96. *Homologues of Phenol.*

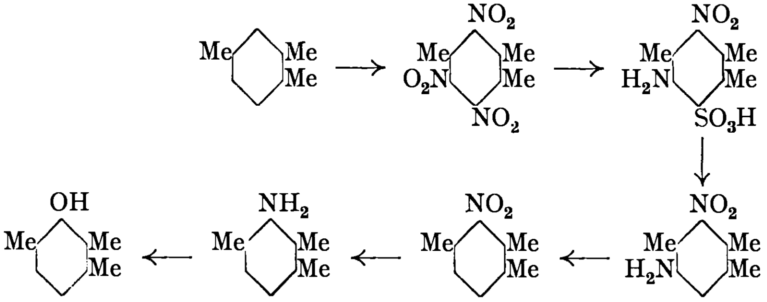
By Gilbert T. Morgan and Alfred E. J. Pettet.

Low-temperature carbonisation of bituminous coal has added another species to the various tars arising from the industrial use of this fuel, and an investigation of the chemical constituents of low-temperature tar and of its aqueous liquor has been pursued during the last eight years in the Chemical Research Laboratory of the Department of Scientific and Industrial Research. In addition to phenol and the cresols, which are appreciably soluble in water, the aqueous liquor, when derived from highly oxygenated coal, contains a relatively large quantity of catechol, with smaller amounts of two homocatechols, resorcinol and quinol (Morgan, Pratt, and Pettet, *J. Soc. Chem. Ind.*, 1929, **48**, 89T; 1931, **50**, 72T). In comparison with tars from high-temperature carbonisation, low-temperature tar contains a high proportion of " tar acids," that is, of phenol and its homologues, among which certain higher members have remarkable properties as bactericides and as wetting agents (Morgan, *ibid.*, 1928, **47**, 131; Morgan, Pratt, and Pettet, *J. Soc. Dyers and Colourists*, 1933, **49**, 125).

Among the products already recognised in our investigation of low-temperature tar are phenol, the three cresols, five of the six xylenols, and 3-methyl-5-ethylphenol, the whole of which accounts, in general, for only 50—60% of the total content of crystallisable phenols. As the series is ascended, the task of identification becomes increasingly difficult, so that it is essential to have recourse to authentic specimens of higher phenols prepared by synthetic processes, and the present communication relates to the production of certain homologues containing methyl and ethyl substituents and having the general formula C_9H_{11}·OH.

This series includes the hitherto unknown 2 : 3 : 6-*trimethylphenol* (consecutive ψ-cumenol), which is of scientific interest as being the only missing member of the group of methyl-substituted phenols which begins with the cresols and ends with pentamethylphenol. This gap has now been filled by the following synthesis :—

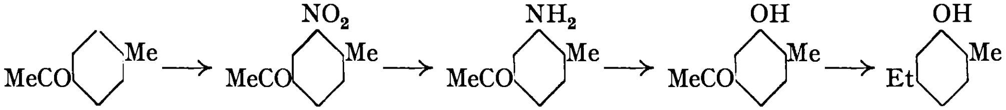
I. 2 : 3 : 6-*Trimethylphenol.*



2 : 3 : 6-Trimethylaniline, obtained, through four intermediates, from ψ-cumene (Huender, *Rec. trav. chim.*, 1915, **34**, 9), was diazotised to yield the corresponding phenol.

Of ten possible methylethylphenols, the following five have already been synthesised by methods which establish their constitution : 2-methyl-4-ethylphenol (Clemmensen, *Ber.*, 1914, **47**, 54), 2-methyl-6-ethylphenol (Auwers and Wittig, *Ber.*, 1924, **57**, 1270), 3-methyl-4-ethylphenol (Auwers and Mauss, *Annalen*, 1928, **460**, 240), 3-methyl-6-ethylphenol (Auwers, Bundesmann, and Wieners, *Annalen*, 1926, **447**, 162), and 4-methyl-6-ethylphenol (Hill and Graf, *J. Amer. Chem. Soc.*, 1915, **37**, 1843), while 3-methyl-5-ethylphenol has been isolated from coke-oven tar by Kruber and Schmitt (*Ber.*, 1931, **64**, 2270) and from low-temperature tar by ourselves, but has not hitherto been synthesised. Of the five methylethylphenols not yet synthesised, we have now prepared the following isomerides :—

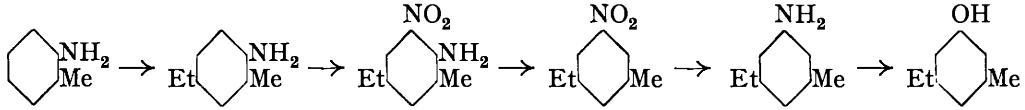
II. 2-*Methyl*-5-*ethylphenol* was obtained by the following series of reactions :—



The orientation of the phenol and of the intermediates utilised in this synthesis follows from that of the mono-nitrated *p*-methylacetophenone (Errera, *Gazzetta*, 1891, **21**, 92; Brady and Day, this vol., p. 114).

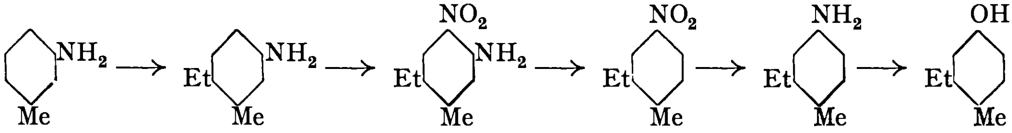
Impure 2-methyl-5-ethylphenol has also been obtained from the unoriented " α "-sulphonic acid of *p*-ethyltoluene (Bayrac, *Bull. Soc. chim.*, 1895, **13**, 890), but its configuration was not determined.

III. 3-*Methyl*-5-*ethylphenol* was synthesised as follows :—



The configuration of the first intermediate product, obtained by condensing *o*-toluidine with ethyl alcohol (Benz, *Ber.*, 1882, **15**, 1650), was confirmed by conversion of the base into 2-methyl-4-ethylphenol, while the constitution of 3-methyl-5-ethylphenol was settled by oxidation of its methyl ether to 5-methoxy*iso*phthalic acid. The position of the side chains in the final product of the synthesis establishes the configuration of the remaining three intermediates.

IV. 4-*Methyl*-3-*ethylphenol.* This synthesis was effected in a manner similar to that of 3-methyl-5-ethylphenol, but commencing with *m*-toluidine :—



The configuration of the first intermediate product was established by direct conversion in this case into 3-methyl-4-ethylphenol, while the second intermediate was proved to be 2-*nitro*-5-*methyl*-4-*ethylaniline* by removal of the amino-group, followed by reduction to give 4-methyl-3-ethylaniline, a known compound (Hill and Graf, *loc. cit.*).

EXPERIMENTAL.

I. 2 : 3 : 6-*Trimethylphenol.*—2 : 3 : 6-Trimethylaniline (5 g.) (Huender, *loc. cit.*) was diazotised in dilute sulphuric acid, and the diazonium solution decomposed to give 2 : 3 : 6-*trimethylphenol,* which crystallised from petroleum (b. p. 40—60°) in colourless needles (2 g.), m. p. 62° (Found : C, 79·2; H, 8·8. $C_9H_{12}O$ requires C, 79·4; H, 8·8%). The p-*xenylcarbamate* has m. p. 189° (Found : C, 79·8; H, 6·3. $C_{22}H_{21}O_2N$ requires C, 79·8; H, 6·3%).

II. 2-*Methyl*-5-*ethylphenol.*—A mixture of 40 c.c. of concentrated nitric acid with 60 c.c. of concentrated sulphuric acid was added to a well-stirred solution of 65 c.c. of *p*-methylacetophenone in 150 c.c. of concentrated sulphuric acid cooled to 0°. The reaction mixture was poured on ice, and the precipitated nitro-compound washed successively with water and ice-cold alcohol and finally recrystallised from the least possible quantity of boiling alcohol. Yield, 44 g. of 3-nitro-4-methylacetophenone, m. p. 62°.

Iron filings (55 g.) were added during 1½ hours to a stirred suspension of 3-nitro-4-methylacetophenone (40 g.) in 1% hydrochloric acid (100 c.c.) at 95—100°. The product was made alkaline with ammonia, and the precipitate extracted with ether. 3-Amino-4-methylacetophenone (Brady and Day, *loc. cit.*), removed from the ethereal extract by dilute mineral acid and liberated by addition of ammonia, crystallised from petroleum (b. p. 60—80°) in colourless leaflets (30 g.), m. p. 81° (Found : C, 72·6; H, 7·5; N, 9·4. Calc. for $C_9H_{11}ON$: C, 72·5; H, 7·4; N, 9·4%).

The foregoing base (20 g.) was diazotised in dilute sulphuric acid, and the diazonium solution decomposed by pouring into boiling 20% sulphuric acid. The crude 3-*hydroxy*-4-*methylacetophenone* separating from the cooled solution was crystallised successively from petroleum (b. p. 60—80°) and benzene. It separated in colourless prisms (15 g.), m. p. 119—120° (Found : C, 71·8; H, 6·7. $C_9H_{10}O_2$ requires C, 72·0; H, 6·7%).

3-Hydroxy-4-methylacetophenone (15 g.) and amalgamated zinc (45 g.) were refluxed for 6 hours with 45 c.c. of concentrated hydrochloric acid and 45 c.c. of water. The resulting mixture was distilled in steam and yielded 7 g. of 2-*methyl*-5-*ethylphenol,* b. p. 224° (Found : C, 79·2; H, 8·9. $C_9H_{12}O$ requires C, 79·4; H, 8·8%). The p-*xenylcarbamate* has m. p. 160° (Found : C, 79·5; H, 6·4. $C_{22}H_{21}O_2N$ requires C, 79·8; H, 6·3%). The *p*-xenylcarbamate of the " α "-phenol prepared according to Bayrac's instructions melted at 154—158°, and addition of 2-methyl-5-ethylphenyl *p*-xenylcarbamate raised this m. p. to 155—159°.

III. 3-*Methyl*-5-*ethylphenol.*—Fuming nitric acid (120 c.c.) was dropped into a solution of 50 g. of 2-methyl-4-ethylacetanilide (Benz, *loc. cit.*) in 120 c.c. of glacial acetic acid, the temperature of which was allowed to rise to 40°. After 5 hours at room temperature, the product was poured on ice, and the precipitated solid recrystallised from aqueous alcohol to give 45 g. of 6-*nitro*-2-*methyl*-4-*ethylacetanilide,* pale yellow needles, m. p. 142° (Found : C, 59·4; H, 6·4; N, 12·7. $C_{11}H_{14}O_3N_2$ requires C, 59·5; H, 6·3; N, 12·6%). Deacetylation of this compound by boiling for 5 hours with 25% hydrochloric acid gave 6-*nitro*-2-*methyl*-4-*ethylaniline,* which crystallised from petroleum (b. p. 60—80°) in brilliant red prisms, m. p. 64° (Found : C, 60·1; H, 6·8. $C_9H_{12}O_2N_2$ requires C, 60·0; H, 6·7%).

A solution of 40 g. of 6-nitro-2-methyl-4-ethylaniline in 400 c.c. of 80% sulphuric acid was diazotised and poured into 1,500 c.c. of boiling industrial alcohol. After removal of excess of alcohol and distillation of the residue in steam, 1-*nitro*-3-*methyl*-5-*ethylbenzene* separated from the distillate as a yellow oil (27 g.), b. p. 262—264° (Found : C, 65·4; H, 6·8. $C_9H_{11}O_2N$ requires C, 65·5; H, 6·7%).

Iron filings (45 g.) were added during 1½ hours to 1-nitro-3-methyl-5-ethylbenzene (25 g.), suspended in 150 c.c. of 1% hydrochloric acid at 95—100°. The product was rendered ammoniacal and the crude base obtained by distillation in steam was redistilled to give 10 g. of 3-*methyl*-5-*ethylaniline,* b. p. 233° (Found : C, 79·9; H, 9·8. $C_9H_{13}N$ requires C, 80·0; H, 9·6%), the *acetyl* derivative of which has m. p. 111° (Found : C, 74·5; H, 8·6; N, 8·2. $C_{11}H_{15}ON$ requires C, 74·6; H, 8·5; N, 7·9%).

The diazonium sulphate solution obtained from 20 g. of the foregoing base was poured into boiling 20% sulphuric acid, and the resulting phenol continuously removed by a current of steam. After purification from neutral by-products, 11 g. of 3-methyl-5-ethylphenol were obtained, m. p. 51°, b. p. 233° (Found: C, 79·2; H, 9·1. Calc. for $C_9H_{12}O$: C, 79·4; H, 8·8%). This homologue of phenol crystallises from petroleum (b. p. 40—60°) in stout colourless prisms, having an odour indistinguishable from that of *m*-5-xylenol. The phenylcarbamate, m. p. 151°, does not depress the melting point (151°) of *m*-5-xylenyl phenylcarbamate, but the p-*xenylcarbamate*, m. p. 125° (Found: C, 79·7; H, 6·4. $C_{22}H_{21}O_2N$ requires C, 79·8; H, 6·3%), and p-*xenoate*, m. p. 70° (Found: C, 83·6; H, 6·3. $C_{22}H_{20}O_2$ requires C, 83·5; H, 6·3%), depress the melting points, 148° and 120° respectively, of the corresponding *m*-5-xylenol derivatives.

3-Methyl-5-ethylphenol methyl ether (2 g.), suspended in 150 c.c. of 5% caustic soda solution at 95—100°, was oxidised by the addition, during 8 hours, of 400 c.c. of 4% potassium permanganate solution. After removal of manganese dioxide, 5-methoxy*iso*phthalic acid was liberated from the concentrated filtrate, and esterified with methyl alcohol. *Methyl 5-methoxy*-iso*phthalate*, crystallised from petroleum (b. p. 60—80°), had m. p. 109°, unchanged by admixture with an authentic specimen (Found: C, 58·6; H, 5·4. $C_{11}H_{12}O_5$ requires C, 58·9; H, 5·4%).

It is essential that the nitration of 2-methyl-4-ethylacetanilide (p. 420) be carried out in the absence of sulphuric acid, since, if this acid is used to assist the reaction, the product is 5-*nitro-2-methyl-4-ethylacetanilide*, m. p. 143° (Found: C, 59·3; H, 6·4. $C_{11}H_{14}O_3N_2$ requires C, 59·5; H, 6·3%). The configuration of this *m*-nitration product was proved by the following series of reactions: deacetylation gave 5-*nitro-2-methyl-4-ethylaniline*, golden needles, m. p. 74° (Found: C, 60·1; H, 6·8. $C_9H_{12}O_2N_2$ requires C, 60·0; H, 6·7%), which was deaminated to give 1-*nitro-4-methyl-2-ethylbenzene*, b. p. 253—263° (Found: C, 65·2; H, 6·8. $C_9H_{11}O_2N$ requires C, 65·5; H, 6·7%). Reduction of this nitro-compound provided 4-methyl-2-ethylaniline, b. p. 230° (*acetyl* derivative, m. p. 132°. Found: C, 74·9; H, 8·5. $C_{11}H_{15}ON$ requires C, 74·6; H, 8·5%), which was converted by the diazonium reaction into 4-methyl-2-ethylphenol (phenylcarbamate, m. p. 99°, not depressed by admixture with an authentic specimen).

IV. 4-*Methyl-3-ethylphenol*.—*m*-Toluidine (500 g.) was heated in an autoclave for 6 hours at 280° with a solution of anhydrous zinc chloride (580 g.) in absolute alcohol (220 g.), and the semi-solid product was worked up by solution in concentrated hydrochloric acid, followed by addition of excess of ammonia. The liberated oil was extracted with ether and separated into 40 g. of phenolic oil, 70 g. of neutral oil, and 468 g. of basic oil. The bases were fractionally distilled, and the sulphates of the fraction b. p. 220—250°/760 mm. were crystallised from 10% sulphuric acid and decomposed to yield 57 g. of 3-*methyl-4-ethylaniline*, b. p. 236° (Found: C, 80·0; H, 9·8; N, 10·2. $C_9H_{13}N$ requires C, 80·0; H, 9·6; N, 10·4%), the *acetyl* derivative of which formed pearly leaflets (from petroleum), m. p. 90° (Found: C, 74·6; H, 8·5; N, 7·9. $C_{11}H_{15}ON$ requires C, 74·6; H, 8·5; N, 7·9%). For the orientation of its substituents, 3-methyl-4-ethylaniline was converted, through the diazonium reaction, into 3-methyl-4-ethylphenol, m. p. 26°, b. p. 235°; the p-*xenylcarbamate* had m. p. 152° (Found: C, 79·5; H, 6·3. $C_{22}H_{21}O_2N$ requires C, 79·8; H, 6·3%), not depressed by admixture with the *p*-xenylcarbamate, m. p. 152°, of an authentic specimen of this phenol prepared from 4-aceto-*m*-cresol.

Fuming nitric acid (145 c.c.) was dropped into a solution of 3-methyl-4-ethylacetanilide (60 g.) in glacial acetic acid (145 c.c.), the temperature of which was allowed to rise to 40°. After 5 hours at room temperature, the product was poured on ice, and the precipitated solid crystallised from industrial alcohol to give 43 g. of 2-*nitro-5-methyl-4-ethylacetanilide*, yellow needles, m. p. 103° (Found: C, 59·3; H, 6·4; N, 12·7. $C_{11}H_{14}O_3N_2$ requires C, 59·5; H, 6·3; N, 12·6%). The alcoholic mother-liquors yielded a second *nitro*-compound, colourless needles (from petroleum), m. p. 109° (Found: C, 59·3; H, 6·4. $C_{11}H_{14}O_3N_2$ requires C, 59·5; H, 6·3%). Deacetylation of the principal nitration product by boiling for 2 hours with 25% hydrochloric acid yielded 2-*nitro-5-methyl-4-ethylaniline*, dull orange prisms (from carbon tetrachloride), m. p. 90° (Found: C, 59·8; H, 6·9. $C_9H_{12}O_2N_2$ requires C, 60·0; H, 6·7%).

The foregoing substituted nitroaniline (27 g.) was diazotised in 80% sulphuric acid (270 c.c.), and the diazonium solution poured into 900 c.c. of boiling industrial alcohol. Removal of excess of alcohol and distillation of the residue in steam yielded 15 g. of 1-*nitro-4-methyl-3-ethylbenzene*, m. p. 23°, b. p. 271° (Found: C, 65·4; H, 6·8. $C_9H_{11}O_2N$ requires C, 65·5; H, 6·7%).

Reduction of 1-nitro-4-methyl-3-ethylbenzene (14 g.) with iron filings and dilute hydrochloric acid gave 8 g. of 4-methyl-3-ethylaniline, b. p. 234—235°, the *acetyl* derivative of which had m. p. 88° (Found: C, 74·6; H, 8·5. $C_{11}H_{15}ON$ requires C, 74·6; H, 8·5%), not depressed by admixture with the acetyl derivative of authentic 4-methyl-3-ethylaniline prepared by reduction of 3-chloroaceto-4-methylacetanilide (Hill and Graf, *loc. cit.*).

The diazonium sulphate solution obtained from 6 g. of 4-methyl-3-ethylaniline was decomposed by boiling 20% sulphuric acid to yield 3·5 g. of 4-*methyl*-3-*ethylphenol*, b. p. 234—235° (Found : C, 79·3; H, 8·8. $C_9H_{12}O$ requires C, 79·4; H, 8·8%); p-*xenylcarbamate*, m. p. 162° (Found : C, 79·7; H, 6·5. $C_{22}H_{21}O_2N$ requires C, 79·8; H, 6·3%).

CHEMICAL RESEARCH LABORATORY,
TEDDINGTON, MIDDLESEX.

[*Received, February* 26*th*, 1934.]