Oxidations with Phenyl Iodosoacetate. Part III. Primary Aromatic Amines in Acetic Acid.*

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The oxidation of a primary aromatic amine with phenyl iodosoacetate in acetic acid solution yields generally the corresponding azo-compound. *o*-Nitroamines do not yield the furazan oxides which are formed in high yields in benzene solution (Part II).

In Part II * it was shown that a number of primary aromatic amines were oxidised by phenyl iodosoacetate in benzene solution to the corresponding azo-compounds in yields ranging from traces to almost quantitative, 1—2 mol. of reagent being consumed. Certain amines yielded other products: *o*-nitroanilines, for instance, formed the corresponding furazan oxides in high yield.

The action of phenyl iodosoacetate in acetic acid solution on a number of primary aromatic amines has now been examined. Except as noted in the Table, the uptakes had reached the values shown in 24 hours at room temperature and increased negligibly slowly thereafter, and azo-compounds were isolated in the yields shown, but unidentified mixtures were obtained from some other amines.

Although hydrazobenzene was almost quantitatively converted into azobenzene, no identifiable oxidation product was obtained from aniline but only a little acetanilide. It is not the reaction of acetanilide that is here being observed, however, since this is much slower than that of aniline (cf. Barlin and Riggs, following paper). In acetic acid solution at least, aniline is not initially oxidised to hydrazobenzene in the manner postulated by Pausacker (*J.*, 1953, 107). On the other hand, the negatively substituted amines examined (except 2 : 4-dinitroaniline, which consumed no reagent, and 2-nitro-1-naphthylamine, which gave an unidentified mixture of products) gave good yields of the azo-compounds, and furazan oxides were not obtained from *o*-nitro-amines (cf. Part II): this difference from the results in benzene solution recalls the experience of Green and Rowe (*J.*, 1912, **101**, 2449, 2455) who obtained benzofurazan oxide from *o*-nitroaniline and alkaline hypochlorite, but 2 : 2′-dinitroazobenzene by means of the neutral reagent. The possibility that in acetic acid there is interference with the internal hydrogen bonding of *o*-nitro-amines will be discussed in a later paper.

β-Naphthylamine gave an unexpected result. Although variable quantities of a green, high-melting compound, apparently identical with that of Part II, were obtained in different experiments, no 1 : 2 : 6 : 7-dibenzophenazine was isolated. The principal products were 2-acetamido-1 : 4-naphthaquinone (up to 34%) and a compound, $C_{22}H_{16}O_2N_2$ (25%), which is probably a β-naphthylamine anil of the quinone. When boiled with dilute hydrochloric acid the second compound yielded some β-naphthylamine and *ca.* 50% of 2-β-naphthylamino-1 : 4-naphthaquinone which was synthesised for comparison. The latter product could arise by hydrolysis of the anil and nucleophilic displacement of the acetamido-group (or the amino-group produced from it by hydrolysis) by β-naphthylamine—this displacement was substantiated by experiment. Under certain conditions the oxidation product, at first obtained in red plates, crystallised in purple needles of the same m. p., a mixture showing no depression. Since the amino-group of 2-amino-1 : 4-naphthaquinone is amidic and unlikely to be acetylated by acetic acid, and phenyl iodosoacetate cannot function as an acetylating agent, the 2-acetamido-1 : 4-naphthaquinone probably arises from the oxidation of aceto-β-naphthalide formed *in situ*; the naphthalide is indeed oxidised by phenyl iodosoacetate to the quinone in good yield but the quinone anil is not produced (Barlin and Riggs, *loc. cit.*). Since the anil is not formed from the quinone and β-naphthylamine in cold glacial acetic acid, and in view of the *meta*-acetoxylation reaction described by Barlin and Riggs, it is probable that an acetoxyl group enters the 4-position and a β-naphthyl-

* Part II, *J.*, 1953, 1989.

amino-group the 1-position, subsequent oxidation to the quinone anil occurring. On this basis the product is 2-acetamido-1 : 4-naphthaquinone 1-β-naphthylimide.

Experimental

Analyses are by Dr. K. W. Zimmermann, C.S.I.R.O. Microanalytical Laboratory, Melbourne. Samples were dried at 100°/0·5 mm. for analysis. The acetic acid used was purified (Orton and Bradfield, *J.*, 1927, 983) and had m. p. 16·3°. Ultra-violet spectra were measured in 95% alcohol on a Hilger Uvispek spectrophotometer.

Quantitative experiments were conducted as described in Part II, with acetic acid (25 ml.) in place of the benzene. A control solution showed a negligible drop in titre.

For the isolation of the products the amine (1 g.) in a little acetic acid was treated with the required amount of phenyl iodosoacetate in acetic acid (20 ml. per g.). After the required time at room temperature the mixture was evaporated as far as possible at the water-pump at <40°, and the residue was evaporated with water and alcohol under reduced pressure until free from acetic acid and iodobenzene. The residue, dried by evaporation with benzene, was extracted successively with boiling benzene and chloroform, and the cold concentrated extracts were chromatographed successively on alumina (British Drug Houses; 20 g. per g. of amine) with the same solvents as eluting media. Azo-compounds when produced were in the first benzene band, and were identified by mixed m. p. with the samples prepared in Part II, or by analyses, as shown in the Table. Acetanilide, m. p. and mixed m. p. 114°, was obtained by crystallisation from dilute alcohol of the residue from this band from the oxidation of aniline; *o*-toluidine gave a trace of white crystals, m. p. 75° from benzene–light petroleum (b. p. 60—70°); *p*-toluidine gave a few red needles, m. p. 165—167° from light petroleum (b. p. 70—80°).

Unidentified mixtures were obtained, with consumption (mols.) of iodosoacetate as stated, from: aniline 2·2, *o*- 2·0, *m*- 2·3, and *p*-toluidine 1·5, mesidine 1·3, α-naphthylamine 2·2, and 2-nitro-1-naphthylamine 2·0.

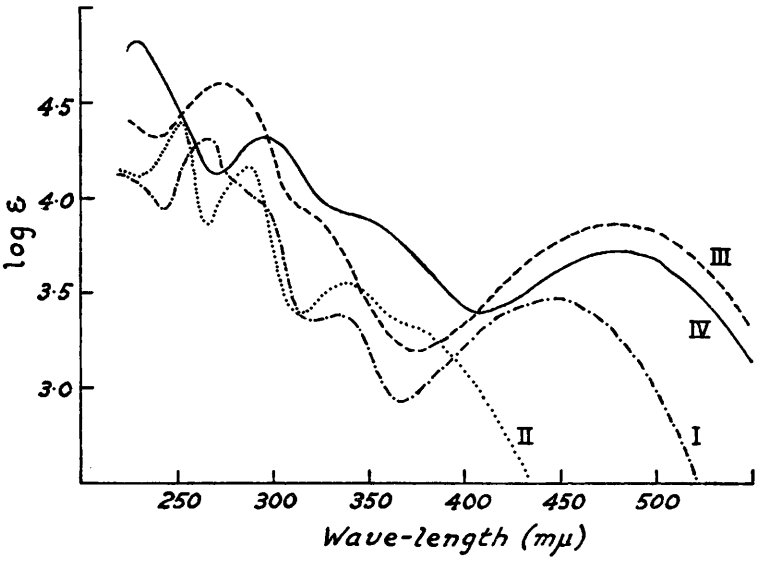
Amine	$PhI(OAc)_2$ consumed (mol.)	Azo-compound Yield (%)	M. p.*
o-Anisidine	1·9	1	153°
p- ,,	1·9	4	162
o-Chloroaniline	2·1	25	135
m- ,,	1·5	34	101
p- ,,	2·2 [a]	24	186 [b]
o-Nitroaniline	0·9	23 [c]	216 [d]
m- ,,	1·1	61	150
p-Nitroaniline	0·5 [e]	63	224°
4-Chloro-2-nitroaniline	0·2 [f]	32	251 [g]
1-Nitro-2-naphthylamine	0·8	38	315 [h]
Hydrazobenzene	1·1	97	68

* Mixed m. p.s were the same within 2° for known products.

[a] Increased to 3·0 in 6 days. [b] Sample prepared in Part II had m. p. 184°. [c] *o*-Nitroaniline (17%) was recovered. [d] An authentic sample (Green and Rowe, *loc. cit.*), crystallised from alcohol, had m. p. 196°, raised by chromatography on alumina from benzene and further crystallisation to 215°. In our hands, hypochlorite rendered neutral to phenolphthalein with acetic acid produced a little benzofurazan oxide which was removed by steam-distillation. Found, for azo-compound from iodosoacetate oxidation: C, 53·5; H, 3·2; N, 20·7. Calc. for $C_{12}H_8O_4N_4$: C, 52·9; H, 3·0; N, 20·6%. [e] Increased to 1·1 in 5 days. [f] Increased to 1·5 in 7 days. [g] 4 : 4′-*Dichloro*-2 : 2′-*dinitroazobenzene*, red needles from benzene [Found: C, 42·3; H, 1·9; N, 15·9%; *M* (Rast), 303. $C_{12}H_6O_4N_4Cl_2$ requires C, 42·3; H, 1·8; N, 16·4%; *M*, 341]. [h] Increased to 1·4 in 7 days. [i] 1 : 1′-*Dinitro*-2 : 2′-*azonaphthalene*, yellow needles from benzene (Found: C, 65·0; H, 3·4; N, 15·0. $C_{20}H_{12}O_4N_4$ requires C, 64·5; H, 3·3; N, 15·0%).

Oxidation of β-*Naphthylamine.*—β-Naphthylamine (10 g.) in a little acetic acid was treated with phenyl iodosoacetate (54 g.) in acetic acid (750 ml.). After 20 hr. at room temperature the mixture was evaporated as above. The residue was dried by distillation with chloroform, a trace only of a dark green substance being undissolved. A chloroform extract was chromatographed on alumina (150 g.). Almost the whole of the starting material was accounted for in the first (red) band, later fractions giving no crystalline products. The material from this band (9·4 g.) dissolved partly in cold benzene, and the sparingly soluble residue (2·8 g.) crystallised from alcohol in yellow plates, m. p. 206° [Found: C, 67·2; H, 4·3; N, 6·6%; *M* (cryoscopic in nitrobenzene), 212. Calc. for $C_{12}H_9O_3N$: C, 67·0; H, 4·2; N, 6·5%; *M*, 215]. The m. p. was undepressed in admixture with 2-acetamido-1 : 4-naphthaquinone, and the product was hydrolysed by concentrated sulphuric acid (Fieser, " Experiments in Organic Chemistry," Heath, New York, 2nd edn., 1941, p. 288) to 2-amino-1 : 4-naphthaquinone, m. p. and mixed m. p. 206° (from alcohol).

The benzene-soluble material was rechromatographed on alumina (50 g.) from benzene and yielded a red band followed by a yellow band from which more (0·6 g.) 2-acetamido-1 : 4-naphthaquinone was isolated. The residue from the last portion of the red band yielded a trace of purple material, m. p. at least 234—238° (from ethyl acetate), which was not further examined. The residue (3·5 g.) from the remainder of the red band was rechromatographed on alumina from benzene, the initial clear red eluate being collected in four fractions, each of which yielded red plates or purple needles, m. p. 210—211°, on crystallisation from alcohol; a mixture of the two forms also had m. p. 210—211° (yield, 2·5 g.). Recrystallisation of the red plates from a warm concentrated solution in alcohol yielded the purple needles, and these were reconverted into the red plates by slower crystallisation from a more dilute solution in the cold. 2-*Acetamido*-1 : 4-*naphthaquinone* β-*naphthylimide* separated from methanol as red plates, m. p. 210—212° [Found : C, 77·5, 77·8; H, 5·1, 4·8; N, 8·1, 8·3%; *M* (Rast), 358. $C_{22}H_{16}O_2N_2$ requires C, 77·6; H, 4·7; N, 8·2%; *M*, 338].



I, 2-*Amino*-1 : 4-*naphthaquinone*.
II, 2-*Acetamido*-1 : 4-*naphthaquinone*.
III, 2-β-*Naphthylamino*-1 : 4-*naphthaquinone*.
IV, 2-*Acetamido*-1 : 4-*naphthaquinone* β-*naphthylimide* (*both forms*).
(*All curves determined in* 95% *alcohol.*)

In another experiment the quinone was obtained in 6% yield, the red plates in 25% yield, and the green compound in 14% yield. The last was insoluble in most of the common solvents, but formed a deep blue solution in nitrobenzene from which it separated in lustrous leaflets, m. p. >300° (cf. Part II). Absorption spectra are recorded in the Figure.

Hydrolysis of the Red Plates.—The compound (100 mg.) was refluxed with 2N-hydrochloric acid (10 ml.) for 2 hr. The scarlet needles (50 mg.) that separated were recrystallised from methanol and had m. p. 194°, undepressed in admixture with 2-β-*naphthylamino*-1 : 4-*naphthaquinone* prepared as below [Found : C, 79·9, 80·3; H, 4·4, 4·4; N, 4·6, 4·7%; *M* (Rast), 274. $C_{20}H_{13}O_2N$ requires C, 80·3; H, 4·4; N, 4·7%; *M*, 299]. The filtrate from the hydrolysis was concentrated to small bulk and cooled. The pink flakes (30 mg.) that separated had m. p. *ca.* 250° (decomp.) and were converted by benzoyl chloride and alkali into benzo-β-naphthalide, m. p. and mixed m. p. 158°.

2-β-*Naphthylamino*-1 : 4-*naphthaquinone*.—(*a*) 1 : 4-Naphthaquinone (500 mg.) and β-naphthylamine (500 mg.) were refluxed together in alcohol (10 ml.) for 2 hr. The dark product was chromatographed on alumina (10 g.) from benzene, the deep red eluate evaporated, and the residue (600 mg.) crystallised from methanol to give scarlet needles, m. p. 194° (Found : C, 80·1; H, 4·2; N, 5·1%).

(*b*) 2-Acetamido-1 : 4-naphthaquinone (63 mg.) and β-naphthylamine (60 mg.) were refluxed

in 2N-hydrochloric acid (10 ml.) for 2 hr. The red solid was chromatographed as above to yield scarlet needles, m. p. 194° from methanol, undepressed in admixture with the above product.

Attempt to Prepare a β-*Naphthylamine Anil of* 2-*Acetamido*-1 : 4-*naphthaquinone.*—The quinone (79 mg.) and β-naphthylamine (101 mg.) were shaken with glacial acetic acid (10 ml.) until dissolved. After 24 hr. the reddish solution was evaporated to dryness at the water pump and the residue treated with alcohol (10 ml.). The bright yellow residue had m. p. 206° and was clearly not the desired product. Chromatography of the total product on alumina from benzene gave an initial pink fraction from which a few colourless crystals, m. p. 108° [from light petroleum (b. p. 70—60°)], probably β-naphthylamine, were obtained.

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