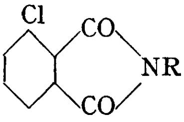
32. *Arylaminophthalic Acid Derivatives.*

By G. J. Marriott and Robert Robinson.

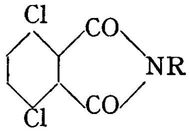
3-Arylamino- and 3 : 6-diarylamino-phthalanils are coloured substances as already indicated by Pratt and Perkins (1918). The series corresponding to these types has been extended in order to study the effect of substituents on the colour and in view of the formal analogy with the similarly constituted anthraquinone derivatives.

The substances are stable pigments and are fast to light but when dispersed the tinctorial intensity is not comparable with that of other insoluble colouring matters of use in the arts.

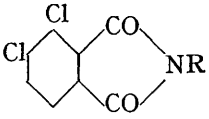
An investigation of the reactivity of the chlorine atoms in chlorinated phthalic acids towards aromatic amines led to the preparation of a number of coloured mono- and di-arylaminophthalic acid derivatives. The following compounds were prepared by heating 3-chloro-, 3 : 6-dichloro-, or 3 : 4-dichloro-phthalic acids with aromatic amines (Graebe and Gourevitz, *Ber.*, 1900, **33**, 2024).



I, R = Phenyl
II, R = *p*-Tolyl
III, R = 4-Methoxyphenyl
IV, R = *β*-Naphthyl
V, R = 4-Nitrophenyl



VI, R = Phenyl
VII, R = *p*-Tolyl

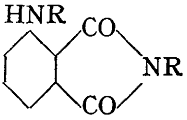


VIII, R = Phenyl

On heating dihalogenated phthalanils with aniline, Pratt and Perkins (*J. Amer. Chem. Soc.*, 1918, **40**, 198) found that one α-chlorine atom was displaced by the anilino-group, the product being orange in colour. They also isolated a small quantity of bright scarlet 4 : 5-dichloro-3 : 6-dianilinophthalanil after prolonged boiling of tetrachlorophthalanil or 4 : 5-dichloro-3 : 6-di-iodophthalanil with aniline. This appears to be the only example of a diarylaminophthalimide derivative so far described in the literature.

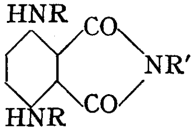
In the present work the general method used for replacing chlorine atoms in chlorophthalanils by aromatic amines was that of Frey (*Ber.*, 1912, **45**, 1358) for a similar reaction in the anthraquinone series, *viz.*, the action of various aromatic amines, potassium carbonate, and copper-bronze at temperatures ranging from 135° to 220° : the following compounds were thus prepared :

Orange



IX, R = Phenyl
X, R = *p*-Tolyl
XI, R = 4-Methoxyphenyl
XII, R = *β*-Naphthyl

Red



XIII, R = R′ = Phenyl
XIV, R = R′ = *p*-Tolyl
XV, R = R′ = 4-Methoxyphenyl
XVI, R = *o*-Carboxyphenyl, R′ = phenyl

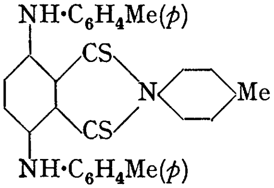
It appeared that copper-bronze was essential for the replacement of both chlorine atoms of the dichlorophthalanils by arylamino-residues and, even when it was used, by-products could usually be isolated arising from the reaction of only one of the chlorine atoms. From the fact that the chlorine atom in position 3 is known to be active in this respect, it is inferred that this is the one replaced. This is confirmed by the fact that Pratt and Perkins (*loc. cit.*) could not effect replacement of the chlorine atoms of 4 : 5-dichlorophthalanil. They therefore considered the product of the action of aniline on 3 : 4-dichlorophthalanil to be 4-chloro-3-anilinophthalanil.

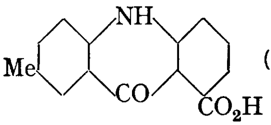
A further complicating factor in these reactions was the replacement of the chlorine in the phthalic acid nucleus by hydrogen, accompanied by the oxidation of the arylamine. This led to contamination of the red 3 : 6-diarylaminophthalimide derivatives with orange monoarylamino-compounds and oxidation products of the amines (*e.g.*, 4 : 4′-azotoluene from *p*-toluidine).

During the reaction the phthalimide ring is opened by the alkali and an interchange of amines takes place so that, when the ring is again closed on treatment with hot acids, that amine which is present in excess occurs in the phthalarylimide structure. Tingle and Rolker (*J. Amer. Chem. Soc.*, 1908, **30**, 1886) showed that it is possible to effect an interchange of the aromatic group attached to the nitrogen of a phthalamic acid. This type of interchange has been realised in the present work : the anilo-groups of 3-chlorophthalanil and 3 : 6-dichlorophthalanil have been replaced by the corresponding groups derived from *p*-toluidine, *p*-anisidine, etc. The reverse displacement of a β-naphthylimino-group by an anilo-group was also effected.

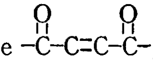
By heating these compounds with hydrazine hydrate in pyridine solution, a series of *NN'*-phthalhydrazides was prepared. The reaction was retarded by arylamino-groups in the 3-position, prolonged boiling being necessary with the 3 : 6-diarylamino-compounds. Reissert and Holle (*Ber.*, 1911, **44**, 3033) prepared thiophthalanil by the action of phosphorus pentasulphide in boiling benzene on phthalanil. A dark green solid (XX) was obtained by this method from (XIV). 3-*Methylacridone*-6-*carboxylic acid* (XXI) was prepared from (X) by the action of 70% sulphuric acid at 160—170°. The properties of this compound are very similar to those of the acridone-3 (and 1)-carboxylic acids (Ullmann, *Annalen*, 1907, **355**, 353). Similar reactions are known in the anthraquinone series (*Chem. Centr.*, 1902, I, 79; 1913, II, 553).

(XX.)





(XXI.)

The substitution of arylamino-groups in phthalimide has the same auxochromic effect as in the anthraquinone series. The 3-arylaminophthalanils are yellow, but the 3 : 6-diarylaminophthalanils are red. The colours, however, are diminished (to cream and orange respectively) when two nitrogens are present in the ring as is the case with the *NN'*-phthalhydrazides. The chromophoric group in all three series may be  $-\overset{\overset{\large O}{\|}}{C}-C{=}C-\overset{\overset{\large O}{\|}}{C}-$, which is partially neutralised by the presence of the ring nitrogens, two being more effective than one. Thus a decrease in colour intensity occurs in the series : anthraquinone, phthalimide, *NN'*-phthalhydrazide derivatives.

Many of the compounds here described are diphenylamine derivatives and as such give intense colour reactions on the addition of oxidising agents to their solutions in concentrated sulphuric acid. This colour, in the case of diphenylamine itself, is due to the formation of the sulphate of diphenoquinonedianil (Wieland, *Ber.*, 1913, **46**, 3300; 1919, **52**, 889). When the *p*-position to nitrogen is free in the aryl residue of the above compounds, the coloration is found to be relatively stable and is probably due to the formation of a compound of the above type. However, when this position is occupied, less stable colorations are observed; these may involve the *o*-positions or be due to hemiquinonoid salts (cf. Walden, " Chemie der freien Radikale," Leipzig, 1924).

Experiments on the replacement of chlorine in the chlorophthalic acids by aryloxy-groups and the conversion of the products into xanthones will be reported later.

EXPERIMENTAL.

3-Chlorophthalanil (I) was prepared in quantitative yield by the method of Graebe and Gourevitz (*loc. cit.*) by heating equimolecular proportions of 3-chlorophthalic acid or anhydride and aniline at 200—220° until the evolution of steam ceased. The condensation was also performed in boiling acetic acid by the method of Pratt and Perkins (*loc. cit.*). In subsequent reactions the latter method was found to give 80—90% yields when aniline and *p*-toluidine were used but poor yields with *p*-anisidine, β-naphthylamine or *p*-nitroaniline.

The product crystallised from acetic acid in pale cream-coloured needles, m. p. 189—190° (Found : C, 65·4; H, 3·2; Cl, 14·2. Calc. for $C_{14}H_8O_2NCl$: C, 65·2; H, 3·1; Cl, 13·8%). The colourless solution in concentrated sulphuric acid became deep purple on the addition of potassium dichromate; the colour rapidly faded to greenish-brown.

3-*Chloro*-N-p-*tolylphthalimide* (II) crystallised from acetic acid in colourless needles, m. p. 160·5° (Found : C, 66·6; H, 3·7. $C_{15}H_{10}O_2NCl$ requires C, 66·3; H, 3·7%). Sulphuric acid and potassium dichromate gave a reddish-brown coloration, changing to a pale greenish-yellow.

3-*Chloro*-N-p-*anisylphthalimide* (III) crystallised from acetic acid in lemon-yellow needles, m. p. 198° (Found : C, 62·6; H, 3·5. $C_{15}H_{10}O_3NCl$ requires C, 62·7; H, 3·7%). Sulphuric acid and potassium dichromate gave a red-brown colour, changing to a pale greenish-yellow.

3-*Chloro*-N-β-*naphthylphthalimide* (IV) crystallised from acetic acid in light brown needles,

m. p. 211° (Found: C, 70·4; H, 3·2. $C_{18}H_{10}O_2NCl$ requires C, 70·2; H, 3·2%). Sulphuric acid and potassium dichromate gave a fairly stable reddish-brown coloration.

3-*Chloro*-N-p-*nitrophenylphthalimide* (V) was prepared both by nitration of 3-chlorophthalanil and by condensation of 3-chlorophthalic acid with *p*-nitroaniline. The products were identical; white needles from acetic acid, m. p. 290° (Found: Cl, 11·9. $C_{14}H_7O_4N_2Cl$ requires Cl, 11·7%).

3 : 6-Dichlorophthalanil (VI) crystallised from glacial acetic acid in pale yellow needles, m. p. 194°. Pratt and Perkins (*loc. cit.*) give m. p. 197—198° (corr.). Sulphuric acid and potassium dichromate gave a transient purple colour, changing to brown.

3 : 6-*Dichloro*-N-p-*tolylphthalimide* (VII) crystallised from acetic acid in pale yellow needles, m. p. 231° (Found: C, 58·7; H, 3·0. $C_{15}H_9O_2NCl_2$ requires C, 58·8; H, 2·9%). Sulphuric acid and potassium dichromate gave a reddish-brown colour, changing to pale yellow.

3 : 4-Dichlorophthalanil (VIII) crystallised from alcohol in colourless needles, m. p. 179—180°. Pratt and Perkins (*loc. cit.*) give m. p. 181—181·5° (corr.). Sulphuric acid and potassium dichromate gave a transient purple colour, changing to brown.

3-*Anilinophthalanil* (IX).—A mixture of 3-chlorophthalanil (6 g.), aniline (30 g.), anhydrous potassium carbonate (5 g.), and copper-bronze (0·5 g.) was heated with stirring at 160—170° for 3 hours. The black tarry liquid was then thoroughly washed with hot dilute hydrochloric acid. The black product was dried and crystallised twice from pyridine and twice from acetone and acetic acid, forming yellow prisms, m. p. 144·5—145° (Found: C, 76·6; H, 4·5. $C_{20}H_{14}O_2N_2$ requires C, 76·4; H, 4·5%). Yield, 38%. This *compound* gave a colourless solution in concentrated sulphuric acid which on the addition of potassium dichromate became deep red, changing to a deep bluish-purple.

3-p-*Toluidino*-N-p-*tolylphthalimide* (X) was obtained from (I) and (II) in 39% yield by condensations with *p*-toluidine at 145—150° for 4 hours. The product crystallised from acetone in orange needles, m. p. 152° (Found: C, 77·1; H, 5·3. $C_{22}H_{18}O_2N_2$ requires C, 77·2; H, 5·3%). The yellow solution in sulphuric acid became deep green on the addition of potassium dichromate, the colour rapidly changing to a dirty brown.

3-p-*Anisidino*-N-p-*anisylphthalimide* (XI) was obtained from (I) and (III) in 51% and 53% yields by condensations with *p*-anisidine at 160—170° for 4 hours, and at 145—150° for 6 hours respectively. Orange needles were obtained from acetic acid, m. p. 171—172° (Found: C, 70·0; H, 5·0. $C_{22}H_{18}O_4N_2$ requires C, 70·6; H, 4·8%). The colourless solution in sulphuric acid became reddish-brown with potassium dichromate, rapidly changing to a pale greenish-brown colour.

3-β-*Naphthylamino*-N-β-*naphthylphthalimide* (XII).—The compound (IV) was condensed with β-naphthylamine at 145—150° for 6 hours to give the required *substance* in 46% yield. Lemon-yellow needles separated from acetic acid, m. p. 220° (Found: C, 80·8; H, 4·3. $C_{28}H_{18}O_2N_2$ requires C, 81·2; H, 4·3%). The yellow solution in sulphuric acid gave a stable blood-red coloration with potassium dichromate.

No crystalline products were isolated from attempted condensations of 3-chlorophthalanil with *o*-phenylenediamine or with anthranilic acid.

A solution of 3-β-naphthylamino-*N*-β-naphthylphthalimide (XII) (0·5 g.) in aniline (20 c.c.), containing potassium carbonate (5 g.) in suspension, was heated with stirring at 170° for 30 minutes. The cooled mixture was treated with hot dilute hydrochloric acid, and the tarry residue crystallised from pyridine and thrice from acetic acid. Orange needles were obtained, m. p. 167° (Found: N, 7·6. $C_{24}H_{16}O_2N_2$ requires N, 7·7%). The product is thus 3-β-*naphthylamino*-N-*phenylphthalimide* (XVII).

4-*Chloro*-3-p-*toluidino*-N-p-*tolylphthalimide* was obtained from (VIII) by a condensation with *p*-toluidine at 155—160° for 4 hours. The black tarry product was extracted (Soxhlet) with light petroleum (b. p. 60—80°). The pale yellow needles formed were collected and recrystallised from acetic acid; m. p. 208—209° (yield, 9%) (Found: C, 70·2; H, 4·7; N, 8·1. $C_{22}H_{17}O_2N_2Cl$ requires C, 70·1; H, 4·5; N, 7·4%).

Action of Aniline on 3 : 4-*Dichlorophthalanil.*—Pratt and Perkins (*loc. cit.*) prepared 4-chloro-3-anilinophthalanil by boiling 3 : 4-dichlorophthalanil with aniline for 36 hours. An Ullmann condensation carried out under reflux for 6 hours gave a product which was finally isolated in orange-yellow needles (yield, 10%), m. p. 144·5—145°, identified by mixed m. p. with (IX) (Found: C, 76·5; H, 4·6; N, 8·7. Calc. for $C_{20}H_{14}O_2N_2$: C, 76·4; H, 4·5; N, 8·9%).

3 : 6-*Dianilinophthalanil* (XIII) was obtained from (VI) in 15% yield by condensation with aniline at 150—160° for 3 hours and at 135° for a further 20 hours. After extraction of the tarry residues (Soxhlet) with light petroleum (b. p. 40—60°), red needles were isolated, m. p. 197° (Found: C, 77·2; H, 4·6. $C_{26}H_{19}O_2N_3$ requires C, 77·0; H, 4·7%). The colourless

solution in sulphuric acid gave a stable, deep blue coloration on the addition of a trace of potassium dichromate.

3 : 6-*Di*-p-*toluidino*-N-p-*tolylphthalimide* (XIV) was prepared from (VI) (20 g.) by condensation with *p*-toluidine at 165—175° for 5 hours. After extraction (Soxhlet) with light petroleum (b. p. 60—80°), the product consisted of a mixture of red and orange crystals (19 g.). By fractional crystallisation from alcohol, bright red needles were obtained, m. p. 164° (yield, 7 g.; 23%) (Found: C, 77·4; H, 5·5; N, 9·4. $C_{29}H_{25}O_2N_3$ requires C, 77·8; H, 5·5; N, 9·4%). The colourless solution in sulphuric acid became bluish-green on the addition of potassium dichromate.

From the mother-liquors of the above crystallisation, orange needles were isolated and identified with (X). This compound was present to the extent of about 50% of the crude product.

This condensation was tried under various conditions:

(a) From a condensation with *p*-toluidine and (VII) at 130—145° for 5 hours, orange needles were obtained together with a small quantity of the red product. On separation, the orange compound was found to be 6-*chloro*-3-p-*toluidino*-N-p-*tolylphthalimide*, m. p. 166—167° (Found: C, 70·0; H, 4·5. $C_{22}H_{17}O_2N_2Cl$ requires C, 70·1; H, 4·5%).

(b) A condensation at 220—230° for 2 hours gave a tarry mixture of orange and red compounds.

(c) A condensation at 140—150° for 5 hours, without the addition of copper-bronze, gave none of the red product.

(d) The use of nitrobenzene as a solvent for the reaction (cf. Ullmann, *Ber.*, 1906, **39**, 1693) gave a negligible yield of a yellow condensation product.

(e) Replacement of the copper-bronze and potassium carbonate by a mixture of potassium and copper acetates and heating at 95—105° for 19 hours resulted in the isolation of orange needles, which melted at 181—182°, then became viscous and appeared to melt again at 194°. These are an inseparable mixture of the initial material (VI) and 6-chloro-3-*p*-toluidino-*N*-*p*-tolylphthalimide (Found: C, 65·0; H, 4·1. $C_{14}H_7O_2NCl_2$ requires C, 57·5; H, 2·4. $C_{21}H_{15}O_2N_2Cl$ requires C, 69·5; H, 4·1%).

(f) The use of copper carbonate as a catalyst was tried in a condensation of (VI) and *p*-toluidine at 130—140° for 4 hours. An impure specimen of (X) was isolated, formed by reduction of the initial material. 4 : 4′-Azotoluene also was extracted from the tarry residues with light petroleum; m. p. 144—145°. Perkin (J., 1880, **37**, 553) gives m. p. 143° (Found: C, 80·1; H, 6·7; N, 12·4. Calc. for $C_{14}H_{14}N_2$: C, 80·0; H, 6·7; N, 13·3%).

3 : 6-*Di*-p-*anisidino*-N-p-*anisylphthalimide* was obtained from (VI) in 20% yield by condensation with *p*-anisidine at 150—160° for 3 hours. Deep bronze-coloured needles were obtained from alcohol, m. p. 167—168° (Found: C, 70·5; H, 4·9; N, 8·4. $C_{29}H_{25}O_5N_3$ requires C, 70·3; H, 5·0; N, 8·5%). The colourless solution in sulphuric acid became olive-green on the addition of potassium dichromate.

3 : 6-*Di*-(2′-*carboxyanilino*)*phthalanil* (XVI).—This was obtained from (VI) in 15% yield by condensation with anthranilic acid at 170—180° for 3 hours. The residues were treated with excess of hot potassium carbonate solution and filtered off. On acidification of the filtrates, a mixture of the product and anthranilic acid was obtained; the latter was removed by repeated boiling with hydrochloric acid. The insoluble residue crystallised from acetic acid in orange needles, m. p. 302° (decomp.) (Found: C, 67·7; H, 4·1. $C_{28}H_{19}O_6N_3$ requires C, 68·1; H, 3·8%). The *product* gave bluish-red solutions with alkali carbonates and bicarbonates, the former, exposed to air, fading after 24 hours. The yellow solution in sulphuric acid became deep blue on the addition of potassium dichromate.

A similar condensation at 150—160° gave 6-*chloro*-3-(2′-*carboxyanilino*)*phthalanil*, yellow needles, m. p. 277—278° (Found: C, 64·7; H, 3·5. $C_{21}H_{13}O_4N_2Cl$ requires C, 64·3; H, 3·3%). In these two condensations it is probable that the anilo-group of the 3 : 6-dichlorophthalanil was not replaced by the anthranilic acid residue, since insufficient carbonate was used in the condensation for the mixture to be alkaline and the phthalimide ring to be opened.

3-*Anilinophthalhydrazide* (XVIII).—A solution of 3-anilinophthalanil (0·5 g.) in pyridine (10 c.c.) was refluxed with hydrazine hydrate (2 c.c.) for 1 hour and then poured into dilute hydrochloric acid. The white precipitate was extracted with sodium carbonate solution, reprecipitated with acid, and crystallised from acetic acid, being obtained in practically quantitative yield as cream-coloured needles, m. p. 335° (decomp.) (Found: N, 16·3. $C_{14}H_{11}O_2N_3$ requires N, 16·4%). The colourless solution in sulphuric acid became permanganate-coloured on the addition of potassium dichromate.

3-p-*Toluidinophthalhydrazide* (XVIII) was obtained similarly from (X) as cream-coloured needles, m. p. *ca.* 320° (decomp.) (Found: N, 15·8. $C_{15}H_{13}O_2N_3$ requires N, 15·7%). The colourless solution in sulphuric acid became olive-green on the addition of potassium dichromate.

3-p-*Anisidinophthalhydrazide* (XVIII), prepared from (XI), formed cream-coloured needles, m. p. 320° (decomp.) (Found: C, 63·8; H, 4·7. $C_{15}H_{13}O_3N_3$ requires C, 63·6; H, 4·6%). The colourless solution in sulphuric acid became greenish-brown on the addition of potassium dichromate, but the colour faded rapidly.

3-β-*Naphthylaminophthalhydrazide* (XVIII) was obtained from (XII) as yellow needles, m. p. 325° (decomp. above 320°) (Found: N, 13·6. $C_{18}H_{13}O_2N_3$ requires N, 13·9%). The yellow solution in sulphuric acid became reddish-brown on the addition of potassium dichromate.

3 : 6-*Dianilinophthalhydrazide* (XIX) was obtained from (XIII) as a mixture of red and yellow needles, which on warming gave a homogeneous yellow product, m. p. 276—277° (Found: N, 16·1. $C_{20}H_{16}O_2N_4$ requires N, 16·3%). The pale blue solutions of this and the following compound in sulphuric acid became deep blue on the addition of potassium dichromate.

3 : 6-*Di*-p-*toluidinophthalhydrazide* (XIX) was prepared from (XIV) as red needles which became orange at 120°, blackened at 260°, and had m. p. *ca.* 285° (Found: N, 14·9. $C_{22}H_{20}O_2N_4$ requires N, 15·1%).

Attempts to produce phthalo-*N*-phenylhydrazides by treating the substituted phthalanil (XI) with phenylhydrazine or with *p*-nitrophenylhydrazine in pyridine solution were unsuccessful, the initial material always being recovered.

3 : 6-*Di*-p-*toluidino*-N-p-*tolyldithiophthalimide* (XX).—A mixture of 3 : 6-di-*p*-toluidino-*N*-*p*-tolylphthalimide (XIV) (0·5 g.), phosphorus pentasulphide (10 g.), a trace of aniline, and benzene (25 c.c.) was refluxed for 4 hours. The solid formed was collected and washed with hot benzene. After removal of the benzene by steam, the black residue was treated with hot alcoholic potassium hydroxide and then extracted with benzene. The solid obtained on removal of the solvent crystallised from alcohol in dark green needles, m. p. 127—128° after softening at 124—125° (yield, 50%) (Found: S, 13·3. $C_{29}H_{25}N_3S_2$ requires S, 13·4%).

A dilute solution of this compound in sulphuric acid is greenish-yellow and darkens to green on standing. At 100° the colour becomes violet and, on further heating, changes to red and brown. The addition of potassium dichromate to a cold sulphuric acid solution produces a violet colour. The compound is slowly precipitated from sulphuric acid solution after dilution with water.

3-*Methylacridone*-6-*carboxylic Acid* (XXI).—3-*p*-Toluidino-*N*-*p*-tolylphthalimide (0·5 g.) and sulphuric acid (36 c.c. of 70%) were heated together at 160—170° for 1 hour. The mixture was poured into water, the liquid filtered, and the solid dissolved in sodium carbonate solution, reprecipitated with acid, and crystallised (with difficulty) from pyridine. Small, pale yellow prisms were obtained, m. p. 302° (decomp.) (Found: C, 70·5; H, 4·7; N, 6·2. $C_{15}H_{11}O_3N$ requires C, 71·1; H, 4·4; N, 5·5%). The *substance* is difficultly soluble in alcohol, acetic acid and pyridine and the solutions exhibit a strong blue fluorescence; the yellow solution in sulphuric acid is not fluorescent.

Other dehydrating agents were unsuccessfully tried in the above reaction. (XI) and (XII) were refluxed for 4 and 9 hours respectively with phosphoryl chloride and both were recovered unchanged.

The authors thank the Department of Scientific and Industrial Research for a grant made to one of them.

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[*Received, November* 30*th*, 1938.]