

556. *Hydroxybenzotropones. Part IV.** 1 : 2 : 3 : 4-Tetrahydro-5 : 8-dimethoxy-2 : 3-methylene-1 : 4-dioxonaphthalene.

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The compound previously regarded as (I) is now shown by synthesis to be (II; R = OMe). Anomalies in the ultraviolet absorption of this type of compound are discussed.

Two syntheses of 4 : 7-dimethoxyindane-1 : 3-dione are reported.

IN Part I¹ we described the synthesis of a compound, regarded as the benzocycloheptadienedione (I), the structure being partly supported by comparison with another considered to be the indane (III). We have since shown² that the latter is in fact a dimethoxycoumarin and have therefore reconsidered structure (I). We noted previously that much of the evidence for structure (I) would also satisfy the isomer (II; R = OMe); the issue has now been decided by synthesis of the latter. The cyclopropane (II; R = H) has recently been obtained³ by dibromination of the dione (IV; R = H) and treatment of the crude product with excess of sodium iodide in acetone. Applying this procedure to our dimethoxy-dione (IV; R = OMe) we obtained a product which contained the desired material but it proved more satisfactory to convert the corresponding dihydroxy-dione (IV; R = OH) into the cyclopropane (II; R = OH) and methylate the product. The dione (II; R = OH) is very similar to β -hydronaphthazarin, showing the same blue fluorescence in organic solvents, but of course it does not enolise in alkaline solution. The compound (II; R = OMe) thus obtained is identical with the substance previously

* Part III, *J.*, 1955, 2244.

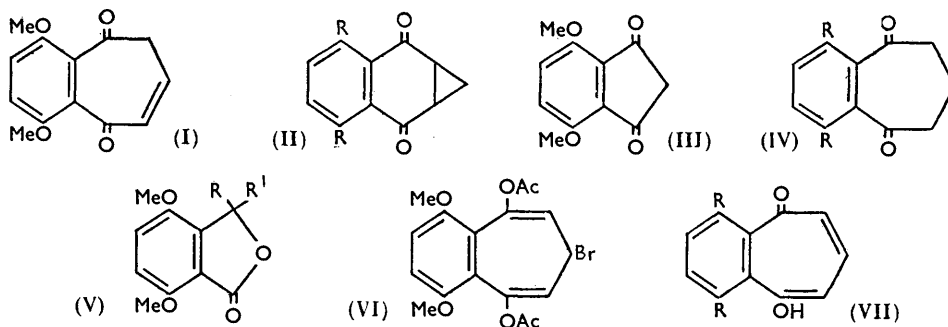
¹ Sorrie and Thomson, *J.*, 1955, 2233.

² Garden, Hayes, and Thomson, *J.*, 1956, 3315.

³ Buchanan and Sutherland, *J.*, 1956, 2620.

regarded as (I). The new material is virtually colourless; the colour of our earlier specimen can be removed by crystallisation from methanol and chromatography.

Among the evidence previously advanced in favour of structure (I), rather than (II; R = OMe), was solubility in hot alkali and failure to form a naphthazarin when heated



with hydrobromic acid-acetic acid.⁴ The essential facts have been confirmed. The dione (II; R = OMe) forms a yellow solution in hot aqueous sodium hydroxide but is rapidly deposited unchanged on cooling: this must be a process of physical solution, not enolisation. The dione (II; R = OMe) rapidly decomposed in hot hydrobromic acid-acetic acid forming a black, alkali-insoluble, precipitate. However, when the diluted filtrate was made alkaline a trace of a naphthazarin was indicated by the colour change. The ultraviolet absorption of these compounds also shows some unexpected features. In Part II⁴ we pointed out that conversion of brominated dimethoxybenzocycloheptenediones into tetrahydromethylenedioxonaphthalenes (II) resulted in a bathochromic shift (*ca.* 50 $m\mu$) of their long-wavelength bands which we ascribed to conjugation of the three-membered ring with the adjacent carbonyl groups. We now find that the shift for the compounds (IV; R = OMe) and (II; R = OMe) is again of the same order (from 330 $m\mu$ to 370 $m\mu$), whereas the dihydroxy-diones (IV; R = OH) and (II; R = OH) both have the same long-wave maximum (at 401 $m\mu$). Buchanan and Sutherland³ observed also that (IV; R = H) and (II; R = H) showed only a trifling displacement (*ca.* 5 $m\mu$) of this band which was true of all their compounds, none of which contains *peri*-substituents. Our original interpretation is therefore wrong and it seems much more likely that the displacements which occur in the *peri*-methoxy-compounds have a steric origin. From the infrared spectra of the diones (IV; R = OMe and H) and related compounds it was concluded⁵ that the carbonyl groups in (IV; R = OMe) are forced out of the plane of the benzene ring by the methoxyl groups. On bridging the seven-membered ring to form the dioxotetralin (II; R = OMe) coplanarity of the carbonyl groups with the benzene ring is largely restored and the increased conjugation is revealed in (a) a shift of the carbonyl band in the infrared spectrum from 1702 (in IV; R = OMe) to 1687 cm.^{-1} (in II; R = OMe) (in CHCl_3 : for comparable data see ref. 5), and (b) a bathochromic displacement of the long-wavelength band in the ultraviolet region. In the absence of the methoxyl groups the effect of bridging the seven-membered ring is much smaller as the carbonyl groups in (IV; R = H) lie not far from the plane of the benzene ring [$\nu_{\text{C=O}}$ 1689, and for (II; R = H) $\nu_{\text{C=O}}$ 1684 cm.^{-1} , both in CHCl_3] and in the pair (IV; R = OH) and (II; R = OH) coplanarity is enforced by strong intramolecular hydrogen bonding. In (IV; R = OH) the carbonyl band is at 1638 and in (II; R = OH) at 1636 cm.^{-1} (both in CHCl_3).

There remains the problem of how the cyclopropane derivative (II) arose from the dienol acetate (VI) in the original synthesis. From this compound (or the mono-enol

⁴ Sorrie and Thomson, *J.*, 1955, 2238.

⁵ Farmer, Hayes, and Thomson, *J.*, 1956, 3600.

acetate) and methanolic potassium hydroxide an orange-red solution is obtained but none of the products isolated after acidification gave an orange-red colour in alcoholic alkali. This suggests that the hydroxybenzotropone (VII; R = OMe) may be formed initially and is then rearranged to the dione (II). Treatment of the hydroxybenzotropone (VII; R = H) with diazomethane yields the bridged compound (II; R = H) as well as the expected methyl ether.⁶

The authentic dimethoxyindanedione (III) has now been synthesised by Claisen condensation of dimethyl 3 : 6-dimethoxyphthalate with ethyl acetate, and also by condensing 3 : 6-dimethoxyphthalic anhydride with acetic anhydride in the presence of potassium acetate to give the phthaloylacetic acid (V; RR' = CH·CO₂H) which was rearranged to the desired indanedione on treatment with sodium methoxide. Alkaline hydrolysis of the β-diketone (III) leads to 2-acetyl-3 : 6-dimethoxybenzoic acid isolated as the tautomeric lactol (V; R = Me, R' = OH). The latter was also obtained from the acid (IV; RR' = CH·CO₂H) by hydrolysis with aqueous sodium hydrogen carbonate. An attempted synthesis of the indanedione (III) by direct condensation of malonic acid with quinol dimethyl ether in trifluoroacetic anhydride yielded only 2 : 5-dimethoxyacetophenone.

EXPERIMENTAL

4 : 7-Dimethoxyindane-1 : 3-dione.—(a) (cf. ref. 7) Finely powdered 3 : 6-dimethoxyphthalic anhydride (6 g.), freshly fused potassium acetate (4 g.), and acetic anhydride (8 ml.) were heated on a steam-bath for 2 hr., and then kept at 150–155° (oil-bath) for 3 hr. The cooled mixture was stirred with water (20 ml.). The precipitate was washed with water and cold methanol until the filtrate was colourless, and then stirred into aqueous sodium hydrogen carbonate (5%). Acidification of the filtered solution with dilute hydrochloric acid gave 3 : 6-dimethoxyphthaloylacetic acid, yellow needles (from dioxan), m. p. 264° (39%) (Found : C, 57.7; H, 4.1. C₁₂H₁₀O₆ requires C, 57.6; H, 4.0%). Sodium methoxide [from sodium (1.5 g.) and methanol (15 ml.)] was added with vigorous shaking to a solution of this acid (1.5 g.) in methanol (35 ml.). The resulting jelly was set aside for 2 hr., then heated on a steam-bath for 5 hr. with occasional shaking, cooled, and left overnight at room temperature. The yellow sodium salt was collected, dried, and dissolved in hot dilute hydrochloric acid (20 ml.). The cooled solution was extracted with chloroform, and the extract dried (CaCl₂) and evaporated. 4 : 7-Dimethoxyindane-1 : 3-dione formed needles (from methanol), m. p. 201° (81%) (Found : C, 63.9; H, 5.1. C₁₁H₁₀O₄ requires C, 64.05; H, 4.9%). Light absorption : λ_{max.} (in EtOH), 259, 360, and 441 mμ (log ε 4.34, 3.71, and 3.35, respectively); ν_{C=O} (in CHCl₃), 1708 and 1740 cm.⁻¹.

(b) Dimethyl 3 : 6-dimethoxyphthalate (1.7 g.), ethyl acetate (4 ml.), and powdered sodium (0.3 g.) were heated with ethanol (2–3 drops) on a steam-bath for 6 hr., and then left overnight at room temperature. The precipitate was collected, washed with a little cold ethyl acetate, and dried. The sodio-derivative was dissolved in warm N-hydrochloric acid (50 ml.), and the solution cooled and extracted with chloroform. The residue from the dried extract was sublimed at 150°/0.1 mm. and then crystallised from methanol, forming needles, m. p. 201° (280 mg.), identical with those obtained in (a). The dioxime separated from dimethylformamide in microcrystals, m. p. 295–298° (decomp.) (Found : C, 55.7; H, 5.0; N, 11.6. C₁₁H₁₂O₄N₂ requires C, 55.9; H, 5.1; N, 11.85%); the benzylidene derivative formed yellow needles, m. p. 218° (from methanol) (Found : C, 73.3; H, 4.7. C₁₈H₁₄O₄ requires C, 73.45; H, 4.8%).

3-Hydroxy-4 : 7-dimethoxy-3-methylphthalide.—The above dione (0.3 g.) was refluxed in 2N-sodium hydroxide (7 ml.) for 1 hr., cooled, and acidified with dilute hydrochloric acid. The precipitated lactol formed slender needles (from water), m. p. 200° (160 mg.) (Found : C, 58.7; H, 5.2. C₁₁H₁₂O₅ requires C, 58.9; H, 5.4%). ν_{C=O} 1770, ν_{OH} 3581 cm.⁻¹ (in CHCl₃). The same compound was obtained by warming a solution of 3 : 6-dimethoxyphthaloylacetic acid in aqueous sodium hydrogen carbonate.

2 : 5-Dimethoxyacetophenone.—A mixture of quinol dimethyl ether (1 g.), malonic acid (1 g.), and trifluoroacetic anhydride (3.5 g.) was kept at 50–60° for 6 hr., then cooled and poured into excess of aqueous sodium hydrogen carbonate (5%). The dried ethereal extract

⁶ Buchanan, J., 1954, 1060.

⁷ Koelsch and Prill, J. Amer. Chem. Soc., 1945, 67, 1296.

was distilled at 0.05 mm. to give unchanged quinol dimethyl ether, b. p. 120—125° (bath temp.), m. p. 56°, and a fraction, b. p. 140—145° (bath temp.), m. p. 21° (needles). 2 : 5-Dimethoxyacetophenone 2 : 4-dinitrophenylhydrazone had m. p. and mixed m. p. 172°.

1 : 2 : 3 : 4-Tetrahydro-5 : 8-dimethoxy-2 : 3-methylene-1 : 4-dioxonaphthalene.—(a) A solution of bromine (1.5 ml., 2 mol.) in acetic acid (5 ml.) was added to one of 1' : 4'-dihydroxybenzocycloheptene-3 : 7-dione (3.1 g.) in the same solvent (40 ml.). After 48 hr. the crystals of 4 : 6-dibromo-1' : 4'-dihydroxybenzocycloheptene-3 : 7-dione were collected. They formed fine yellow needles [from light petroleum (b. p. 100—120°)], m. p. 180° (58%) (Found : C, 36.3; H, 2.2; Br, 44.0. $C_{11}H_8O_4Br_2$ requires C, 36.3; H, 2.2; Br, 43.9%). The dibromo-compound (2.8 g.) and sodium iodide (12 g.) in acetone (100 ml.) were refluxed for 2 hr. On cooling, iodine was removed by addition of excess of aqueous sodium thiosulphate and the acetone by warming. 1 : 2 : 3 : 4-Tetrahydro-5 : 8-dihydroxy-2 : 3-methylene-1 : 4-dioxonaphthalene separated in bright yellow needles [from light petroleum (b. p. 100—120°)], m. p. 173° (66%) (Found : C, 64.5; H, 3.85. $C_{11}H_8O_4$ requires C, 64.7; H, 3.95%). Light absorption in EtOH : λ_{max} . 230, 260, and 401 $m\mu$ ($\log \epsilon$ 4.20, 4.03, and 4.02, respectively). It formed a stable orange solution in aqueous sodium carbonate. A solution of this dihydroxy-dione (0.7 g.) in acetone (30 ml.) was refluxed for 1 hr. with dimethyl sulphate (3.5 ml.) and anhydrous potassium carbonate (9 g.). Dilution with water and removal of the acetone left the dimethyl ether, m. p. 163° (80%) (from methanol or ethyl acetate-light petroleum) (Found : C, 67.4; H, 5.2. $C_{13}H_{12}O_4$ requires C, 67.2; H, 5.2%). Light absorption : λ_{max} . (in EtOH) 229 and 370 $m\mu$ ($\log \epsilon$ 4.11 and 3.72, respectively); $\nu_{C=O}$ 1687 cm^{-1} (in $CHCl_3$).

(b) Bromine (0.5 mol.; 2 mol.) in acetic acid (2 ml.) was added to 1' : 4'-dimethoxybenzocycloheptene-3 : 7-dione (1.17 g.) in the same solvent (10 ml.). After 5 hr., the yellow crystals were washed with light petroleum and treated with sodium iodide (3 g.) in acetone (25 ml.) as above. The product, pale yellow microcrystals, m. p. 150—154° (0.67 g.), was digested with hot light petroleum (b. p. 100—120°; 30 ml.) and then decanted. The residue, crystallised from methanol, had m. p. 163° (34%).

(c) 3-Acetoxy-1' : 4'-dimethoxybenzocyclohepta-1 : 3-dien-7-one (1.4 g.) was treated with *N*-bromosuccinimide followed by methanolic potassium hydroxide as previously described.¹ The initial orange product (0.5 g.; m. p. 150—153°) was crystallised from methanol (charcoal) and then chromatographed in benzene on alumina to give colourless material, m. p. and mixed m. p. 163°, spectroscopically identical with that obtained in (a). After collection of the initial product from chloroform-light petroleum, the mother liquor was concentrated yielding a few sticky crystals. These separated from ethyl acetate-light petroleum in golden yellow plates, m. p. 131° (3 mg.) (Found : C, 65.7; H, 5.5. $C_{12}H_{10}O_4$ requires C, 66.0; H, 4.6%). They gave a pale yellow solution in cold aqueous sodium carbonate and an orange-yellow solution in concentrated hydrochloric acid.

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