21. *A Reaction of Certain Diazosulphonates derived from β-Naphthol-1-sulphonic Acid. Part XVII. Conversion of Nitro-3-aryl- and Nitro-3-aryl-4-methyl-phthalaz-1-ones into Corresponding Phthalaz-4-ones by Migration of the Nitroaryl Group, and Related Reactions.*

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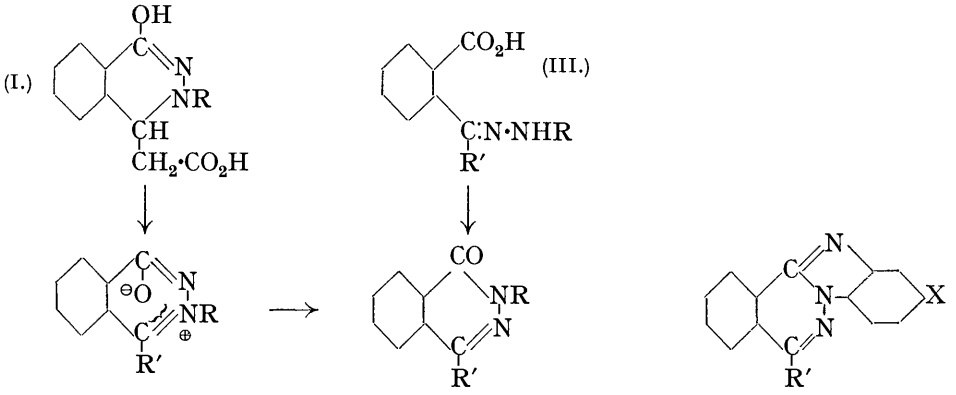
In Part XI (J., 1933, 1068) it was stated that when 1-hydroxy-3-(4′-nitrophenyl)-3 : 4-dihydrophthalazine-4-acetic acid (I; R = 4′-nitrophenyl) was heated with dilute hydrochloric acid (1 : 7·5) in a sealed tube at 175° for 6 hours, the product appeared to be a mixture of 4′-nitro-3-phenyl- and 4′-nitro-3-phenyl-1-methyl-phthalaz-4-one (IV; R = 4′-nitrophenyl, R′ = H and Me respectively). The latter compounds had been obtained hitherto only by the reaction of *p*-nitrophenylhydrazine with *o*-phthalaldehydic acid (J., 1928, 2555) and with acetophenone-*o*-carboxylic acid (J., 1931, 1923) respectively, since the products of the action of boiling dilute sulphuric acid (J., 1928, 2553) and cold acid dichromate (J., 1931, 1070) respectively on (I; R = 4′-nitrophenyl) are the isomerides 4′-nitro-3-phenyl- and 4′-nitro-3-phenyl-4-methyl-phthalaz-1-one (II; R = 4′-nitrophenyl, R′ = H and Me respectively). The above reaction with dilute hydrochloric acid in a sealed tube therefore indicated not only that nitroarylphthalaz-4-ones could be obtained in a new way, but also that this involved the possibility of converting nitroarylphthalaz-1-ones into the corresponding phthalaz-4-ones. We have now studied these reactions in detail and have established that this type of conversion can be effected readily. In order to avoid confusion, the nomenclature used in previous parts of this series is retained, although it follows from the present investigation that the two series of nitroarylphthalazones are differentiated more clearly and correctly if compounds (IV) are termed nitro-2-aryl- and nitro-2-aryl-4-methyl-phthalaz-1-ones instead of nitro-3-aryl- and nitro-3-aryl-1-methyl-phthalaz-4-ones.

Numerous nitro- and amino-3-arylphthalaz-4-ones, and the corresponding 1-methyl compounds, required for purposes of reference in the present investigation have already been described (J., 1936, 311). It proved desirable, however, to prepare compounds containing a nitro- or an amino-group in the 2′-position and, in doing so, we observed a property peculiar to the 2′-nitro-compounds which made it clear that the substance, pale yellow needles, m. p. 239°, considered to be 2′-amino-3-phenyl-1-methylphthalaz-4-one (*ibid.*, p. 314), is not that compound. The actual colourless 2′-*amino*-3-*aryl*- and 2′-*amino*-3-*aryl*-1-*methyl-phthalaz*-4-*ones* (IV; R = 2′-aminoaryl, R′ = H and Me respectively) are obtained satisfactorily only from the corresponding *o*-carboxy-benzaldehyde- and -acetophenone-2′-nitroarylhydrazones (III; R′ = H and Me respectively) with aqueous sodium sulphide, which effects both ring closure and reduction, whereas yellow substances with different properties are the main products of reducing (IV; R = 2′-nitroaryl, R′ = H or Me) with aqueous-alcoholic sodium sulphide. The amino-compounds (IV) readily form *acetyl* derivatives, are diazotisable and couple to form azo-dyes, and, when heated with dilute hydrochloric acid (1 : 8) in a sealed tube at 180° for 6 hours, are converted almost quantitatively into the basic 2′ : 4-*anhydro*-derivatives (V; R′ = H or Me). On the other hand, the yellow substances yield only traces of the acetyl derivative of (IV) (possibly derived from a little of the amino-compound that may be present), are not diazotisable, and are not convertible into (V). Owing to the fact that variable analyses are obtained according to the conditions used in crystallisation and drying, the yellow substances were not examined further, but they may well be intermediate hydroxylamine derivatives which cannot be reduced to the amino-compounds.

The study of the influence of variations in the conditions on the conversion of (II; R = nitroaryl, R′ = H or Me) into (IV; R = nitroaryl, R′ = H or Me) is facilitated by the great differences in properties between the two types of compound, by means of which mixtures are separated with exceptional ease. Compounds (II) are both acidic and basic; in many cases they form readily soluble hydrochlorides, and all dissolve readily in aqueous sodium hydroxide, but are practically insoluble in such hydrocarbon solvents as benzene

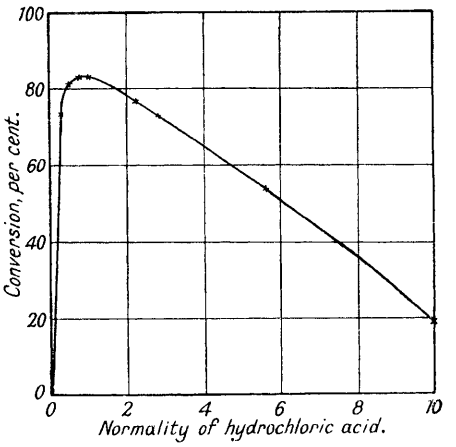
and toluene. On the other hand, compounds (IV) are insoluble in aqueous mineral acids and alkalis, but are readily soluble in hydrocarbon solvents.



(I.) (II.) (III.) (IV.) (V; R′ = H or Me; X = H, Me, or Cl.)

In general, nitro-3-arylphthalaz-1-ones (II; R′ = H) and the corresponding 4-methyl compounds (II; R′ = Me) are best converted into nitro-3-arylphthalaz-4-ones (IV; R′ = H) and the corresponding 1-methyl compounds (IV; R′ = Me), respectively, by heating with dilute hydrochloric acid in a sealed tube at temperatures between 170° and 190° for 6 hours; temperatures above 190° usually result in some decomposition and the product is charred. Under similar conditions, the conversion is also brought about by dilute sulphuric acid, as well as by dilute acetic acid to a less extent, but water alone and aqueous alkalis are ineffective. The ratio of the weight of (II; R′ = H or Me) to the volume of dilute hydrochloric acid appears to be of little importance, but with tubes of the capacity that we employed 1—1·5 g. of (II) to 18 c.c. acid is most satisfactory. The strength of the acid used, however, has a marked effect on the rate and extent of conversion, as is illustrated by Fig. 1, which shows the percentage yield of (IV) obtained when (II; R = 4′-nitrophenyl, R′ = Me) (1 g.) is heated with dilute hydrochloric acid (18 c.c.; various strengths) at 180° for 6 hours.

FIG. 1.



This conversion proceeds most readily when approximately 1·2*N*-hydrochloric acid is used, and we employed acid of this strength generally throughout the investigation. In most cases, the conversion is neat at an appropriate temperature, being unaccompanied by any side reaction, and usually it is possible to account for 90—95% of (II) by recovering unaltered material. The temperature employed is very important in certain cases, because with (II; R = 2′-nitroaryl, or 2′-halogeno- or 2′ : 6′-dihalogeno-4′-nitrophenyl, R′ = Me), although compounds (IV; R′ = Me) are obtained at a suitably high temperature, different compounds (VI) (see p. 93) are produced at a lower temperature. On the other hand, compound (II; R = 4′-nitrophenyl, R′ = Me) is converted into the corresponding compound (IV) to some extent even by refluxing with dilute hydrochloric acid.

The results for the conversion of (II; R = 4′-nitrophenyl, R′ = Me) into (IV; R = 4′-nitrophenyl, R′ = Me) by heating with dilute hydrochloric acid in a sealed tube at 180° for various times (see p. 99) indicate that the reaction approximately follows a unimolecular course, the average value of k being 48×10^{-4}.

The ease of conversion of (II; R = nitroaryl, R′ = H or Me) into the corresponding compound (IV) varies considerably with the nature and position of substituents in the

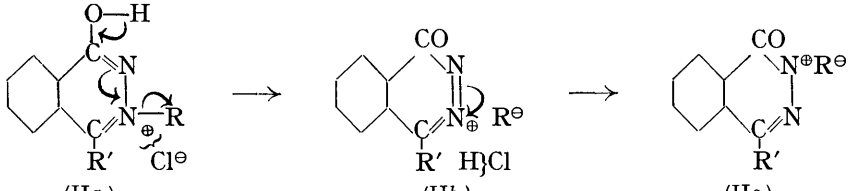
3-phenyl nucleus, as is illustrated in the table, where the percentage conversion is that obtained after heating for 6 hours.

	R′ = H.		R′ = Me.	
R.	% Conversion.	$k \times 10^4$.	% Conversion.	$k \times 10^4$.
4′-Nitrophenyl	66	30	82	48
4′-Nitro-2′-methylphenyl	20	5	27	9
2′-Chloro-4′-nitrophenyl	—	—	49	19
2′-Bromo-4′-nitrophenyl	—	—	27	9
2′ : 6′-Dichloro-4′-nitrophenyl	46	17	17	4·5
2′ : 6′-Dibromo-4′-nitrophenyl	20 *	3	—	—
3′-Nitrophenyl	14	4	25	8
2′-Nitrophenyl	—	—	65	30
2′-Nitro-4′-methylphenyl	36	12	53	21
4′-Chloro-2′-nitrophenyl	68	32	74	37

* After heating for 10 hours.

The figures given for (R = 2′-nitroaryl or halogeno-4′-nitrophenyl, R′ = Me) do not strictly indicate the velocity of conversion of (II) into (IV), because in these cases there is certainly formation of some of the corresponding compound (VI) during preliminary heating, although at the temperatures ultimately attained in the above experiments, (VI) is converted into (IV). The fact that (R = 2′ : 6′-dichloro-4′-nitrophenyl, R′ = Me) is the only example amongst those examined where the yield of (IV) is less than is the case with the analogous lower homologue (R′ = H), is due to the necessity for an abnormally high temperature of conversion with the former in order to avoid formation of the corresponding compound (VI). Compounds (II) containing a nitro-group in the *o*- or the *p*-position of the 3-phenyl nucleus are converted into (IV) much more readily than is the case when the nitro-group is in the *m*-position, halogen in the *o*-position reduces the rate of conversion considerably, the retarding influence of bromine being much greater than that of chlorine, and a methyl group in either the *o*- or the *p*-position also has a notable retarding effect.

The following mechanism, involving migration of the nitroaryl group, is suggested for the conversion of compounds (II; R′ = H or Me) into (IV; R′ = H or Me). The nitroaryl group (R) is considered to migrate, with its pair of binding electrons, as an anion. Thus, the first stage is an electronic redistribution in the hydrochloride of the nitro-3-arylphthalaz-1-one (II*a*; R′ = H or Me), promoted by the electron-attracting group (R), leading to the separation of the latter as an anion (II*b*). A further redistribution of electrons then occurs (II*c*), followed by the reattachment of the anionic group (R) at the 2-nitrogen atom with formation of (IV; R′ = H or Me).



(II*a*.) (II*b*.) (II*c*.)

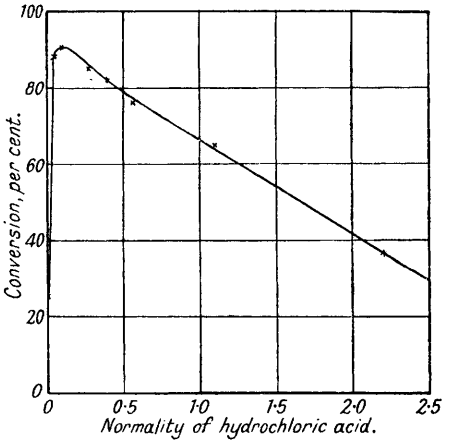
The actual velocity of the conversion is governed by the ease of separation of the nitroaryl group (R), the succeeding changes being so rapid as to be incapable of measurement. Thus, although the group (R) is shown in (II*b*) as a free ion, it is considered to be captured immediately by the positive 2-nitrogen atom (II*c*) before it can escape into the bulk of the reaction mixture. Such a mechanism closely resembles that suggested by Stevens and co-workers for the rearrangement of phenacyl- and acetonyl-benzyldimethylammonium salts (J., 1928, 3193; 1930, 2107, 2119; 1932, 55, 1926), and is preferred to the alternative type of mechanism in which the migrating aryl group is considered to attract one or both of the lone pair of electrons on the nitrogen atom to which it is migrating (cf. the conversion of *N*-phenylbenziminophenyl ethers into benzoyldiphenylamines, and the reversible rearrangement of triarylbenzenylamidines : Chapman, J., 1925, **127**, 1992; 1927, 1743; 1929, 2133; 1930, 2462; 1932, 1770; see also Bennett, *Ann. Reports*, 1929, **26**, 123).

The literature, however, appears to contain no example of the migration of an aryl group from one nitrogen atom to another nitrogen atom in a ring, as occurs in our case.

That our reaction is intramolecular in character and does not involve the presence of free ions, is clear from the fact that when a mixture of equal quantities of (II; R = 4'-nitrophenyl, R' = Me) and (II; R = 2' : 6'-dichloro-4'-nitrophenyl, R' = H) is heated under conditions suitable for conversion, only (IV; R = 4'-nitrophenyl, R' = Me) and (IV; R = 2' : 6'-dichloro-4'-nitrophenyl, R' = H) are obtained. If free ions were actually present at any stage during the conversion, the reaction product would be expected to contain also (IV; R = 4'-nitrophenyl, R' = H) and (IV; R = 2' : 6'-dichloro-4'-nitrophenyl, R' = Me), but no trace of these two compounds could be detected.

It has already been mentioned that certain nitro-3-aryl-4-methylphthalaz-1-ones (II; R' = Me) give a different product when heated with dilute hydrochloric acid at a temperature lower than that required for conversion into (IV; R' = Me). This novel reaction proceeds most readily with (II; R = 2'-nitroaryl, R' = Me), in which case the conversion is best effected by refluxing with dilute hydrochloric acid and 2-(2'-*nitroarylamino*)-3-*methylene*iso*indolinone* (VI; R = 2'-nitroaryl) separates progressively in yellow needles. Compounds (VI) are of a new type in these investigations, isomeric with the corresponding compounds (II; R' = Me) and (IV; R' = Me), and are insoluble in both dilute mineral acids and aqueous alkalis. In agreement with the constitution proposed, they are hydrolysed by boiling alcoholic sodium ethoxide with formation of the corresponding *o*-carboxyacetophenone-2'-nitroarylhydrazones (III; R' = Me), and are oxidised by chromic acid to the corresponding N-2'-*nitroarylaminophthalimides* (named phthalyl-2'-nitroarylhydrazides in J., 1935, 1808). The product of their reduction varies with the reagent used, boiling aqueous-alcoholic sodium sulphide producing the corresponding 2'-amino-3-aryl-1-methylphthalaz-4-ones (IV; R = 2'-aminoaryl, R' = Me), and iron powder and acetic acid the 2-(2'-*aminoarylamino*)-3-*methylene*iso*indolinones* (VI; R = 2'-aminoaryl).

FIG. 2.



It is noteworthy that in the latter case the $C{:}CH_2$ linkage is *not* reduced with formation of 2-(2'-aminoarylamino)-3-methyl*iso*indolinone. This stability of the methylene group is further exemplified by the facts that compounds (VI; R = 2'-nitroaryl) do not react with bromine water, or form perchlorates, or react in the ways that 1-methoxy-3-(4'- and 3'-nitroaryl)-4-methylene-3 : 4-dihydrophthalazines do (cf. J., 1936, 1704), although an intense violet colour is produced when (VI; R = 2'-nitrophenyl) is boiled with *p*-dimethylaminobenzaldehyde in acetic anhydride solution in presence of a little sulphuric acid. Finally, compounds (VI; R = 2'-nitroaryl) are converted into the corresponding 2'-nitro-3-aryl-1-methylphthalaz-4-one (IV; R' = Me) by heating with dilute hydrochloric acid (1 : 8) in a sealed tube at 180—190° for 6 hours, or much more readily by heating a solution in concentrated sulphuric acid at 180° for 1—2 minutes. As fuming sulphuric acid is equally effective in the latter method, it is clear that this conversion of (VI; R = 2'-nitroaryl) into (IV; R = 2'-nitroaryl, R' = Me) does not involve the addition and subsequent removal of the elements of water. Compounds (VI; R = 2'-nitroaryl) cannot be synthesised, because methylenephthalide (Gabriel, *Ber.*, 1884, **17**, 2521) does not react with an *o*-nitroarylhydrazine in boiling alcoholic or glacial acetic acid solution, and when a mixture of the two is heated at 120° the product is (III; R = 2'-nitroaryl, R' = Me).

The conversion of (II; R = 2'-nitroaryl, R' = Me) into (VI; R = 2'-nitroaryl) is influenced considerably by the strength of the acid employed, as is illustrated by Fig. 2, which shows the percentage yield of (VI) obtained when (II; R = 2'-nitrophenyl, R' = Me)

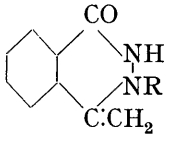
(1·5 g.) is heated with dilute hydrochloric acid (18 c.c.; various strengths) in a sealed tube at 150° for 6 hours.

Under these conditions, water alone effects this conversion to a moderate extent, but the maximum yield of (VI) is obtained when approximately 0·1—0·2*N*-hydrochloric acid is used. As already stated, with (II; R = 2′-nitroaryl, R′ = Me) this conversion is best carried out by refluxing with dilute hydrochloric acid, in which case the maximum effect is produced by somewhat stronger acid than when a sealed tube is employed. The results for the conversion of (II; R = 2′-nitrophenyl, R′ = Me) into the corresponding compound (VI) by refluxing with 0·8*N*-hydrochloric acid for various times (see p. 102) indicate that the reaction approximately follows the unimolecular law, the average value of k being 41×10^{-3}.

The only compounds other than (II; R = 2′-nitroaryl, R′ = Me) that we have succeeded in converting into the corresponding compounds (VI) are (II; R = 2′-halogeno-4′-nitro- or 2′ : 6′-dihalogeno-4′-nitro-phenyl, R′ = Me). With these 4′-nitro-compounds, however, the reaction occurs much less readily; for instance, refluxing with dilute hydrochloric acid is ineffective, and heating with dilute hydrochloric acid in a sealed tube at 160—165° for 6 hours is necessary in order to obtain the 2-(2′-*halogeno*-4′-*nitro*- and 2′ : 6′-*dihalogeno*-4′-*nitro*-*phenylamino*)-3-*methylene*iso*indolinone* (VI). The latter compounds possess similar properties and undergo similar reactions to those already outlined for their 2′-nitro-analogues.

The ease of conversion of (II; R = nitroaryl, R′ = Me) into the corresponding compounds (VI; R = nitroaryl) varies considerably with the nature and position of substituents in the 3-phenyl nucleus, and the reaction velocities in the cases which we have studied are in the order R = 4′-chloro-2′-nitrophenyl > 2′-nitrophenyl > 2′-nitro-4′-methylphenyl ≫ 2′-chloro-4′-nitrophenyl > 2′-bromo-4′-nitrophenyl > 2′ : 6′-dichloro-4′-nitrophenyl > 2′ : 6′-dibromo-4′-nitrophenyl.

The rearrangement of (II) to (VI), although also intramolecular in character, is probably entirely different in mechanism from that suggested for the conversion of (II) into (IV), and merely involves a change of linkage in the tautomeric methylene form (II*d*) of (II; R′ = Me).

(II*d*.)  (VI.)

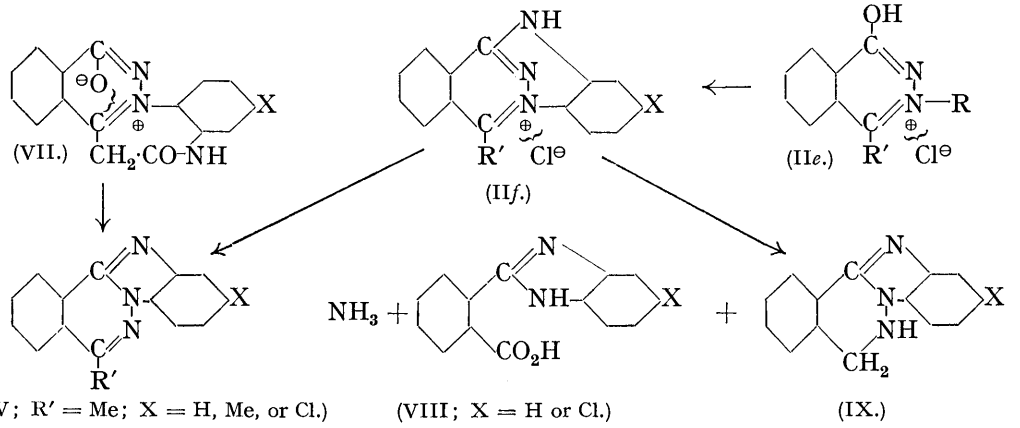
It is considered to be most improbable that the conversion of nitro-3-aryl-4-methylphthalaz-1-ones (II; R′ = Me) into nitro-3-aryl-1-methylphthalaz-4-ones (IV; R′ = Me) involves the intermediate formation of the corresponding compound (VI), because there is no evidence of the formation of (VI; R = 3′- or 4′-nitrophenyl); moreover it is impossible to obtain analogues of (VI) from (II; R = nitroaryl, R′ = H), yet the latter are convertible into (IV; R = nitroaryl, R′ = H).

p- and *m*-Amino-3-phenylphthalaz-1-ones (II; R = 4′- or 3′-aminophenyl, R′ = H) and the corresponding 4-methyl compounds cannot be converted into the amino-derivatives of the respective 4-ones (IV; R = 4′- or 3′-aminophenyl, R′ = H or Me), but are recovered unaltered after heating with dilute hydrochloric acid in a sealed tube. This supports the mechanism suggested for the conversion of (II; R = nitroaryl, R′ = H or Me) into (IV; R = nitroaryl, R′ = H or Me), because the amino-group is capable of electron release, and it is improbable that the positive ammonium group, which would promote the reaction, would be formed under the conditions employed.

o-Amino-3-arylphthalaz-1-ones (II; R = 2′-aminoaryl, R′ = H) and the corresponding 4-methyl compounds (II; R = 2′-aminoaryl, R′ = Me), however, do react when heated with dilute hydrochloric acid (1 : 8) in a sealed tube at 180° for 6 hours, although in quite unexpected ways. These new reactions take an entirely different course with (II; R′ = Me) from that with (II; R′ = H). Thus, 2′-amino-3-aryl-4-methylphthalaz-1-ones (II; R = 2′-aminoaryl, R′ = Me) or 2′-amino-3-arylphthalaz-1-one-4-acetic acid lactams

(VII) are converted into 2′ : 4-anhydro-2′-amino-3-aryl-1-methylphthalaz-4-ones (V; R′ = Me), identical with the compounds already obtained under the same conditions from (IV; R = 2′-aminoaryl, R′ = Me), although the yield is not as good as in the latter case. On the other hand, with (II; R = 4′-chloro-2′-aminophenyl, R′ = H) the 2-nitrogen atom is eliminated as ammonia, and 5-chloro-2-phenylbenziminazole-*o*-carboxylic acid (VIII; X = Cl) and 5-chloro-*o*-benzylenebenziminazole (IX; X = Cl) (cf. J., 1935, 1798) are obtained. The sulphate of the substance which possesses the properties of 2′-amino-3-phenylphthalaz-1-one (*loc. cit.*) behaves similarly, and is converted into ammonia, 2-phenylbenziminazole-*o*-carboxylic acid, and *o*-benzylenebenziminazole. In this remarkable reaction, as the 2-nitrogen atom is eliminated by reduction to ammonia, naturally the oxidation product (VIII) is formed in much greater quantity than the reduction product (IX).

In view of the non-reactivity of the 4′- and 3′-amino-analogues, the first stage of these reactions with both (II; R = 2′-aminoaryl, R′ = H) and (II; R = 2′-aminoaryl, R′ = Me) is almost certainly the removal of 1 molecule of water from the 2′-amino- and the 1-hydroxyl group of the hydrochloride (II*e*). The resulting (II*f*; R′ = H) is so unstable that it decomposes immediately with elimination of the 2-nitrogen atom as ammonia, whilst most of the residue is oxidised to (VIII) and the remainder is reduced to (IX). The corresponding (II*f*; R′ = Me) is rather more stable owing to the presence of the 4-methyl group, which can react in the methylene form, and so only rearrangement occurs with formation of (V; R′ = Me). This rearrangement may take place by a mechanism essentially similar to that suggested for the conversion of (II; R = nitroaryl, R′ = H or Me) into (IV; R = nitroaryl, R′ = H or Me), or merely by change of linkage in (II*f*) resulting in the formation of the hydrochloride of (V).



The reactivity of the 2′-amino-group is further illustrated, and an additional relationship of the compounds under discussion established, by the fact that (VI; R = 2′-aminophenyl) is readily converted into (V; R′ = Me, X = H) by heating with dilute hydrochloric acid (1 : 8) in a sealed tube at 180° for 6 hours. In this case it is improbable that the 2′-amino-group and the 1-keto-group of (VI) would react with removal of 1 molecule of water. Consequently, the first stage in this conversion is more likely to be an intramolecular rearrangement with formation of (IV; R = 2′-aminophenyl, R′ = Me), followed by removal of 1 molecule of water from the latter : the ease with which (VI; R = nitroaryl) is converted into (IV; R = nitroaryl, R′ = Me) tends to support this view.

We have fully confirmed the suggestion that the product of heating (I; R = 4′-nitrophenyl) with dilute hydrochloric acid (1 : 7·5) in a sealed tube at 175° for 6 hours is a mixture of (IV; R = 4′-nitrophenyl, R′ = H) and (IV; R = 4′-nitrophenyl, R′ = Me) (J., 1933, 1068) [compare Bucherer and Fröhlich (*J. pr. Chem.*, 1931, **132**, 87), who considered this reaction to be mere decarboxylation of (I)]. These two compounds are formed in a ratio of approximately 45 : 55, and, although they cannot be separated by fractional crystallisation, after reduction of the mixture of nitro-compounds, some (IV; R = 4′-

aminophenyl, R′ = Me) can be isolated by fractional crystallisation of the mixed amino-compounds. This proof of the presence of (IV; R = 4′-nitrophenyl, R′ = Me) in the product under these conditions is of interest, because the sole product of heating (I; R = 4′-nitrophenyl) with dilute hydrochloric acid (1 : 2) in a sealed tube, or of refluxing it with dilute sulphuric acid, is (II; R = 4′-nitrophenyl, R′ = H). On the other hand, when (I; R = 3′-nitrophenyl) is heated with dilute hydrochloric acid (1 : 7·5) under the same conditions as the 4′-nitro-isomeride, the product is (II; R = 3′-nitrophenyl, R′ = H), some of which is converted into (IV; R = 3′-nitrophenyl, R′ = H) by prolonging the period of heating, but none of the corresponding methyl compounds (II or IV; R′ = Me) could be detected. Compound (I; R = 2′-nitrophenyl), however, behaves similarly to the 4′-nitro-isomeride, except that it is necessary to heat at 190—195°; the product is a mixture of (IV; R = 2′-nitrophenyl, R′ = H) and (IV; R = 2′-nitrophenyl, R′ = Me) in which the latter predominates.

When (I; R = 4′-aminophenyl) is heated with dilute hydrochloric acid in a sealed tube, the sole product is (II; R = 4′-aminophenyl, R′ = H), but the behaviour of (I; R = 2′-aminophenyl) is entirely different. In the latter case, the reaction probably proceeds *via* (II; R = 2′-aminophenyl, R′ = H) and (II; R = 2′-aminophenyl, R′ = Me), for the products are ammonia, 2-phenylbenziminazole-*o*-carboxylic acid (VIII; X = H), and 2′ : 4-anhydro-2′-amino-3-phenyl-1-methylphthalaz-4-one (V; R′ = Me, X = H). No doubt, *o*-benzylenebenziminazole (IX; X = H) also is formed to a small extent and in this case is lost during the crystallisation of (V).

Experimental.

o-*Carboxybenzaldehyde-2′-nitroarylhydrazones* (III; R′ = H).—These compounds (or their lactone forms) were prepared as described for their analogues (J., 1928, 2555; 1936, 312).

Methods of converting (III) *into* 2′-*Nitro*-3-*arylphthalaz*-4-*ones* (IV; R′ = H).—In all cases 0·5 g. of (III) was used. (i) Heating at 20° below the m. p. of the corresponding compound (IV) for 15 minutes; refluxing with (ii) alcohol (10 c.c.) for 1 hour, or (iii) glacial acetic acid (5 c.c.) for 20 minutes, or (iv) nitrobenzene (5 c.c.) for 1 hour, or (v) acetic anhydride (5 c.c.) for ½ hour, or (vi) acetic anhydride (5 c.c.) and pyridine (3 drops) for 3 hours; (vii) dissolution in cold concentrated sulphuric acid (10 c.c.), the solution being left over-night. Any unchanged (III) was extracted with alkali.

2′-*Amino*-3-*arylphthalaz*-4-*ones* (IV; R′ = H, R = 2′-aminoaryl).—These compounds were made only from (III) [method (a)], as reduction of (IV; R = 2′-nitroaryl) gave yellow substances [method (b)] with different properties. (a) A suspension of (III) (5 g.) in water (100 c.c.) was heated with sodium sulphide crystals (50 g.) in water (50 c.c.) at 50—60° until the bluish-red colour of the solution changed to orange-yellow, and almost colourless crystals had separated. (b) Finely divided (IV) (5 g.) was refluxed with a solution of sodium sulphide crystals (50 g.) in water (125 c.c.) and alcohol (125 c.c.) until the red colour of the solution changed to orange and yellow needles had separated.

2′ : 4-*Anhydro*-2′-*amino*-3-*arylphthalaz*-4-*ones* (V; R′ = H).—These compounds were prepared by heating (IV; R′ = H, R = 2′-aminoaryl) (1 g.) with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180° for 6 hours. The reaction mixture was either a colourless solution or a suspension of colourless needles of the hydrochloride and was neutralised with aqueous sodium hydroxide.

Reduction of (III *and* IV; R = 2′-*Nitrophenyl*).—(a) 2′-Amino-3-phenylphthalaz-4-one (J., 1936, 312). (b) The *substance* crystallised from alcohol in bright yellow needles, m. p. 248° (yield, 3·2 g.) (Found : C, 66·55; H, 4·6; N, 16·55. $C_{14}H_{11}O_2N_3$ requires C, 66·4; H, 4·35; N, 16·6%).

2′ : 4-*Anhydro*-2′-*amino*-3-*phenylphthalaz*-4-*one* crystallised from methyl alcohol in colourless needles, m. p. 178° (yield 0·9 g.; 97·4%) (Found : C, 76·4; H, 4·5; N, 18·7. $C_{14}H_9N_3$ requires C, 76·7; H, 4·1; N, 19·2%), readily soluble in dilute mineral acids, but insoluble in aqueous alkalis.

m-*Nitro*-p-*tolylhydrazine*.—The following method of preparation gave better results than that described by Davies (J., 1922, **121**, 720). A fine suspension of *m*-nitro-*p*-toluidine (18 g.) in concentrated hydrochloric acid (160 c.c.) and water (50 c.c.) was diazotised at 0° with sodium nitrite (8·5 g.) in water (25 c.c.), and the excess of nitrous acid was destroyed with urea. The filtered cold diazo-solution was added during 1 hour with good agitation to a solution of stannous

chloride (45 g.) in concentrated hydrochloric acid (60 c.c.) at − 14°, the precipitate filtered off and dissolved in boiling water (300 c.c.) (charcoal), and tin removed with hydrogen sulphide. After boiling, sodium chloride was added until the hydrochloride began to separate in yellow needles, which were collected and dissolved in water, and the base liberated at 60° by addition of sodium acetate. *m*-Nitro-*p*-tolylhydrazine crystallised from alcohol in bright red needles, m. p. 112° (yield, 10·8 g.; 54·6%) (Davies, *loc. cit.*, gives m. p. 110°).

(III; R = 2′-*Nitro*-4′-*methylphenyl*) crystallised from alcohol in bright red needles, m. p. 228° (refluxed for 10 minutes; yield, 90·2%) (Found: N, 14·4. $C_{15}H_{13}O_4N_3$ requires N, 14·05%), soluble in sodium carbonate and hydroxide solutions with orange-red and bluish-red colours, respectively. Conversion into (IV; R = 2′-nitro-4′-methylphenyl): Methods (i) to (iv) nil; (v) and (vi) complete; (vii) 92%.

(IV; R = 2′-*Nitro*-4′-*methylphenyl*) crystallised from glacial acetic acid in large, almost colourless prisms, m. p. 195° (Found: C, 64·15; H, 3·85; N, 15·1. $C_{15}H_{11}O_3N_3$ requires C, 64·1; H, 3·9; N, 14·95%), insoluble in aqueous alkalis and hydrochloric acid. This compound and the 4′-chloro-analogue described below were best prepared by method (vii).

Reduction of (III *and* IV; R = 2′-*Nitro*-4′-*methylphenyl*).—(a) An intractable tar was obtained on concentrating the reaction mixture. (b) The *substance* crystallised from alcohol in bright yellow needles (3 g.), m. p. 216° (Found: C, 65·4; H, 4·7; N, 15·6. $C_{15}H_{13}O_2N_3$ requires C, 67·4; H, 4·85; N, 15·7%). The *acetyl* derivative crystallised from alcohol in colourless needles, m. p. 190° (Found: N, 14·25. $C_{17}H_{15}O_2N_3$ requires N, 14·3%), but the 2′ : 4-anhydro-derivative was not prepared, as all attempts to obtain it from the yellow compound were unsuccessful.

4-*Chloro*-2-*nitrophenylhydrazine*.—This compound, prepared from 4-chloro-2-nitroaniline (20 g.) as described above for the 4-methyl analogue, crystallised from alcohol in dark brownish-red needles, m. p. 137° (yield, 11·6 g.; 53·4%); the results were better than those obtained with the method of Plant and Rosser (J., 1928, 2462), who give m. p. 134°.

(III; R = 4′-*Chloro*-2′-*nitrophenyl*) crystallised from alcohol in bright red needles, m. p. 237° (refluxing was unnecessary; yield, 90%) (Found: N, 13·0. $C_{14}H_{10}O_4N_3Cl$ requires N, 13·1%), soluble in sodium carbonate and hydroxide solutions with orange-red and purple colours, respectively. Conversion into (IV; R = 4′-chloro-2′-nitrophenyl): Methods (i) to (iv) nil; (v) 97%; (vi) complete; (vii) 89%.

(IV; R = 4′-*Chloro*-2′-*nitrophenyl*) crystallised from glacial acetic acid in colourless, prismatic needles, m. p. 213—214° (Found: C, 55·9; H, 2·8; N, 13·8; Cl, 11·75. $C_{14}H_8O_3N_3Cl$ requires C, 55·7; H, 2·65; N, 13·9; Cl, 11·8%).

Reduction of (III *and* IV; R = 4′-*Chloro*-2′-*nitrophenyl*).—(a) 4′-*Chloro*-2′-*amino*-3-*phenylphthalaz*-4-*one* crystallised from alcohol in long, colourless needles, m. p. 236° (yield, 3·5 g.; 82·4%) (Found: N, 15·2; Cl, 12·8. $C_{14}H_{10}ON_3Cl$ requires N, 15·45; Cl, 13·1%); the *acetyl* derivative crystallised from alcohol in colourless needles, m. p. 289° (Found: N, 13·1. $C_{16}H_{12}O_2N_3Cl$ requires N,13·4%). (b) The *substance* crystallised from alcohol in yellow needles, m. p. 239° (yield, 3·3 g.) (Found: C, 60·05; H, 3·75; N, 14·95; Cl, 12·6. $C_{14}H_{10}O_2N_3Cl$ requires C, 58·4; H, 3·5; N, 14·6; Cl, 12·3%).

2′ : 4-*Anhydro*-4′-*chloro*-2′-*amino*-3-*phenylphthalaz*-4-*one* crystallised from methyl alcohol in long, colourless, feathery needles, m. p. 230° (yield, 0·9 g.; 96·4%) (Found: C, 66·35; H, 3·5; N, 16·9; Cl, 14·2. $C_{14}H_8N_3Cl$ requires C, 66·3; H, 3·15; N, 16·6; Cl, 14·0%).

o-*Carboxyacetophenone*-2′-*nitroarylhydrazones* (III; R′ = Me).—These compounds (or their lactone forms) were prepared as described for their analogues (cf. J., 1931, 1923; 1936, 313).

Conversion of (III) *into* 2′-*Nitro*-3-*aryl*-1-*methylphthalaz*-4-*ones* (IV; R′ = Me).—Methods (i) to (vii) as described for the unmethylated compounds (p. 96) were used.

2′-*Amino*-3-*aryl*-1-*methylphthalaz*-4-*ones* (IV; R′ = Me, R = 2′-aminoaryl).—These compounds were made only from (III) as described for the unmethylated compounds [method (a)] (*loc. cit.*), for reduction of (IV; R = 2′-nitroaryl) gave yellow substances [method (b)] (*loc. cit.*) with different properties.

2′ : 4-*Anhydro*-2′-*amino*-3-*aryl*-1-*methylphthalaz*-4-*ones* (V; R′ = Me).—These were prepared as described for the unmethylated compounds (*loc. cit.*).

Reduction of (III *and* IV; R = 2′-*Nitrophenyl*).—(a) 2′-*Amino*-3-*phenyl*-1-*methylphthalaz*-4-*one* crystallised from alcohol in colourless needles, m. p. 241° (yield, 3 g.; 71·5%) (Found: C, 71·6; H, 5·4; N, 16·6. $C_{15}H_{13}ON_3$ requires C, 71·7; H, 5·2; N, 16·7%). (b) The *substance* crystallised from alcohol in yellow needles, m. p. 239° (cf. J., 1936, 314) (Found in material crystallised from alcohol and dried at 100° for 1 hour: C, 67·7; H, 5·0; N, 16·25. Found in

material crystallised from pyridine and dried at 130° for 2 hours: C, 72·1; H, 4·6; N, 16·95. $C_{15}H_{13}O_2N_3$ requires C, 67·4; H, 4·85; N, 15·7%).

2′ : 4-*Anhydro*-2′-*amino*-3-*phenyl*-1-*methylphthalaz*-4-*one* crystallised from aqueous alcohol in colourless, feathery needles, m. p. 163° (yield, 0·9 g.; 97%) (Found: C, 76·8; H, 4·75; N, 18·3. $C_{15}H_{11}N_3$ requires C, 77·25; H, 4·7; N, 18·0%), readily soluble in dilute mineral acids, but insoluble in aqueous alkalis.

(III; R = 2′-*Nitro*-4′-*methylphenyl*) crystallised from alcohol in orange, feathery needles, m. p. 175°, resolidifying and melting again at 256—257° owing to formation of (IV; R = 2′-nitro-4′-methylphenyl) (refluxed for 10 minutes; yield, 90·6%) (Found: N, 13·85. $C_{16}H_{15}O_4N_3$ requires N, 13·4%); it was soluble in aqueous sodium carbonate and hydroxide solutions with orange-red and bluish-red colours, respectively. Conversion into (IV; R = 2′-nitro-4′-methylphenyl): Methods (i) complete; (ii) nil; (iii) 74%; (iv) to (vii) complete.

(IV; R = 2′-*Nitro*-4′-*methylphenyl*) crystallised from glacial acetic acid in colourless prisms, m. p. 258° (Found: C, 65·1; H, 4·4; N, 14·15. $C_{16}H_{13}O_3N_3$ requires C, 65·1; H, 4·4; N, 14·2%), insoluble in aqueous alkalis and hydrochloric acid. This compound and the 4′-chloro-analogue described below were best prepared by method (vii).

Reduction of (III *and* IV; R = 2′-*Nitro*-4′-*methylphenyl*).—(a) 2′-*Amino*-3-*phenyl*-1 : 4′-*dimethylphthalaz*-4-*one* crystallised from alcohol in colourless needles, m. p. 203° (yield, 3·5 g.; 82·7%) (Found: C, 72·25; H, 5·7; N, 15·9. $C_{16}H_{15}ON_3$ requires C, 72·45; H, 5·65; N, 15·85%); the *acetyl* derivative crystallised from alcohol in colourless needles, m. p. 263° (Found: C, 70·1; H, 5·95; N, 14·1. $C_{18}H_{17}O_2N_3$ requires C, 70·35; H, 5·55; N, 13·7%). (b) The *substance* crystallised from alcohol in bright yellow needles, m. p. 264—265° (yield, 2·75 g.) (Found: C, 70·2; H, 5·55; N, 15·4. $C_{16}H_{15}O_2N_3$ requires C, 68·3; H, 5·3; N, 14·95%). After concentration of the filtrate, colourless needles, m. p. and mixed m. p. with the amino-compound from method (a) 203° (yield, 0·7 g.; 16·5%), were obtained.

2′ : 4-*Anhydro*-2′-*amino*-3-*phenyl*-1 : 4′-*dimethylphthalaz*-4-*one* crystallised from aqueous alcohol in pale cream-coloured, feathery needles, m. p. 186° (yield, 0·9 g.; 96·5%) (Found: C, 77·7; H, 5·2; N, 17·3. $C_{16}H_{13}N_3$ requires C, 77·7; H, 5·25; N, 17·0%).

(III; R = 4′-*Chloro*-2′-*nitrophenyl*) crystallised from alcohol in orange, feathery needles, m. p. 185—186° (refluxing was unnecessary; yield, 95%) (Found: N, 12·4. $C_{15}H_{12}O_4N_3Cl$ requires N, 12·6%), soluble in sodium carbonate and hydroxide solutions with orange-red and purple colours, respectively. Conversion into (IV; R = 4′-chloro-2′-nitrophenyl): Methods (i) complete; (ii) nil; (iii) 70%; (iv) to (vii) complete.

(IV; R = 4′-*Chloro*-2′-*nitrophenyl*) crystallised from glacial acetic acid in colourless prisms, m. p. 261° (Found: C, 57·35; H, 3·3; N, 13·1; Cl, 11·5. $C_{15}H_{10}O_3N_3Cl$ requires C, 57·05; H, 3·15; N, 13·3; Cl, 11·25%).

Reduction of (III *and* IV; R = 4′-*Chloro*-2′-*nitrophenyl*).—(a) 4′-*Chloro*-2′-*amino*-3-*phenyl*-1-*methylphthalaz*-4-*one* crystallised from alcohol in colourless needles, m. p. 222—223° (yield, 3·8 g.; 88·7%) (Found: C, 63·5; H, 4·6; N, 15·0; Cl, 12·3. $C_{15}H_{12}ON_3Cl$ requires C, 63·05; H, 4·2; N, 14·7; Cl, 12·4%); the *acetyl* derivative crystallised from alcohol in colourless needles, m. p. 304° (Found: N, 12·85. $C_{17}H_{14}O_2N_3Cl$ requires N, 12·8%). (b) The *substance* crystallised from alcohol in yellow needles, m. p. 212° (yield, 2·7 g.) (Found: C, 61·2; H, 4·35; N, 14·25; Cl, 11·85. $C_{15}H_{12}O_2N_3Cl$ requires C, 59·7; H, 4·0; N, 13·9; Cl, 11·8%).

2′ : 4-*Anhydro*-4′-*chloro*-2′-*amino*-3-*phenyl*-1-*methylphthalaz*-4-*one* crystallised from dilute acetic acid in long, colourless, silky needles, m. p. 193° (yield, 0·9 g.; 96%) (Found: C, 67·4; H, 4·0; N, 16·1; Cl, 13·5. $C_{15}H_{10}N_3Cl$ requires C, 67·3; H, 3·75; N, 15·7; Cl, 13·3%).

Conversion of Nitro-3-*aryl*-(II; R′ = H) *and Nitro*-3-*aryl*-4-*methyl-phthalaz*-1-*ones* (II; R′ = Me) *into the Corresponding Phthalaz*-4-*ones* (IV; R′ = H or Me).—The best conditions for effecting this conversion were determined and the influence of substituents in the 3-phenyl group was then examined. In general, the conversion was effected by heating (II; R′ = H or Me) (1—1·5 g.) with dilute hydrochloric acid (18 c.c.; various strengths) in a sealed tube at 160—190° for a definite period (usually 6 hours). At the end of the reaction, the tube normally contained a mass of brownish-coloured crystals, sometimes slightly charred. After cooling and filtering, the crystals and filtrate were examined separately. The crystals consisted mainly of (IV), but sometimes contained some (II) or its hydrochloride, whereas the filtrate contained only unaltered (II). According to the particular compound (II) employed, the product was purified in one or several of three ways: (a) extraction with warm dilute hydrochloric acid, in which only compounds (II) are soluble, and this resulted in a good separation in many cases; (b) extraction with warm aqueous sodium hydroxide, in which only compounds (II) are soluble; or (c) extraction with boiling benzene, in which compounds (IV) are readily

soluble, whereas compounds (II) are almost insoluble. Separation can be effected almost quantitatively by these methods, and the yields of compounds (IV) given below are those obtained after complete removal of unaltered (II).

Conversion of (II; R = 4′-*Nitrophenyl*, R′ = H) *into* (IV; R = 4′-*Nitrophenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1928, 2553) was heated with (i) dilute hydrochloric acid (18 c.c.; 1 : 8), (ii) dilute sulphuric acid (18 c.c.; 1 : 8), (iii) water (18 c.c.), or (iv) aqueous sodium hydroxide (16 c.c.; 1 : 20), at 180° for 6 hours in each case. 4′-Nitro-3-phenylphthalaz-4-one was obtained from (i) and (ii) and crystallised from glacial acetic acid in fine, colourless, silky needles, m. p. and mixed m. p. with a synthetic specimen (*ibid.*, p. 2555) 258° [yield : (i) 1·00 g., 66·6%, (ii) 0·31 g., 20·6%]. There was no conversion in (iii) and decomposition occurred in (iv).

Conversion of (II; R = 4′-*Nitrophenyl*, R′ = Me) *into* (IV; R = 4′-*Nitrophenyl*, R′ = Me).—(a) *Variation in reagent.* Compound (II) (1·5 g.) (J., 1931, 1070) was heated with (i) dilute hydrochloric acid (18 c.c.; 1 : 8), (ii) dilute sulphuric acid (18 c.c.; 1 : 8), (iii) dilute acetic acid (18 c.c.; 1 : 8), or (iv) water (18 c.c.), at 180° for 6 hours in each case. 4′-Nitro-3-phenyl-1-methylphthalaz-4-one crystallised from glacial acetic acid in fine, colourless, silky needles, m. p. and mixed m. p. with a synthetic specimen (*ibid.*, p. 1924) 214° [yield : (i) 1·23 g., 82%; (ii) 1·10 g., 73·3%; (iii) 0·41 g., 27·3%; (iv) nil]. (b) *Variation in time.* Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for various times. In each case, both (IV) and unaltered (II) were isolated, and the velocity constant $1/t$. log $100/(100 - x)$ for a unimolecular reaction was calculated :

Time (minutes) (t)	90	125	182	270	360	540
% (IV) (x)	38	47	59	69	82	89
% (II) recovered	55	47	31	25	11	3
$k \times 10^4$	53	51	49	43	48	43

(c) *Variation in strength of acid.* Compound (II) (1 g.) was heated with dilute hydrochloric acid at 180° for 6 hours :

10*N*-Acid, c.c.	0·5	1	1·5	2	3	5	10	18
Water, c.c.	17·5	17	16·5	16	15	13	8	—
(IV), %	74	81	82	82	77	73	54	19
$k \times 10^4$	37	46	48	48	41	36	22	6

(d) *Variation in ratio of* (II) *to acid.* Compound (II) was heated with dilute hydrochloric acid (1 : 8) at 180° for 6 hours :

(II), g.	1	1	1	0·5	0·5
Acid, c.c.	10	18	25	18	25
(IV), %	81	82	81	80	78

(e) *Variation in temperature.* Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 150° for 6 hours [yield of (IV), 0·23 g.; 23%]. The conversion was also effected by refluxing (II) (1 g.) with dilute hydrochloric acid [25 c.c.; (i) 1 : 5·25, (ii) 1 : 11·5] for 12 hours [yield : (i) 9%, (ii) 19%].

Conversion of (II; R = 4′-*Nitro*-2′-*methylphenyl*, R′ = H) *into* (IV; R = 4′-*Nitro*-2′-*methylphenyl*, R′ = H).—The preparation of (II) (J., 1932, 479) was improved. Compound (I; R = 4′-nitro-2′-methylphenyl) (10 g.) was refluxed with concentrated sulphuric acid (50 c.c.) and water (60 c.c.) for 1 hour; the solution was then diluted with water (110 c.c.), boiled (charcoal), and filtered hot. The sulphate crystallised on cooling and was neutralised. Compound (II) (1·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for 6 hours. 4′-Nitro-3-phenyl-2′-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (*ibid.*, p. 482) 188° (yield, 0·30 g.; 20%).

Conversion of (II; R = 4′-*Nitro*-2′-*methylphenyl*, R′ = Me) *into* (IV; R = 4′-*Nitro*-2′-*methylphenyl*, R′ = Me).—Compound (II) (1·5 g.) (*ibid.*, p. 481) was best heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours, because much decomposition of (IV) occurred at 180°. 4′-Nitro-3-phenyl-1 : 2′-dimethylphthalaz-4-one crystallised from alcohol in almost colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 314) 178° (yield, 0·41 g.; 27·3%).

Conversion of (II; R = 2′-*Chloro*-4′-*nitrophenyl*, R′ = Me) *into* (IV; R = 2′-*Chloro*-4′-*nitrophenyl*, R′ = Me).—Compound (II) (1 g.) (J., 1932, 17) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 190° for 6 hours, because the use of a lower temperature resulted in the formation of (VI; R = 2′-chloro-4′-nitrophenyl) (see p. 103). 2′-Chloro-4′-nitro-3-phenyl-1-

methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 314) 206° (yield, 0·49 g.; 49%).

Conversion of (II; R = 2′-*Bromo*-4′-*nitrophenyl*, R′ = Me) *into* (IV; R = 2′-*Bromo*-′4-*nitrophenyl*, R′ = Me).—Compound (II) (1 g.) (J., 1935, 1137) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 200° for 6 hours, because the use of a lower temperature resulted in the formation of (VI; R = 2′-bromo-4′-nitrophenyl) (see p. 104). 2′-Bromo-4′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (*loc. cit.*) 200—202° (yield, 0·27 g.; 27%).

Conversion of (II; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*, R′ = H) *into* (IV; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1931, 1084) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at (i) 180°, or (ii) 170°, for 6 hours. 2′ : 6′-Dichloro-4′-nitro-3-phenylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 313) 179° [yield: (i) 0·70 g., 46·6%; (ii) 0·51 g., 34%].

Conversion of (II; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*, R′ = Me) *into* (IV; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*, R′ = Me).—Compound (II) (1 g.) (J., 1931, 1085) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 200° for 6 hours, because the use of a lower temperature resulted in the formation of (VI; R = 2′ : 6′-dichloro-4′ nitrophenyl) (see p. 104) and a mixture was obtained even at 190°. 2′ : 6′-Dichloro-4′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 315) 235° (yield, 0·17 g.; 17%).

Conversion of (II; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*, R′ = H) *into* (IV; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1931, 1084) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 165° for 10 hours, because much decomposition occurred at higher temperatures, *e.g.*, 180°. 2′ : 6′-Dibromo-4′-nitro-3-phenylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 313) 190° (yield, 0·30 g.; 20%).

Attempted Conversion of (II; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*, R′ = Me) *into* (IV; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*, R′ = Me).—Compound (II) (1·5 g.) (J., 1931, 1085) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at (i) 165°, (ii) 180°, or (iii) 200°, for 6 hours. In each case, the product melted from 219—225° and appeared to be a mixture of 2′ : 6′-dibromo-4′-nitro-3-phenyl-1-methylphthalaz-4-one (J., 1936, 315) and (VI; R = 2′ : 6′-dibromo-4′-nitrophenyl) (see p. 104), from which neither was isolated pure.

Conversion of (II; R = 3′-*Nitrophenyl*, R′ = H) *into* (IV; R = 3′-*Nitrophenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1928, 2561) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for (i) 6 hours, or (ii) 40 hours. 3′-Nitro-3-phenylphthalaz-4-one crystallised from alcohol in almost colourless needles, m. p. and mixed m. p. with a synthetic specimen (*ibid.*, p. 2563) 240° [yield: (i) 0·21 g., 14%; (ii) 0·92 g., 61·3%].

Conversion of (II; R = 3′-*Nitrophenyl*, R′ = Me) *into* (IV; R = 3′-*Nitrophenyl*, R′ = Me).—Compound (II) (1 g.) (J., 1936, 1709) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours, because much decomposition of (IV) occurred at 180°. 3′-Nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1931, 1925) 167° (yield, 0·25 g.; 25%).

Conversion of (II; R = 2′-*Nitrophenyl*, R′ = Me) *into* (IV; R = 2′-*Nitrophenyl*, R′ = Me).—In the preparation of (II) (J., 1935, 1807), instead of neutralising the reaction mixture with sodium carbonate, it is advantageous to filter the crystalline complex salt that separates and neutralise it with ammonia. Compound (II) (1·5 g.) was heated with dilute hydrochloric acid [18 c.c.; (i) 1 : 35, (ii) 1 : 17, or (iii) 1 : 8] at 180° for 6 hours, or (iv) (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for 1 hour. 2′-Nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (J., 1931, 1924) 202° [yield: (i) 1·00 g., 66·6%); (ii) 1·06 g., 70·6%; (iii) 0·98 g., 65·3%; (iv) 0·49 g., 49%]. The use of a lower temperature than 180° resulted in the formation of (VI; R = 2′-nitrophenyl) (see p. 102).

Conversion of (II; R = 2′-*Nitro*-4′-*methylphenyl*, R′ = H) *into* (IV; R = 2′-*Nitro*-4′-*methylphenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1936, 1107) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 170° for 6 hours. 2′-Nitro-3-phenyl-4′-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (p. 97) 195° (yield, 0·54 g.; 36%).

Conversion of (II; R = 2′-*Nitro*-4′-*methylphenyl*, R′ = Me) *into* (IV; R = 2′-*Nitro*-4′-*methylphenyl*, R′ = Me).—Compound (II) (1 g.) (J., 1936, 1108; preferably isolated *via* the

complex salt as described above for the 2′-nitro-analogue) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 185° for 6 hours, because the use of a lower temperature resulted in formation of (VI; R = 2′-nitro-4′-methylphenyl) (see p. 102). 2′-Nitro-3-phenyl-1 : 4′-dimethylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (p. 98) 258° (yield, 0·53 g.; 53%).

Conversion of (II; R = 4′-*Chloro*-2′-*nitrophenyl*, R′ = H) *into* (IV; R = 4′-*Chloro*-2′-*nitrophenyl*, R′ = H).—Compound (II) (1·5 g.) (J., 1935, 1806) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for 6 hours. 4′-Chloro-2′-nitro-3-phenylphthalaz-4-one crystallised from glacial acetic acid in colourless, prismatic needles, m. p. and mixed m. p. with a synthetic specimen (p. 97) 213—214° (yield, 1·02 g.; 68%).

Conversion of (II; R = 4′-*Chloro*-2′-*nitrophenyl*, R′ = Me) *into* (IV; R = 4′-*Chloro*-2′-*nitrophenyl*, R′ = Me).—Compound (II) (1·5 g.) (J., 1935, 1807; with modified method of isolation as for the 2′-nitro-analogue above) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 190° for 6 hours, because the use of a lower temperature resulted in the formation of (VI; R = 4′-chloro-2′-nitrophenyl) (see p. 103). 4′-Chloro-2′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from glacial acetic acid in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (p. 98) 261° (yield, 1·11 g.; 74%).

Proof of the Intramolecular Character of the Conversion of (II; R = *Nitroaryl*, R′ = H or Me) *into* (IV; R = *Nitroaryl*, R′ = H or Me).—A mixture of (II; R = 2′ : 6′-dichloro-4′-nitrophenyl, R′ = H) (1 g.) and (II; R = 4′-nitrophenyl, R′ = Me) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 180° for 6 hours. The product, after removal of unaltered phthalaz-1-ones, crystallised from alcohol in almost colourless needles, m. p. 206—207° (X).

Mixed Melting Points of 2′ : 6′-*Dichloro*-4′-*nitro*-3-*phenylphthalaz*-4-*one* (*A*) *and* 4′-*Nitro*-3-*phenyl*-1-*methylphthalaz*-4-*one* (*B*).

A, % by wt. ...	0	5	13	26	30	40	46	51	68	89	100
M. p.	214°	208°	202°	192°	188°	169°	162°	163°	168°	174°	179°

The product (X) corresponded in all respects with a mixture (Y) prepared from 8% of (A) and 92% of (B); the mixture (Y) melted at 206—207°, as did also a mixture of (X) and (Y). Pure (A) (0·008 g.) was then added to (X) (0·013 g.) to give a mixture which should consist of 44% of (A) and 56% of (B); this mixture melted at 166°, which corresponded with the m. p. of a mixture of 43% of (A) and 57% of (B). It was concluded, therefore, that the original mixture (X) consisted solely of (A) and (B) in the proportion 8 : 92. The great difference between the quantities of (A) and (B) formed in the conversion is due to the greater reaction velocity in the case of (II; R = 4′-nitrophenyl, R′ = Me) than in the case of (II; R = 2′ : 6′-dichloro-4′-nitrophenyl, R′ = H).

Conversion of Certain Nitro-3-*aryl*-4-*methylphthalaz*-1-*ones* (II; R′ = Me) *into* 2-(*Nitroarylamino*)-3-*methylene*isoindolinones (VI; R = nitroaryl).—In general, this conversion was effected by heating (II; R′ = Me) (1—1·5 g.) with dilute hydrochloric acid (18 c.c.; various strengths) in a sealed tube at a temperature lower than that required for conversion into (IV; R′ = Me). Conversion was readily effected by refluxing (II; R = 2′-nitroaryl, R′ = Me) with dilute hydrochloric acid, but with such 4′-nitro-analogues as undergo the conversion, temperatures of 150—170° were necessary. Unaltered (II) was removed from the product by extraction with boiling dilute hydrochloric acid (1 : 1); separation was also possible by means of the greater solubility of (VI) in boiling benzene.

Reactions of 2-(*Nitroarylamino*)-3-*methylene*isoindolinones.—*Hydrolysis.* Compound (VI) (1 g.) was refluxed with alcoholic sodium ethoxide (0·2 g. of sodium in 25 c.c. of alcohol) until the colour of the solution changed from bright red to reddish-brown (20—45 minutes). The mixture was poured on ice (50 g.) and acidified with hydrochloric acid, and the *o*-carboxyacetophenonenitroarylhydrazone (III; R′ = Me) collected. *Reduction.* (a) Compound (VI) (1 g.) was refluxed with a solution of sodium sulphide crystals (10 g.) in water (50 c.c.) and alcohol (50 c.c.) until almost colourless crystals of the amino-3-aryl-1-methylphthalaz-4-one (IV; R′ = Me) separated from the orange solution (30—45 minutes). (b) Iron powder (0·75 g.) was added to a boiling solution of (VI) (1 g.) in glacial acetic acid (25 c.c.) and water (10 c.c.). The resulting green solution was diluted with water (50 c.c.) and partly neutralised with aqueous sodium hydroxide until brownish crystals of the 2-(aminoarylamino)-3-methylene*iso*indolinone (VI; R = aminoaryl) separated. *Oxidation.* A solution of chromium trioxide (0·5 g.) in water (10 c.c.) was added to a solution of (VI) (1 g.) in glacial acetic acid (25 c.c.) at 80°, and the *N*-nitroarylaminophthalimide precipitated by dilution with water (100 c.c.). *Action of mineral*

acids. (a) Compound (VI) (1·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180—200° for 6 hours. (b) A solution of (VI) (1 g.) in concentrated sulphuric acid (25 c.c.) was heated at 180° for a few minutes until the deep reddish-brown colour had changed to pale yellow. After cooling, the nitro-3-aryl-1-methylphthalaz-4-one (IV; R′ =Me) was precipitated by pouring the solution on ice (100 g.).

Conversion of (II; R = 2′-*Nitrophenyl*, R′ = Me) *into* (VI; R = 2′-*Nitrophenyl*).—(a) Compound (II) (2 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours (yield, 1·51 g.; 75·5%). *Variation in strength of acid.* Compound (II) (1·5 g.) was heated with water, or dilute hydrochloric acid, at 150° for 6 hours :

10*N*-Acid, c.c.	—	0·11	0·22	0·5	0·78	1	2	4	9	18
Water, c.c.	18	17·89	17·78	17·5	17·12	17	16	14	9	—
(VI), g.	0·37	1·32	1·37	1·26	1·23	1·14	0·98	0·55	0·05	—
(VI), %	24·6	88	91·3	84	82	76	65·3	36·6	3·3	—

(b) Compound (II) (5 g.) was refluxed with dilute hydrochloric acid (125 c.c.; 1 : 11·5) for 1½ hours (yield, 4·8 g.; 96%). *Variations in strength of acid and time.* Compound (II) (1 g.) was refluxed with dilute hydrochloric acid [25 c.c.; (i) 1 : 4, (ii) 1 : 11·5, (iii) 1 : 24].

(i) No conversion occurred after ½ hour.

(ii) Time (minutes) (t)	5	7	10	12	15	17	20	30
(VI) (x), %	19	23	32	41	48	53	58	66
$k \times 10^3$	42	37	38	44	43	45	43	36

(iii) The yield of (VI) was 10% after 5 minutes and 20% after 10 minutes.

2-(2′-*Nitrophenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol or glacial acetic acid in yellow prismatic needles and from benzene in yellow hexagonal plates, m. p. 179° (Found : C, 64·2; H, 4·0; N, 15·0. $C_{15}H_{11}O_3N_3$ requires C, 64·05; H, 3·9; N, 14·95%), soluble in boiling aqueous-alcoholic sodium hydroxide with a deep crimson colour and insoluble in hydrochloric acid. *Hydrolysis.* *o*-Carboxyacetophenone-2′-nitrophenylhydrazone crystallised from alcohol in orange prisms, m. p. and mixed m. p. with a synthetic specimen (J., 1931, 1924) 184° (yield, 0·95 g.; 89·3%), converted by cold concentrated sulphuric acid into 2′-nitro-3-phenyl-1-methylphthalaz-4-one, m. p. 202°. *Reduction.* (a) 2′-Amino-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (p. 97) 241° (yield, 0·6 g.; 67·2%). (b) 2-(2′-*Aminophenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol in colourless rectangular plates, m. p. 227—228° (decomp.) after becoming brown at 220° (yield, 0·52 g.; 58·2%) (Found : C, 72·1; H, 5·35; N, 17·25. $C_{15}H_{13}ON_3$ requires C, 71·7; H, 5·2; N, 16·7%). When (0·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180° for 6 hours, and the mixture rendered alkaline with sodium hydroxide, 2′ : 4-anhydro-2′-amino-3-phenyl-1-methylphthalaz-4-one, colourless feathery needles, m. p. and mixed m. p. with the specimen already described (p. 98) 163° (yield, 0·41 g.; 88·3%), was obtained. *Oxidation.* *N*-2′-Nitrophenylaminophthalimide (phthalyl-2′-nitrophenylhydrazide) crystallised from glacial acetic acid in pale yellow prisms, m. p. and mixed m. p. with a synthetic specimen (J., 1935, 1812) 293—294° (yield, 0·65 g.; 64·5%). *Action of mineral acids.* 2′-Nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen 202° [yield : (a) 1·10 g., 73·3% ; (b) 0·96 g., 96%].

Conversion of (II; R = 2′-*Nitro*-4′-*methylphenyl*, R′ = Me) *into* (VI; R = 2′-*Nitro*-4′-*methylphenyl*).—(a) Compound (II) (1·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours (yield, 0·66 g.; 44%). *Variation in strength of acid.* Compound (II) (1 g.) was heated with water, or dilute hydrochloric acid, at 160° for 6 hours :

10*N*-Acid, c.c.	—	0·22	0·5	1	2
Water, c.c.	18	17·78	17·5	17	16
(VI), %	33	88	81	67	44

(b) Compound (II) (5 g.) was refluxed with dilute hydrochloric acid (125 c.c.; 1 : 24) for 1½ hours (yield, 4·65 g.; 93%). *Variation in time.* Compound (II) (1 g.) was refluxed with dilute hydrochloric acid (25 c.c.; 1 : 11·5) :

Time (minutes)	10	15	20	30
(VI), %	14	23	27	38

2-(2′-*Nitro*-4′-*methylphenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol in bright yellow needles, m. p. 194° (Found : C, 65·15; H, 4·55; N, 14·2. $C_{16}H_{13}O_3N_3$ requires C, 65·1; H, 4·4; N, 14·2%), soluble in boiling aqueous-alcoholic sodium hydroxide with a

bluish-red colour. *Hydrolysis.* *o*-Carboxyacetophenone-2′-nitro-4′-methylphenylhydrazone crystallised from alcohol in orange feathery needles, m. p. and mixed m. p. with a synthetic specimen (p. 98) 175°, resolidifying and melting again at 256—257° (yield, 0·92 g.; 86·7%). *Reduction.* (a) 2′-Amino-3-phenyl-1 : 4′-dimethylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (p. 98) 203° (yield, 0·67 g.; 74·6%). (b) Although a variety of conditions were used, little product could be isolated. This crystallised from dilute alcohol in brownish plates, m. p. 237° (decomp.) with previous darkening, and was probably 2-(2′-amino-4′-methylphenylamino)-3-methylene*iso*indolinone, but the quantity was insufficient for analysis. *Oxidation.* *N*-2′-Nitro-4′-methylphenylaminophthalimide crystallised from glacial acetic acid in yellow prismatic needles, m. p. and mixed m. p. with a synthetic specimen (see below) 263° (yield, 0·58 g.; 57·6%). *Action of mineral acids.* 2′-Nitro-3-phenyl-1 : 4′-dimethylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen 258° [yield: (a) 0·87 g., 58%; (b) 0·92 g., 92%].

o-*Carboxybenzo-2′-nitro-4′-methylphenylhydrazide.*—Solutions of *o*-nitro-*p*-tolylhydrazine (2 g. in 200 c.c.) and of phthalic anhydride (2 g. in 50 c.c.) in chloroform were mixed and the yellow needles formed were filtered off after 12 hours. o-*Carboxybenzo-2′-nitro-4′-methylphenylhydrazide* crystallised from chloroform in yellow needles, m. p. 260—261° (yield, 3·5 g.; 92·8%) (Found: N, 13·25. $C_{15}H_{13}O_5N_3$ requires N, 13·3%), soluble in cold dilute sodium carbonate solution with an intense violet colour.

N-2′-*Nitro-4′-methylphenylaminophthalimide*, produced when the above *o*-carboxy-hydrazide (2 g.) was dissolved in boiling glacial acetic acid, crystallised from this solvent in yellow prismatic needles, m. p. 263° (yield, 1·7 g.; 90·1%) (Found: C, 60·3; H, 3·9; N, 14·35. $C_{15}H_{11}O_4N_3$ requires C, 60·6; H, 3·7; N, 14·15%), soluble in boiling dilute sodium hydroxide solution with a violet colour owing to regeneration of the *o*-carboxy-hydrazide.

Conversion of (II; R = 4′-*Chloro*-2′-*nitrophenyl*, R′ = Me) *into* (VI; R = 4′-*Chloro*-2′-*nitrophenyl*).—(a) Compound (II) (1·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours (yield, 1·08 g.; 72%). (b) Compound (II) (5 g.) was refluxed with dilute hydrochloric acid (125 c.c.; 1 : 24) for 1 hour (yield, 4·8 g.; 96%). *Variation in strength of acid.* Compound (II) (1 g.) was refluxed with dilute hydrochloric acid [25 c.c.; (i) 1 : 11·5, (ii) 1 : 24] for ½ hour [yield: (i) 78%, (ii) 91%].

2-(4′-*Chloro*-2′-*nitrophenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol in yellow needles, m. p. 224° (Found: C, 56·75; H, 3·35; N, 13·4; Cl, 10·95. $C_{15}H_{10}O_3N_3Cl$ requires C, 57·05; H, 3·15; N, 13·3; Cl, 11·25%), soluble in boiling aqueous-alcoholic sodium hydroxide with an intense bluish-red colour. *Hydrolysis.* *o*-Carboxyacetophenone-4′-chloro-2′-nitrophenylhydrazone crystallised from alcohol in orange feathery needles, m. p. and mixed m. p. with a synthetic specimen (p. 98) 185—186° (yield, 0·88 g.; 83·3%). *Reduction.* (a) 4′-Chloro-2′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (p. 98) 222—223° (yield, 0·62 g.; 68·5%). (b) 2-(4′-*Chloro*-2′-*aminophenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol in colourless rectangular plates, m. p. 228° (decomp.) after darkening at 210° (yield, 0·55 g.; 60·8%) (Found: C, 63·1; H, 4·25; N, 14·45. $C_{15}H_{12}ON_3Cl$ requires C, 63·05; H, 4·2; N, 14·7%). *Oxidation.* *N*-4′-Chloro-2′-nitrophenylaminophthalimide crystallised from glacial acetic acid in yellow needles, m. p. and mixed m. p. with a synthetic specimen (see below) 265° (yield, 0·56 g.; 55·6%). *Action of mineral acids.* 4′-Chloro-2′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen 261° [yield: (a) 0·94 g., 62·6%; (b) 0·96 g., 96%].

N-4′-*Chloro*-2′-*nitrophenylaminophthalimide*, prepared similarly to the 2′-nitro-4′-methyl-analogue (above), *via* o-*carboxybenzo-4′-chloro-2′-nitrophenylhydrazide*, yellow prismatic needles, m. p. 263—264° (yield, 95%) (Found: N, 12·75; Cl, 10·8. $C_{14}H_{10}O_5N_3Cl$ requires N, 12·5; Cl, 10·6%), crystallised from glacial acetic acid in yellow needles, m. p. 265° (yield, 90%) (Found: C, 52·9; H, 2·6; N, 13·35; Cl, 11·05. $C_{14}H_8O_4N_3Cl$ requires C, 52·9; H, 2·5; N, 13·2; Cl, 11·2%), soluble in boiling dilute sodium hydroxide solution with an intense violet colour owing to regeneration of the *o*-carboxy-hydrazide.

Conversion of (II; R = 2′-*Chloro*-4′-*nitrophenyl*, R′ = Me) *into* (VI; R = 2′-*Chloro*-4′-*nitrophenyl*).—Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 160° for 6 hours. 2-(2′-*Chloro*-4′-*nitrophenylamino*)-3-*methylene*iso*indolinone* crystallised from alcohol in pale yellow prisms, m. p. 164° (yield, 0·66 g.; 66%) (Found: C, 56·9; H, 3·35; N, 13·7; Cl, 10·8. $C_{15}H_{10}O_3N_3Cl$ requires C, 57·05; H, 3·15; N, 13·3; Cl, 11·25%), soluble in boiling aqueous-alcoholic sodium hydroxide with a deep red colour. *Hydrolysis.* *o*-Carboxyacetophenone-2′-chloro-4′-nitrophenylhydrazone crystallised from alcohol

in orange-yellow needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 314) 160° (yield, 0·92 g.; 87%). *Reduction.* (a) 2′-Chloro-4′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen (*loc. cit.*) 197° (yield, 0·56 g.; 61·9%). *Action of mineral acid.* Method (b), but at 200°. 2′-Chloro-4′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen 206° (yield, 0·9 g.; 90%).

Conversion of (II; R = 2′-*Bromo*-4′-*nitrophenyl*, R′ = Me) *into* (VI; R = 2′-*Bromo*-4′-*nitrophenyl*).—Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 165° for 6 hours (the yield was halved at 160°). 2-(2′-*Bromo*-4′-*nitrophenylamino*)-3-*methylene*-iso*indolinone* crystallised from alcohol in pale brownish-yellow, prismatic needles, m. p. 201° (yield, 0·65 g.; 65%) (Found : C, 50·2; H, 3·15; N, 11·4; Br, 22·35. $C_{15}H_{10}O_3N_3Br$ requires C, 50·0; H, 2·8; N, 11·65; Br, 22·2%), soluble in boiling aqueous-alcoholic sodium hydroxide with an intense red colour. *Hydrolysis.* *o*-Carboxyacetophenone-2′-bromo-4′-nitrophenylhydrazone crystallised from alcohol in orange-yellow needles, m. p. and mixed m. p. with a synthetic specimen (J., 1935, 1137) 154° (yield, 0·9 g.; 85·7%). *Reduction.* (a) 2′-Chloro-4′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen (J., 1936, 315) 130° (decomp.) (yield, 0·56 g.; 61·1%). *Action of mineral acid.* Method (b), but at 200°. 2′-Bromo-4′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless prisms, m. p. and mixed m. p. with a synthetic specimen 200—202° (yield, 0·88 g.; 88%).

Conversion of (II; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*, R′ = Me) *into* (VI; R = 2′ : 6′-*Dichloro*-4′-*nitrophenyl*).—Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 160° for 6 hours. 2-(2′ : 6′-*Dichloro*-4′-*nitrophenylamino*)-3-*methylene*-iso*indolinone* crystallised from alcohol in pale brownish-yellow, prismatic needles, m. p. 173° (yield, 0·36 g.; 36%) (Found : C, 51·6; H, 2·7; N, 12·0; Cl, 20·5. $C_{15}H_9O_3N_3Cl_2$ requires C, 51·4; H, 2·55; N, 12·0; Cl, 20·3%), soluble in boiling aqueous-alcoholic sodium hydroxide with a deep red colour. *Action of mineral acid.* Method (b), but at 200°. 2′ : 6′-Dichloro-4′-nitro-3-phenyl-1-methylphthalaz-4-one crystallised from alcohol in colourless needles, m. p. and mixed m. p. with a synthetic specimen 235°.

Attempted Conversion of (II; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*, R′ = Me) *into* (VI; R = 2′ : 6′-*Dibromo*-4′-*nitrophenyl*) (cf. p. 100).—Compound (II) (1 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) at 165° for 6 hours. The product, m. p. 219—221°, appeared to be a mixture of (VI; R = 2′ : 6′-dibromo-4′-nitrophenyl) and 2′ : 6′-dibromo-4′-nitro-3-phenyl-1-methylphthalaz-4-one, from which the former could not be isolated. This was confirmed by heating a solution of the mixture in concentrated sulphuric acid for a few minutes, only 2′ : 6′-dibromo-4′-nitro-3-phenyl-1-methylphthalaz-4-one, m. p. and mixed m. p. with a synthetic specimen 237°, being obtained.

Conversion of 2′-*Amino*-3-*aryl*-4-*methylphthalaz*-1-*ones* (II; R′ = Me) *and of* 2′-*Amino*-3-*arylphthalaz*-1-*one*-4-*acetic Acid Lactams* (VII) *into* 2′ : 4-*Anhydro*-2′-*amino*-3-*aryl*-1-*methylphthalaz*-4-*ones* (V; R′ = Me).—This conversion was effected by heating (a) (II; R = 2′-aminoaryl, R′ = Me) (1 g.), and (b) (VII) (1 g.), with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180° for 6 hours. The resulting dark brown solution with a faint green fluorescence was rendered alkaline with aqueous sodium hydroxide; the brownish precipitate was collected, dried, and extracted with boiling benzene, and, after removal of the solvent from the extract, the residue (V; R′ = Me) was crystallised repeatedly. When (II; R = 4′- or 3′-aminophenyl, R′ = H or Me) was heated with dilute hydrochloric acid under the same conditions, no reaction occurred and in each case unaltered (II) was recovered almost quantitatively.

2′ : 4-Anhydro-2′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from methyl alcohol in colourless needles, m. p. and mixed m. p. with the specimen already described (p. 98) 163° [yield : (a) 0·47 g., 50·6%; (b) 0·40 g., 47·5%].

2′ : 4-Anhydro-2′-amino-3-phenyl-1 : 4′-dimethylphthalaz-4-one crystallised from aqueous alcohol in pale cream-coloured needles, m. p. and mixed m. p. with the specimen already described (p. 98) 186° [yield : (b) 0·43 g., 50·7%]. In this case, the substance, colourless needles, m. p. 311—313° (decomp.) (J., 1936, 1107), was used, although repeated analyses of numerous samples did not support the constitution of 2′-amino-3-phenyl-4′-methylphthalaz-1-one-4-acetic acid lactam.

2′ : 4-Anhydro-4′-chloro-2′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from dilute acetic acid in long colourless needles, m. p. and mixed m. p. with the specimen already described (p. 98) 193° [yield : (a) 0·70 g., 74·7%; (b) 0·64 g., 74·5%].

Conversion of 2'-Amino-3-arylphthalaz-1-ones (II; R' = H) *into a Mixture of* (VIII) *and* (IX).—This conversion was effected by heating (II; R = 2'-aminoaryl) (1·5 g.) with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180° for 6 hours. The resulting brown solution, containing pale brown crystals, was rendered alkaline with warm aqueous sodium hydroxide (evolution of ammonia) and filtered. The precipitate was dried and extracted with boiling benzene, the solvent removed from the extract, and the residue (IX) crystallised. The alkaline filtrate was acidified carefully with acetic acid, and the colourless precipitate (VIII) crystallised.

In the case of (II; R = 2'-aminophenyl, R' = H), the sulphate (1·5 g.) (J., 1935, 1805) of the substance, which possessed the properties of 2'-amino-3-phenylphthalaz-1-one, although analyses did not support that constitution, was used. *o*-Benzylenebenziminazole crystallised from aqueous alcohol in colourless rectangular plates, m. p. and mixed m. p. with an authentic specimen (*ibid.*, p. 1806) 212° (yield, 0·06 g.; 6·8%), and 2-phenylbenziminazole-*o*-carboxylic acid crystallised from aqueous acetic acid in colourless needles, m. p. and mixed m. p. with an authentic specimen (*loc. cit.*) 270° (yield, 0·72 g.: 70·8%).

(II; R = 4'-Chloro-2'-aminophenyl, R' = H) also was used. 5-Chloro-*o*-benzylenebenziminazole crystallised from aqueous alcohol in small colourless plates, m. p. and mixed m. p. with an authentic specimen (*loc. cit.*) 242° (yield, 0·20 g.; 15%), and 5-chloro-2-phenylbenziminazole-*o*-carboxylic acid crystallised from glacial acetic acid in small colourless needles, m. p. and mixed m. p. with an authentic specimen (*loc. cit.*) 285° (yield, 0·91 g.; 60·4%); (II) (0·15 g.; 10%) was recovered unaltered.

Action of Dilute Hydrochloric Acid on (I; R = 4'-*Nitrophenyl*).—Compound (I) (1·5 g.) was heated in a sealed tube with (a) dilute hydrochloric acid (18 c.c.; 1 : 2) at 150° for 12 hours, and (b) dilute hydrochloric acid (18 c.c.; 1 : 7·5) at 170—175° for 6 hours. After neutralisation with sodium carbonate, the sole reaction product isolated from (a) was 4'-nitro-3-phenylphthalaz-1-one, yellow needles, m. p. 333°. The product from (b), however, was a dark brown, semi-crystalline, slightly charred mass, which was collected, ground with cold sodium carbonate solution, washed with water, and dried (yield, 1 g.); it crystallised from alcohol–pyridine (6 : 1, charcoal) in straw-coloured needles, m. p. 217—219° (X) (Found: C, 63·65; H, 3·65; N, 14·9. Calc. for $C_{14}H_9O_3N_3$: C, 62·9; H, 3·4; N, 15·7. Calc. for $C_{15}H_{11}O_3N_3$: C, 64·05; H, 3·9; N, 14·95%) (cf. J., 1933, 1068). Repeated crystallisations from this mixture of solvents gave pale straw-coloured, silky needles, m. p. 221—222° (Found: C, 63·7; H, 3·7; N, 15·3%), two further crystallisations from glacial acetic acid gave almost colourless, silky needles, m. p. 226—227° (Found: C, 63·4; H, 3·7; N, 15·3%), and a final crystallisation from nitrobenzene gave long, colourless, silky needles, m. p. 228—230° (Found: C, 63·35; H, 3·7; N, 15·4%). In all cases, melting was preceded by softening, and the products possessed all the properties of mixtures of 4'-nitro-3-phenyl- and 4'-nitro-3-phenyl-1-methyl-phthalaz-4-one, from which neither could be isolated by fractional crystallisation. This was supported by examination of deliberately prepared mixtures of the two compounds, as well as by the above analytical results.

Mixed Melting Points of 4'-Nitro-3-phenylphthalaz-4-one (*A*) *and 4'-Nitro-3-phenyl-1-methylphthalaz-4-one* (*B*).

(A), % by wt.	0	33	40	50	60	72	100
M. p.	214°	209°	211°	215°	226°	237°	258°
M. p. after one crystn. from glacial acetic acid	—	213°	218°	225°	233°	240°	—

A mixture, which corresponded in all respects with (X), was prepared by dissolving (A) (0·4 g.) and (B) (0·6 g.) in boiling glacial acetic acid and collecting the colourless needles (Y) after 15 minutes when the temperature had fallen to 55°; the mixture (Y) [Found: C, 63·65; H, 3·85; N, 15·3. Calc. for a mixture of 45% of (A) and 55% of (B): C, 63·55; H, 3·7; N, 15·3%], (X), and a mixture of (X) and (Y), all melted at 217—219°.

When (X) (2 g.) was reduced by boiling with a solution of sodium sulphide crystals (6 g.) in water (20 c.c.) and alcohol (10 c.c.) for 20 minutes, brownish prisms (1·1 g.), m. p. 184—187°, separated on cooling. Prolonged fractional crystallisation from alcohol gave a little 4'-amino-3-phenyl-1-methylphthalaz-4-one, almost colourless prisms, m. p. 201—203° (Found: C, 71·35; H, 5·2; N, 16·85. Calc. for $C_{15}H_{13}ON_3$: C, 71·7; H, 5·2; N, 16·7%), and mixed m. p. with a synthetic specimen (J., 1935, 314) 203—204°; the acetyl derivative crystallised from alcohol in colourless needles, m. p. and mixed m. p. with an authentic specimen (*loc. cit.*) 252° (Found: C, 69·3; H, 5·0; N, 14·0. Calc. for $C_{17}H_{15}O_2N_3$: C, 69·6; H, 5·1; N, 14·3%).

Action of Dilute Hydrochloric Acid on (I; R = 3'-*Nitrophenyl*).—Compound (I) (2 g.) was

heated in a sealed tube with (a) dilute hydrochloric acid (18 c.c.; 1 : 7·5) at 170—175° for 6 hours, and (b) dilute hydrochloric acid (18 c.c.; 1 : 8) at 165° for 48 hours. The sole reaction product isolated from (a) was 3′-nitro-3-phenylphthalaz-1-one, pale yellow needles, m. p. 324°. The product from (b) was a mixture, which was separated in the usual manner into 3′-nitro-3-phenylphthalaz-4-one, colourless needles, m. p. and mixed m. p. 240° (yield, 0·6 g.; 36·8%), and 3′-nitro-3-phenylphthalaz-1-one, m. p. and mixed m. p. 324° (yield, 0·4 g.; 24·5%).

Action of Dilute Hydrochloric Acid on (I; R = 2′-*Nitrophenyl*).—Compound (I) (1·5 g.) was heated in a sealed tube with dilute hydrochloric acid (18 c.c.; 1 : 8) at (a) 165°, (b) 175—180°, and (c) 190—195°, for 6 hours. No reaction occurred in (a) and (b), but in (c) a brown, slightly charred mass was obtained. The united product from four experiments was ground with sodium carbonate solution, then with sodium hydroxide solution, and washed with water, and the residue dried (yield, 1·8 g.). Repeated fractional crystallisation from alcohol (charcoal) gave colourless prisms, m. p. 176° after softening at 172° (X) [Found: C, 63·5; H, 3·95; N, 15·65. Calc. for a mixture of 50% of (A) and 50% of (B): C, 63·5; H, 3·65; N, 15·35%], and colourless prisms, m. p. 187° after softening at 182° (X′) [Found: C, 63·6; H, 3·75; N, 14·7. Calc. for a mixture of 25% of (A) and 75% of (B): C, 63·8; H, 3·8; N, 15·1%]. Both (X) and (X′) possessed all the properties of mixtures of 2′-nitro-3-phenyl- and 2′-nitro-3-phenyl-1-methyl-phthalaz-4-one, from which neither could be isolated by fractional crystallisation.

Mixed Melting Points of 2′-Nitro-3-phenylphthalaz-4-one (*A*) *and 2′-Nitro-3-phenyl-1-methylphthalaz-4-one* (*B*).

(A), % by wt. ...	0	22	32	39	46	50	55	69	75	88	100
M. p.	202°	189°	184°	179—180°	176°	176°	179°	185—186°	191°	196°	201°

The product (X) corresponded in all respects with a mixture (Y) prepared from 50% of (A) and 50% of (B); the mixture (Y) melted at 176°, as did also a mixture of (X) and (Y), and a mixture of (X) and (B), whereas a mixture of (X) and (A) melted at 182°. The product (X′) corresponded in all respects with a mixture (Y′) prepared from 25% of (A) and 75% of (B); the mixture (Y′) melted at 187°, as did also a mixture of (X′) and (Y′), whilst a mixture of (X′) and (A) melted at 181°, and a mixture of (X′) and (B) melted at 192—193°.

Action of Dilute Hydrochloric Acid on (I; R = 4′-*Aminophenyl*).—Compound (I) (1·5 g.) was heated in a sealed tube with (a) dilute hydrochloric acid (18 c.c.; 1 : 2) at 150° for 12 hours, and (b) dilute hydrochloric acid (18 c.c.; 1 : 7·5) at 175° for 6 hours. In each case, the sole reaction product isolated was 4′-amino-3-phenylphthalaz-1-one, deep straw-coloured prisms, m. p. 259° (cf. J., 1933, 1068).

Action of Dilute Hydrochloric Acid on (I; R = 2′-*Aminophenyl*).—Compound (I) (1·5 g.) was heated with dilute hydrochloric acid (18 c.c.; 1 : 8) in a sealed tube at 180° for 6 hours. The reaction mixture was rendered alkaline with warm aqueous sodium hydroxide (evolution of ammonia) and filtered. The precipitate was dried and extracted with boiling benzene, and the solvent removed from the extract; the residue of 2′ : 4-anhydro-2′-amino-3-phenyl-1-methylphthalaz-4-one crystallised from aqueous alcohol in colourless feathery needles, m. p. and mixed m. p. with the specimen already described (p. 98) 163° (yield, 0·43 g.; 37·4%). Careful acidification of the alkaline filtrate with acetic acid, followed by crystallisation of the precipitate from dilute acetic acid, gave 2-phenylbenziminazole-*o*-carboxylic acid, colourless needles, m. p. and mixed m. p. with an authentic specimen 270° (yield, 0·62 g.; 51·6%).

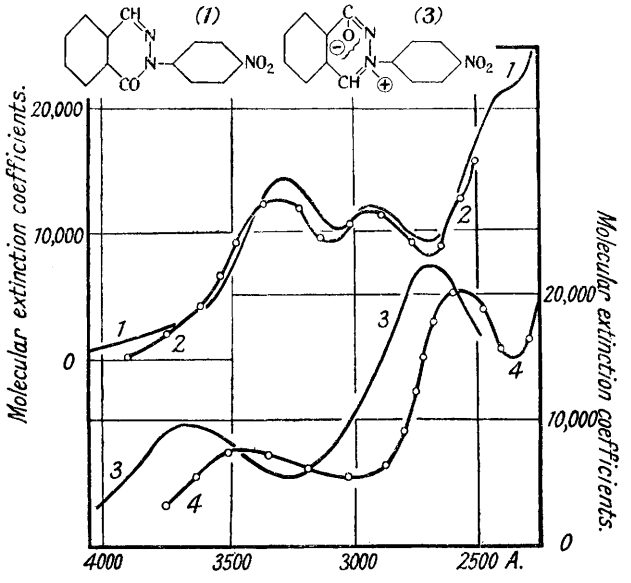
The Absorption Spectra of Certain Nitroarylphthalazones and Related Compounds (by A. E. Gillam).

In view of the relationships that have now been established between the corresponding isomerides (II; R = nitroaryl, R′ = H) and (IV; R = nitroaryl, R′ = H) and between the corresponding isomerides (II; R = nitroaryl, R′ = Me), (IV; R = nitroaryl, R′ = Me), and (VI; R = nitroaryl), a study of the absorption spectra of some typical examples of these compounds appeared to be of interest. The apparatus used was a Hilger E_3 quartz spectrograph fitted with a Spekker photometer, a tungsten-steel high-tension spark being employed as the source of light. The solvent was in all cases ethyl alcohol specially purified until transparent down to about 2100 A.

The first group of compounds examined comprised 4′-nitro-3-phenylphthalaz-1-one (II; R = 4′-nitrophenyl, R′ = H), the corresponding 4-methyl compound (II; R′ = Me), 4′-nitro-3-phenylphthalaz-4-one (IV; R = 4′-nitrophenyl, R′ = H), and the corresponding 1-methyl compound (IV; R′ = Me). The absorption curves are reproduced in Fig. 3. It will be seen that (a) the absorption of the 1-ones is quite different from that of the 4-ones, and (b) the introduction of the 1-methyl group into the 4-one produces no appreciable change in

the absorption, whereas introduction of the 4-methyl group into the 1-one causes a displacement of the maxima towards the ultra-violet (3670 A. ⟶ 3460 A.).

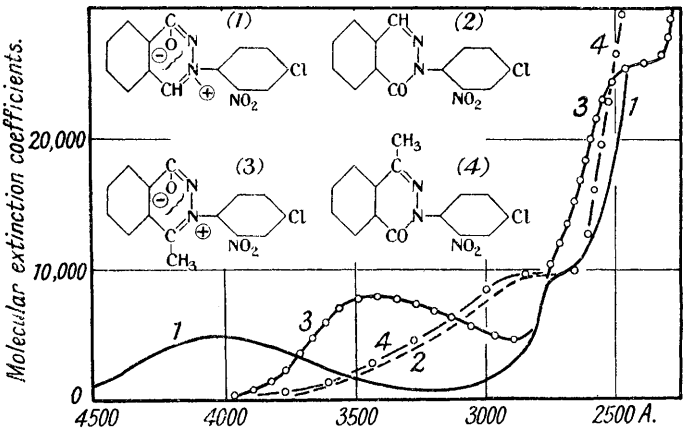
FIG. 3.



1. ——— 4′-*Nitro*-3-*phenylphthalaz*-4-*one*.
2. ○——○ 4′-*Nitro*-3-*phenyl*-1-*methylphthalaz*-4-*one*.
3. ——— 4′-*Nitro*-3-*phenylphthalaz*-1-*one*.
4. ○——○ 4′-*Nitro*-3-*phenyl*-4-*methylphthalaz*-1-*one*.

The methyl group is usually regarded as a transparent group, *i.e.*, one without chromophoric properties, but when a hydrogen atom is replaced by it the effect on the resulting absorption spectrum depends upon the position of the hydrogen atom relative to the chromophoric group.

FIG. 4.



1. ——— 4′-*Chloro*-2′-*nitro*-3-*phenylphthalaz*-1-*one*.
2. — — — 4′-*Chloro*-2′-*nitro*-3-*phenylphthalaz*-4-*one*.
3. ○——○ 4′-*Chloro*-2′-*nitro*-3-*phenyl*-4-*methylphthalaz*-1-*one*.
4. ○- - -○ 4′-*Chloro*-2′-*nitro*-3-*phenyl*-1-*methylphthalaz*-4-*one*.

In general, when a hydrogen atom not directly attached to a chromophoric group is replaced by methyl, the absorption spectrum is unaltered or only slightly altered, but when a hydrogen atom directly attached to an active chromophoric group is replaced by methyl, some displace-

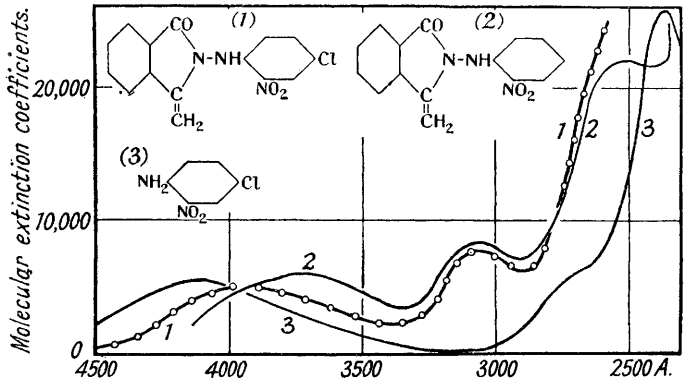
ment of the absorption bands may be expected. Stilbene and the methylstilbenes illustrate this point (Ley and Rinke, *Ber.*, **1923**, **56**, 771; Ley, " Handbuch der Physik," **21**, 121).

		$\lambda_{max.}$, A.
Stilbene	$C_6H_5 \cdot CH:CH \cdot C_6H_5$	2950
α-Methylstilbene	$C_6H_5 \cdot C(CH_3):CH \cdot C_6H_5$	2690
αβ-Dimethylstilbene	$C_6H_5 \cdot C(CH_3):C(CH_3) \cdot C_6H_5$	2400
p-Methylstilbene	$C_6H_5 \cdot CH:CH \cdot C_6H_4 \cdot CH_3(p)$	2950

The fact that in the 4′-nitrophenylphthalazones the 1-methyl group has no influence on the absorption in the case of the 4-one, whilst the 4-methyl group has a marked hypsochromic effect in the 1-one, must be ascribed to a steric effect of the methyl group in the latter case. This difference is consistent with the apparent structure of the two types of compounds, for in the 1-one the 4-methyl group is directly attached to the chromophoric system responsible for the near ultra-violet band (see below), whereas this is not so with the 1-methyl group in the 4-one (cf. II and IV).

The absorption curves of the four analogous 4′-chloro-2′-nitro-compounds are reproduced in Fig. 4. Again the 4-ones are less strongly absorbing in the near ultra-violet than the 1-ones and the introduction of the 1-methyl group into the 4-one results in little difference in the absorption, whereas the 4-methyl group in the case of the 1-one causes a large hypsochromic effect (4030 A. ⟶ 3430 A.).

FIG. 5.



1. ○——○ 2-(4′-*Chloro*-2′-*nitrophenylamino*)-3-*methylene*iso*indolinone*.
2. ——·—— 2-(2′-*Nitrophenylamino*)-3-*methylene*iso*indolinone*.
3. ——— 4-*Chloro*-2-*nitroaniline*.

When the absorption curve of 4′-nitro-3-phenylphthalaz-1-one (Fig. 3) is compared with that of the 4′-chloro-2′-nitro-analogue (Fig. 4), it is seen that the long-wave band is displaced to longer wave-lengths (3670 A. ⟶ 4030 A.). These absorption bands must therefore be due to the chromophore of the nitroarylamine residue, the change in location being associated with the change in the position of the nitro-group from para- to ortho-. This is clearly indicated by the close analogy between the absorption of these particular phthalazones and that of *p*- and *o*-nitroaniline (Morton and McGookin, J., 1934, 901):

	$\lambda_{max.}$, A.	$\epsilon_{max.}$
4′-Nitro-3-phenylphthalaz-1-one	3670	9,600
p-Nitroaniline	3740	15,000
4′-Chloro-2′-nitro-3-phenylphthalaz-1-one	4030	4,900
o-Nitroaniline	4040	5,400

The absorption curves of 2-(2′-nitrophenylamino)-3-methylene*iso*indolinone (VI; R = 2′-nitrophenyl) and the 4′-chloro-2′-nitro-analogue are reproduced in Fig. 5.

In compounds of the complexity of those at present under discussion, it is difficult to associate the various absorption bands with particular chromophoric groups in the molecule with any degree of certainty. Nevertheless, from the foregoing evidence it is clear that the complex chromophore formed by substituting hydrogen in the nitroarylamine is responsible for much of the absorption of the 1-ones. As a further confirmation the absorption of 4-chloro-2-nitroaniline was examined (Fig. 5). The long-wave absorption band is very similar in location,

intensity, and general shape to the bands of 4′-chloro-2′-nitro-3-phenylphthalaz-1-one (Fig. 4) and 2-(4′-chloro-2′-nitrophenylamino)-3-methylene*iso*indolinone :

	$\lambda_{max.}$, A.	$\epsilon_{max.}$
4-Chloro-2-nitroaniline	4100	5400
4′-Chloro-2′-nitro-3-phenylphthalaz-1-one	4030	4900
2-(4′-Chloro-2′-nitrophenylamino)-3-methylene*iso*indolinone	3950	5000

The evidence that the near ultra-violet absorption of 4-chloro-2-nitroaniline persists in the above *iso*indolinone being accepted, the new molecular environment of the chromophoric group must displace the maximum from 4100 A. to 3950 A. The very similar absorption of the corresponding 1-one has already been shown to be closely comparable with that of *o*-nitroaniline (*vide supra*), but the fact that, despite the similarity of its molecular environment with that of the *iso*indolinone, it has its maximum displaced by 80 A. to longer wave-lengths can be attributed to the additional double bond with which the chromophore is conjugated (3950 A. $\longrightarrow$ 4030 A.; cf. II). As the absorption of 4-chloro-2-nitroaniline does not persist in the derived 4-ones (Fig. 4), other groups in the structurally different molecules of this series of compounds must cause the displacement of the absorption to shorter wave-lengths.

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