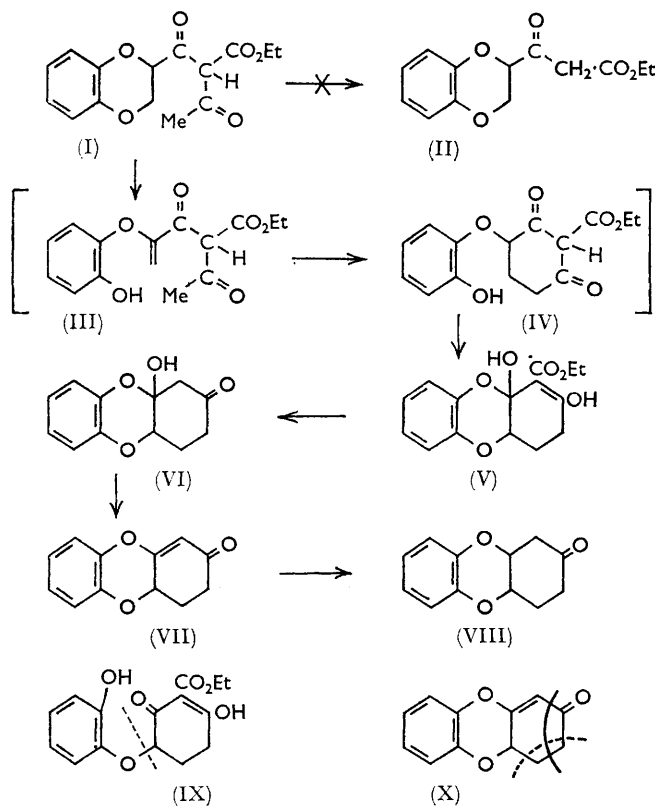


Tetrahydrodibenzo-*p*-dioxins from Ethyl 1,4-Benzodioxan-2-carboxylate and Ethyl Acetoacetate

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Reaction of the sodium enolate of ethyl acetoacetate with ethyl 1,4-benzodioxan-2-carboxylate gives ethyl 3,4,4a,10a-tetrahydro-2,10a-dihydroxydibenzo-*p*-dioxin-1-carboxylate and 4,4a-dihydrodibenzo-*p*-dioxin-2(3*H*)-one in small yield. A mechanism is proposed.

CONDENSATION of ethyl 1,4-benzodioxan-2-carboxylate with the sodium enolate of ethyl acetoacetate was carried out in an attempt to prepare the β -keto-ester (II) *via* the presumed intermediate (I). The conditions were those used for the preparation of ethyl benzoylacetate.¹ The major crystalline product was catechol, which is formed when ethyl 1,4-benzodioxan-2-carboxylate is heated with sodium ethoxide. Two minor crystalline products, (A) C₁₅H₁₆O₆, isomeric with (I), and (B) C₁₂H₁₀O₃, were isolated, and shown by chemical and physical methods to have structures (V) and (VII), respectively.



In agreement with the assignments, compound (V) was hydrolysed and decarboxylated to give the hydroxyketone (VI), which with 2,4-dinitrophenylhydrazine in ethanolic hydrochloric acid (50:1) was readily dehydrated to give the same 2,4-dinitrophenylhydrazone as was given by (VII). Dehydration of (VI) to (VII) in the absence of 2,4-dinitrophenylhydrazine did not proceed so cleanly and purification by preparative t.l.c.

was necessary. Cold trifluoroacetic acid cleanly converted (VI) into (VII).[†] With palladium-charcoal catalyst the $\alpha\beta$ -unsaturated ketone (VII) absorbed hydrogen (1 mol.) and gave the saturated ketone (VIII). This, with platinum catalyst, was reduced to the corresponding secondary alcohol.

In the mass spectrum of (V) the fragment *m/e* 183 can arise by the fission shown in (IX). The presence of the ethoxycarbonyl group of (V) is confirmed by the formation of fragments *m/e* 247 (*M* - EtO), 246 (*M* - EtOH), 219 (247 - CO), 218 (246 - CO), 137 (183 - EtOH; *m** 102.5), and 110 (183 - CO₂Et). The molecular ion of (VII) loses ethylene (X; dotted line) to give the fragment *m/e* 174 (*m** 150) which then loses CO to give *m/e* 146 (*m** 122.5). The molecular ion also loses keten (X; full line) to give *m/e* 160 (*m** 126.7). The other physical measurements are consistent with the structures proposed. The n.m.r. spectrum of (V) confirms the enolic structure assigned.

The formation of (V) from (I) can be explained by a reverse Michael reaction to give (III) followed by a different forward Michael reaction to give (IV), which is the ring-opened form of the hemi-acetal (V).

EXPERIMENTAL

Infrared spectra were determined for Nujol mulls and u.v. spectra for solutions in methanol. N.m.r. spectra were measured at 100 Mc./sec. with tetramethylsilane as internal standard.

Condensation of Ethyl 1,4-Benzodioxan-2-carboxylate with Ethyl Acetoacetate.—Ethyl acetoacetate (26.7 g., 0.205 mole) was added to a solution of sodium (4.6 g., 0.2 mole) in ethanol (60 c.c.); the ethanol was then evaporated off under reduced pressure. Ethyl 1,4-benzodioxan-2-carboxylate (41.6 g., 0.2 mole) was added and the mixture was heated at 150° for 6 hr. and then at 180° for 1 hr. Sulphuric acid (1%; 1 l.) was added and the mixture was extracted with ether (3 × 250 c.c.). The extract was washed with saturated aqueous sodium hydrogen carbonate, and then with water, and was then dried. The ether was evaporated off and the residual oil (30.3 g.) deposited a solid, ethyl 3,4,4a,10a-tetrahydro-2,10a-dihydroxydibenzo-*p*-dioxin-1-carboxylate, which formed plates (2 g.), m.p. 169–170° (from methanol) (Found: C, 61.2; H, 5.65. C₁₅H₁₆O₆ requires C, 61.6; H, 5.5%), ν_{\max} 3450 and 1652 cm⁻¹, τ (CDCl₃) -2.2 (s, exchangeable in D₂O, enolic 2-OH), 3.17 (4H, s, aromatic), 5.83 (2H, q, O-CH₂-CH₃), 6.01 (q, X part of ABX, *J* 10 and 6 c./sec., 4a-H), 6.80 (s, exchange-

[†] Reagent suggested by Dr. W. B. Turner.

¹ S. M. McElvain and K. H. Weber, *Org. Synth.*, Coll. Vol. III, 1955, 379.

able in D₂O, 10a-OH), 6·9—7·9 (4H, m, methylenes), and 8·73 (3H, t, CH₂·CH₃), *m/e* 292 (C₁₅H₁₆O₆) 275, 247, 246, 229, 219, 218, 201, 183, 162, 155, 137, 121, 110, and 95.

The oil remaining after removal of the solid was distilled and fractions (a) b.p. 126—172°/1·5 mm. (10·2 g.) and (b) b.p. 172—180°/1·5 mm. (1·8 g.) were collected. Fraction (a) solidified and gave catechol, m.p. and mixed m.p. 105° (from light petroleum). Fraction (b) was crystallised from light petroleum (b.p. 60—80°) and gave 4,4a-dihydrodibenzo-*p*-dioxin-2(3H)-one as prisms, 1·3 g., m.p. 140—141° (Found: C, 71·0; H, 4·9. C₁₂H₁₀O₃ requires C, 71·3; H, 5·0%), λ_{\max} 246, 274, and 284 m μ (log ϵ 4·11, 4·17, and 4·13), ν_{\max} 1662 cm.⁻¹, τ (CDCl₃) 2·8—3·3 (4H, m, aromatic), 4·28 (1H, *J* < 1 c./sec., C=CH), 5·42 (t, X part of ABX, *J* 6 and 6 c./sec., 4a-H), and 7·34—8·00 (4H, m, methylenes), *m/e* 202 (C₁₂H₁₀O₃), 174 (C₁₀H₈O₃), 160, 147, 146, 145, 134, 133, 131, 121, 118, 110, 109, and 105. The 2,4-dinitrophenylhydrazones formed needles, m.p. 237—238° (from ethanol) (Found: C, 57·2; H, 3·3; N, 14·7. C₁₈H₁₄N₄O₆ requires C, 56·55; H, 3·7; N, 14·7%), λ_{\max} 261, 296, and 391 m μ (log ϵ 4·10, 3·99, and 4·37).

3,4,4a,10a-Tetrahydro-10a-hydroxydibenzo-*p*-dioxin-2(1H)-one.—A solution of ethyl 3,4,4a,10a-tetrahydro-2,10a-dihydroxydibenzo-*p*-dioxin-1-carboxylate (0·48 g.) in 5% aqueous sodium hydroxide (15 c.c.) was kept at 25° for 1·5 hr. The solution was acidified with hydrochloric acid and then heated at 100°. Evolution of carbon dioxide stopped after 10 min. The dibenzo-*p*-dioxinone, which separated from the cooled solution formed needles, m.p. 178—179° (from ethyl acetate) (Found: C, 65·2; H, 5·4. C₁₂H₁₂O₄ requires C, 65·4; H, 5·5%), ν_{\max} 3360 and 1738 cm.⁻¹, τ (dimethyl sulphoxide) 2·9 (1H, s, exchangeable in D₂O, OH), 3·22 (4H, s, aromatic), 4·79 (q, X part of ABX, *J* 11 and 5 c./sec., 4a-H), and 7·0—8·4 (6H, methylenes). The 2,4-dinitrophenylhydrazone, prepared in ethanolic hydrochloric acid (50 : 1), formed needles, m.p. and mixed m.p. with that of 4,4a-dihydrodibenzo-*p*-dioxin-2(3H)-one 237—238°.

Dehydration of 3,4,4a,10a-Tetrahydro-10a-hydroxydibenzo-*p*-dioxin-2(1H)-one.—(a) A solution of the dibenzo-*p*-dioxin-

one (250 mg.) in ethanol (25 c.c.) and conc. hydrochloric acid (0·5 c.c.) was kept at room temperature for 16 hr. and the ethanol was then removed *in vacuo*. Water was added and the organic material was extracted with ether. The extract was separated by chromatography on a preparative silica plate developed with methanol-chloroform (3 : 17). The fraction (147 mg.) *R_F* 0·82 was eluted and crystallised from light petroleum (b.p. 60—80°) to give 4,4a-dihydrodibenzo-*p*-dioxin-2(3H)-one, m.p. and mixed m.p. 140—141°. The fraction (92 mg.) *R_F* 0·72 was starting material, m.p. and mixed m.p. 178—179°.

(b) A solution of the dibenzo-*p*-dioxinone (90 mg.) in trifluoroacetic acid (3 c.c.) was kept at room temperature for 24 hr. Water was added and the product, extracted with chloroform, had m.p. and mixed m.p. 140—141° [from light petroleum (b.p. 60—80°)].

3,4,4a,10a-Tetrahydrodibenzo-*p*-dioxin-2(1H)-one.—4,4a-Dihydrodibenzo-*p*-dioxin-2(3H)-one (1·0 g.) in ethanol (20 c.c.) was shaken with palladium-charcoal (50%; 0·2 g.) in hydrogen at 1 atm. Hydrogen (1 mol.) was consumed. The product formed needles, m.p. 203—204° (from ethyl acetate) (Found: C, 71·1; H, 5·9. C₁₂H₁₂O₃ requires C, 70·6; H, 5·9%), ν_{\max} 1720 cm.⁻¹, τ (CDCl₃) 3·18 (4H, s, aromatic), 5·8—6·3 (2H, m, 4a- and 10a-H), and 6·9—8·5 (6H, m, methylenes).

1,2,3,4,4a,10a-Hexahydrodibenzo-*p*-dioxin-2-ol.—(a) 3,4,4a,10a-Tetrahydrodibenzo-*p*-dioxin-2(1H)-one (0·1 g.) in ethanol (10 c.c.) was shaken with pre-reduced Adams catalyst (50 mg.) in hydrogen at 1 atm. until absorption of hydrogen ceased. The product formed needles, m.p. 183—184° [from ethyl acetate-light petroleum (b.p. 40—60°)] (Found: C, 69·8; H, 6·5. C₁₂H₁₄O₃ requires C, 69·9; H, 6·8%), ν_{\max} 3250 cm.⁻¹.

(b) Reduction of 4,4a-dihydrodibenzo-*p*-dioxin-2(3H)-one under the above conditions gave the same product, m.p. and mixed m.p. 183—184°.

We thank Dr. B. R. Webster for the mass spectral data and Mr. D. Greatbanks for the n.m.r. data.

[8/607 Received, April 30th, 1968]