Nitro- and Amino-pyrocatechols

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Mononitration of pyrocatechol monobenzenesulphonate gave 4-nitropyrocatechol 2-benzenesulphonate and 3-nitropyrocatechol 1-benzenesulphonate. More vigorious conditions of nitration yielded 3,5-dinitropyrocatechol 1-benzenesulphonate. From these compounds the corresponding nitropyrocatechols and their acetates, benzenesulphonates, and methyl ethers were prepared. Reduction of the mononitro-compounds gave the corresponding aminopyrocatechols, from which several acetyl derivatives were prepared.

THE nitro-derivatives of polyhydric phenols are generally prepared by nitration of either the parent phenols or their corresponding methyl ethers or acetates. Difficulties associated with these reactions are sensitivity of the phenols to oxidation by the nitrating media, instability of the acetates to acid hydrolysis, the need to demethylate methyl ethers, and difficulties of separation and purification of the products.

Partially phenylsulphonylated polyhydric phenols [1] are stable to acid hydrolysis and can, therefore, be used in reactions in strongly acidic media (*e.g.* nitration). This paper describes the preparation of mononitropyrocatechols, of 3,5-dinitropyrocatechol, and of their benzenesulphonates, acetates, and methyl ethers, as well as the acetyl and phenylsulphonyl derivatives of monoamino-pyrocatechols.

Pyrocatechol monobenzenesulphonate gives, under mild conditions of nitration, *o*- and *p*-nitrophenol. In a homogeneous medium (*e.g.* acetic acid solution) a mixture was obtained which could be separated, only with considerable losses, by fractional crystallisation. In a heterogenous reaction consisting of nitric acid a chlorinated solvent, and the phenol, two products, A and B, separated. The nitro-compound A, being insoluble in the chlorinated solvent, is precipitated during the course of the reaction. On alkaline hydrolysis it gave followed by hydrolysis it yielded 3-nitropyrocatechol 2-methyl ether. Thus the nitro-compound B was characterized as the 3-nitropyrocatechol 1-benzenesulphonate.

Both nitro-compounds, A and B, on benzenesulphonylation gave dibenzenesulphonates. Attempts to prepare the 4-nitropyrocatechol 1-benzenesulphonate and the 3-nitropyrocatechol 2-benzenesulphonate, by partial hydrolysis of the dibenzenesulphonates failed.

Under more vigorous conditions, nitration of pyrocatechol monobenzenesulphonate gave a single dinitrocompound. The same product was obtained by nitration of 4-nitropyrocatechol 2-benzenesulphonate and of 3-nitropyrocatechol 1-benzenesulphonate. This dinitrocompound on hydrolysis gave 3,5-dinitropyrocatechol. Methylation followed by hydrolysis yielded 3,5-dinitropyrocatechol 2-methyl ether. Thus the dinitro-compound was characterized as the 3,5-dinitropyrocatechol 1-benzenesulphonate.

Reduction of 4-nitropyrocatechol 2-benzenesulphonate, with sodium dithionite solution, yielded 4-aminopyrocatechol 2-benzenesulphonate. The same amine was prepared from pyrocatechol monobenzenesulphonate, by coupling with *p*-diazonitrobenzene followed by reduction of the formed diazo-dye. This verifies that the nitro-group was in the *para*-position to the free hydroxy-

characterized as the 4-acetamidopyrocatechol 2-benzenesulphonate, while the diacetyl derivative was characterized as the 4-acetamidopyrocatechol 1-acetate 2-benzenesulphonate. Similarly treated, 3-nitropyrocatechol 1-benzenesulphonate yielded 3-aminopyrocatechol 1-benzenesulphonate, 3-acetamidopyrocatechol 1-benzenesulphonate, and 3-acetamidopyrocatechol 1-benzenesulphonate 2-acetate.

EXPERIMENTAL

Nitration of Pyrocatechol Monobenzenesulphonate.[1]—Nitric acid (*d* 1·4; 4 ml.) was added, in portions of 1 ml., to a stirred solution of pyrocatechol monobenzenesulphonate (12·5 g.) in trichloroethylene (100 ml.), at 40°. The speed of stirring must be regulated in order to keep the nitric acid dispersed in fine droplets, during the course of the reaction. Stirring was continued, at this temperature, for 15 min. after a crystalline product had started to precipitate, and then for 3 hr. at 10°. The precipitated crystalline product was filtered off, washed with water to free it from acid, and dried to give 4-*nitropyrocatechol* 2-*benzenesulphonate* (6·5 g., 44%). Crystallisation from toluene gave light yellow crystals, m.p. 125° (Found: N, 4·4; S, 10·8. $C_{12}H_9NO_6S$ requires N, 4·7; S, 10·9%). Acetylation with acetic anhydride and a drop of conc. sulphuric acid yielded 4-*nitropyrocatechol* 1-*acetate* 2-*benzenesulphonate*, m.p. 81—82° (from methanol) (Found: N, 3·8; S, 9·4. $C_{14}H_{11}NO_7S$ requires N, 4·1; S, 9·5%). Methylation with diazomethane gave 4-*nitropyrocatechol* 2-*benzenesulphonate* 1-*methyl ether*, m.p. 161—162° (from benzene) (Found: N, 4·3; S, 10·6. $C_{13}H_{11}NO_6S$ requires N, 4·5; S, 10·4%). Benzenesulphonylation with benzenesulphonyl chloride in pyridine produced 4-*nitropyrocatechol bisbenzenesulphonate*, m.p. 136—137° (from toluene) (Found: N, 3·0; S, 14·5. $C_{18}H_{13}NO_8S_2$ requires N, 3·2; S, 14·7%). On partial hydrolysis the dibenzenesulphonate gave only 4-nitropyrocatechol 2-benzenesulphonate.

The trichloroethylene mother-liquor was stirred with 50 ml. of water, to wash out the traces of nitric acid, then evaporated, and the residue was treated with methanol (5 ml.); the crystals which separated were filtered off, and dried to give 3-*nitropyrocatechol* 1-*benzenesulphonate* (5·2 g., 35%), m.p. 101—102° (yellow plates from methanol) (Found: N, 4·6; S, 11·1. $C_{12}H_9NO_6S$ requires N, 4·7; S, 10·9%). Acetylation yielded 3-*nitropyrocatechol* 1-*benzenesulphonate* 2-*acetate*, m.p. 71—72° (from methanol) (Found: N, 4·0; S, 9·7. $C_{14}H_{11}NO_7S$ requires N, 4·1; S, 9·5%). Methylation with diazomethane gave 3-*nitropyrocatechol* 1-*benzenesulphonate* 2-*methyl ether*, m.p. 69—70° (from methanol) (Found: N, 4·3; S, 10·3. $C_{13}H_{11}NO_6S$ requires N, 4·5; S, 10·4%). Benzenesulphonylation with benzenesulphonyl chloride in pyridine yielded 3-*nitropyrocatechol bisbenzenesulphonate*, m.p. 120—121° (from methanol) (Found: N, 3·4; S, 14·8. $C_{18}H_{13}NO_8S_2$ requires N, 3·2; S, 14·7%). When subjected to partial hydrolysis this diester gave only 3-nitropyrocatechol 1-benzenesulphonate.

Hydrolysis of 4-*Nitropyrocatechol* 2-*Benzenesulphonate.*—20% Potassium hydroxide solution (17 ml.) was added dropwise, at 60°, to a stirred solution of 4-nitropyrocatechol 2-benzenesulphonate (3 g.) in methanol (30 ml.). Stirring was continued, at this temperature, for 30 min. to give a red solution; this was diluted with water to 150 ml. and acidified with hydrochloric acid. Any precipitate, being anhydrolysed ester, was filtered off; the filtrates were extracted with ether, and the ethereal extracts were evaporated to give 4-nitropyrocatechol (1·5 g., 96%). Crystallisation from benzene gave yellow crystals, m.p. 173—174° (lit., 177°;[3] 174°;[4] 173°;[5] 172—174°[6]). Acetylation with acetic anhydride and a drop of conc. sulphuric acid gave 4-*nitropyrocatechol diacetate* m.p. 81°. Balaban[7] reported a m.p. 98° for the same product. In order to examine if our product was a diacetate or a partially acetylated product, a sample was treated with diazomethane, but no reaction occurred (Found: C, 50·0; H, 3·7; N, 5·6. $C_{12}H_9NO_6$ requires C, 50·2; H, 3·8; N, 5·8%). Methylation with diazomethane gave the dimethyl ether, m.p. 97—98° (from 70% methanol) (lit., 95—96°;[8] 96°;[9] 98°[10]).

3-*Nitropyrocatechol.*—The compound was obtained in 95% yield from 3-nitropyrocatechol 1-benzenesulphonate by a similar hydrolysis. Crystallisation from light petroleum gave yellow prisms, m.p. 86° (lit., 84°;[6] 86°[11]). Acetylation gave 3-*nitropyrocatechol diacetate*, m.p. 67—68° (from methanol) (Found: C, 50·4; H, 4·0; N, 5·9. $C_{12}H_9NO_6$ requires C, 50·2; H, 3·8; N, 5·8%). Methylation with diazomethane yielded the dimethyl ether, m.p. 64° (needles from methanol) (lit., 64—65°[12,13]).

4-*Nitropyrocatechol* 1-*Methyl Ether.*—Potassium hydroxide solution (20%; 11·2 ml.) was added dropwise, at 60°, to a stirred suspension of pulverized 4-nitropyrocatechol 2-benzenesulphonate 1-methyl ether (3·1 g.) in methanol (50 ml.). Stirring was continued for 5 min.; the orange-red solution was cooled to room temperature, diluted with water to 300 ml., acidified with hydrochloric acid, and kept cooled for complete deposition. The precipitated yellow needles were filtered off, washed with water and dried to give 4-nitropyrocatechol 1-methyl ether. Extraction of the filtrates with ether, gave further product (total 1·6 g., 94%). Crystallisation from warm water gave yellow needles, m.p. 104—105° (lit., 103—104°;[9] 105°[14]). The product was identical to an authentic sample, (mixed m.p. and analysis). Acetylation gave the acetate, m.p. 100—101° (needles from methanol) (lit., 101—102°[13]). Methylation with diazomethane yielded 4-nitropyrocatechol dimethyl ether which was identical (mixed m.p.), with the product of methylation of 4-nitropyrocatechol.

3-*Nitropyrocatechol* 2-*Methyl Ether.*—The compound was obtained from 3-nitropyrocatechol 1-benzenesulphonate 2-methyl ether, by a similar hydrolysis in 90% yield. It was identical to an authentic sample (analysis and mixed m.p.). Crystallisation from light petroleum–trichloroethylene (1 : 2 v/v), gave needles, m.p. 68—69° (lit., 68·5—69·5°[13]). Methylation with diazomethane yielded the dimethyl ether, which was identical (mixed m.p.) with the product of methylation of 3-nitropyrocatechol.

3,5-*Dinitropyrocatechol* 1-*Benzenesulphonate.*—Pulverized pyrocatechol monobenzenesulphonate (5 g.) was added in portions, at 50°, to stirred nitric acid (*d* 1·4; 25 ml.). The

[3] J. Meulenhoff, *Rec. Trav. chim.*, 1925, **44**, 150.
[4] H. Dakin, *J. Amer. Chem. Soc.*, 1920, **42**, 490.
[5] F. Gilbert, F. Laxon, and E. Prideaux, *J. Chem. Soc.*, 1927, 2295.
[6] D. Rosenblatt. J. Epstein, and M. Levitch, *J. Amer. Chem. Soc.*, 1953, **75**, 3277.
[7] I. Balaban, *J. Chem. Soc.*, 1929, 1088.
[8] F. Tiemann and S. Matsmoto, *Ber.*, 1876, **9**, 939.
[9] R. Wegscheider and A. Klemenc, *Monatsh.*, 1910, **31**, 734.
[10] M. de Lange, *Rec. Trav. chim.*, 1926, **45**, 19.
[11] H. Weselsky and S. Benedikt, *Monatsh.*, 1882, **3**, 386.
[12] H. Vermeulen, *Rec. Trav. chim.*, 1906, **25**, 24.
[13] A. Oxford, *J. Chem. Soc.*, 1926, 2004.

ester first dissolved and then a yellow crystalline product was precipitated. The temperature was left to rise to 70°; after 15 min. the reaction mixture was cooled, diluted with water to 250 ml., and kept set aside. The precipitated product was filtered off, washed with water to free it from acid, and dried to give 3,5-*dinitropyrocatechol* 1-*benzenesulphonate* (5·4 g., 80%). The same compound was obtained upon nitration of 4-nitropyrocatechol 2-benzenesulphonate and 3-nitropyrocatechol 1-benzenesulphonate. Crystallisation from methanol gave yellow flakes, m.p. 146—147° (Found: N, 8·0; S, 9·6. $C_{12}H_8N_2O_8S$ requires N, 8·2; S, 9·4%). Acetylation gave the acetate, m.p. 89—90° (from methanol). Methylation with diazomethane yielded 3,5-*dinitropyrocatechol* 1-*benzenesulphonate* 2-*methyl ether*, m.p. 108—109° (from trichloroethylene) (Found: N, 7·8; S, 9·3. $C_{13}H_{10}N_2O_8S$ requires N, 7·9; S, 9·1%).

Hydrolysis of 3,5-*Dinitropyrocatechol* 1-*Benzenesulphonate.*—20% Potassium hydroxide solution (17 ml.) was added dropwise, at 50°, to a stirred dispersion of pulverized 3,5-dinitropyrocatechol 1-benzenesulphonate (3·4 g.) in methanol (50 ml.). The yellow potassium salt of the phenol initially precipitated gradually disappeared; the temperature was then raised to 65°. After 5 min. the red-brown solution was cooled to room temperature, diluted with water to 250 ml., and set aside to cool. The precipitate was filtered off, washed with water, and dried to give 3,5-dinitropyrocatechol. Extraction with ether of the mother-liquor added more product (total 1·9 g., 95%). Crystallisation from alcohol yielded yellow prisms, m.p. 164—165° (lit., 164°; [5,15] 166—5° [16]). The product was identified with a sample prepared by an alternative method (mixed m.p. and analysis). Acetylation gave the diacetate, m.p. 113—114° (from methanol) (lit., 124°; [15] 112—114° [17]). Methylation with diazomethane yielded the dimethyl ether m.p. 101—102° (from benzene–light petroleum 1 : 2 v/v) (lit., 102°; [18] 101° [19]).

3,5-*Dinitropyrocatechol* 2-*Methyl Ether.*—20% Potassium hydroxide solution (11·5 ml.) was added dropwise, at 50°, to a stirred dispersion of pulverised 3,5-dinitropyrocatechol 1-benzenesulphonate 2-methyl ether (3·5 g.) in methanol (50 ml.). The reaction mixture was kept at this temperature for 10 min.; the solution was cooled to room temperature, diluted with water to 300 ml., acidified with hydrochloric acid, extracted with ether, and the ethereal extracts were evaporated to leave 3,5-dinitropyrocatechol 2-methyl ether (1·9 g., 90%). The product was identical (mixed m.p.) with a sample prepared by an alternative method. Crystallisation from trichloroethylene yielded yellow needles, m.p. 79—80° (lit., 80° [18]). Crystallisation from water gave a hydrate, m.p. 51—53°. Acetylation gave 3,5-*dinitropyrocatechol* 1-*acetate* 2-*methyl ether*, m.p. 91—92° (needles from methanol) (Found: C, 42·4; H, 2·9; N, 10·7. $C_9H_8N_2O_7$ requires C, 42·2; H, 3·1; N, 10·9%). Methylation with diazomethane yielded the dimethyl ether identified with the product obtained on methylation of 3,5-dinitropyrocatechol.

Reduction of 4-*Nitropyrocatechol* 2-*Benzenesulphonate.*—Successive quantities of sodium dithionite solution (10%), were added to a boiling solution of 4-nitropyrocatechol 2-benzenesulphonate (5·9 g.) in methanol (100 ml.), until the yellow solution was completely decolourised. Water was then added to a total volume of 500 ml., and the mixture was kept cooled for two days. The precipitated product, colourless flakes, was filtered off, washed with water, and dried *in vacuo* to give 4-*aminopyrocatechol* 2-*benzenesulphonate* (4·5 g., 85%). The same product was obtained by coupling pyrocatechol monobenzenesulphonate with *p*-diazonitrobenzene and reduction of the diazo-dye so formed, with sodium dithionite. Crystallization from benzene yielded colourless flakes, m.p. 140—141° (Found: N, 5·1; S, 12·3. $C_{12}H_{11}NO_4S$ requires N, 5·3; S, 12·1%). When the amine treated, at room temperature, with acetic anhydride dissolves and the solution, on cooling, precipitates 4-*acetamidopyrocatechol* 2-*benzenesulphonate*, m.p. 180—181° (from alcohol) (Found: C, 54·5; H, 4·0; N, 4·4; S, 10·5. $C_{14}H_{13}NO_5S$ requires C, 54·7; H, 4·2; N, 4·6; S, 10·4%). Under stronger conditions (80—90° in the presence of a drop of conc. sulphuric acid) acetylation of the amine or of the acetamide, gave 4-*acetamidopyrocatechol* 1-*acetate* 2-*benzenesulphonate*, m.p. 115—116° (from benzene) (Found: C, 54·8; H, 4·4; N, 3·9; S, 9·3. $C_{16}H_{15}NO_6S$ requires C, 55·0; H, 4·3; N, 4·0; S, 9·2%).

4-*Aminopyrocatechol* 1-*Acetate* 2-*Benzenesulphonate.*—The product was obtained by a same reduction from 4-nitropyrocatechol 1-acetate 2-benzenesulphonate. Crystallisation from methanol yielded prisms, m.p. 135—136° (Found: C, 54·8; H, 4·1; N, 4·5; S, 10·3. $C_{14}H_{13}NO_5S$ requires C, 54·7; H, 4·2; N, 4·6; S, 10·4%). Acetylation gave a diacetate which was identified, by analysis and mixed m.p., with the product obtained on further acetylation of 4-acetamidopyrocatechol 2-benzenesulphonate.

3-*Aminopyrocatechol* 1-*Benzenesulphonate.*—The amine was obtained by a same reduction from 3-nitropyrocatechol 1-benzenesulphonate, in 90% yield, m.p. 130—131° (from trichloroethylene) (Found: N, 5·5; S, 11·9. $C_{12}H_{11}NO_4S$ requires N, 5·3; S, 12·1%). Monoacetylation gave 3-*acetamidopyrocatechol* 1-*benzenesulphonate*, m.p. 102—103° (from alcohol) (Found: C, 54·8; H, 4·3; N, 4·4; S, 10·3. $C_{14}H_{13}NO_5S$ requires C, 54·7; H, 4·2; N, 4·6; S, 10·4%). Further acetylation yielded 3-*acetamidopyrocatechol* 1-*benzenesulphonate* 2-*acetate*, m.p. 161—162° (from benzene) (Found: C, 55·1; H, 4·1; N, 4·1; S, 9·1. $C_{16}H_{15}NO_6S$ requires C, 55·0; H, 4·3; N, 4·0; S, 9·2%).

3-*Aminopyrocatechol* 1-*Benzenesulphonate* 2-*Acetate.*—This amine was prepared by a same reduction from 3-nitropyrocatechol 1-benzenesulphonate 2-acetate, m.p. 128° (from benzene) (Found: N, 4·7; S, 10·3. $C_{14}H_{13}NO_5S$ requires N, 4·6; S, 10·4). Acetylation with acetic anhydride gave a diacetyl derivative which was identified, by analysis and mixed m.p., with the product obtained on further acetylation of 3-acetamidopyrocatechol 1-benzenesulphonate.

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[14] F. Reverdin and P. Crépieaux, *Ber.*, 1905, **38**, 2258.
[15] R. Nietzki and F. Moll, *Ber.*, 1893, **26**, 2183.
[16] M. Heertjes, A. Knape, and H. Talsma, *J. Chem. Soc.*, 1954, 1868.
[17] F. Kehrmann and F. Prunier, *Helv. Chem. Acta*, 1924, **7**, 984.
[18] F. Pollecoff and R. Robinson, *J. Chem. Soc.*, 1918, **113**, 654.
[19] J. Blanksma, *Rec. Trav. chim.*, 1904, **23**, 112.