohol. Yield, 67%; m. p. 216° after softening at 195° (Found : N, 25·1. $C_6H_7O_3N_3$ requires N, 24·9%). Under 5 mm., the diamide sublimed unchanged.

A mixture of 2 g. of the diamide and 4 g. of phosphoric oxide were heated by means of a glycerol bath in a vertical tube with a wide horizontal side arm. At about 115°/5 mm. in a slow stream of dry air a colourless liquid distilled into the side arm and solidified. At 175° a solid sublimed, and condensed much nearer the vertical tube than the first distillate, which it did not contaminate. The sublimate was the diamide, m. p. and mixed m. p. 216°. The liquid was 3 : 4-*dicyano*-5-*methyl*iso*oxazole* (XVI), which formed a mass of radiating needles, m. p. 32°, b. p. 115°/12 mm. without decomposition and 245°/760 mm. with some decomposition; yield, 1·1 g. (70%) (Found : C, 54·1; H, 2·3; N, 32·1. $C_6H_3ON_3$ requires C, 54·1; H, 2·3; N, 31·6%). About 3 hours' heating at 115—120°/5 mm. were necessary for the preparation of the dinitrile in a state of purity. At 160°/5 mm., the diamide and phosphoric oxide yielded a distillate in 30 minutes, but the product would not solidify. The diamide was unchanged by 6 hours' refluxing with an excess of acetic anhydride.

A current of dry hydrogen chloride was passed through a solution of 1 g. of 3 : 4-dicyano-5-methyl*iso*oxazole in absolute alcohol for 1½ hours, after which no further precipitation occurred. The precipitate was retained (A); the filtrate was freed from alcohol and poured on ice. Ethyl 5-methyl*iso*oxazole-3 : 4-dicarboxylate was precipitated; it was identified by m. p. and mixed m. p. (55°) and by conversion into the diamide, m. p. 216°. The precipitate (A) was washed free from ammonium chloride with water and crystallised from water or alcohol. White plates of 4(or 3)-*cyano*-5-*methyl*iso*oxazole*-3(or 4)-*carboxyamide* separated, m. p. 225°, depressed to 191° on admixture with the diamide (Found : C, 48·1; H, 3·4. $C_6H_5O_2N_3$ requires C, 47·7; H, 3·3%). This cyanoamide was also readily formed by shaking the dinitrile for a few minutes with 10% aqueous caustic potash; it was identified by m. p. and mixed m. p. (225°) and by analysis (Found : C, 47·4; H, 3·4%).

3 : 4-Dicyano-5-methyl*iso*oxazole yielded no pigment when heated under the usual conditions

with copper-bronze, cuprous chloride, aluminium chloride, etched magnesium, zinc or sodium amyloxide.

Pyridazine Series.

Ethyl 3 : 6-dimethyl-4 : 5-dihydropyridazine-4 : 5-dicarboxylate (XVIII) was prepared from diacetylsuccinic ester in 91% yield by the method of Paal and Ubber (*loc. cit.*). There was no indication of the formation of a diamide when it was shaken for some time with concentrated aqueous ammonia. It was oxidised to ethyl 3 : 6-dimethylpyridazine-4 : 5-dicarboxylate following Paal and Ubber (*loc. cit.*). 25 G. of the latter were shaken vigorously with an excess of aqueous ammonia (*d* 0·880) and kept overnight. 3 : 6-*Dimethylpyridazine*-4 : 5-*dicarboxyamide* (XVII) separated as a white powder, which was washed thoroughly with cold water, hot alcohol and ether. Yield, theoretical; m. p. 240°, not very sharp owing to charring and sublimation of the corresponding imide (Found : C, 49·1; H, 5·4; N, 28·4. $C_8H_{10}O_2N_4$ requires C, 49·5; H, 5·2; N, 28·9%). The diamide was insoluble in ether, alcohol, water, pyridine and hydrocarbons. It was hydrolysed slowly by cold aqueous caustic soda and decomposed by hot water. It was also readily prepared by passing dry ammonia gas through an alcoholic solution of the diester at room temperature.

The diamide at 240°/10 mm. gave a sublimate of long yellowish needles of the corresponding imide. There was some gross decomposition, which also occurred when the imide was resublimed. 3 : 6-*Dimethylpyridazine*-4 : 5-*dicarboxyimide* formed needles from alcohol, m. p. 240° (decomp.); yield, 44% (Found : C, 54·3; H, 3·7; N, 23·9. $C_8H_7O_2N_3$ requires C, 54·2; H, 3·95; N, 23·7%). The imide re-formed the diamide when ammonia was passed through its alcoholic solution.

Unsuccessful attempts were made to prepare a copper pigment of the phthalocyanine type direct from the imide by (i) the action of reduced copper and ammonium aminosulphonate at 200—240° and (ii) the action of cupric chloride and urea at 210°.

The following attempts were made to prepare the dinitrile or the cyanoamide from the diamide : (i) phosphoric oxide at 180—240°/2 mm. yielded a little imide and produced much decomposition; (ii) carbonyl chloride at 60° (passed into a pyridine solution) yielded unchanged diamide and a water-soluble oil; (iii) acetic anhydride at various temperatures from 20° to the b. p. also gave unchanged diamide, imide, and water-soluble material.

The action of thionyl chloride or phosphorus pentachloride on 3 : 6-dimethylpyridazine-4 : 5-dicarboxylic acid (Paal and Ubber, *loc. cit.*) yielded no acid chloride, apparently owing to ring fission.

Furan Series.

Ethyl 2 : 5-dimethylfuran-3 : 4-dicarboxylate was prepared from diacetylsuccinic ester in 94% yield by Knorr's method (*Ber.*, 1884, **17**, 2863). The conversion into the corresponding diamide (compare Seka, *loc. cit.*) was very difficult. For instance, 17 g. of the ester were heated at 90° and 700 lb./sq. in. for 24 hours with a large excess of liquid ammonia, 1 g. of diamide being formed and 15 g. of unchanged ester being recovered. The diamide after several crystallisations from water melted at 236° (sealed tube). Seka gives m. p. 243—244°.

The diamide (500 mg.) was refluxed for 6 hours with acetic anhydride (3 c.c.), and the hot solution added to water. White bunches of needles of 4-*cyano*-2 : 5-*dimethylfuran*-3-*carboxylic acid* separated on cooling, and were recrystallised from water (charcoal); m. p. 174° (Found : C, 58·6; H, 4·6. $C_8H_7O_3N$ requires C, 58·2; H, 4·2%). The acid was soluble with effervescence in aqueous sodium bicarbonate, and was therefore not the corresponding 3 : 4-dicarboxyimide.

11·7 G. of 5-cyano-3-methylfuran-4-carboxylic acid, m. p. 204° (Rinkes, *loc. cit.*), were converted into the silver salt, which was refluxed for 3 days with 9·5 c.c. of methyl iodide in 200 c.c. of dry ether. Removal of the solvent then left an oil, which solidified on cooling and was extracted with benzene. The benzene was removed, and the residual *methyl* ester crystallised from water (charcoal), giving stout needles, m. p. 49°; yield, 26% (Found : C, 58·3; H, 4·4. $C_8H_7O_3N$ requires C, 58·2; H, 4·2%). This ester was hydrolysed when kept with aqueous ammonia (*d* 0·880) overnight, and remained unchanged after being kept in alcoholic ammonia at 50° for 2 days.

Triazole Series (With J. M. WRIGHT).

Diaminomaleinitrile (XIX) (Linstead, Noble, and Wright, preceding paper) was converted into dicyanotriazole (XX), following Grischkevitsch-Trochimovski and Fialkov (*locc. cit.*). The yellow crystalline product was recrystallised from ether–light petroleum, which yielded clear, practically colourless prisms, m. p. 145—148° (lit., 145—150°). The dinitrile is immediately soluble with effervescence in aqueous sodium bicarbonate, and a dilute aqueous solution dissolves zinc with evolution of hydrogen. The silver salt is precipitated by the addition of silver nitrate and is not dissolved by the cautious addition of dilute nitric acid. Warming with an excess of nitric acid converts the flocculent silver salt into a microcrystalline precipitate of the free dicyanotriazole. The dinitrile does not form a methyl ether when boiled with methanol alone.

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