480. *New Observations on the Elbs Persulphate Oxidation.*

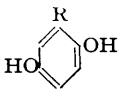
By J. Forrest and V. Petrow.

Elbs persulphate oxidation of phenols has yielded appreciable quantities of catechols (II) in addition to quinols (I). *m*-Substituted phenols have likewise been converted into derivatives of types (I) and (II), 4-substituted catechols (III) not being obtained.

The formation of dihydric phenols by oxidation of monohydric phenols with potassium persulphate in alkaline solution, discovered by Elbs (*J. pr. Chem.*, 1893, [ii], **48**, 179), has formed the subject of numerous publications (see Baker and Brown, *J.*, 1948, 2303, for a brief review). The reaction involves the intermediate formation of a potassium hydroxyphenyl sulphate which is subsequently hydrolysed in acid solution to a quinol, a fact elegantly exploited by Baker and Brown (*loc. cit.*) for the preparation of quinol monomethyl ethers. Although the reaction mechanism proposed by the latter authors would lead one to expect the simultaneous formation of catechol and quinol derivatives from suitably constituted phenols, only quinols have hitherto been obtained; the formation of catechols, in somewhat lower yield, has been limited to cases in which the *para*-position was occupied.

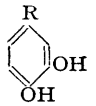
We have recently had occasion to study the preparation of gentisic acid (I; R = CO_2H) by the Elbs persulphate oxidation of salicylic acid (cf. Mauthner, *J. pr. Chem.*, 1940, **156**, 150). Although the expected oxidation product was readily obtained in the crude state, purification presented difficulty owing to the presence of a persistent acidic impurity. However, fractional distillation of the derived methyl esters led to ready separation of methyl catechuate (II; R = CO_2Me) in *ca.* 15% of the total yield of dihydroxy-acid.

o-Nitro- and *o*-chloro-phenol and salicylaldehyde each similarly gave the catechol (II) and the quinol (I) derivatives (contrast Elbs, *loc. cit.*; Schering, G.P. 81,086; Baker and Brown, *loc.*



(I.)

(II.)



(III.)

cit.; and Neubauer and Flatow, *Z. physiol. Chem.*, 1907, **52**, 380. Further, *m*-substituted phenols [*m*-hydroxy-benzaldehyde (Hodgson and Beard, *J.*, 1927, 2339) and -benzoic acid] gave compounds of type (I) with smaller quantities of compounds of type (II); 4-substituted catechols (III) could not be isolated.

Potassium persulphate proved, in general, a more reliable oxidising agent than the corresponding ammonium salt (cf. Baker and Brown, *loc. cit.*), which gave variable total yields, but did not materially affect the proportions of the isomers obtained. For *ortho*-substituted phenols the crude alkali hydroxyphenyl sulphate was decomposed without previous removal of unchanged material as described by Baker and Brown (*loc. cit.*), after which the products were extracted with an organic solvent and fractionated *in vacuo*. Extraction of unchanged material before decomposition of the sulphate proved necessary, however, with *m*-substituted phenols, as separation of the latter from their oxidation products could not be effected by distillation. Carboxylic acids were esterified before fractionation.

The catechols and quinols were separated by fractionation under reduced pressure. Purification of the catechols by redistillation proved more convenient than the method employing their lead salts which was, in any case, best avoided when working with easily hydrolysed esters.

Experimental.

Both potassium and ammonium persulphate were employed for the oxidations, which were carried out essentially as described by Baker and Brown (*loc. cit.*). All distillations were carried out using a nitrogen leak. The identities of the oxidation products were checked in all instances by mixed m. p. determinations with authentic materials.

Gentisic and Catechuic Acids.—(*a*) Crude gentisic acid (900 g.) was heated under reflux for 8—10 hours with methanol (11·7 l.) containing concentrated sulphuric acid (180 ml.). Three-fifths of the methanol were distilled off and the residue was poured into water (*ca.* 10 l.). The product was extracted with ether (4 × 1·5 l.) and separated into fractions (i) b. p. 55—65°/0·5 mm. (175 g.), (ii) b. p. 65—95°/0·5 mm. (*ca.* 120 g.), and (iii) b. p. 120—130°/0·5 mm. (475 g.), by distillation under reduced pressure employing a 6-inch " bubble and pear " column.

Fraction (i) consisted of methyl salicylate. Fraction (iii) was immediately crystallised from chloroform–light petroleum (b. p. 40—60°), yielding methyl gentisate (435 g.), m. p. 86—87°. The mother-liquors were freed from solvent and added to fraction (ii) which was redistilled, material of b. p. 80—85°/0·4 mm. (*ca.* 120 g.) being collected. Crystallisation from chloroform–light petroleum (b. p. 40—60°) (1 : 3) gave methyl catechuate (78 g.) in stout shining blades, m. p. 78—80° (Found : C, 57·0; H, 5·0. Calc. for $C_8H_8O_4$: C, 57·1; H, 4·8%).

The ratio of gentisate : catechuate was approx. 6 : 1.

(*b*) Potassium persulphate (209 g.) was slowly added, with stirring, to *m*-hydroxybenzoic acid (100 g.) dissolved in a cold solution of sodium hydroxide (138 g.) in water (3075 ml.). After 48 hours at room temperature the mixture was acidified to Congo-red with 10N-sulphuric and filtered, and unchanged acid extracted with ether. The aqueous liquors were heated to 90° for 1 hour, cooled, acidified with concentrated hydrochloric acid (50 ml.), and extracted thoroughly with ether. Esterification of the brown semi-crystalline product (42 g.), followed by distillation under reduced pressure, gave fractions (i), b. p. 75—95°/0·4 mm. (800 mg.), identified as methyl catechuate (530 mg.), m. p. 78—79° (Found : C, 57·3; H, 4·8%), and (ii), b. p. 95—125°/0·4 mm., which proved to be methyl gentisate (11·2 g.) (*p*/*o* ratio = 20 : 1).

Nitroquinol and 3-*Nitrocatechol.*—*o*-Nitrophenol (300 g.) was oxidised (cf. Elbs, *loc. cit.*) in sodium hydroxide solution (400 g. in 6 l. of water) with ammonium persulphate (500 g.) for 40 hours at room temperature. The liquors were then acidified to Congo-red and filtered, and the filtrate was heated at 80° for 30 minutes. The product was extracted with ethyl acetate (3 × 1·5 l.), the solvent removed, and the residue extracted with ether (3 × 1·5 l.). The material so obtained was thoroughly extracted with boiling light petroleum (b. p. 60—80°), the combined extracts were freed from solvent, and the residue was distilled as above. 3-Nitrocatechol, b. p. 80—95°/0·7 mm. (7·5 g.), was obtained, and after purification from light petroleum, formed yellow needles (7·1 g.), m. p. 86° (Found : C, 46·8; H, 3·3; N, 9·4. Calc. for $C_6H_5O_4N$: C, 46·5; H, 3·2; N, 9·0%).

The fraction insoluble in light petroleum was added to the high-boiling residue and distillation continued without a column. Nitroquinol was obtained, having b. p. 95—120°/0·5 mm. and forming red rhombs (43—44 g.), m. p. 132—133°, from boiling water (*p*/*o* ratio = 6 : 1).

Quinol and Catechol.—The black semi-crystalline oil (*ca.* 40 g.) obtained by oxidising phenol was heated under reflux with benzene for 10 minutes and allowed to cool; crude quinol (22 g.) separated and was removed. The benzene liquors were evaporated to dryness, and the residue was dissolved in 50% aqueous alcohol (100 ml.) (distilled water employed throughout) and treated with an excess of an aqueous concentrated solution of lead acetate. The flocculent white precipitate was coagulated by heating the mixture on a water-bath for 15 minutes. It was then collected and washed with a little alcohol, and the wet, uncaked product dissolved in hot aqueous acetic acid (40 ml. of 1 : 1), diluted with water (200 ml.), and extracted with ether (3 × 150 ml.). The brown material so obtained gave catechol (2·0 g.), b. p. 190—230°, on distillation. After purification from benzene it formed shining plates (1·85 g.), m. p. 104—106° (Found : C, 65·2; H, 5·6. Calc. for $C_6H_6O_2$: C, 65·5; H, 5·5%) (*p*/*o* ratio = 10 : 1).

Chloroquinol and 3-Chlorocatechol.—Distillation (column) of the black oily product obtained by oxidising *o*-chlorophenol (385 g.) gave fractions (i), b. p. 70—100°/1 mm. (16·5 g.), and (ii), b. p. 100—120°/1 mm. (129 g.). Redistillation of fraction (i) gave 3-chlorocatechol (11—12 g.), b. p. 65—67°/0·5 mm., crystallising from light petroleum (b. p. 40—60°) in white flakes, m. p. 46—47° (Found : C, 50·1; H, 3·4; Cl, 24·7. Calc. for $C_6H_5O_2Cl$: C, 49·8; H, 3·5; Cl, 24·5%) (*p*/*o* ratio = 10 : 1). Crystallisation of fraction (ii) from the chloroform gave chloroquinol (110 g.), shining white plates, m. p. 103°.

Gentisaldehyde and Catechualdehyde.—(*a*) Oxidation of salicylaldehyde (600 g.) gave a black tarry oxidation product (250 g.) which was shaken twice with boiling benzene (2 × 1·4 l.), the supernatant liquors being decanted each time. The combined benzene extracts (charcoal) were concentrated to *ca.* 1·2 l., gentisaldehyde (170 g.) separating on cooling, in feathery yellow plates, m. p. 98—99°. The mother-liquors were taken to dryness, and the residue was distilled (column) under reduced pressure, the fraction of b. p. 60—85°/0·2 mm. being collected. Crystallisation of this fraction from benzene–light petroleum (b. p. 40—60°) gave catechualdehyde (24—27 g.) in lemon-yellow needles, m. p. 104—105° (Found : C, 60·2; H, 4·5. Calc. for $C_7H_6O_3$: C, 60·9; H, 4·4%). A further quantity (1·5 g.) was isolated from the mother-liquors by the lead-salt technique. Gentisaldehyde (10 g.) (fraction, b. p. 85—115°/0·2 mm.) was obtained from the residue in the distillation flask (*p*/*o* ratio = 7 : 1).

(*b*) *m*-Hydroxybenzaldehyde (100 g.) was oxidised as described by Hodgson and Beard (*loc. cit.*) and the product isolated with ether and distilled under reduced pressure (column). Catechualdehyde, b. p. 70—80°/0·2 mm., distilled (Found : C, 61·1; H, 4·6. Calc. for $C_7H_6O_3$: C, 60·9; H, 4·4%), followed by the main bulk of the gentisaldehyde, b. p. 85—110°/0·2 mm. These were purified as before (800 mg. and 18 g.) (*p*/*o* ratio = 22 : 1).

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