722. *Heterocyclic Imines and Amines. Part II.* Derivatives of* iso*Indoline and* iso*Indolenine.*

By P. F. Clark, J. A. Elvidge, and R. P. Linstead.

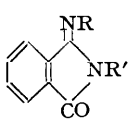
The reaction between imino-derivatives of *iso*indoline and bases has been further studied. 3-Imino-1-oxo*iso*indoline (I; R = R′ = H) gives the 2-unit products (I; R ≠ H, R′ = H) when condensed with 2-aminonaphthalene and 3-aminopyridine. Two mols. of (I; R = R′ = H) condense with 2 : 7-diaminonaphthalene, 3 : 5-diaminopyridine, and 2 : 4-diaminopyrimidine yielding the 3-unit products (III).

1 : 3-Di-imino*iso*indoline (II; R = R′ = H) gives the 3-unit compounds (II; R = R′ ≠ H) when condensed with an excess of the bases, aniline, 2-naphthylamine, *n*-butylamine, 3-aminopyridine, and aminopyrazine. The dipyrazinylimino-product formed a dimethiodide.

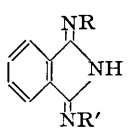
Di-imino*iso*indoline also reacts stepwise, forming with 1 mol. of base the monosubstituted imines (II; R′ = H), which are alternatively prepared by the catalysed addition of amines to phthalonitrile. The monosubstituted di-imines (II; R′ = H, R ≠ H) are hydrolysed to the oxo-compounds (I; R′ = H), and condense easily with a further mol. of primary base. Secondary bases also condense, yielding 3-amino-1-imino*iso*indolenine derivatives.

Quantitative degradations have been made, structures are discussed, and light-absorption data given.

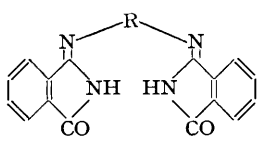
The *iso*indoline-imines (I and II; R = R′ = H) condense readily with primary amines, with elimination of ammonia, to give substituted imino-derivatives (I; R′ = H, R ≠ H) and (II) (Part I *). Further examples of these condensations are now described and the structures of the products discussed.



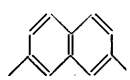
(I)



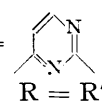
(II)



(III)

a; R = 

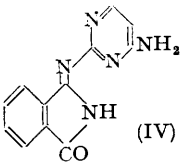
b; R = 

c; R = 

With 2-aminonaphthalene and 3-aminopyridine, the oxo-imine (I; R = R′ = H) yielded the 2-unit products (I; R = 2-$C_{10}H_7$, R′ = H) and (I; R = 3-C_5H_4N, R′ = H), as expected.

* Part I, *J.*, 1952, 5000. The original title of the series " Heterocyclic Imines " has been expanded in the light of new knowledge on the structure of the group of compounds under investigation.

Further, analogously to *m*-phenylenediamine (Part I), 2 : 7-diaminonaphthalene condensed in boiling alcohol with 2 mols of the oxo-imine (I; R = R′ = H), forming the 3-unit product (III*a*). 3 : 5-Diaminopyridine likewise gave the product (III*b*), and it showed no obvious tendency to react stepwise as does 2 : 6-diaminopyridine (Part I).


(IV)

The less reactive 2 : 4-diaminopyrimidine was best condensed with (I; R = R′ = H) in boiling nitrobenzene, (III*c*) being formed. Under milder conditions a mixture was obtained, mainly of 2-unit products, one of which was isolated. This may have the orientation (IV) because benzoylation and oxidation (cf. Wolf, Anderson, Kaczka, Harris, Arth, Southwick, Mozingo, and Folkers, *J. Amer. Chem. Soc.*, 1947, **69**, 2753) failed to yield benzoylguanidine.

The formation of the bis-condensation products (III), by interaction of the foregoing (sterically favourable) diamines with the oxo-imine (I; R = R′ = H), indicated that macrocycles should result from their condensation with the di-imine (II; R = R′ = H). A macrocycle has been prepared in this way from 2 : 6-diaminopyridine (Elvidge and Linstead, *J.*, 1952, 5008). However, we studied first the condensations of relevant monoamines with di-imino*iso*indoline. This gave the expected linear products, the structures of which were established. Their light absorptions are given in the Table (p. 3596). The preparation of further macrocycles will be described later.

With an excess of aniline in boiling alcohol, 1 : 3-di-imino*iso*indoline (II; R = R′ = H) gave 1 : 3-diphenylimino*iso*indoline (II; R = R′ = Ph). This base was also prepared from its deep-yellow hydrochloride, described in Part I. Mr. N. Haddock of Imperial Chemical Industries Limited, Dyestuffs Division, had reported to us the formation of the monosubstitution product, 1-imino-3-phenylimino*iso*indoline (II; R = Ph, R′ = H) (cf. Bayer Farbenfabr., Indian P. 43,679), and we confirmed its formation from the di-imine with 1 mol. of aniline, and as an intermediate in the reaction with an excess of aniline.

The monophenyl product (II; R = Ph, R′ = H) was also obtained from the sodium methoxide-catalysed interaction of phthalonitrile and aniline in methanol, a process which appears general (Bayer Farbenfabr., *loc. cit.*) and which with *n*-butylamine afforded 3-butylimino-1-imino*iso*indoline (II; R = Bu^n, R′ = H).

The unsubstituted imino-group of these products is reactive. Thus with an excess of butylamine, (II; R = Bu^n, R′ = H) readily gave 1 : 3-dibutylimino*iso*indoline (II; R = R′ = Bu^n), also obtained directly from di-imino*iso*indoline and an excess of butylamine. The monophenylimine (II; R = Ph, R′ = H) with aniline yielded the 1 : 3-diphenylimino-compound, whilst brief treatment with hydrochloric acid hydrolysed it to the oxo-compound (I; R = Ph, R′ = H); boiling hydrochloric acid rapidly gave 1 mol. each of phthalimide and aniline. Under the last conditions, the 1 : 3-diphenylimino-compound (II; R = R′ = Ph) was split to 1 mol. of phthalimide and 2 mols. of aniline (isolated as phenylazo-2-naphthol).

These hydrolyses and reactions supported the *iso*indoline structures. We made some additional experiments with 1-oxo-3-phenylimino*iso*indoline (I; R = Ph, R′ = H), however, because of apparent discrepancies with the literature.

Thus a compound with the same superficial properties as our oxo-phenylimine (I; R = Ph, R′ = H), which Porter, Robinson, and Wyler (*J.*, 1941, 620) prepared from monothiophthalimide and aniline, was reported by them to yield *N*-phenylphthalimide on hydrolysis. Reissert and Holle (*Ber.*, 1911, **44**, 3027) gave the 2-phenyl structure (I; R = H, R′ = Ph) to a seemingly identical compound from fusion of thiophthalanil and urea. They gave its methyl derivative the 3-methylimino-2-phenyl structure (I; R = Me, R′ = Ph). We found that the oxo-phenylimine yielded phthalimide almost immediately with hot aqueous acid, which confirms our 3-phenylimino-structure (I; R = Ph, R′ = H). After prolonged boiling and partial evaporation of the solution, *N*-phenylphthalimide was indeed obtained, but this is clearly a secondary product, without direct significance for the structure of the phenylimine. We regard Reissert and Holle's 2-phenyl structure as incorrect: evidently the urea fusion involves a molecular rearrangement. Additional evidence came from an examination of the methyl derivative.

We prepared this methyl derivative, which tallied with Reissert and Holle's description,

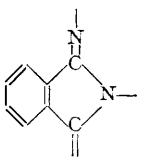
from the 1-oxo-3-phenyliminoisoindoline with methyl sulphate and alkali. That it had the 2-methyl-3-phenylimino-structure (I; R = Ph, R′ = Me), and not Reissert's proposed structure, was confirmed by its rapid hydrolysis with acid to *N*-methylphthalimide, and by an alternative preparation. 3-Imino-1-oxoisoindoline (I; R = R′ = H) was warmed with methyl sulphate yielding a methyl hydrogen sulphate; this was shown to be the salt of the 3-imino-2-methyl derivative (I; R = H, R′ = Me) by its hydrolysis with boiling water to *N*-methylphthalimide. Reaction of the imine salt with aniline produced the 2-methyl-1-oxo-3-phenyliminoisoindoline already encountered.

We next showed that the stepwise reaction of 1 : 3-di-iminoisoindoline with aniline was paralleled by its behaviour with some other amines. From the di-imine, with β-naphthylamine, either the mononaphthylimino-product (II; R = β-$C_{10}H_7$, R′ = H) or 1 : 3-dinaphthyliminoisoindoline (II; R = R′ = β-$C_{10}H_7$) was formed depending on the conditions. Conversion of the former into the latter product occurred readily with an excess of β-naphthylamine in boiling alcohol. With warm concentrated hydrochloric acid, the monoimine (II; R = β-$C_{10}H_7$, R′ = H) was hydrolysed to the oxo-compound (I; R = β-$C_{10}H_7$, R′ = H), identical with that from 3-imino-1-oxoisoindoline (I; R = R′ = H) and β-naphthylamine. Much more vigorous hydrolysis of the monoimine (II; R = β-$C_{10}H_7$, R′ = H) was required to effect further degradation: a boiling mixture of concentrated hydrochloric acid and ethanol produced phthalic acid and β-naphthylamine in high yields and equivalent proportions. Surprisingly, the dinaphthyliminoisoindoline (II; R = R′ = β-$C_{10}H_7$) resisted these conditions, but was split to phthalic acid and 2 mols. of β-naphthylamine by a boiling concentrated hydrochloric–acetic acid mixture.

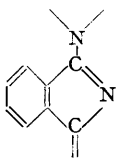
Thus the 1 : 3-disubstituted imino-compounds (II) derived from aniline and β-naphthylamine (and from 2-aminopyridine, Part I) are hydrolysed with very different ease. This no doubt depends on solubility differences, as well as on the stability of the C:N link, which are both influenced by the substituents.

The condensation in boiling ethanol of 1 : 3-di-iminoisoindoline with 3-aminopyridine, even in excess, gave only the monosubstituted imine (II; R = 3-C_5H_4N, R′ = H). The 1 : 3-di-3′-pyridyliminoisoindoline (II; R = R′ = 3-C_5H_4N) was produced by heating the reactants in butanol. Aminopyrazine, on the other hand, gave the 1 : 3-dipyrazinylimino-compound (II; R = R′ = $C_4H_3N_2$) directly under mild conditions. This product formed a dimethiodide, like the corresponding pyridine analogue (Part I).

Fine Structure.—The iminoisoindoline structures for the compounds described above and in the earlier paper are consistent with the reactions so far studied. The compound



A, Iminoisoindoline type.



B, Aminoisoindolenine type.

(I; R = Ph, R′ = Me) has a fixed iminoisoindoline structure (type *A*), but presumably the other (incompletely substituted) derivatives are capable of tautomerism and may exist in the amino-isoindolenine form (type *B*). Indeed, the amino-form *B* might be expected to predominate over imino-forms (see Angyal and Angyal, *J.*, 1952, 1461). The cation of these bases will exist as a resonance-stabilised hybrid.

To gather information on the fine structure of the bases we prepared several fully substituted derivatives of the second tautomeric form *B* by condensing secondary amines with the imines (I; R = R′ = H), (II; R = R′ = H), and (II; R = H, R′ = Ph).

The oxo-imine (I; R = R′ = H) with (undried) morpholine yielded the phthalic amide morpholide (V), also prepared by fission of phthalimide with aqueous morpholine. However, with redistilled (drier) morpholine, the oxo-imine gave the required substitution product, $C_{12}H_{12}O_2N_2$, which necessarily has the 3-morpholino-1-oxoisoindolenine structure (VI). This absorbs ultra-violet light to much longer wave-lengths than *o*-cyanobenzamide

or the phthalic amide derivative (V) which lack the fused pyrrolic ring (see Table). The compound (VI) was also formed from 1 : 3-di-imino*iso*indoline (II; R = R′ = H) under these conditions, the expected morpholino-imine evidently having been hydrolysed

Light-absorption data.

(For ethanol solutions, except where otherwise indicated.)

Compound	$\lambda_{max.}$ (Å)	ε
o-Cyanobenzamide	2260	13,400
(V)	2270	8,600
Phthalimide	2260 *	17,600
	2360	10,000
(I; R = R′ = H)	2270	11,500
	2370	10,500
	2510	6,570
	2920	3,500
(I; R = Ph, R′ = Me)	2470 *	17,900
	2510	18,900
	2810, 2910, 3020	3,800
(VI)	2510	7,350
	2670	9,900
	2800	8,400
	3070	3,700
	3270, 3430	3,200
(I; R = 2-$C_{10}H_7$, R′ = H)	2420, 2510	10,900
	2800	11,700
	3300, 3520	5,700
(I; R = 3-C_5H_4N, R′ = H)	2280, 2420	16,500
	2510, 2560	17,800
	2800	8,000
	2900, 3020	6,900
	3240	4,700
(III*a*) in dioxan	2260	69,000
	2510	59,500
	2560	73,500
	2600	59,500
	2800	22,800
	2900, 3020	21,200
	3300 *	10,800
	3460	14,100
	3580	10,800
(III*b*) in H·CO·NMe_2	2800	11,400
	3040	14,700
	3250	8,000
	3480	7,000
(III*c*) in H·CO·NMe_2	2800	17,100
	3020	14,800
	3170	13,700
	3380	11,800
(II; R = R′ = H)	2510, 2560	12,500
	3030	4,600
(II; R = Ph, R′ = H)	2510, 2570	14,800
	2650	16,300
	2800	12,400
	3040, 3240, 3300	9,300
	3600	7,300
(II; R = R′ = Ph)	2510, 2570, 2640	12,200
	3030, 3280	8,900
	3480	7,700
	3650	6,500
(II; R = 2-$C_{10}H_7$, R′ = H)	2300	55,500
	2510	16,800
	2590, 2660	21,700
	3430	7,600
	3670	8,400
(II; R = R′ = 2-$C_{10}H_7$)	2270, 2340	63,500
	3260	9,100
	3600	10,700
(II; R = Bu, R′ = H)	2510	12,000
	2580, 2640	13,600
	2800 *	7,000
	3040	5,400
	3150 *	4,600
(II; R = R′ = Bu)	2510	8,000
	2660	11,000
	2780	8,000
	3040, 3150	6,000
(II; R = 3-C_5H_4N, R′ = H)	2680	15,700
	2800	11,300
	3450	8,900
	3600 *	7,100
(II; R = R′ = 3-C_5H_4N)	2350	29,900
	2570	14,300
	2660, 2800, 2900, 3040, 3150	12,500
	3530	10,700
(II; R = R′ = 2-$C_4H_3N_2$)	2350	19,500
	2650	16,200
	2800, 2940, 3050, 3240	18,000
	3480	12,900
	3860	19,500
	4100	9,600
(VII; R = O)	2270	29,100
	2360	25,600
	2650, 2800, 2900	9,600
	3750	11,300
(VII; R = CH_2)	2640	13,400
	2800	11,000
	3600 *	13,000
	3790	14,500
	3880 *	13,000
(VIII)	2580	11,200
	2680, 2810, 2900	12,400
	3680	14,600

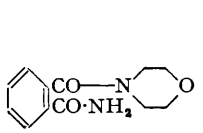
* Inflexion.

to (VI) by traces of moisture. With aqueous acid the *iso*indolenine (VI) yielded phthalimide and morpholine, the hydrolysis proceeding as readily as that of the true *iso*indoline (I; R = Ph, R′ = Me).

The monophenylimine (II; R = Ph, R′ = H) condensed with morpholine, piperidine, and *N*-methylaniline in boiling alcohol to yield the 3-amino-1-imino*iso*indolenines (VII; R = O, and R = CH_2), and (VIII). Acid hydrolysis of the methylanilino-derivative (VIII) rapidly gave phthalimide, aniline (isolated as phenylazo-2-naphthol), and *N*-methyl-

aniline (isolated as the *p*-nitroso-derivative), in approximately equivalent proportions. The same unsymmetrical *iso*indolenine (VIII) was formed by methylation of 1 : 3-diphenyliminoisoindoline (II; R = R′ = Ph) with sodamide and methyl iodide.

From the light-absorption data given in the Table it is possible tentatively to assign fine structures to some of the incompletely substituted compounds: these may have



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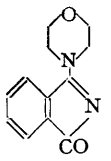

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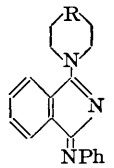
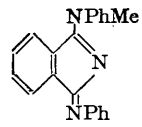


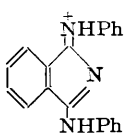
(VII)



(VIII)

structures of either type *A* or *B*. In the oxo-series, the fixed 1-oxo*iso*indoline (I; R = Ph, R′ = Me), of type *A*, shows a maximum at 3020 Å (ε = 3800), whilst the fixed 1-oxo-*iso*indolenine (VI), of type *B*, shows additional maxima at the longer wave-lengths of 3270 and 3430 Å (ε = 3200). The derivatives (I; R = Ph, R′ = H) and (III; R = *m*-C_6H_4) have maxima (see Part I) at 3240, 3380 Å (ε = 4450), and at 3300, 3380 Å (ε = 8400), respectively, and both may therefore be presumed to exist (in the solvents named in the Table) in the tautomeric 3-amino-1-oxo*iso*indolenine form, *B*, corresponding with (VI). The same conclusion may be drawn for the other compounds (III).

The fixed 3-amino-1-imino*iso*indolenines (VII; R = O and CH_2) and (VIII) show maxima at 3680—3790 Å (ε = 11,000—14,000), but the parent 1 : 3-di-imino*iso*indoline (II; R = R′ = H), and the monobutyl and dibutyl derivatives show less intense maxima at the shorter wave-lengths of 3020—3200 Å (ε = 4000—6000). Hence it seems that these last three compounds exist largely in the *iso*indoline form, of type *A*. The spectra of the mono- and the di-phenylimino-derivatives (II; R = Ph, R′ = H and Ph) appear composite and suggest that these derivatives are tautomeric mixtures in solution (*A* ⇌ *B*); similar conclusions apply to the heterocyclic derivatives. In the naphthyl series (II; R = β-$C_{10}H_7$, R′ = H and β-$C_{10}H_7$) the *iso*indolenine form, *B*, appears to predominate, as judged from the intensity patterns: there is a rise in intensity at the maximum of longest wave-length, as there is in the spectra of (VII) and (VIII). The spectrum of 1 : 3-diphenyliminoisoindoline hydrochloride (see Part I) is broadly of this type, but there are differences in detail consistent with the cation's being a resonance hybrid (one bond structure is shown inset): there is absorption of somewhat higher intensity (ε = 20,000) at a longer wave-length (3980 Å) than for the related non-resonant compounds.



Studies on the fine structure of compounds of the same general type are being continued.

Experimental

Products from 3-*Imino*-1-*oxo*iso*indoline*.—(a) *From monoamines*. The oxo-imine (1 g.), 2-naphthylamine (1 g.), and ethanol (20 c.c.) were heated under reflux for 16 hr., and the solution was then chilled. The 3-2′-*naphthylimino*-1-*oxo*iso*indoline* (0·84 g., 45%) crystallised from ethanol as yellow needles, m. p. 198—199° (Found: C, 79·75; H, 4·5; N, 10·5. $C_{18}H_{12}ON_2$ requires C, 79·4; H, 4·4; N, 10·3%).

3-Aminopyridine (0·5 g.), prepared from 3-bromopyridine (McElvain and Goese, *J. Amer. Chem. Soc.*, 1943, **65**, 2231) by Hertog and Wibaut's method (*Rec. Trav. chim.*, 1936, **55**, 122), 3-imino-1-oxo*iso*indoline (0·78 g.), and ethanol (10 c.c.) were heated under reflux for 22 hr., and the solution was then cooled. 1-*Oxo*-3-3′-*pyridyliminoiso*indoline (0·79 g., 66·5%) crystallised from ethanol as very pale yellow needles, m. p. 222° (Found: C, 69·8; H, 4·3; N, 19·0. $C_{13}H_9ON_3$ requires C, 69·9; H, 4·1; N, 18·8%).

(b) *From diamines*. 2 : 7-Diaminonaphthalene (1 g.), 3-imino-1-oxo*iso*indoline (1·9 g.), and ethanol (25 c.c.) were heated under reflux for 1 day. The yellowish-brown product (1·1 g., 41%) was taken up in boiling pyridine, and the filtered solution evaporated until crystallisation

occurred. Sublimation of the solid at 300°/0·5 mm. afforded bright yellow crystals, m. p. 312°, of 2 : 7-*di*-(1-*oxo*-3-iso*indolinylideneamino*)*naphthalene* (III*a*) (Found : C, 74·8; H, 4·3; N, 14·0. $C_{26}H_{16}O_2N_4$ requires C, 75·0; H, 3·9; N, 13·5%).

3 : 5-Diaminopyridine (0·5 g.) [prepared in 57% yield from 3 : 5-dibromopyridine (McElvain and Goese, *loc. cit.*) and ammonia (*d* 0·88) in the presence of copper sulphate at 160° for 24 hr. (cf. Hertog and Wibaut, *loc. cit.*)] was heated with 3-imino-1-oxo*iso*indoline (1·35 g.) in ethanol (20 c.c.) under reflux for 40 hr. From 2-ethoxyethanol, the 3 : 5-*di*-(1-*oxo*-3-iso*indolinylidene-amino*)*pyridine* (III*b*) (0·96 g., 57%) crystallised as very pale yellow needles, m. p. 343—344° (Found : C, 67·95; H, 3·8; N, 18·85. $C_{21}H_{13}O_2N_5$ requires C, 68·6; H, 3·6; N, 19·1%).

2 : 4-Diaminopyrimidine (0·2 g.) and 3-imino-1-oxo*iso*indoline (0·53 g.) were boiled in nitrobenzene (10 c.c.), ammonia being evolved vigorously at first and then slowly but steadily. After 17 hr., the clear solution was cooled. The 2 : 4-*di*-(1-*oxo*-3-iso*indolinylideneamino*)-*pyrimidine* (III*c*) (0·593 g., 88%) separated from nitrobenzene as very pale yellow needles, m. p. 288—289° (Found : C, 64·8; H, 3·55; N, 23·0. $C_{20}H_{12}O_2N_6$ requires C, 65·2; H, 3·3; N, 22·8%).

2 : 4-Diaminopyrimidine (0·5 g.) was heated under reflux in 2-ethoxyethanol (10 c.c.) with 3-imino-1-oxo*iso*indoline (0·67 g.) until the evolution of ammonia had almost ceased. When cooled, the solution deposited a crystalline mixture (0·65 g.), m. p. 235—258°. Fractional crystallisation from nitrobenzene gave in minute yield very pale yellow needles of 2 : 4-di-(1-oxo-3-*iso*indolinylideneamino)pyrimidine (Found : N, 21·8), m. p. and mixed m. p. 287°, and yellow 3-(4 ?-*amino*-2 ?-*pyrimidylimino*)-1-*oxo*iso*indoline*, m. p. 274° (Found : C, 59·7; H, 3·85; N, 29·1. $C_{12}H_9ON_5$ requires C, 60·2; H, 3·8; N, 29·3%). A third fraction had m. p. 264°, and light absorption max. (in ethanol) at 2510, 2650, 2800, 2900, 3300, 3450, 3650 Å (ε = 7900, 10,750, 7900, 7900, 6900, 6900, 6900, respectively).

Products from 1 : 3-*Di-imino*iso*indoline and Aniline.*—(a) *Preparations.* The di-imine (3 g.), aniline (4 g.), and ethanol (30 c.c.) were heated together under reflux. Ammonia was evolved. During the first 1—2 hr., the yellow monophenylimine (see below) separated, but this later redissolved, and the solution became darker. After 16 hr. the solution was evaporated, and the residue triturated repeatedly with light petroleum (b. p. 60—80°). The 1 : 3-*diphenyl-imino*iso*indoline* (3·82 g., 62%) crystallised from light petroleum (b. p. 40—60°) as pale yellow needles, m. p. 129° (Found : C, 80·8; H, 5·2; N, 14·2. $C_{20}H_{15}N_3$ requires C, 80·8; H, 5·1; N, 14·1%). The same compound (0·71 g.), m. p. and mixed m. p. 129°, was obtained by treatment of the deep yellow hydrochloride (Part I, *loc. cit.*) (1 g.) with boiling 0·1N-sodium hydroxide for 1 hr., and extraction of the product with boiling light petroleum (b. p. 40—60°).

1 : 3-Di-imino*iso*indoline (5 g.), aniline (3·2 g.), and ethanol (30 c.c.) were heated under reflux for 2 hr. A solid had then separated and evolution of ammonia had slackened. From ethanol, 1-*imino*-3-*phenylimino*iso*indoline* (6 g., 79%) separated as a yellow microcrystalline powder, m. p. 203° (decomp.) (Found : C, 76·0; H, 5·0; N, 19·1. $C_{14}H_{11}N_3$ requires C, 76·0; H, 5·0; N, 19·0%). When this imine (0·1 g.) was treated with aniline (0·1 g.) in boiling ethanol (5 c.c.) for 5 hr., ammonia was evolved. Passage of hydrogen chloride through the cooled solution precipitated 1 : 3-diphenylimino*iso*indoline hydrochloride (0·12 g., 69%), which, after crystallisation from glacial acetic acid, had m. p. 276°, not depressed by authentic material (Part I, *loc. cit.*).

(b) *Hydrolyses.* 1-Imino-3-phenylimino*iso*indoline (0·5 g.) was warmed for 5—10 sec. with concentrated hydrochloric acid (10 c.c.). Cold water was added, and the solution decanted from a little undissolved material into aqueous ammonia. The precipitate was crystallised from ethanol, and had m. p. 170° alone and in admixture with 1-oxo-3-phenylimino*iso*indoline (Part I, *loc. cit.*).

When 1-imino-3-phenylimino*iso*indoline (0·63 g.), ethanol (10 c.c.), and 2N-hydrochloric acid (20 c.c.) were heated together under reflux for 15 min. and the solution was cooled in ice, phthalimide separated. The filtrate was evaporated to dryness, and the residue taken up in 2N-hydrochloric acid (10 c.c.) and filtered from undissolved phthalimide (total yield, 0·39 g.; 0·93 mol.), m. p. 230—231°. The filtrate contained aniline (0·92 mol.), which was diazotised and coupled with 2-naphthol, yielding phenylazo-2-naphthol (0·65 g.), m. p. and mixed m. p. 131°.

Hydrolysis of 1 : 3-diphenylimino*iso*indoline (0·5 g.) under similar conditions yielded phthalimide (0·23 g., 0·93 mol.) and aniline (1·80 mols.), isolated as phenylazo-2-naphthol (0·75 g.), the products being identified by mixed m. p.s.

Hydrolysis of 1-*Oxo*-3-*phenylimino*iso*indoline.*—(*a*) The compound (500 mg.), water (20 c.c.), and concentrated hydrochloric acid (1 c.c.) were heated together under reflux for 5 min. On

cooling of the solution in ice, phthalimide separated as needles (288 mg., 0·87 mol.), m. p. and mixed m. p. 230—231°.

(*b*) 1-Oxo-3-phenylimino*iso*indoline (500 mg.), water (20 c.c.), and concentrated hydrochloric acid (0·25 c.c.) were heated together under reflux for 20 hr., and the solution which had evaporated somewhat was cooled. The white crystalline product (260 mg.), m. p. *ca.* 195—197°, was insoluble in cold aqueous sodium hydroxide. Recrystallisation from ethanol afforded needles of *N*-phenylphthalimide, m. p. 205° (Found: C, 75·25; H, 4·0; N, 6·4. Calc. for $C_{14}H_9O_2N$: C, 75·3; H, 4·1; N, 6·3%).

2-*Methyl*-1-*oxo*-3-*phenylimino*isoindoline.—(*a*) 3-Imino-1-oxo*iso*indoline (1·46 g.) and methyl sulphate (1·26 g.; redistilled) were heated slowly to 65°, and the melt then cooled. From methanol, 3-*imino*-2-*methyl*-1-*oxo*isoindolinium *methyl sulphate* crystallised with m. p. 243° (Found: C, 43·9; H, 4·4; N, 10·0; S, 11·8. $C_{10}H_{12}O_5N_2S$ requires C, 44·1; H, 4·4; N, 10·3; S, 11·8%). When its aqueous solution was boiled and then cooled, *N*-methylphthalimide separated (m. p. and mixed m. p. 134°; yield, quantitative).

The methyl sulphate (0·18 g.), aniline (0·5 c.c.), and methanol (10 c.c.) were heated under reflux for 17 hr. The solution was evaporated to a small volume and cooled. The 2-*methyl*-1-*oxo*-3-*phenylimino*iso*indoline* (0·11 g., 70%) formed pale yellow needles, m. p. 144°, from acetone (Found: C, 76·3; H, 5·2; N, 12·2. $C_{15}H_{12}ON_2$ requires C, 76·2; H, 5·1; N, 11·85%). When the compound (0·1 g.) was heated under reflux with 0·1N-hydrochloric acid (5 c.c.) for several minutes and the solution cooled, silky needles of *N*-methylphthalimide separated (0·06 g., 88%; m. p. and mixed m. p. 134°).

(*b*) 1-Oxo-3-phenylimino*iso*indoline (0·5 g.), N-sodium hydroxide (20 c.c.), methyl sulphate (0·5 c.c.), and benzene (25 c.c.) were shaken together for 1·5 hr. The benzene layer was separated, washed with water, and evaporated. Recrystallisation of the residue from light petroleum (b. p. 60—80°) afforded pale yellow needles of the 2-methyl derivative, m. p. 141—142° and mixed m. p. 142—143°.

Addition of Amines to Phthalonitrile.—(*a*) Methanol (25 c.c.) in which sodium (5 mg.) had been dissolved, phthalonitrile (2·56 g.), and aniline (1·86 g.) were heated together under reflux for 4 hr. On cooling, 1-imino-3-phenylimino*iso*indoline (2 g., 46%) separated, having m. p. and mixed m. p. 203° (decomp.).

(*b*) Sodium (5 mg.) was dissolved in methanol (25 c.c.), and phthalonitrile (2·56 g.) and *n*-butylamine (1·45 g.) were added. The solution was heated under reflux for 3 hr., filtered from a little phthalocyanine, and evaporated, and the residue was extracted with boiling benzene and triturated with ether and acetone. The residual 3-n-*butylimino*-1-*imino*iso*indoline* (3·8 g., 94%) separated from methanol (charcoal) as a colourless powder, m. p. 162—163° (decomp.) (Found: C, 71·4; H, 7·8; N, 20·9. $C_{12}H_{15}N_3$ requires C, 71·6; H, 7·5; N, 20·9%).

1 : 3-*Di*-n-*butylimino*iso*indoline*.—(*a*) 3-*n*-Butylimino-1-imino*iso*indoline (1 g.) and *n*-butylamine (5 c.c.) were heated under reflux for 3 hr., during which ammonia was evolved. The solution was evaporated under reduced pressure and the residue crystallised from ether, to yield 1 : 3-*di*-n-*butylimino*iso*indoline* (1·15 g., 90%) as needles, m. p. 132° (Found: C, 74·2; H, 9·1; N, 15·9. $C_{16}H_{23}N_3$ requires C, 74·7; H, 9·0; N, 16·3%).

(*b*) The same product (0·83 g., 95%) was obtained from 1 : 3-di-imino*iso*indoline (0·5 g.) and *n*-butylamine (5 c.c.), similarly.

Products from 1 : 3-*Di-imino*iso*indoline and* β-*Naphthylamine.*—(a) *Preparations.* The di-imine (2 g.) and β-naphthylamine (5 g.) were heated in *n*-butanol (40 c.c.) under reflux until evolution of ammonia ceased. The solution was cooled, and the product which separated was washed with light petroleum (b. p. 80—100°). 1 : 3-*Di*-2′-*naphthylimino*iso*indoline* (4·2 g., 76%) crystallised from light petroleum (b. p. 80—100°) as yellow needles, m. p. 148—149° (Found: C, 84·3; H, 5·4; N, 10·7. $C_{28}H_{19}N_3$ requires C, 84·6; H, 4·8; N, 10·6%).

When 1 : 3-di-imino*iso*indoline (3 g.) and β-naphthylamine (2·9 g.) were allowed to react together in boiling ethanol (30 c.c.) for 16 hr., and the solution cooled, 1-*imino*-3-2′-*naphthylimino*iso*indoline* separated (4·26 g., 76%), which, from ethanol containing a trace of ammonia, crystallised as yellow needles, m. p. 203—204° (decomp.) (Found: C, 80·0; H, 4·95; N, 15·3. $C_{18}H_{13}N_3$ requires C, 79·7; H, 4·8; N, 15·5%). Treatment of this imine (0·5 g.) with β-naphthylamine (0·3 g.) in boiling ethanol (10 c.c.) for 16 hr., evaporation of the solution, and trituration of the residue with light petroleum (b. p. 80—100°), yielded 1 : 3-di-2′-naphthylimino*iso*indoline (0·56 g., 76%), m. p. and mixed m. p. 148—149°.

(b) *Hydrolyses.* Stirring 1-imino-3-2′-naphthylimino*iso*indoline (0·5 g.) with concentrated hydrochloric acid (10 c.c.) gave a red salt, rapidly converted into a yellow solid when the mixture was warmed. Water was added, and the solid warmed with aqueous ammonia and washed

with water. The 3-2′-naphthylimino-1-oxo*iso*indoline had m. p. 180—190°, raised on crystallisation from ethanol (charcoal) to 198—199° and not depressed by authentic material (above).

1-Imino-3-2′-naphthylimino*iso*indoline (0·5 g.), ethanol (10 c.c.), and concentrated hydrochloric acid (20 c.c.) were heated under reflux for 25 min. The solution was evaporated to dryness under reduced pressure, and the residue stirred with N-sodium hydroxide (10 c.c.) at 40° for 10 min., leaving insoluble β-naphthylamine (0·23 g., 0·87 mol.), m. p. and mixed m. p. 111° (acetyl derivative, m. p. 132°). The alkaline filtrate was acidified with concentrated hydrochloric acid, the precipitated phthalic acid collected, and the filtrate evaporated to dryness. Removal of inorganic salts with water (3 c.c.) left phthalic acid (total yield, 0·24 g., 0·78 mol.), m. p. 193° (decomp.). The *S*-benzylthiuronium salt had m. p. 158° alone and when mixed with the authentic salt of phthalic acid.

Hydrolysis of 1 : 3-di-2′-naphthylimino*iso*indoline (0·5 g.) for 2 hr. with boiling glacial acetic acid (10 c.c.) and concentrated hydrochloric acid (10 c.c.) yielded β-naphthylamine (0·38 g., 2·0 mols.) and phthalic acid (0·18 g., 0·86 mol.), separated and identified as before.

Products from 1 : 3-*Di-imino*iso*indoline and* 3-*Aminopyridine.*—(*a*) The di-imine (1 g.) and 3-aminopyridine (0·65 g.) in ethanol (10 c.c.) were heated under reflux for 17 hr., and the solution was then cooled. 1-*Imino*-3-3′-*pyridylimino*iso*indoline* (0·95 g., 62%) separated from ethanol as a bright yellow crystalline powder, m. p. 207° (Found : C, 70·4; H, 4·8; N, 25·4. $C_{13}H_{10}N_4$ requires C, 70·3; H, 4·5; N, 25·2%). The same product, m. p. and mixed m. p. 207°, was formed in 72% yield from an analogous reaction with 2 mols. of the aminopyridine (1·3 g.).

(*b*) The preceding product (1 g.) and 3-aminopyridine (0·43 g.) in butanol were heated under reflux for 24 hr., during which ammonia was evolved. The solution was evaporated. Trituration of the residue with light petroleum (b. p. 40—60°) afforded a pale yellow powder (1·18 g.), m. p. 142—147°, which crystallised from aqueous ethanol as solvated yellow needles, m. p. 122—123° (decomp.). After being dried at 100°/0·01 mm. for 2 hr., the 1 : 3-*di*-3′-*pyridylimino*iso*indoline* was very pale yellow and had m. p. 186° (Found : C, 72·0; H, 4·6; N, 23·3. $C_{18}H_{13}N_5$ requires C, 72·2; H, 4·4; N, 23·4%).

1 : 3-*Dipyrazinylimino*iso*indoline.*—Aminopyrazine (0·5 g.) (Weijlard, Tishler, and Erickson, *J. Amer. Chem. Soc.*, 1945, **67**, 802), 1 : 3-di-imino*iso*indoline (0·38 g.), and butanol (10 c.c.) were heated under reflux for 17 hr., ammonia being evolved. When cooled, the solution deposited yellowish-green crystals of 1 : 3-*dipyrazinylimino*iso*indoline* (0·52 g.), m. p. 250°, raised to 257° by recrystallisation from butanol or 2-ethoxyethanol (Found : C, 63·3; H, 3·6; N, 32·5. $C_{16}H_{11}N_7$ requires C, 63·8; H, 3·7; N, 32·55%).

Heating the dipyrazinylimino*iso*indoline with methyl iodide at 90—100° for 17 hr. gave the *dimethiodide*, which crystallised from aqueous ethanol as orange needles, m. p. 280—281° (Found : I, 43·6. $C_{18}H_{17}N_7I_2$ requires I, 43·4%).

The dimethiodide (0·456 g.) was heated with N-hydrochloric acid (10 c.c.) under reflux for 5 min., and the dark solution evaporated. The black tarry residue was boiled with concentrated hydrochloric acid, the solution was evaporated, the residue taken up in 2N-sodium hydroxide, and the solution treated twice with charcoal, concentrated, and acidified. The precipitate was washed with a little water, leaving phthalic acid (72 mg.), m. p. 190° (decomp.); the *S*-benzylthiuronium salt had m. p. and mixed m. p. 158°.

Derivatives of 3-*Amino*-1-*imino*iso*indolenine.*—(*a*) 3-Imino-1-oxo*iso*indoline (0·5 g.) was dissolved in hot ethanol (15 c.c.) and morpholine (0·5 c.c.; not distilled) added. After 2 days, the solution was evaporated and the residue triturated with ether, yielding crystals, m. p. 124—127°. From benzene (charcoal), the *amide morpholide* (V) of phthalic acid formed needles, m. p. 134° (Found : C, 62·0; H, 6·15; N, 11·9. $C_{12}H_{14}O_3N_2$ requires C, 61·5; H, 6·0; N, 12·0%). The same compound (1·03 g.), m. p. and mixed m. p. 133—135°, was obtained by shaking phthalimide (0·75 g.) with 1 : 1 aqueous morpholine (10 c.c.) and evaporating the solution under reduced pressure.

3-Imino-1-oxo*iso*indoline (1 g.) and morpholine (1 g., fractionated) were boiled together in ethanol (20 c.c.) for 17 hr., and the solution was evaporated to small bulk. Colourless needles (1·22 g.), m. p. 190—191°, separated. From ethanol or benzene, the 3-*morpholino*-1-*oxo*iso*indolenine* (VI) crystallised as needles, m. p. 191° (Found : C, 66·7; H, 5·8; N, 13·3. $C_{12}H_{12}O_2N_2$ requires C, 66·65; H, 5·6; N, 13·0%).

Similar interaction of 1 : 3-di-imino*iso*indoline (1 g.) and morpholine (1 g.; fractionated) in ethanol gave ammonia and a little phthalocyanine (identified spectroscopically). From the filtrate, on evaporation, needles separated (0·7 g.), having m. p. 125—130°, raised to 155—160°, and then to 191° on recrystallisation from ethanol and, later, benzene. The final product was identical (mixed m. p.) with 3-morpholino-1-oxo*iso*indolenine.

(*b*) 1-Imino-3-phenylimino*iso*indoline (1 g.), morpholine (1 c.c.; redistilled), and ethanol (20 c.c.) were heated under reflux for 17 hr. The hot solution was treated with charcoal, evaporated to small bulk, and cooled. The 3-*morpholino*-1-*phenylimino*iso*indolenine* (VII; R = O) (0·5 g.) crystallised from benzene–light petroleum (b. p. 60—80°) as yellow needles, m. p. 165° (Found: C, 74·3; H, 6·1; N, 14·1. $C_{18}H_{17}ON_3$ requires C, 74·2; H, 5·9; N, 14·4%).

(*c*) Similar interaction of 1-imino-3-phenylimino*iso*indoline (1 g.) and piperidine (1 c.c.) in ethanol gave a viscous red oil, which solidified partly when triturated with light petroleum (b. p. 40—60°). The mass was drained on porous tile overnight, then dissolved in a minimum of benzene, and the solution diluted to 50 c.c. with light petroleum (b. p. 60—80°). 1-*Phenylimino*-3-*piperidino*iso*indolenine* (VII; R = CH_2) (0·2 g.) slowly separated, and on recrystallisation from light petroleum (b. p. 100—120°) formed yellow needles, m. p. 118° (Found: C, 79·0; H, 6·6; N, 14·2. $C_{19}H_{19}N_3$ requires C, 78·8; H, 6·6; N, 14·5%).

(*d*) 1-Imino-3-phenylimino*iso*indoline (1 g.), *N*-methylaniline (1 c.c.), and ethanol (20 c.c.) were heated under reflux for 24 hr. The solution was evaporated under reduced pressure and ether added. Starting material (0·45 g.), m. p. 200—201°, was filtered off, the filtrate evaporated, and the residual gum triturated with light petroleum (b. p. 60—80°) (50 c.c.). When left at room temperature the extract slowly deposited a yellow crystalline solid: the first crop (1 hr.), which softened from 120°, was rejected, and the second crop (90 mg.) (several days), m. p. 120—124°, was recrystallised several times from ethanol–water. The 3-N-*methylanilino*-1-*phenylimino*iso*indolenine* (VIII) formed yellow prisms, m. p. 128° (Found: C, 80·2; H, 5·55; N, 13·5. $C_{21}H_{17}N_3$ requires C, 80·4; H, 5·7; N, 13·9%).

The same compound (mixed m. p. undepressed) was prepared by heating 1 : 3-diphenylimino*iso*indoline (1 g.) in dry benzene (40 c.c.) with powdered sodamide (0·3 g.) for 1·5 hr. and then with methyl iodide (3 c.c.) until the mixture began to darken (*ca.* 20 min.); the mixture was then shaken with several lots of water, and the benzene layer dried and evaporated (yield, 0·84 g.; m. p. 122—123°, raised to 127—128° on recrystallisation).

When 3-*N*-methylanilino-1-phenylimino*iso*indolenine (96·9 mg.) was heated under reflux with 2N-hydrochloric acid (5 c.c.) for 3 min., and the solution cooled in ice, phthalimide crystallised (33·7 mg., 0·73 mol.; m. p. and mixed m. p. 231—232°). The filtrate was treated slowly at *ca.* 5° with sodium nitrite (60 mg.) in water. After 10 min., the oil which had separated was taken up in ether (*E*). The aqueous layer was added to 2-naphthol (150 mg.) in ice-cold 2N-sodium hydroxide (6 c.c.), yielding phenylazo-2-naphthol (74·1 mg., 0·96 mol.), m. p. 126—127°. The extract *E* was dried ($MgSO_4$) and treated with dilute ethanolic hydrogen chloride (1 c.c.) for 30 min., then washed with aqueous sodium carbonate and water. Evaporation of the ether yielded *N*-methyl-*p*-nitrosoaniline, which crystallised from benzene as greenish-yellow plates (29·5 mg., 0·7 mol.), m. p. and mixed m. p. 114—115°.

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Department of Organic Chemistry, Imperial College of Science and Technology, South Kensington, London, S.W.7. [*Received, July 14th,* 1953.]