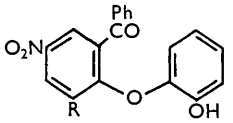
377. ortho-*Hydroxylation of Phenols. Part V.* Dibenzodioxins from Catechols and Analogous Cyclisations.*

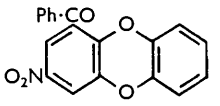
By J. D. Loudon and F. McCapra.

The formation of dibenzodioxins from *o*-nitrophenyl ethers of catechols is reported and correlated with other reactions of similar type.

Catechol ethers of types (I; R = H and NO_2) are readily prepared by hydroxylation of the corresponding phenyl ethers, or substituted phenyl ethers, and yield the appropriate catechols by ether scission. Piperidine which is an efficient reagent for scission in the mononitro-series was found in the dinitro-series to be less reliable than phenylhydrazine.* This is now shown to be due in part at least to the incidence of cyclisation, *e.g.*, (I; R = NO_2) ⟶ (II), which is promoted by warm piperidine, pyridine, or alkali but is not incurred to any appreciable extent with phenylhydrazine. Presumably the last reagent, by initial attack on the carbonyl centre, provides the opportunity for preferred cyclisation to 5 : 7-dinitro-1 : 3-diphenylindazole with elimination of the catechol residue.



(I)



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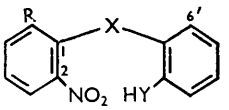

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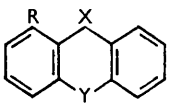
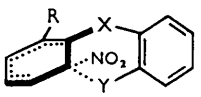


(IV)



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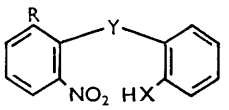

(VI)

Hillyer,[1] using unnecessarily severe conditions, showed that picryl chloride and catechol condense in presence of alkali to form 1 : 3-dinitrodibenzodioxin (as II; NO_2 for Ph·CO),

* Part IV, *J.*, 1954, 1134.

[1] Hillyer, *Chem. Centr.*, 1900, **1**, 723; 1901, **2**, 1121.

the picryl analogue of (I) being undoubtedly an intermediate. This was an extension of Turpin's reaction [2] by which, subject to certain conditions, phenoxazines (IV; X = NH, Y = O) may be obtained by elimination of nitrous acid from an intermediate of type (III). In particular cases analogous cyclisations to phenazines (IV; X = Y = NH),[3] phenoxathiins (IV; X = S, Y = O),[4] and phenothiazines (IV; X = NH, Y = S) [5] are also known. The success of such cyclisations generally depends on the presence of a substituent R in the 6-position of the intermediate (III) and this substituent is usually, but not invariably, a nitro-group or other electron-attracting group. 2-Hydroxy-2'-nitrodiphenylamines are the most extensively examined [6] and it has been suggested that in the absence of the substituent R the conformation of these compounds is fixed by hydrogen-bonding between the amino- and the nitro-group and is thus unfavourable to cyclisation.[6,7] Consistently with this view substitution of the amino-hydrogen atom confers the ability to form phenoxazines even when the substituent R is lacking.[7,8] Hydrogen-bonding however cannot be important for dioxin formation and here we find that picryl chloride, 2-chloro-3 : 5-dinitrobenzophenone, and 1-chloro-2 : 6-dinitrobenzene readily react with catechol in presence of potassium carbonate affording the appropriate dibenzodioxins, whereas 1-chloro-2 : 4-dinitrobenzene does not do so and under forceful conditions yields catechol bis-2 : 4-dinitrophenyl ether by intermolecular reaction. Apparently the presence of a group R in the intermediate (III; X = Y = O) is again an important factor.

These cyclisations may all be described as unoriented nucleophilic substitutions at an aromatic centre. Their prototype is the intermolecular displacement of a nitro-group in 1 : 3 : 5-trinitrobenzene by methoxide ion.[9] Here the nitro-groups, although their (*o* : *p*)-orienting effects are not enlisted, are responsible for attracting the anion and predisposing the system to nucleophilic attack which is complete after a single replacement. In the compounds (III) steric congestion can assist nucleophilic attack (*a*) by inhibiting resonance between a donor group X and the *ortho*-nitrated nucleus, (*b*) by enforcing a conformation which brings the nucleophilic Y into position for alternative attack at centre 1 or 2. The latter course leads *via* the transition state (V) to cyclisation, the former results in a Smiles rearrangement, (III) $\rightleftharpoons$ (VI). This view of the cyclisation is consistent with a range of polar character in the substituent R, it explains the effect of a large group X (*e.g.*, substituted imino) when R is hydrogen, and the relative ineffectiveness of R when transferred to the 6'-position.[6] At the same time it is in harmony with Bunnett's view [10] of the stereochemistry of the Smiles rearrangement, an oriented reaction, in which steric acceleration appears to be maximal when the 6'-position is substituted.

The possibility of Smiles rearrangement in compounds of type (I) where the catechol nucleus is unsymmetrically substituted makes the structures of derived dibenzodioxins ambiguous.[11]

Experimental

3 : 5-*Dinitro*-2-(2 : 3 : 5-*trimethylphenoxy*)*benzophenone*, m. p. 138° (from ethanol), was formed in 80% yield when 2-chloro-3 : 5-dinitrobenzophenone (5 g.) was added portionwise to a solution of 2 : 3 : 5-trimethylphenol (7·5 g.) in pyridine (40 c.c.) and after 15 hr. the whole was poured into dilute sulphuric acid (Found: C, 65·1; H, 4·4. $C_{22}H_{18}O_6N_2$ requires C, 65·0; H, 4·4%).

[2] Turpin, *J.*, 1891, **59**, 722; Ullmann, *Annalen*, 1909, **366**, 79; Ullman and Sané, *Ber.*, 1911, **44**, 3730.
[3] Kehrmann and Kramer, *Ber.*, 1900, **33**, 3078; Kehrmann and Punti, *Ber.*, 1911, **44**, 2622.
[4] Mauthner, *Ber.*, 1905, **38**, 1411; Stevenson and Smiles, *J.*, 1931, 718.
[5] Kehrmann and Steinberg, *Ber.*, 1911, **44**, 3011; Wight and Smiles, *J.*, 1935, 340.
[6] Brady and Waller, *J.*, 1930, 1218.
[7] Roberts and Clark, *J.*, 1935, 1312.
[8] Boothroyd and Clark, *J.*, 1953, 1499.
[9] de Bruyn, *Rec. Trav. chim.*, 1890, **9**, 208.
[10] Okamoto and Bunnett, *J. Amer. Chem. Soc.*, 1956, **78**, 5357, 5363; Bunnett, *Quart. Rev.*, 1958, **12**, 12.
[11] Part II, Loudon and Scott, *J.*, 1953, 265.

2-(2-*Hydroxy*-3 : 5 : 6-*trimethylphenoxy*)-3 : 5-*dinitrobenzophenone*.—The bright red solution formed by warming the preceding compound (0·5 g.) in concentrated sulphuric acid (2·5 c.c.) was cooled, diluted with glacial acetic acid (12 c.c.), and titrated with a solution (1·3 c.c.) of 30% hydrogen peroxide (1 vol.) in acetic acid (2 vol.). After 15 min. the *product* was collected and formed yellow prisms, m. p. 176°, from acetic acid (Found: C, 62·7; H, 4·0. $C_{22}H_{18}O_7N_2$ requires C, 62·6; H, 4·3%).

3 : 4 : 6-*Trimethylcatechol*.—Phenylhydrazine (0·8 c.c.) was added to a solution of the preceding compound (0·5 g.) in benzene (10 c.c.) and after 15 hr. at ordinary temperature 5 : 7-dinitro-1 : 3-diphenylindazole which had separated was filtered off. The filtrate was extracted with very dilute aqueous sodium hydroxide, the aqueous layer being run directly into a concentrated solution of ammonium sulphate acidified with dilute sulphuric acid. The *trimethylcatechol* so liberated was recovered and dried in ether, and sublimed at 20 mm., forming colourless crystals (yield 56%) of sharp m. p. 110° from light petroleum (b. p. 60—80°) (Found: C, 70·9; H, 8·1. $C_9H_{12}O_2$ requires C, 71·0; H, 7·95%). Beer, Jaquiss, Robertson, and Savige [12] who do not record analyses report m. p. 118—120°.

6-*Benzoyl*-1 : 3 : 4(or 1 : 2 : 4)-*trimethyl*-7-*nitrodibenzo*-p-*dioxin*.—By using piperidine (0·35 c.c.) in place of phenylhydrazine in the preceding experiment, the same catechol was obtained in meagre yield, and the ultimate benzene solution afforded the *dioxin* as yellow needles, m. p. 241° (Found: C, 70·7; H, 4·3; N, 4·0. $C_{22}H_{17}O_3N$ requires C, 70·4; H, 4·6; N, 3·7%). This dibenzodioxin was the sole product isolated when the (hydroxytrimethylphenoxy)dinitrobenzophenone was (*a*) heated in aqueous pyridine, (*b*) warmed with piperidine, (*c*) heated in acetone with suspended potassium carbonate, or (*d*) dissolved in ethanol and treated with dilute sodium hydroxide. Treated in concentrated sulphuric acid with a drop of dilute nitric acid it gave the blue colour characteristic of dibenzodioxins.

1-*Benzoyl*-3-*nitrodibenzo*-p-*dioxin* (II).—(*a*) A solution of 2-*o*-hydroxyphenoxy-3 : 5-dinitrobenzophenone (0·2 g.) in pyridine (5 c.c.) was treated with water to incipient turbidity and then heated at 100° for 1 hr. The *dioxin*, which separated from the cooled solution, had m. p. 146° (from ethanol) (Found: C, 68·9; H, 3·7. $C_{19}H_{11}O_5N$ requires C, 68·5; H, 3·3%). (*b*) The same compound was obtained when a solution of catechol (1 mol.) and 2-chloro-3 : 5-dinitrobenzophenone (1 mol.) in acetone was heated with potassium carbonate (1 mol.) for 30 min. before the whole was added to dilute hydrochloric acid. The same reagents at ordinary temperature afforded the benzophenone (I; R = NO_2), m. p. and mixed m. p. 160°.

1 : 3-Dinitrodibenzo-*p*-dioxin, m. p. 194° (from benzene), was obtained when a solution of catechol (1 g.) and picryl chloride (0·5 g.) in acetone (20 c.c.) was gently warmed and the whole added to water (Found: C, 52·7; H, 2·2. Calc. for $C_{12}H_6O_6N_2$: C, 52·6; H, 2·2%). Hillyer [1] records m. p. 192—192·5°.

1-*Nitrodibenzo*-p-*dioxin*, m. p. 126° (from methanol), was prepared, as in the preceding experiment, from 1-chloro-2 : 6-dinitrobenzene (Found: C, 63·1; H, 3·1. $C_{12}H_7O_4N$ requires C, 62·9; H, 3·1%).

Catechol bis-2 : 4-*dinitrophenyl ether*, m. p. 136° (from ethanol), was obtained by heating a mixture of catechol, 1-chloro-2 : 4-dinitrobenzene, and potassium carbonate (1 mol. each) until reaction was complete; it was liberated by trituration with water (Found: C, 49·1; H, 2·5. $C_{18}H_{10}O_{10}N_4$ requires C, 48·9; H, 2·3%).

Attempts to prepare catechol mono-2 : 4-dinitrophenyl ether failed to provide a pure product. However, by heating guaiacol 2 : 4-dinitrophenyl ether with hydrobromic acid in acetic acid an oily phenol was obtained and was characterised (*a*) by formation of a crystalline, bronze-coloured sodium salt (in which the metal appeared to be covalently bound), (*b*) by remethylation to the guaiacol ether, and (*c*) by scission with hot piperidine to catechol. Attempts to convert this phenol or its sodium salt into 2-nitrobenzodioxin failed, nor could elimination of nitrite ion be detected.

THE UNIVERSITY, GLASGOW, W.2. [*Received, January 28th*, 1959.]

[12] Beer, Jaquiss, Robertson, and Savige, *J.*, 1954, 3672.