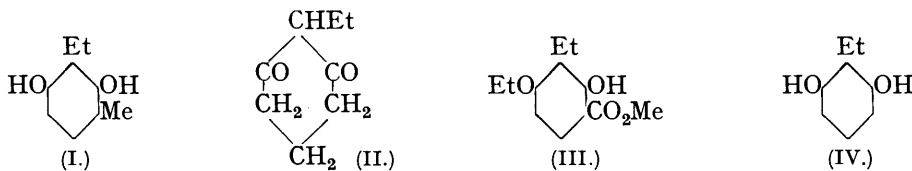


322. *Some Homologues of Resorcinol.*

By ROBERT ROBINSON and R. C. SHAH.

COYNE, RAISTRICK, and ROBINSON (*Phil. Trans.*, 1930, **220**, 297) arrived at the conclusion that a phenolic degradation product of citrinin must be 4-methyl-2-ethylresorcinol (I). We have synthesised this substance, which has the expected melting point and properties but, mixed with a specimen of the citrinin derivative, exhibits a depressed melting point.

We are not, however, convinced of the authenticity of the product from natural sources * and must leave the question of its identity or non-identity with 4-methyl-2-ethylresorcinol in abeyance pending the preparation of fresh material. In the meantime we describe the synthesis of isomeric methylethylresorcinols as a matter of independent interest.



The first objective of our work was 2-ethylresorcinol and we prepared the ethyldihydroresorcinol (II) in the hope of finding a convenient route, but this substance itself was not sufficiently accessible for our purpose. The nuclear alkylation of resorcinol derivatives offered better prospects and we therefore carefully studied the necessary conditions of the reaction.

The discovery of nuclear alkylation of polyhydric phenols appears to be due to Herzig and Zeisel (*Monatsh.*, 1888, **9**, 217, 882; 1889, **10**, 144; 1890, **11**, 291, 311); Kauffler (*Monatsh.*, 1900, **21**, 993) showed that nuclear ethylation is a much less facile process than nuclear methylation.

A. G. Perkin (J., 1895, **67**, 900) methylated β -resorcylic acid by means of methyl iodide and potassium hydroxide and obtained 2-hydroxy-4-methoxy-3-methylbenzoic acid. The constitution of this acid and of the nuclear-methylated pænanol obtained from resacetophenone (Gregor, *Monatsh.*, 1894, **15**, 437; Wechsler, *ibid.*, p. 239; Perkin, *loc. cit.*) rested until recently on the production from it of 2:6-dihydroxytoluene (Herzig and Wenzel, *Monatsh.*, 1903, **24**, 906) by heating the acid with hydriodic acid. It appears, however, that no direct comparison with an authentic specimen, for example, one synthesised by Ullmann's method (*Ber.*, 1884, **17**, 1963), was made.

The position has been clarified by Jones and Robertson (J., 1932, 1689), who have supplied an acceptable proof of the accuracy of Perkin's original suggestion. A point overlooked by these authors, and one that strengthens the case, is the following.

Jones and Robertson applied the Hoesch reaction to 2:6-dihydroxytoluene and benzonitrile and obtained 2:4-dihydroxy-3-methylbenzophenone, m. p. 177°, which they methylated to obtain its monomethyl ether, m. p. 125°; the same substances, m. p. 177° and m. p. 125°, had been already obtained by Kostanecki and Tambor (*Ber.*, 1895, **28**, 2305) by nuclear methylation of 2:4-dihydroxybenzophenone.

Perkin (*loc. cit.*) had failed to ethylate the nucleus of resorcinol derivatives, obtaining only *O*-ethyl ethers, but the observations of Crabtree and Robinson on the mechanism of the reaction (J., 1918, **113**, 868) suggested a possible line of experimental attack of the problem. These authors indicated that the nuclear methylation of resacetophenone is a reaction of alkali-metal derivatives of the ketone itself (not of pænanol, the monomethyl ether) and that it is favoured by an excess of alkali. Following this up, we have found that the optimum conditions for the nuclear methylation of resacetophenone (1 mol.) involve the use of potassium hydroxide (4 mols.) and methyl iodide (about 5 mols.). Along these lines nuclear ethylation was proved to be possible in the case of resacetophenone and, less readily, in that of β -resorcylic aldehyde. It occurs to a surprisingly large extent in the case of methyl β -resorcylic acid with formation of methyl 2-hydroxy-4-ethoxy-3-ethylbenzoate (III) along with methyl 2:4-diethoxybenzoate. This welcome observation made 2-ethylresorcinol available by the combined de-ethylating and decarboxylating action of hot hydriodic acid. The formation of (I) from (III) was accomplished by introduction of the formyl group by Gattermann's method and reduction of the aldehyde by Clemmensen's method, an improvement of which is mentioned on p. 1497.

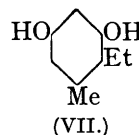
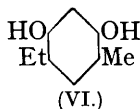
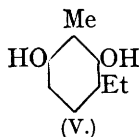
This method of nuclear alkylation, using the esters of phenolic acids, may be expected

* The specimen had deteriorated; originally of m. p. 98–99°, it had m. p. 65–70° after the interval of two or three years.

to be of great service in synthetic work. For instance, methyl orsellinate is found to be directly and conveniently methylated with formation of methyl rhizonate, and an account of this application will be submitted later.

Other methylethylresorcinols were much more readily synthesised.

2-Methyl-4-ethylresorcinol (V) is obtained from resacetophenone by nuclear methylation, Clemmensen reduction, and demethylation. 6-Methyl-4-ethylresorcinol (VI) is obtained from resacetophenone by Clemmensen reduction, formylation, and a second stage of reduction. 5-Methyl-4-ethylresorcinol (VII) is the reduction product of orsacetophenone.



(V), (VI) and (VII) differ from the citrinin degradation product; the preparation of the remaining three isomerides is in progress.

EXPERIMENTAL.

2-Ethyl-dihydroresorcinol (II).—It was thought that the condensation of glutaconic ester with methyl ketones might give rise to 2-acylresorcinols (these are now accessible in other ways), but in exploratory work with acetophenone we obtained only the auto-condensation product of ethyl glutaconate, m. p. 95—97° (Curtis and Kenner, J., 1914, 105, 282), under all the conditions tested.

We next sought a supply of γ -butyrobutyric acid, hitherto obtained only by the oxidation of coniine (Wolfenstein, *Ber.*, 1895, 28, 1464).

(A) Ethyl α -acetoglutarate (139 g.) was added carefully during about 3 hours to granulated sodium (14 g.) in anhydrous ether (1200 c.c.). Next day *n*-butyryl chloride (166 g.) was slowly added and after 12 hours the mixture was refluxed for 10 hours. The crude ethyl α -aceto- α -butyrylglutarate, isolated in the known manner, distilled at 180—210°/30 mm. and was hydrolysed as follows. The ester (75 g.) was shaken with aqueous sodium hydroxide (1500 c.c. of 1%) for 12 hours; a part remained undissolved. Sodium hydroxide (10 g.) was added, and the mixture shaken for 12 hours more; the oil then dissolved completely. Still more sodium hydroxide (20 g.) was added and the mixture was boiled for 4 hours and then concentrated on the steam-bath, acidified with hydrochloric acid, saturated with ammonium sulphate, and repeatedly extracted with ether. The oil (20 g.) so isolated was easily soluble in cold water and furnished a solid semicarbazone; it solidified in a freezing mixture but became liquid on attaining room temperature and was evidently a mixture of butyrobutyric acid and acetobutyric acid and this was confirmed by analysis of the semicarbazone, m. p. 180° (Found : C, 46.9; H, 7.4; N, 20.9. Calc. for $C_{19}H_{17}O_3N_3$: C, 45.0; H, 6.9; N, 22.5. Calc. for $C_{11}H_{21}O_3N_3$: C, 50.2; H, 7.9; N, 19.5%), which appears to be a constant-melting mixture of the semicarbazones of γ -acetobutyric and γ -butyrobutyric acids.

The semicarbazone was hydrolysed by means of boiling dilute hydrochloric acid and an acid recovered that crystallised in a freezing mixture and liquefied again at the ordinary temperature.

The crude acid (20 g.) mixed with absolute alcohol (40 c.c.) and sulphuric acid (2 c.c.) was refluxed for 6 hours. The ester was isolated by means of ether and had b. p. 95—100°/2 mm. (yield, 14 g., essentially consisting of ethyl butyrobutyrate). Alternative methods of hydrolysis of acetobutyrylglutaric ester were tested but no better process could be devised. The reagents used were alcoholic sulphuric acid (compare Kermack and Smith, J., 1929, 814), ammonia in ethereal solution, and aqueous ammonia and ammonium chloride.

An alternative synthesis of butyrobutyric acid was investigated as follows.

(B) Ethyl *C*-butyrylacetate was prepared according to Bouveault and Bongert (*Bull. Soc. chim.*, 1902, 27, 1049) with some modifications. Butyryl chloride (36 g.) was added gradually to an ethereal suspension (300 c.c.) of ethyl sodioacetate (from 53 g. of the ester and 6.9 g. of sodium). The mixture was refluxed for 10 hours, and the product isolated by means of ether and distilled. The first fraction, consisting mostly of unaltered ester (80—100°/15 mm.), was rejected; the second fraction, b. p. 110—130°/15 mm. (50 g.), was a mixture of *C*-acyl and *O*-acyl compounds. It was shaken in ether at 0° successively with 500 c.c., 100 c.c., and 100 c.c. of 6% potassium hydroxide solution. The alkaline extracts were mixed,

ice added, and the liquid acidified with concentrated hydrochloric acid; the separated oil was collected by means of ether and distilled (b. p. 111—115°/20 mm.) and was almost pure *C*-butyrylacetoacetic ester (38 g.). It developed a brown coloration with alcoholic ferric chloride and dissolved readily in dilute aqueous sodium hydroxide. The alkali-insoluble oil (10 g.), recovered from ethereal solution, gave no ferric reaction.

Ethyl *C*-butyrylacetoacetate was converted into ethyl butyroacetate by the action of dry ammonia in dry ether.

The crude butyroacetic ester (70 g.) was added to alcoholic sodium ethoxide (from 16.5 g. of sodium and 275 c.c. of alcohol), ethyl β -chloropropionate (136 g.) was introduced and after 12 hours the mixture was refluxed for 6 hours. The isolated oil was distilled, the middle fraction, b. p. 120—160°/15 mm. (45 g.), consisting of crude ethyl butyrolglutarate.

This ester (30 g.) was boiled with aqueous potassium hydroxide (15 g. in 375 c.c.) for 3 hours, more potassium hydroxide (8 g.) added, and boiling continued for a further 3 hours. The liquid was evaporated to dryness on the steam-bath, the residue dissolved in the minimum of water and acidified with concentrated hydrochloric acid. The acid was isolated (14 g.) and esterified as before. Ring closure to 2-ethylidihydroresorcinol gave no better yield than by the method under (A).

(C) The cyclisation of ethyl butyrobutyrate was carried out in four ways: (1) with sodium ethoxide in alcoholic solution, (2) with sodium ethoxide in ethereal suspension, (3) with granulated sodium, and (4) with sodamide in ether. The best yield was obtained by the second method. To a mixture of granulated sodium (4 g.) and dry ether (about 300 c.c.), absolute alcohol (10 c.c.) was added gradually with cooling. When the formation of sodium ethoxide was completed the crude butyrobutyric ester (14 g.) was carefully added. The colourless sodium salt that separated was collected and triturated with dilute sulphuric acid; the waxy solid (5 g.) crystallised from benzene in lustrous plates (2 g.), m. p. 175—177° (decomp.) (Found: C, 68.2; H, 8.5. $C_8H_{12}O_2$ requires C, 68.6; H, 8.6%). This substance has the properties of its class; it is slightly soluble in cold water, freely soluble in methyl and ethyl alcohols, and sparingly soluble in light petroleum.

Action of Bromine on 2-Ethylidihydroresorcinol.—A number of experiments were performed with 1 mol., 2 mols., 3 mols. and a large excess of bromine with and without the required quantities of anhydrous sodium acetate. The solvents used were glacial acetic acid and chloroform. In all cases red tarry products were found, except in the two following examples, in which small quantities of well-defined substances were obtained.

(1) A chloroformic solution of bromine in excess was added to one of ethylidihydroresorcinol and kept at room temperature for a few days. Most of the bromine evaporated; a viscous mass containing embedded crystals remained. It was washed with light petroleum and the solid then crystallised from the same solvent in plates, m. p. 75—77° (Found: C, 35.5; H, 3.0; Br, 52.7. $C_8H_{10}O_2Br_2$ requires C, 32.4; H, 3.4; Br, 54.0%). It gave a brown coloration with aqueous ferric chloride.

(2) A solution of 2-ethylidihydroresorcinol (1 mol.) in glacial acetic acid containing dissolved sodium acetate (3 mols.) was treated with bromine (3 mols.) and kept at room temperature for some days. A brown oil was isolated by means of ether and gradually solidified; the solid was washed and crystallised from light petroleum in plates, m. p. 92—94° (decomp.) (Found: Br, 68.7. $C_8H_9O_2Br_3$ requires Br, 63.6%). The yields of the above substances of doubtful nature were very low.

Attempts to dehydrogenate ethylidihydroresorcinol by means of palladium-black under various conditions were unsuccessful, the dihydroresorcinol being recovered completely unchanged.

Simplified Preparation of Resacetophenone.—Powdered zinc chloride (300 g.) was dissolved in glacial acetic acid (300 g.) by heating. Resorcinol (200 g.) was added, the mixture heated just to boiling (about 142°), and the heating discontinued. Nencki and Sieber (*J. pr. Chem.*, 1881, 23, 147) poured the reaction mixture into a large volume of water and purified the impure resacetophenone so precipitated by crystallisation from hot dilute hydrochloric acid, but the process is tedious and inconvenient, as crystallisation necessitates the use of large volumes of dilute hydrochloric acid. A much better yield of moderately pure well-crystallised product can be obtained by simply diluting the reaction mixture with about 1 vol. of concentrated hydrochloric acid and 1 vol. of water. On keeping, the slightly orange-yellow resacetophenone crystallised (yield, about 260 g.; m. p. 133—140°. Nencki and Sieber report a yield of 57%).

2-Hydroxy-4-methoxy-3-methylacetophenone.—Potassium hydroxide (70 g., 4 mols.) was dissolved in methyl alcohol (400 c.c.) by heating and resacetophenone (69 g.) was then added

and went readily into solution. The mixture was cooled in a freezing mixture, and methyl iodide (225 g., 5 mols.) was added all at once with shaking; if two layers separated, homogeneity was restored by the addition of more methyl alcohol. The temperature was then gradually allowed to rise, and potassium iodide separated. Next day the mixture was refluxed for 3 hours, with the addition of more methyl iodide if necessary, until a neutral reaction was obtained. Worked up in the known manner, the product after crystallisation from alcohol was obtained in plates (18 g.), m. p. 80—82° (Perkin, *loc. cit.*, gives m. p. 83—84°).

6-Methoxy-3-ethyl-o-cresol.—The foregoing nuclear methylation product of resacetophenone (15 g.) was boiled with hydrochloric acid (120 c.c. of 15%), alcohol (40 c.c.), and amalgamated zinc (60 g.) for 10 hours, concentrated hydrochloric acid (20 c.c.) being added after 4 hours. The oil which separated was collected by means of ether; b. p. 128—131°/15 mm. (Found: C, 72.4; H, 8.6; MeO, 18.6. $C_{10}H_{14}O_2$ requires C, 72.3; H, 8.4; 1 MeO, 18.7%). The mobile oil did not give any coloration with alcoholic ferric chloride.

The *p*-nitrobenzoyl derivative was prepared by shaking an ethereal solution of the phenol and *p*-nitrobenzoyl chloride with dilute aqueous sodium hydroxide; it crystallised from alcohol in prisms, m. p. 135—137° (Found: N, 4.6. $C_{17}H_{17}O_5N$ requires N, 4.4%).

2-Methyl-4-ethylresorcinol (V).—The methyl ether (5 g.) was gently refluxed with concentrated hydrobromic acid (75 c.c., *d* 1.7) (oil-bath at 125—135°) for 3 hours. Excess of hydrobromic acid was evolved at first and then the constant-boiling mixture was produced. The mixture was diluted with hot water, filtered from tar, treated with a little sodium bisulphite, saturated with sodium chloride, and extracted with ether. The oily residue after removal of the ether crystallised on long keeping; it crystallised from light petroleum (b. p. 60—80°) in flat, pearly, lustrous needles, m. p. 88—90° (Found: C, 70.9; H, 8.0. $C_9H_{12}O_2$ requires C, 71.1; H, 7.9%). The substance can be distilled under reduced pressure (15 mm.) and it does not sublime readily. It is slightly soluble in cold water, much more readily in hot; it is easily soluble in benzene, and sparingly soluble in light petroleum. The aqueous solution gives a transient blue colour with ferric chloride.

The *dimethyl* ether was obtained from the monomethyl ether by methylation in methyl-alcoholic solution by means of potassium hydroxide and methyl sulphate in the usual manner; it had b. p. 115—118°/15 mm. and was a mobile oil (Found: C, 73.4; H, 8.8; MeO, 33.1. $C_{11}H_{16}O_2$ requires C, 73.3; H, 8.9; 2 MeO, 34.4%).

On oxidation of this dimethyl ether with an excess of potassium permanganate at 70—80°, an acid, m. p. 200—205° (efferv.), which was soluble in water and crystallised in plates, was obtained.

Partial oxidation was carried out under the following conditions:

The dimethyl ether (5 g.) was suspended in water (100 c.c.) and a solution of potassium permanganate (25 g.) and potassium hydroxide (10 g.) in water (500 c.c.) was added slowly during 3 hours at 70—80°. The isolated acidic product, which was a viscous oil, was extracted with boiling light petroleum (b. p. 100—120°), and the extracts, on keeping, deposited prismatic crystals along with some tarry matter. The substance was thrice crystallised from benzene, eventually forming colourless prisms, m. p. 114—120° (Found: C, 58.4; H, 5.6. $C_{10}H_{12}O_4 \cdot 0.5H_2O$ requires C, 58.5; H, 6.3%. $C_9H_{10}O_4$ requires C, 59.3; H, 5.5%). This acid is probably 2 : 6-*dimethoxy-3-ethylbenzoic acid*; the alternative formulation as a derivative of phenylacetic acid is much less likely to be correct.

Ethylation of Resacetophenone.—Resacetophenone (15 g., 1 mol.) was added to a solution of potassium hydroxide (17 g., 4 mols.) in methyl alcohol (125 c.c.), which was cooled in ice-water, and ethyl iodide (80 g., *ca.* 5 mols.) added; the solution was then allowed to attain room temperature. Next day it was refluxed for 5 hours, more ethyl iodide being added, if necessary, until the reaction was no longer alkaline. The solvent was evaporated, and water added to the residue, which was extracted with ether. The ethereal extract was washed several times with *N*-sodium hydroxide until acidification of the alkaline washing gave only a turbidity, and then with water. The recovered oil gave a middle fraction (8 g.), b. p. 170—180°/15 mm., insoluble in dilute alkalis and exhibiting a reddish-violet ferric reaction in alcoholic solution (Found: C, 69.7; H, 7.8; EtO, 28.4. $C_{12}H_{16}O_3$ requires C, 69.2; H, 7.6; 1 EtO, 21.6; 2 EtO, 43.2%). This material was evidently a mixture of the *O*-diethyl ether and the *C*-ethyl *O*-ethyl derivative which are the expected products of the reaction. A solid potassium salt separates on trituration with 40% potassium hydroxide solution or on addition to concentrated methyl-alcoholic potash. The purified derivative hydrolyses in contact with water, giving an oil which is doubtless 2-hydroxy-4-ethoxy-3-ethylacetophenone, but the matter was not pursued, as the yield was inferior.

2-Hydroxy-4-ethoxy-3-ethylbenzaldehyde.— β -Resorcylaldehyde (28 g.) was added to alcoholic sodium ethoxide (18 g. of sodium in 300 c.c. of alcohol) and ethyl iodide (160 g.) was introduced with cooling. The mixture was refluxed for 5 hours on the succeeding day and was then neutral. The alcohol was distilled under diminished pressure, water added, and the products isolated as usual. Acidification of the alkaline washings afforded a substance, m. p. 55–60°, which, recrystallised from light petroleum, had m. p. 58–60° (Found : C, 68.3; H, 7.4. $C_{11}H_{14}O_3$ requires C, 68.0; H, 7.2%), and gave a strong iron reaction.

The alkali-insoluble fraction crystallised gradually and after washing with light petroleum had m. p. 68–71° and gave no coloration with ferric chloride in alcoholic solution. It was therefore *O*-diethyl- β -resorcylaldehyde (Tiemann and Levy, *Ber.*, 1877, 10, 2215, give m. p. 71–72°).

The light petroleum extract, on removal of the solvent, gave an oil which exhibited a weak brownish-violet reaction with ferric chloride; distilled at 15 mm., it gave three fractions, of which the most considerable had b. p. 158–162° (Found : C, 67.1; H, 8.0; EtO, 38.1. $C_{11}H_{14}O_3$ requires C, 68.1; H, 7.2; 1 EtO, 23.2; 2 EtO, 46.4%). It was thus a mixture containing a large portion of *O*-diethyl mixed with the *C*-ethyl-*O*-monoethyl derivative.

The ethylation of β -resorcyclic acid was carried out in a similar fashion and the products were found to be *O*-monoethyl- β -resorcyclic acid, m. p. 151°, and its ethyl ester, m. p. 53° (Perkin, *loc. cit.*); the oil insoluble in alkali contained a small proportion of the nuclear-ethylated ester as judged by qualitative tests.

Methyl β -Resorcylate.—The methyl ester of β -resorcyclic acid does not appear to have been previously described. It could not conveniently be prepared by the Fischer-Speier method owing to the sparing solubility of β -resorcyclic acid in methyl-alcoholic hydrogen chloride. A mixture of β -resorcyclic acid (100 g.), methyl alcohol (350 c.c.), and concentrated sulphuric acid (20 c.c.) was refluxed for 10 hours, the methyl alcohol then removed by distillation, and water added to the residue until turbidity was produced. The methyl ester, which separated in flat needles in the course of a few hours, was collected and recrystallised from aqueous methyl alcohol or from chloroform (yield, 60 g.). The crystals contained solvent of crystallisation which was gradually lost on exposure to air, or more readily on heating. The substance, crystallised from chloroform, was dried in a vacuum at 60–70°, m. p. 118–119° (Found : C, 57.3; H, 4.4; MeO, 26.5. $C_8H_8O_4$ requires C, 57.2; H, 4.8; MeO, 26.8%).

The ester is freely soluble in the simple alcohols, hot benzene or chloroform and sparingly soluble in the cold; it is much less readily soluble in light petroleum. The expected products of hydrolysis were identified.

Nuclear Ethylation of Methyl β -Resorcylate.—Methyl β -resorcylate (34 g., 1 mol.) was added to methyl-alcoholic potassium hydroxide (44 g. of potassium hydroxide in 250 c.c.). The mixture was cooled in a freezing mixture, and ethyl iodide (150 g.) added at once. The temperature was then allowed to rise gradually and next day the mixture was refluxed for 4 hours, with the addition of ethyl iodide if necessary, until the reaction was neutral. The product was worked up as in the case of ethylation of resacetophenone. The quasi-acidic fraction was an almost colourless oil which slowly crystallised; recrystallised from light petroleum, it formed plates, m. p. 77–79° (Found : C, 60.9; H, 6.1; EtO + MeO, 45.0. $C_{10}H_{12}O_4$ requires C, 61.2; H, 6.1; EtO + MeO, 45.9%); this substance is doubtless *methyl 2-hydroxy-4-ethoxybenzoate*.

The alkali-insoluble fraction was distilled, giving three fractions : (a) b. p. 182–187°/25 mm.; (b) two-thirds of the whole, b. p. 187–189°/25 mm.; (c) b. p. 189–192°. The middle fraction (22 g.) slowly crystallised, part remaining oily.

Methyl 2-hydroxy-4-ethoxy-3-ethylbenzoate was isolated, by washing this mixture with light petroleum, as elongated prisms, m. p. 52–53° (Found : C, 64.2; H, 7.0; EtO + MeO, 40.0. $C_{12}H_{16}O_4$ requires C, 64.3; H, 7.1; 1 EtO + 1 MeO, 40.2%). This ester is sparingly soluble in light petroleum and readily soluble in benzene. It is insoluble in alkalis and gives an intense violet coloration with alcoholic ferric chloride.

The oily part of the middle fraction was also analysed (Found : C, 64.8; H, 7.1; EtO + MeO, 47.8. $C_{12}H_{16}O_4$ requires C, 64.3; H, 7.1; 1 EtO + 1 MeO, 40.2; 2 EtO + 1 MeO, 60.3%). This material is evidently a mixture containing about 60% of the *C*-ethylated derivative.

The third fraction solidified on keeping and the crystals were washed with aqueous alcohol and recrystallised from the same solvent, forming cubes, m. p. 51–54° (Found : C, 63.6; H, 7.0. $C_{12}H_{16}O_4$ requires C, 64.3; H, 7.1%). *Methyl 2:4-diethoxybenzoate* is insoluble in dilute alkalis and does not develop any coloration with alcoholic ferric chloride.

4-Hydroxy-2-ethoxy-3-ethylbenzoic Acid.—The middle fraction of mixed esters (8 g.) from the foregoing was hydrolysed by means of boiling methyl-alcoholic potassium hydroxide for

3 hours. The solvent was evaporated, the residue acidified, and the precipitated acid collected and dried. Although quite colourless and crystalline, it had m. p. 100—160° and was a mixture of two substances which could be separated by taking advantage of the fact that the *C*-ethyl compound was sparingly soluble in benzene and easily soluble in alcohol, but the *O*-diethyl compound was easily soluble in benzene and sparingly soluble in alcohol. The crude acid was twice extracted with light petroleum (50 c.c., b. p. 60—80°); the residue, on crystallisation from hot benzene gave long woolly needles of the *C*-ethylated acid (2.2 g.), m. p. 172—173° (efferv.) (Found : C, 62.4; H, 6.6; EtO, 21.7. $C_{11}H_{14}O_4$ requires C, 62.8; H, 6.7; 1 EtO, 21.4%). It was sparingly soluble in cold benzene and light petroleum but dissolved readily in alcohol, and then gave an intense violet coloration with ferric chloride.

The benzene mother-liquor from which the *C*-ethyl compound had crystallised and also the light petroleum washings deposited a crystalline solid on evaporation; this was crystallised from alcohol, m. p. 96—97° (Tiemann and Levy, *Ber.*, 1877, **10**, 2217, give m. p. 99° for 2 : 4-diethoxybenzoic acid), and iron reaction negative.

2-Ethylresorcinol (IV).—Hydroxyethoxyethylbenzoic acid (5 g.) was boiled with hydriodic acid (80 c.c., *d* 1.7) for 3 hours, the mixture then diluted with water and heated, and the hot solution filtered. A little sodium bisulphite was added and after saturation with sodium chloride the phenolic product was isolated by means of ether as an oil that solidified on keeping and then crystallised from benzene—light petroleum in rectangular leaflets, m. p. 95—97° (Found : C, 69.2; H, 7.2. $C_8H_{10}O_2$ requires C, 69.5; H, 7.2%). The substance is rather easily soluble in cold water and very readily soluble in hot water. It gave the fluorescein reaction, the alkaline solution of the phthalein being cherry-red (cf. Crabtree and Robinson, *loc. cit.*). It gives a blue colour with alcoholic ferric chloride, and can be sublimed. The substance was distinguished from its isomeride, 4-ethylresorcinol, by direct comparison.

2 : 4-Dihydroxy-3-ethylbenzaldehyde.—A solution of 2-ethylresorcinol (4 g.) and anhydrous hydrogen cyanide (5 c.c.) in anhydrous ether (20 c.c.) was saturated with hydrogen chloride for 4 hours; the aldimine hydrochloride separated after 30 minutes. The ether was decanted, the solid washed with ether and dissolved in water, and the solution heated at 70—80° for 30 minutes. The new aldehyde separated as an oil which solidified on cooling and crystallised from benzene in thick needles, m. p. 115—118°. It contains water of crystallisation which is not wholly lost, even on sublimation under reduced pressure (Found : C, 62.4; H, 6.2. $C_9H_{10}O_3 \cdot 0.5H_2O$ requires C, 61.7; H, 6.3%). A deep violet coloration is developed with alcoholic ferric chloride, and a deep red pyrylium salt is obtained on condensation with 5 : 6-dimethoxy-1-hydrindone in glacial acetic acid solution under the influence of dry hydrogen chloride. The *2 : 4-dinitrophenylhydrazone* separated in dark clusters of brown crimson micro-needles when hot acetic acid solutions of its generators were mixed, m. p. 295° (decomp.) (Found : N, 16.2. $C_{15}H_{14}O_6N_4$ requires N, 16.2%).

4-Methoxy-2-ethylresorcinol (I).—A mixture of zinc amalgam* prepared from zinc dust (5 g.), hydrochloric acid (10 c.c. of 10%), and alcohol (3 c.c.) was heated on a steam-bath under reflux, and the foregoing aldehyde (0.5 g.) added gradually during 1 hour; alcohol (2 c.c.) and concentrated hydrochloric acid (2 c.c.) were then added and the heating was continued for 2 hours. The liquid was decanted, and after saturation with sodium chloride was extracted thrice with ether; the residual zinc was also washed with ether. The ether extracted an oil which solidified to a well-crystallised mass. The solid sublimed readily below 90° under reduced pressure in long, silky, flat needles (0.4 g.), m. p. 98—99° (Found : C, 70.7; H, 8.0. $C_9H_{12}O_2$ requires C, 71.1; H, 7.9%). The dihydric phenol can also be purified by crystallisation from benzene—light petroleum. It is slightly soluble in cold water and much more readily in hot, easily soluble in benzene, and sparingly soluble in light petroleum (b. p. 60—80°). A blue coloration is developed with aqueous ferric chloride. It sublimes easily even at atmospheric pressure and has apparently the properties attributed to the dihydric phenol from citrinin (*loc. cit.*).

2 : 4-Dihydroxy-5-ethylbenzaldehyde.—A mixture of 4-ethylresorcinol (1 g.) (Clemmensen, *Ber.*, 1914, **47**, 54), anhydrous hydrogen cyanide (0.5 c.c.), and anhydrous ether (10 c.c.) was saturated with hydrogen chloride below 0°; the aldimine hydrochloride began to separate after 5 minutes. After 2 hours, the solid was separated, washed with ether, dissolved in water, and heated at 80—90° for 30 minutes. The aldehyde separated as an oil which solidified on cooling and crystallised from benzene or from dilute alcohol in colourless needles, m. p. 130—131°

* Zinc amalgam for reduction by Clemmensen's method is improved by three preliminary treatments with hot hydrochloric acid. A more active amalgam is obtainable from zinc dust, especially from the kind made by pulverising the pure metal.

(Found : C, 65.1; H, 6.1. $C_9H_{10}O_3$ requires C, 65.1; H, 6.0%). It gives a deep violet coloration with alcoholic ferric chloride and condenses with 5 : 6-dimethoxy-1-hydrindone and hydrogen chloride to a deep red pyrylium salt. The 2 : 4-dinitrophenylhydrazone crystallises, very soon after hot solutions of its generators are mixed, in long needles which rapidly change into elongated hæmatite-coloured prisms, m. p. 279° (decomp.) (Found : N, 16.0. $C_{15}H_{14}O_6N_4$ requires N, 16.2%).

6-Methyl-4-ethylresorcinol (VI).—The last-mentioned aldehyde was reduced like 2 : 4-dihydroxy-3-ethylbenzaldehyde, but the oily phenol showed no tendency to crystallise and was distilled, b. p. 150—155°/20 mm. The distillate on keeping in the refrigerator partly solidified and then, after being washed with benzene and light petroleum, gave colourless crystals, m. p. 60—63° (Found in material dried in a high vacuum over phosphoric oxide : C, 71.0; H, 8.0. $C_9H_{12}O_2$ requires C, 71.1; H, 7.9%). The iron reaction was blue-violet.

5-Methyl-4-ethylresorcinol (VII).—Orsacetophenone (10 g.) (Hoesch, *Ber.*, 1915, 48, 1122) was added in small portions during 1 hour to a mixture of zinc amalgam (from 40 g. of zinc dust) and hydrochloric acid (100 c.c. of 10%) kept on a steam-bath. After 2 hours, concentrated hydrochloric acid (20 c.c.) was added, and heating continued for 1 hour. On cooling, the aqueous liquid deposited crystals, which were collected and recrystallised from hot water or benzene, forming plates (5 g.), m. p. 72—82° (Found : C, 63.5; H, 8.2. $C_9H_{12}O_2, 1.5H_2O$ requires C, 62.9; H, 7.9%). The substance, recrystallised from 1% hydrochloric acid, formed long, glistening, flat needles, m. p. 75—80° after drying at 50° in a high vacuum over phosphoric oxide (Found : C, 70.9; H, 8.1. $C_9H_{12}O_2$ requires C, 71.1; H, 7.9%). Dried at the room temperature over phosphoric oxide, the substance always retained 0.25 H_2O . The ferric reaction in aqueous solution is a blue coloration.

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