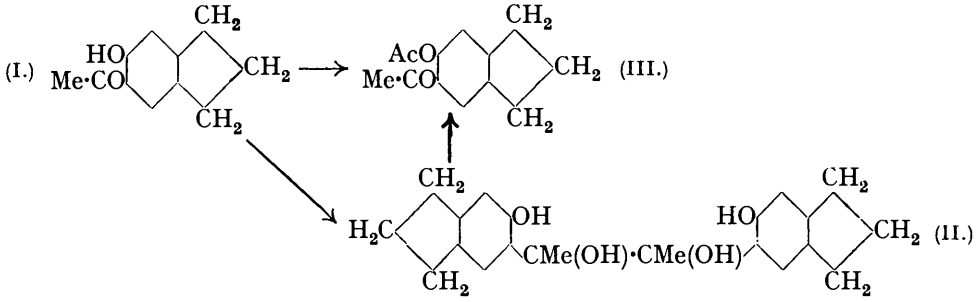
124. *Pinacols Derived from* o-*Hydroxyacetophenones.*

By WILSON BAKER and J. C. MCGOWAN.

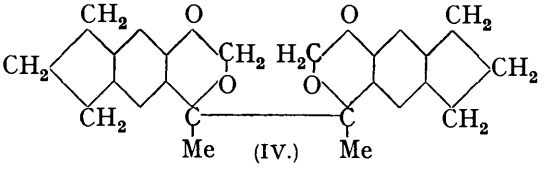
MENTION has been made of the fact that 5-hydroxy-6-acetylhydrindene (I) in sodium hydroxide solution is reduced by zinc dust to one of the two possible inactive forms of the corresponding pinacol, 6-(5-*hydroxyhydrindyl*)*methylpinacol* (II), but that the isomeric 5-hydroxy-4-acetylhydrindene, in which the acetyl group may be regarded as sterically hindered by the adjacent methylene group, is unaffected under these conditions (Baker, this vol., p. 476).



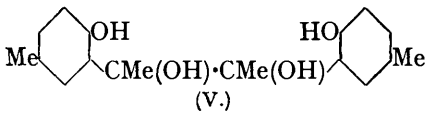
The structure assigned to (II) was based on the following facts: (1) the elementary analysis; (2) it gave no yellow, sparingly soluble sodium salt, as do *o*-hydroxyacetophenones; (3) its alcoholic solution gave an intense blue coloration with ferric chloride, a reaction exhibited by *o*-hydroxybenzyl alcohol and derivatives; (4) its physical properties were not in harmony with those which might be expected of the corresponding secondary alcohol. Molecular-weight determinatons of (II) in camphor gave the low value of 192 (II requires *M*, 354; the secondary alcohol directly derived from I requires *M*, 178), but this result was almost certainly due either to dismutation into (I) and the corresponding secondary alcohol, or to formation of (I) owing to oxidation by the camphor. That such an explanation was probable followed from the observation that with boiling acetic anhydride (II) was converted apparently quantitatively into 5-*acetoxy*-6-*acetylhydrindene* (III), identical with the compound prepared similarly from (I). Molecular-weight determinations

of (II) by the cryoscopic method were impossible owing to the sparing solubility of the substance, and ebullioscopic methods were worthless owing to its instability.

Direct confirmation of the correctness of formula (II) has now been obtained. When treated in dilute acetone solution with sodium hydroxide and methylene sulphate (compare the methylenation of *o*-hydroxybenzyl alcohol; Baker, J., 1931, 1765), the compound yields its dimethylene ether, 4 : 4′-*bis*-(4-*methyl*-6 : 7-*trimethylene*-1 : 3-*benzdioxinyl*) (IV), whose molecular weight indicates the formula given. A further study of these reactions was undertaken in the case of a more accessible *o*-hydroxyacetophenone, namely,



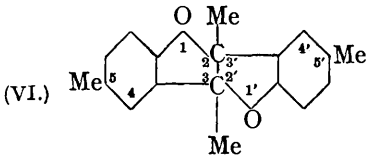
(IV.)



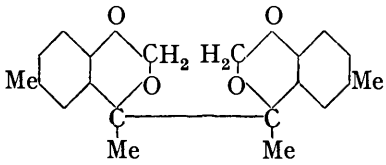
(V.)

3-acetyl-*p*-cresol. The reaction in this case leads to the production of the two stereoisomeric pinacols, 4-*hydroxy*-m-*tolylmethylpinacols* (V), in a total yield of over 80%. The more readily isolable stereoisomer, produced in some 20% yield, has the higher melting point, and will be referred to as the α-pinacol. The lower-melting β-pinacol is produced in 60% yield. It was not found possible to determine the molecular weights of either of these pinacols owing to their reactive nature; the α-pinacol is insufficiently soluble in cold organic solvents and is insufficiently stable in hot solvents. Thus, on heating for a short time with acetic acid, it is converted into one (α-form) of the two possible stereoisomeric forms of the alkali-insoluble 2 : 3 : 5 : 5′-*tetramethylcoumarano*-3′ : 2′ : 2 : 3-*coumaran* (VI). The β-pinacol, on the other hand, is not so readily cyclised; when heated in alcohol with a trace of concentrated hydrochloric acid, or with a solution of sodium acetate in acetic acid, it gives what appears to be a mixture of (VI) and possibly a higher-melting stereoisomer. On the other hand it appears to undergo dismutation on heating in neutral solvents. Thus it cannot be satisfactorily recrystallised from carbon tetrachloride, and 3-acetyl-*p*-cresol may be detected in the mother-liquors.

Each pinacol (V), when treated in dilute acetone solution with sodium hydroxide and methylene sulphate, gives a distinct dimethylene ether; the substances are the stereoisomeric forms of 4 : 4′-*bis*-(4 : 6-*dimethyl*-1 : 3-*benzdioxinyl*) (VII).



(VI.)



(VII.)

There is no conclusive evidence as to which of the two isomeric pinacols (V) is the racemic and which the *meso*-form. On the probable assumption, however, that the more readily produced 2 : 3 : 5 : 5′-tetramethylcoumarano-3′ : 2′ : 2 : 3-coumaran (VI), m. p. 151°, has the two five-membered rings fused in the *cis*-position, the α-pinacol, from which (VI) is smoothly prepared, should be the racemic form, the β-pinacol being consequently the *meso*-form. The argument can, of course, be extended to the two stereoisomeric 4 : 4′-bis-(4 : 6-dimethyl-1 : 3-benzdioxinyl)s (VII), of which the α-isomer is most probably the racemic form, and the β-isomer the *meso*-form.

Most of the above reactions have parallels in the literature. The dismutation of pinacols was probably first observed by Linnemann (*Annalen*, 1865, **133**, 1), the correct interpretation of the reaction being given by Thörner and Zincke (*Ber.*, 1877, **10**, 1473); Cohen (*Rec. trav. chim.*, 1919, **38**, 113) showed that benzophenone pinacols undergo dismutation in presence of alkali; Shoppee (J., 1936, 506) has recently shown that *s*-di-*p*-anisylpinacol undergoes complete dismutation on melting. Coumarano-3′ : 2′ : 2 : 3-coumarans of the type (VI) have been prepared in stereoisomeric forms by the reduction of salicylaldehyde (Tiemann, *Ber.*, 1891, **24**, 3171; Harries, *ibid.*, p. 3175), 2-hydroxy-5-

methylbenzaldehyde (Anselmino, *Ber.*, 1908, **41**, 621), and 2-hydroxy-1-naphthaldehyde (Betti and Mundici, *Gazzetta*, 1906, **36**, ii, 656) with zinc dust and acetic acid, but do not appear to have been previously prepared from the pinacols which must be regarded as intermediates. The ease with which the pinacols undergo this type of ring closure is their most remarkable feature.

Experimental.

6-(5-*Hydroxyhydrindyl*)*methylpinacol* (II).—A mixture of 5-hydroxy-6-acetylhydrindene (I) (2 g.) (Baker, *loc. cit.*) in 4% aqueous sodium hydroxide (50 c.c.) and zinc dust (20 g.) was heated on the water-bath for 6 hours with occasional shaking, then filtered, and the remaining zinc washed with a little dilute sodium hydroxide solution. The combined filtrates were acidified; the solid obtained crystallised from 50% alcohol (50 c.c.) in colourless rectangular plates (1 g.), m. p. 122° (Found: C, 74·8; H, 7·3. $C_{22}H_{26}O_4$ requires C, 74·6; H, 7·3%). The *pinacol* is difficult to crystallise and there is always appreciable loss, probably due to dismutation. It is soluble in dilute aqueous sodium hydroxide with a very pale yellow colour, and its alcoholic solution gives an intense blue ferric chloride coloration, which becomes violet on the addition of water. The solution in concentrated sulphuric acid is yellow.

5-*Acetoxy*-6-*acetylhydrindene* (III).—(a) 5-Hydroxy-6-acetylhydrindene (1 g.) was refluxed for 4 hours with acetic anhydride (10 c.c.), the solution shaken with water, and the solid collected and recrystallised from light petroleum (b. p. 60—80°). The *product* formed stout diamond-shaped plates, m. p. 88° (Found: C, 71·4; H, 6·9; *M*, 210. $C_{13}H_{14}O_3$ requires C, 71·5; H, 6·4%; *M*, 218). (b) An exactly similar experiment with the pinacol (II) gave a product melting at 88° either alone or when mixed with the acetate prepared as in (a). Hydrolysis of this acetate with dilute alcoholic sodium hydroxide readily gave 5-hydroxy-6-acetylhydrindene, m. p. 59°.

4 : 4′-*Bis*-(4-*methyl*-6 : 7-*trimethylene*-1 : 3-*benzdioxinyl*) (IV).—A solution of 6-(5-hydroxyhydrindyl)methylpinacol in dilute acetone was treated with 10% aqueous potassium hydroxide, and methylene sulphate added in small portions at a time with shaking and warming. The solid alkali-insoluble *ether* (IV) was collected, washed, and crystallised twice from ethyl alcohol. It formed fern-like aggregates of prisms, m. p. 172° (Found: C, 75·6; H, 6·5; *M*, 335. $C_{24}H_{26}O_4$ requires C, 76·1; H, 6·9%; *M*, 378). The substance dissolves in concentrated sulphuric acid with a bright orange colour.

Stereoisomeric Forms of 4-*Hydroxy*-m-*tolylmethylpinacol* (V).—The following method of reduction and isolation of the products was adopted as the result of a large number of experiments. 3-Acetyl-*p*-cresol (40 g.; see Baker, J., 1933, 1388), sodium hydroxide (40 g.), water (1000 c.c.), and zinc dust (200 g.) were heated together on the water-bath for 10 hours with continuous mechanical stirring. The cooled solution was filtered from the excess of zinc and made faintly acid to litmus by the addition of 20% acetic acid, and the precipitated solid was collected after standing overnight, washed with dilute acetic acid, and dried at room temperature. It was now digested with boiling absolute alcohol for 1 hour and, after cooling, the residual solid, the α-*pinacol*, was collected by filtration, the β-*pinacol* remaining in the alcoholic solution.

The α-pinacol (yield, 8 g.) is best recrystallised from alcohol, in which it is very sparingly soluble, by continuously extracting the solid in a Soxhlet apparatus, and separates in minute, almost rectangular plates, which melt with evolution of gas at about 273° when rapidly heated (Found: C, 71·4; H, 7·5. $C_{18}H_{22}O_4$ requires C, 71·5; H, 7·3%). The substance is difficultly soluble in all ordinary organic solvents.

The β-pinacol was obtained from the alcoholic solution (above) by evaporation to a syrup; it solidified on cooling. The yield after complete removal of the alcohol was 24·5 g. It was crystallised twice from ethyl acetate and obtained as a microcrystalline powder melting with decomposition at about 170° (Found: C, 71·5; H, 7·3. $C_{18}H_{22}O_4$ requires C, 71·5; H, 7·3%).

Both the α- and the β-pinacol give colourless solutions in aqueous sodium hydroxide and orange solutions in concentrated sulphuric acid, reduce Fehling's solution and ammoniacal silver nitrate, and give brilliant blue solutions with alcoholic ferric chloride.

α-2 : 3 : 5 : 5′-*Tetramethylcoumarano*-3′ : 2′ : 2 : 3-*coumaran* (VI).—The α-pinacol (V) was dissolved in boiling glacial acetic acid; on standing, a small quantity of the original pinacol separated. The filtered solution was concentrated and poured into water, and the solid product collected, washed with dilute aqueous sodium hydroxide, and recrystallised twice from alcohol. It formed flat prisms, m. p. 151° (Found: C, 81·1; H, 6·7; *M*, 268. $C_{18}H_{18}O_2$ requires C, 81·2; H, 6·7%; *M*, 268), insoluble in boiling sodium hydroxide solution, and gave no ferric

chloride reaction in alcoholic solution. Its solution in concentrated sulphuric acid is intensely orange.

Ring Closure of the β-Pinacol.—(a) The β-pinacol was boiled for a few minutes in alcoholic solution containing a few drops of concentrated hydrochloric acid. The material which separated on cooling was washed with sodium hydroxide solution and recrystallised three times from alcohol; it formed a powder, m. p. 150—183° (Found: C, 79·0; H, 6·7%). (b) The β-pinacol (4 g.), acetic acid (30 c.c.), and anhydrous sodium acetate (3 g.) were refluxed for 6 hours. The cooled solution was treated with an excess of dilute aqueous sodium hydroxide, and the solid collected, washed, and recrystallised from alcohol. The product had m. p. 150—164°, and a mixture with the product (VI), m. p. 151°, derived from the α-pinacol, melted over the range 150—156°.

Methylenation of the Pinacols (V).—(a) The α-pinacol (5 g.) and sodium hydroxide (8 g.) were treated with sufficient dilute acetone (40%) to give a homogeneous solution. Methylene sulphate (9 g.) was now added, and the mixture warmed on the water-bath for ½ hour. After removal of the acetone, the solid was collected, washed, dried, and extracted with light petroleum in a Soxhlet apparatus. The α-4 : 4′-*bis*-(4 : 6-*dimethyl*-1 : 3-*benzdioxinyl*) which separated from the petroleum was crystallised twice from benzene and obtained in microscopic prisms, m. p. 243° (Found: C, 73·4; H, 6·8; *M*, 331. $C_{22}H_{22}O_4$ requires C, 73·6; H, 6·7%; *M*, 326). The yield was poor.

(b) The β-pinacol was methylenated in exactly the same way. The crude product was precipitated in good yield by the addition of water, collected, washed with dilute sodium hydroxide solution, and crystallised twice from alcohol. The β-4 : 4′-*bis*-(4 : 6-*dimethyl*-1 : 3-*benzdioxinyl*) was obtained as microscopic plates, m. p. 134—135° (Found: C, 73·6; H, 6·7; *M*, 317. $C_{22}H_{22}O_4$ requires C, 73·6; H, 6·7%; *M*, 326). Its solution in concentrated sulphuric acid is deep red.

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