

260. Reactions of *o*-Hydroxybenzylidenediacetophenones. Part IV.
Unsymmetrical 1 : 5-Diketones.

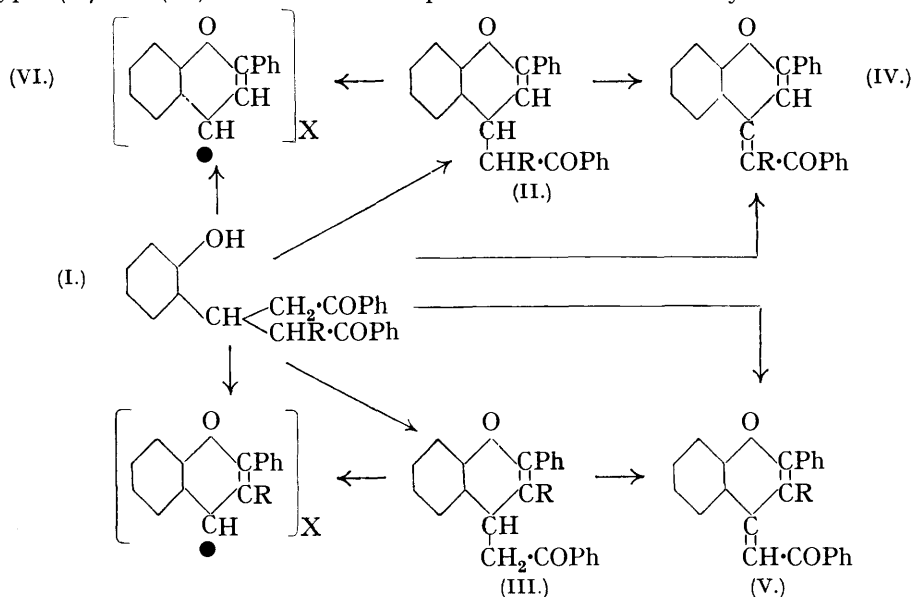
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THE reactions of simple *o*-hydroxybenzylidenediacetophenones described in previous communications (J., 1934, 1255; this vol., pp. 85, 88) make the preparation of similar compounds substituted in the methylene group of interest. Substances of this type, but lacking an *o*-hydroxyl group, have been described by Knoevenagel (*Annalen*, 1894, **281**, 25), Stobbe (*Ber.*, 1902, **35**, 1445, 3978; *Annalen*, 1910, **374**, 237; *J. pr. Chem.*, 1912, **86**, 209), and Allen and Sallens (*Canadian J. Res.*, 1933, **9**, 574).

Unsymmetrical diketones of type (I) may lose water to give a 4-phenacylflavene having the radical R either in the side chain (II) or in the ring (III), each of which will yield the corresponding phenacylidene-flavene (IV or V). $\alpha\gamma$ -Dibenzoyl- β -*o*-hydroxyphenyl- α -phenylpropane (I, R = Ph), prepared by condensation of chalcone with deoxybenzoin in the presence of sodium ethoxide, undergoes ring closure in glacial acetic acid entirely in the first manner, with formation of 4-(α -phenylphenacyl)flavene (II, R = Ph) and 4-(α -phenylphenacylidene)flavene (IV, R = Ph). The constitution of these compounds was established by taking advantage of the observation (Part II) that the action of hydrogen chloride in glacial acetic acid on either the diacetophenones or the 4-phenacylflavenes leads to flavylum salts without a 4-substituent. The isolation in this instance of flavylum ferrichloride (as VI) as the product of this reaction indicates that ring closure had occurred between the hydroxyl group and the carbonyl group of the unsubstituted acetophenone chain.

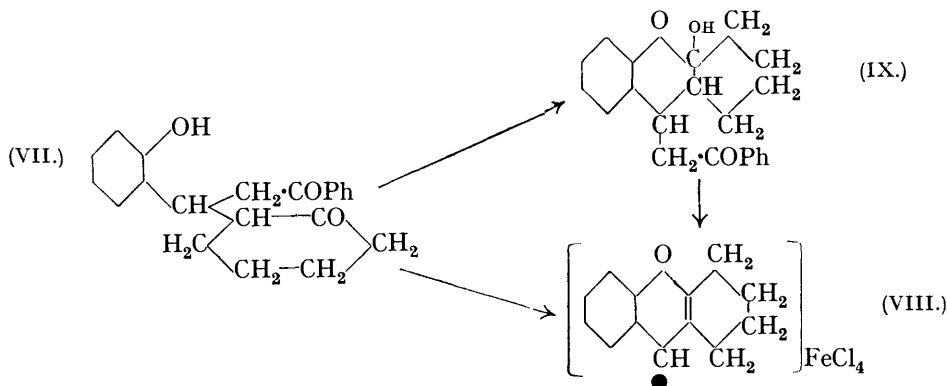
More prolonged heating of this diketone in glacial acetic acid was required than in previously recorded instances to effect ring closure, and in no case was complete conversion into phenylphenacylidene-flavene obtained. In a typical experiment, steam distillation of the reaction mixture yielded only 0.2 g. of deoxybenzoin from 2 g. of diketone,

representing 44% of the expected conversion. The residue was a mixture of compounds of types (II) and (IV). The former compound was not obtained by treatment with cold



acetic acid, but was always formed as a by-product in the preparation of the phenylphenacylidene derivative. The phenacylidene compound formed, as usual, a 4-substituted flavylum ferrichloride.

Two other unsymmetrical diketones examined were derived from cyclic ketones. *cyclo*Hexanone condensed readily with the chalkone in the presence of concentrated sodium hydroxide at 40° to give a good yield of 2-(β -benzoyl- α -o-hydroxyphenylethyl)cyclohexanone (VII). *cyclo*Pentanone, on the other hand, could not be condensed in the usual way, but



under the influence of diethylamine poor yields of the corresponding cyclopentanone were obtained. The crude product was invariably oily and difficult to purify. This compound resembles the unsymmetrical diketone from chalkone and deoxybenzoin in its behaviour with hydrogen chloride in glacial acetic acid followed by ferric chloride, forming only flavylum ferrichloride. The compound (VII) behaves differently in these circumstances, yielding 1 : 2 : 3 : 4-tetrahydroxanthylum ferrichloride (VIII), and an indication of the readiness with which this ring closure occurs is shown by the fact that the same compound is formed by treatment of the diketone with ferric chloride and acetic anhydride in the cold, a reaction which normally leads to substituted pyrylium salts. This diketone also differs from other compounds of this series in its action with glacial acetic acid. By the

usual procedure for the preparation of 4-phenacylflavenes it yields a compound of the same empirical formula, which is readily converted into the same tetrahydroxanthylum salt as the parent substance. It must therefore be the closed compound, 11-hydroxy-9-phenacyl-1 : 2 : 3 : 4 : 10 : 11-hexahydroxanthen (IX).

In the course of the condensation of deoxybenzoin with chalkone, a second compound was isolated in small quantity. This has been shown to be identical with a compound of unknown constitution obtained by Klingemann (*Annalen*, 1893, **275**, 81) by the condensation of deoxybenzoin with acetophenone. It is probable that the procedure used in the condensation of deoxybenzoin with chalkone partly hydrolysed the latter, and that the acetophenone so formed combined with the deoxybenzoin.

EXPERIMENTAL.

αγ-Dibenzoyl-β-*o*-hydroxyphenyl-α-phenylpropane (I, R = Ph).—To a solution of deoxybenzoin (5 g.) in alcohol (100 c.c.) containing sodium (1.5 g.), chalkone (5 g.) was added. The deep red solution was boiled on the water-bath for 2 hours, kept over-night, then poured into water (500 c.c.), and the precipitated solid filtered off and repeatedly crystallised from alcohol, being finally obtained as colourless rhombs (6 g.), m. p. 198° (Found: C, 83.1; H, 5.6. $C_{29}H_{24}O_3$ requires C, 82.9; H, 5.7%).

The alcoholic mother-liquors contained a second more soluble compound which, when pure, separated in rosettes of fine colourless needles, m. p. 200°. It is unaffected by, and may be recrystallised from, boiling glacial acetic acid. Mixed with the compound prepared by the condensation of deoxybenzoin with acetophenone (Klingemann, *loc. cit.*), it had m. p. 200° (Found: C, 84.9; H, 5.5. Calc. for $C_{36}H_{28}O_3$: C, 85.0; H, 5.5%).

4-(α-Phenylphenacylidene)flavene (IV, R = Ph).—The above compound (I, R = Ph) (2 g.) was dissolved in glacial acetic acid (25 c.c.), and the solution boiled for 1 hour, cooled, poured into water, and steam-distilled. The distillate contained deoxybenzoin (0.2 g.). The residue was dissolved in alcohol, precipitated as a solid by pouring into water, dried, and crystallised from light petroleum (b. p. 40–60°). The yellow needles which first separated were recrystallised from alcohol; m. p. 162–163°; yield 0.3 g. (Found: C, 86.9; H, 5.0. $C_{29}H_{20}O_2$ requires C, 87.0; H, 5.0%).

4-(α-Phenylphenacyl)flavene (II, R = Ph).—The light petroleum mother-liquor, on evaporation to half bulk, deposited very pale yellow, fine needles (0.3 g.), m. p. 135–136°, unchanged by repeated recrystallisation (Found: C, 86.7; H, 5.3. $C_{29}H_{22}O_2$ requires C, 86.6; H, 5.5%).

Action of Hydrogen Chloride on αγ-Dibenzoyl-β-*o*-hydroxyphenyl-α-phenylpropane.—The diketone (1.5 g.) was suspended in glacial acetic acid (15 c.c.), and dry hydrogen chloride passed through it for 5 mins. with cooling. Addition of ferric chloride (0.75 g. in 10 c.c. of glacial acetic acid) to the yellow solution produced first a momentary cloudiness and then rapid separation of a yellow crystalline ferrichloride. Crystallisation was complete after an hour, and the solid was then filtered off and recrystallised from glacial acetic acid, being obtained as golden-yellow plates with a tendency to become green; m. p., and mixed m. p. with flavylum ferrichloride, 138° (Found: Fe, 13.6. Calc. for $C_{15}H_{11}OCl_4Fe$: Fe, 13.5%).

4-(α-Phenylphenacyl)flavylum Ferrichloride.—Dry hydrogen chloride was passed through a cooled suspension of the substituted phenacylidene derivative (0.3 g.) in glacial acetic acid (5 c.c.) for 4 minutes. A deep carmine-coloured solution resulted. Ferric chloride (0.2 g. in 5 c.c. of glacial acetic acid) was added, and dull red needles immediately began to separate. After 2 hours, these were filtered off, well washed with ether, and crystallised from glacial acetic acid. The ferrichloride separated as brick-red needles with a metallic sheen, and melted at 196° to a deep red liquid (Found: C, 57.9; H, 3.9; Cl, 24.1; Fe, 9.3. $C_{29}H_{21}O_2Cl_4Fe$ requires C, 58.1; H, 3.5; Cl, 23.7; Fe, 9.35%).

2-(β-Benzoyl-α-*o*-hydroxyphenylethyl)cyclohexanone (VII).—A hot solution of sodium hydroxide (15 g. in 15 c.c. of water) was added to a solution of chalkone (10 g.) and cyclohexanone (20 c.c.) in alcohol (150 c.c.) at 40°. The mixture was kept over-night, and then poured into water (1000 c.c.). The solid product was separated and repeatedly crystallised from alcohol; it formed hard colourless rhombs (8 g.), m. p. 157–158° (Found: C, 78.2; H, 6.9. $C_{21}H_{22}O_3$ requires C, 78.3; H, 6.8%).

11-Hydroxy-9-phenacyl-1 : 2 : 3 : 4 : 10 : 11-hexahydroxanthen (IX).—The above compound (4 g.) was dissolved in glacial acetic acid (40 c.c.) by warming on the water-bath, and kept at room temperature for 24 hours. It was poured into water and the flocculent white precipitate

was filtered off, washed with water, dried, and crystallised from light petroleum (b. p. 60—80°). Colourless, short needles separated, and were purified by recrystallisation from aqueous alcohol; m. p. 123°; yield 2.5 g. (Found : C, 78.4; H, 6.9. $C_{21}H_{22}O_3$ requires C, 78.3; H, 6.8%).

1 : 2 : 3 : 4-Tetrahydroxanthylum Ferrichloride (VIII).—The compound (VII) was cyclised by means of hydrogen chloride and converted into a ferrichloride exactly as with compound (I). The fine yellow needles were filtered off, washed with ether, and recrystallised from cold acetone by the addition of ether. The deep red acetone solution deposited the ferrichloride as golden-yellow blades; m. p. 127° (Found : C, 40.7; H, 3.4; Cl, 38.8; Fe, 14.6. $C_{13}H_{13}OCl_4Fe$ requires C, 40.7; H, 3.4; Cl, 37.1; Fe, 14.6%).

The same compound was obtained from (IX) by the same procedure, and by the action of ferric chloride (1.5 g. in 7 c.c. of 20% hydrochloric acid) on the diketone (3 g.) suspended in glacial acetic acid (30 c.c.) even in the cold (cf. Part II, *loc. cit.*).

2-(β -Benzoyl- α -o-hydroxyphenylethyl)cyclopentanone.—Diethylamine (15 c.c.) was added to a mixture of chalkone (20 g.) and cyclopentanone (10 c.c.) at room temperature. After 10 minutes, the reaction mixture solidified to a paste and more diethylamine (5 c.c.) was added. The mixture, now liquid, was kept for 48 hours, and then poured into water (1000 c.c.). A red oil separated, which slowly solidified during several days. The solid was filtered off, and crystallised from a small volume of alcohol. Almost colourless, glistening plates crystallised out, and were purified by recrystallisation from the same solvent; m. p. 195° (decomp.); yield 2—3 g. (Found : C, 77.7; H, 6.9. $C_{20}H_{20}O_3$ requires C, 77.9; H, 6.5%).

Action of Hydrogen Chloride on the above Diketone.—By the usual procedure, the diketone (0.7 g.) in glacial acetic acid (6 c.c.) afforded a dull orange-coloured ferrichloride. It was recrystallised from acetone-ether, and separated as yellow plates with a green tinge; m. p. and mixed m. p. with flavylum ferrichloride 138° (Found : Fe, 13.7. Calc. for $C_{15}H_{11}OCl_4Fe$: Fe, 13.5%).

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