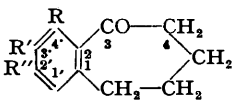
338. *Purpurogallin. Part III. Synthesis of Purpurogallin and Some Analogues.*

By DAVID CAUNT, WILFRID D. CROW, ROBERT D. HAWORTH, and CHARLES A. VODOZ.

2′ : 3′-Dimethoxybenz*cyclo*hepten-3-one (I; R = H, R′ = R″ = OMe) has been oxidised by selenium dioxide to the corresponding 3 : 4-dione (III; R = H, R′ = R″ = OMe), and this oily product has been converted into 4-hydroxy-2′ : 3′-dimethoxybenz*cyclo*heptatrien-3-one (II; R = H, R′ = R″ = OMe) by dehydrogenation with palladium–charcoal in boiling trichlorobenzene. After this preliminary experiment 2′ : 3′ : 4′-trimethoxybenz*cyclo*hepten-3-one (I; R = R′ = R″ = OMe) was converted *via* the oily 3 : 4-dione (III; R = R′ = R″ = OMe) into purpurogallin 2′ : 3′-dimethyl ether (II, R = OH, R′ = R″ = OMe), which was methylated to give the 2′ : 3′ : 4-trimethyl and 2′ : 3′ : 4′ : 4-tetramethyl ethers. Demethylation of the 2′ : 3′ : 4-trimethyl ether yielded purpurogallin (II; R = R′ = R″ = OH) and the 2′-monomethyl ether (II; R = R′ = OH, R″ = OMe). A preliminary summary of these results has already been published (*Chem. and Ind.*, 1949, 149).

THE preparation of 2′ : 3′ : 4′-trimethoxybenz*cyclo*hepten-3-one (I; R = R′ = R″ = OMe) was described in Part I (*J.*, 1948, 1050) but attempts to employ this compound in a synthesis of purpurogallin (II; R = R′ = R″ = OH) were unsuccessful. The cyclic trimethoxy-ketone was oxidised with selenium dioxide, and the oily product probably contained the dione (III; R = R′ = R″ = OMe) because oxidation with hydrogen peroxide yielded γ-(2-carboxy-3 : 4 : 5-trimethoxyphenyl)butyric acid. Attempts to dehydrogenate the crude dione to purpurogallin 2′ : 3′ : 4′-trimethyl ether (II; R = R′ = R″ = OMe) with selenium on palladium–charcoal failed at that time. During these early experiments it was shown that bromination of the cyclic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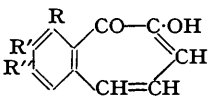
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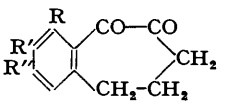
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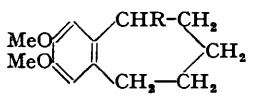
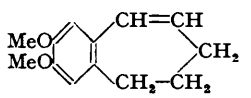
monoketone (I; R = R′ = R″ = OMe) with pyridine hydrobromide perbromide yielded 1′-bromo-2′ : 3′ : 4′-trimethoxybenz*cyclo*hepten-3-one, and condensation with ethyl oxalate in the presence of potassium ethoxide gave ethyl 3-keto-2′ : 3′ : 4′-trimethoxybenz*cyclo*heptene-4-glyoxylate, but the preparation of the cyclic trimethoxy-ketone (I; R = R′ = R″ = OMe) was tedious, and it was decided to make a detailed examination of the properties of the more accessible dimethoxy-analogue (I; R = H, R′ = R″ = OMe).

The preparation of δ-(3 : 4-dimethoxyphenyl)valeric acid (Haworth and Atkinson, *J.*, 1938, 808) has been simplified by an improved preparation of glutaric acid. Cyclisation of the valeric acid with phosphoric oxide in benzene, or preferably by the successive actions of phosphorus pentachloride and stannic chloride in this solvent, gave good yields of 2′ : 3′-dimethoxybenz*cyclo*hepten-3-one. This highly crystalline ketone gave a semicarbazone, a 2 : 4-dinitrophenylhydrazone, and an oxime, and reduction of the last with sodium amalgam yielded 3-amino-2′ : 3′-dimethoxybenz*cyclo*heptene (IV; R = NH_2), m. p. 55°. Attempts to convert this base into

(IV.) 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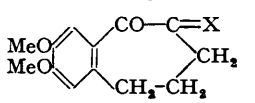
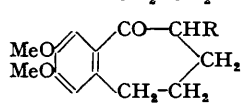
(VI.) 


(VII.)

the corresponding 3-dimethylamino-derivative by refluxing it with methyl iodide and sodium carbonate in acetone solution resulted in deamination with the formation of 2′ : 3′-dimethoxybenz*cyclo*hepta-1 : 3-diene (V); in methyl alcohol a trimethoxy-derivative, probably 2′ : 3′ : 3-trimethoxybenz*cyclo*heptene (IV; R = OMe), resulted. 2′ : 3′-Dimethoxybenz*cyclo*hepten-3-one (I; R = H, R′ = R″ = OMe) reacted with ethyl formate in benzene in the presence of sodium methoxide, yielding 2′ : 3′-dimethoxy-4-hydroxymethylenebenz*cyclo*hepten-3-one (VI; X = CH·OH), and with amyl nitrite in methanolic hydrogen chloride yielding 4-oximino-2′ : 3′-dimethoxybenz*cyclo*hepten-3-one (VI; X = N·OH). Attempts to hydrolyse the oximino-derivative to the corresponding 3 : 4-dione (III; R = H, R′ = R″ = OMe) gave unsatisfactory

results (see p.1634), and reduction with zinc and acetic acid (Hoffmann and Lott, *J. Biol. Chem.*, 1948, **172**, 327) gave 2′ : 3′-dimethoxybenz*cyclo*hepten-3-one (I; R = H, R′ = R″ = OMe). The oximino-ketone (VI; X = N·OH) was readily reduced by hydrogen in presence of palladium charcoal in methyl alcohol containing hydrogen chloride to the hydrochloride of 4-amino-2′ : 3′-dimethoxybenz*cyclo*hepten-3-one (VII; R = NH_2). This was decomposed by nitrous acid to an oily product, the *p*-nitrobenzoate, m. p. 182—183°, of which gave analytical figures in agreement with those required for a *p*-nitrobenzoate of 4-hydroxy-2′ : 3′-dimethoxybenz*cyclo*hepten-3-one (VII; R = OH), but further work along these lines did not appear to be very promising.

It was found that 2′ : 3′-dimethoxybenz*cyclo*hepten-3-one (I; R = H, R′ = R″ = OMe) was oxidised by selenium dioxide in boiling ethanol, acetic anhydride, dioxan, or preferably butanol. The resulting pale yellow oily 2′ : 3′-dimethoxybenz*cyclo*heptene-3 : 4-dione (III; R = H, R′ = R″ = OMe) gave a crystalline dinitrophenylhydrazone, but could not be dehydrogenated to 4-hydroxy-2′ : 3′-dimethoxybenz*cyclo*heptatrien-3-one (II; R = H, R′ = R″ = OMe) with palladium black or palladium–charcoal. At this stage Professor J. W. Cook, F.R.S., kindly informed us of the conversion of benz*cyclo*heptene-3 : 4-dione (III; R = R′ = R″ = H) into 4-hydroxybenz*cyclo*heptatrien-3-one (II; R = R′ = R″ = H)* (Cook and Somerville, *Nature*, 1949, **163**, 410) by means of palladium-charcoal in boiling trichlorobenzene. After some practice with the reagent, the dimethoxy-dione was converted in 9% yield into 4-hydroxy-2′ : 3′-dimethoxybenz*cyclo*heptatrien-3-one (II; R = H, R′ = R″ = OMe), m. p. 147°, which was soluble in alkali, gave a red ferric test, and a crimson coupling product with diazotised *p*-toluidine.

After this experience, renewed attempts were made to convert 2′ : 3′ : 4′-trimethoxybenz*cyclo*hepten-3-one (I; R = R′ = R″ = OMe) into purpurogallin (II; R = R′ = R″ = OH). The benz*cyclo*heptenone was oxidised by selenium dioxide in boiling butanol to the dione (III; R = R′ = R″ = OMe) (2 : 4-dinitrophenylhydrazone, m. p. 181°). Dehydrogenation was then effected with a palladium–charcoal catalyst in boiling trichlorobenzene, and acidification of the alkali-soluble products yielded purpurogallin 2′ : 3′-dimethyl ether (II; R = OH, R′ = R″ = OMe), identical with the dimethyl ether, m. p. 156°, described in Part I (p. 1049). Obviously this synthesis of the dimethyl ether proves that the tropolone-hydroxyl group is not methylated, and this together with the ready acid hydrolysis of the 4′-methyl ether group of purpurogallin 2′: 3′ : 4′ : 4-tetramethyl ether to the 2′ : 3′ : 4-trimethyl ether (see Part I, p. 1049; Part II, *J.*, 1949, 3271, footnote) constitute powerful evidence for the structure of the purpurogallin 2′ : 3′-dimethyl ether. This 2′ : 3′-dimethyl ether was converted by diazomethane into purpurogallin 2′ : 3′ : 4-trimethyl ether, identical with the product described in Part I, and demethylation of this with hydrogen bromide gave purpurogallin (II; R = R′ = R″ = OH), m. p. 276°, together with a small amount of purpurogallin 2′-methyl ether, m. p. 193°. This monomethyl ether was first obtained by Willstätter and Heiss (*Annalen*, 1923, **433**, 17), who regarded it as purpurogallin 4-methyl ether; the new structure has been proved by unpublished results obtained by Mr. A. Critchlow which will be reported shortly.

Experimental.

Glutaric Anhydride.—Difficulty was experienced in reaching the yields quoted (*Org. Synth.*, **10**, 58) for ethyl propane-1 : 1 : 3 : 3-tetracarboxylate. However a considerable improvement was effected by heating the high boiling residual ethyl pentane-1 : 1 : 3 : 3 : 5 : 5-hexacarboxylate (450 g.) with sodium (20·5 g.) in ethyl alcohol (270 c.c.) at 110—115° for 8 hours; decomposition with ice and hydrochloric acid and extraction with ether gave ethyl propane-1 : 1 : 3 : 3-tetracarboxylate (165 g.), b. p. 215—225°/28 mm., unchanged pentanehexacarboxylate (153 g.), and ethyl methylenemalonate (30 g.). Even with this improvement the total yield (60%) was inferior to that obtained by the following modification of Welch's method (*J.*, 1931, 673). Alcoholic potassium hydroxide (5 c.c.; 10%) was added to ethyl malonate (400 g.) and paraformaldehyde (33·5 g.), and the mixture was heated on the water-bath. Further additions of 10% alcoholic potassium hydroxide were made (0·2 and 0·3 c.c. after 1 and 5 hours respectively). After a total of 6 hours' heating, the catalyst was destroyed by neutralisation with hydrochloric acid, and the product distilled as described in *Org. Synth.*, *loc. cit.*; ethyl malonate (110 g.) was recovered, and ethyl propane-1 : 1 : 3 : 3-tetracarboxylate (275 g.) was obtained, together with a small residue (12 g.).

The hydrolysis of the propanetetracarboxylate to glutaric acid was carried out as described (*loc. cit.*), and the conversion into glutaric anhydride was achieved with acetyl chloride in the usual way.

γ-(3 : 4-Dimethoxybenzoyl)butyric Acid and δ-(3 : 4-Dimethoxyphenyl)valeric Acid.—A cooled solution of veratrole (6 g.) and glutaric anhydride (5 g.) in nitrobenzene (20 c.c.) was gradually added at 5° to a solution of aluminium chloride (12 g.) in nitrobenzene (40 c.c.). After 3 hours at 0°, the mixture was decomposed by shaking it with ice and dilute hydrochloric acid for 2 hours, and the precipitated keto-acid was collected (4·8 g.). The nitrobenzene was separated from the filtrate, washed with water, and extracted with sodium carbonate solution, and the acid (1·2 g.) recovered. The combined acids, recrystal-

lised from hot water or chloroform–light petroleum (b. p. 40—60°), gave γ-3 : 4-dimethoxybenzoylbutyric acid, m. p. 140—145° (Haworth and Atkinson, *loc. cit.*, give m. p. 140—142°); the *methyl* ester, b. p. 195—198°, separated from chloroform–light petroleum (b. p. 60—80°) in colourless needles, m. p. 58—59° (Found : C, 63·0; H, 6·5. $C_{19}H_{18}O_3$ requires C, 63·1; H, 6·8%). The constitution of the keto-acid was established by oxidation with potassium permanganate (4 parts) in dilute sodium hydrogen carbonate solution at 40°; veratric acid, m. p. 180°, was isolated.

δ-(3 : 4-*Dimethoxyphenyl*)*valeric acid*, b. p. 193—195°/0·01 mm., m. p. 72°, was prepared by Clemmensen reduction of the above keto-acid as described by Haworth and Atkinson, but the addition of toluene (1 volume for 1 part of keto-acid) was advantageous.

2′ : 3′-*Dimethoxybenz*cyclo*hepten*-3-*one* (I; R = H, R′ = R″ = OMe).—(*a*) A solution of δ-(3 : 4-dimethoxyphenyl)valeric acid (1 g.) in benzene (50 c.c.) was refluxed with phosphoric oxide (10 g.) for 10 minutes. After decomposition with water, the benzene layer was washed with dilute aqueous sodium hydroxide and dried, the solvent removed, and the residue distilled at 0·01 mm., the yield being 0·5 g.

(*b*) Phosphorus pentachloride (11 g.) was added to a solution of δ-3 : 4-dimethoxyphenylvaleric acid (11·8 g.) in dry benzene (50 c.c.) at 0°. After 30 minutes at 0° and then 30 minutes at room temperature, the mixture was gently heated on the water-bath for 15 minutes and then cooled to 0°, and stannic chloride (13·9 g.) in benzene (450 c.c.) added. After 2 hours at 0°, the dark complex was decomposed with ice (200 g.) and concentrated hydrochloric acid (30 c.c.), and the organic layer was washed successively with dilute hydrochloric acid, sodium hydroxide solution, and water. The solvent was removed and the residue distilled at 0·01 mm. the yield being 8·7 g.

2′ : 3′-*Dimethoxybenz*cyclo*hepten*-3-*one* (I; R = H, R′ = R″ = OMe).—This *ketone* had b. p. 161°/0·01 mm. and crystallised from aqueous methyl alcohol or ether–light petroleum (b. p. 60—80°) in colourless prisms, m. p. 63—64° (Found : C, 71·1; H, 7·3. $C_{13}H_{16}O_3$ requires C, 71·1; H, 7·3%). The *oxime* crystallised from ethyl alcohol in colourless prisms, m. p. 152° (Found : C, 66·0; H, 7·4. $C_{13}H_{17}O_3N$ requires C, 66·3; H, 7·3%); the *semicarbazone* separated from aqueous methyl alcohol in colourless needles, m. p. 190—192° (Found : C, 60·8; H, 6·8. $C_{14}H_{19}O_3N_3$ requires C, 60·6; H, 6·9%), and the 2 : 4-*dinitrophenylhydrazone* from chloroform–methyl alcohol in orange prisms, m. p. 234—236° (Found : C, 57·0; H, 4·9; N, 14·0. $C_{19}H_{18}O_6N_4$ requires C, 57·0; H, 5·0; N, 14·0%).

2′ : 3′-*Dimethoxy*-4-*hydroxymethylenebenz*cyclo*hepten*-3-*one* (VI; X = CH·OH).—The foregoing ketone (1 g.) in benzene (8 c.c.) was added to a suspension of sodium methoxide (from 0·4 g. of sodium) in a mixture of benzene (7 c.c.) and ethyl formate (0·68 g.). After 12 hours' shaking at room temperature, the mixture was decomposed with ice, and the product, isolated by means of sodium hydroxide and recovered, was taken up in chloroform. Removal of the solvent gave the *hydroxymethylene-ketone* which crystallised from benzene–light petroleum (b. p. 60—80°) in colourless needles (0·88 g.), m. p. 135—136° (Found : C, 67·9; H, 6·6. $C_{14}H_{16}O_4$ requires C, 67·6; H, 6·5%), which gave a brownish-violet ferric test.

3-*Amino*-2′ : 3′-*dimethoxybenz*cyclo*heptene* (IV; R = NH_2).—3-Oximino-2′ : 3′-dimethoxybenz*cyclo*heptene (1·2 g.), m. p. 152°, in 50% aqueous methyl alcohol (25 c.c.) was reduced at 50° by the gradual addition of 4% sodium amalgam (40 g.). The mixture was stirred, glacial acetic acid was added periodically to maintain slight acidity, and, when the amalgam was exhausted, hydrochloric acid was added until the mixture was acid to Congo-red. The methyl alcohol was removed under reduced pressure, neutral impurities were removed in ether, and after basification the 3-*amino*-compound was isolated with ether; it had b. p. 120°/0·2 mm. and solidified to a mass of colourless prisms, which after crystallisation from ether–light petroleum (b. p. 40—60°) had m. p. 54—55° (Found : C, 70·7; H, 8·3; N, 6·1. $C_{13}H_{19}O_2N$ requires C, 70·6; H, 8·6; H, 6·3%). The *hydrochloride*, prepared in ether, crystallised from methyl alcohol–ether in colourless prisms, m. p. 234° (Found : C, 60·7; H, 7·9; N, 5·6. $C_{13}H_{20}O_2NCl$ requires C, 60·6; H, 7·8; N, 5·4%). The *acetyl* derivative, prepared with acetic anhydride, crystallised from ethyl alcohol in colourless needles, m. p. 166° (Found : C, 68·5; H, 8·3. $C_{15}H_{21}O_3N$ requires C, 68·4; H, 8·0%).

2′ : 3′-*Dimethoxybenz*cyclo*hepta*-1 : 3-*diene* (V).—The base (IV; R = NH_2) (3·8 g.) was warmed in acetone (10 c.c.) with methyl iodide (11·0 g.) and anhydrous sodium carbonate (7 g.) for 1 hour. After evaporation to dryness, extraction with ether gave 2′ : 3′-*dimethoxybenz*cyclo*hepta*-1 : 3-*diene* as a pale yellow oil (1·0 g.), b. p. 150°/0·2 mm. (Found : C, 76·2; H, 7·7; OMe, 29·5. $C_{13}H_{16}O_2$ requires C, 76·4; H, 7·9; OMe, 30·4%).

2′ : 3′ : 3-*Trimethoxybenz*cyclo*heptene* (IV; R = OMe).—The base (IV; R = NH_2) (6·0 g.), methyl iodide (17·5 g.), and anhydrous sodium carbonate were refluxed for 1 hour with methanol (10 c.c.). Evaporation and extraction with ether yielded 2′ : 3′ : 3-*trimethoxybenz*cyclo*heptene* which separated from methyl alcohol in large prisms (2·3 g.), m. p. 62° (Found : C, 71·1; H, 8·6; OMe, 39·7. $C_{14}H_{20}O_3$ requires C, 71·2; H, 8·5; OMe, 39·4%).

4-*Oximino*-2′ : 3′-*dimethoxybenz*cyclo*hepten*-3-*one* (VI; X = N·OH).—2′ : 3′-Dimethoxybenz*cyclo*hepten-3-one (2·5 g.) and redistilled amyl nitrite (1·8 c.c.) in methyl alcohol (5 c.c.) were saturated with hydrogen chloride at −13°. After 7 hours at −8°, the red product was collected and, digested at 30° with 30% aqueous methyl alcohol, and the yellow *oximino*-derivative (1·2 g.) collected and crystallised from methyl alcohol; yellow prisms, m. p. 178° (Found : C, 62·5; H, 5·9; N, 5·6. $C_{13}H_{15}O_4N$ requires C, 62·6; H, 6·1; N, 5·6%), were obtained, which dissolved in sodium hydroxide solution and gave a negative test with cobalt nitrate.

4-*Amino*-2′ : 3′-*dimethoxybenz*cyclo*hepten*-3-*one* (VII; R = NH_2).—The 4-oximino-derivative (VI; X = N·OH) (4·5 g.) was reduced in methyl alcohol (45 c.c.) containing some hydrogen chloride in presence of 10% palladised charcoal (0·5 g.). After 7 hours, when absorption of hydrogen ceased, chloroform was added to redissolve the hydrochloride which had gradually separated, the catalyst was removed, the filtrate was concentrated and cooled, and the 4-*amino*-2′ : 3′-*dimethoxybenz*cyclo*hepten*-3-*one hydrochloride* (4·0 g.) collected; crystallisation from methyl alcohol–ether gave colourless needles, m. p. 255° (Found : C, 57·6; H, 6·8. $C_{13}H_{18}O_3NCl$ requires C, 57·3; H, 6·7%). A solution of this hydrochloride (0·5 g.) and sodium nitrite (0·13 g.) in water (7 c.c.) was warmed at 60°. Nitrogen (35 c.c. at 22°/748 mm.) was evolved and the red oil which separated was taken up in chloroform and recovered. This

nitrogen-free oil (0·43 g.) was mixed with benzene (5 c.c.), *p*-nitrobenzoyl chloride (0·4 g.), and pyridine (12 c.c.) and heated on the water-bath for 3 hours. The p-*nitrobenzoate* of 4-*hydroxy*-2′ : 3′-*dimethoxybenz*cyclo*hepten*-3-*one* (VII; R = OH) separated and crystallised from benzene in colourless prisms, m. p. 182—183° (Found: C, 62·1; H, 5·1. $C_{30}H_{19}O_7N$ requires C, 62·3; H, 5·0%).

2′ : 3′-*Dimethoxybenz*cyclo*heptene*-3 : 4-*dione* (III; R = H, R′ = R″ = OMe).—2′ : 3′-Dimethoxybenz*cyclo*hepten-3-one (I; R = H, R′ = R″ = OMe) (5·8 g.), was refluxed in *n*-butyl alcohol (60 c.c.) for 3 hours with selenium dioxide (3·0 g.). The filtered solution was evaporated under reduced pressure, and the residue was taken up in ether and distilled. 2′ : 3′-Dimethoxybenz*cyclo*hepten-3-one (1·8 g.), b. p. 159—163°/0·1 mm., was recovered, and the *dione* (III; R = H, R′ = R″ = OMe) was obtained as an orange, very viscous oil (2·2 g.), b. p. 175—180°/0·1 mm. (Found: C, 66·5; H, 6·2. $C_{13}H_{14}O_4$ requires C, 66·7; H, 6·0%); it yielded a 2 : 4-*dinitrophenylhydrazone*, which crystallised from toluene in yellow needles, m. p. 253° (Found: C, 55·4; H, 4·1; N, 13·8. $C_{19}H_{18}O_7N_4$ requires C, 55·1; H, 4·4; N, 13·5%). The dione was also obtained in poor yields as follows: the oximino-derivative (VI; X = N·OH) (13·4 g.), dioxan (70 c.c.), concentrated hydrochloric acid (7 c.c.), and pyruvic acid (5 g.) were refluxed for 40 minutes and gave much ether-insoluble resin. The ethereal extract yielded the dione (0·42 g.) which was characterised by the 2 : 4-dinitrophenylhydrazone, m. p. 253°.

4-*Hydroxy*-2′ : 3′-*dimethoxybenz*cyclo*heptatrien*-3-*one* (II; R = H, R′ = R″ = OMe).—The dione (III; R = H, R′ = R″ = OMe) (1·5 g.) was refluxed for 10 hours in *s*-trichlorobenzene (8 g.; b. p. 208°) with 10% palladised charcoal (1 g.) in a nitrogen atmosphere. After dilution with benzene, the filtered solution was washed successively with sodium hydrogen carbonate solution and water, and extracted with sodium hydroxide solution. The product (II; R = H, R′ = R″ = OMe), liberated by acidification and isolated with ether, crystallised from *cyclo*hexane in deep-yellow prisms (0·11 g.), m. p. 147° (Found: C, 67·2; H, 5·3. $C_{13}H_{12}O_4$ requires C, 67·2; H, 5·2%), dissolved in concentrated hydrochloric acid to a deep-yellow solution, and gave a blood-red ferric test and a crimson precipitate with diazotised *p*-toluidine.

γ-(3 : 4 : 5-*Trimethoxybenzoyl*)*butyric Acid and* δ-(3 : 4 : 5-*Trimethoxyphenyl*)*valerie Acid*.—The former acid was prepared as described in Part I (*loc. cit.*, p. 1050) but the hydrolysis with 20% sulphuric acid was allowed to proceed for 90 hours. Instead of reducing this keto-acid as described in Part I (*loc. cit.*, p. 1050) it was preferable on a larger scale to reduce it by Clemmensen's method as follows: The keto-acid (23 g.) in toluene (200 c.c.) was gently refluxed for 15 hours with amalgamated zinc (100 g.) and concentrated hydrochloric acid (200 c.c.). δ-(3 : 4 : 5-Trimethoxyphenyl)valeric acid (20·8 g.), m. p. 68°, was obtained from the toluene layer and purified by vacuum-distillation.

2′ : 3′ : 4′-*Trimethoxybenz*cyclo*hepten*-3-*one* (I; R = R′ = R″ = OMe).—The following conditions proved superior to those described in Part I (*loc. cit.*, p. 1050). δ-(3 : 4 : 5-Trimethoxyphenyl)valeric acid (12·5 g.) in benzene (100 c.c.) was treated with phosphorus pentachloride (9·8 g.) at 0° for ½ hour and the reaction completed by warming the mixture for 10 minutes on the water-bath. The solution was cooled to 0° and gradually added, with shaking, to an ice-cold solution of stannic chloride (12·25 g.) in benzene (2 l.). After 2 hours at 0° the solution was decomposed by the addition of ice (200 g.) and concentrated hydrochloric acid (200 c.c.), and the benzene layer washed successively with dilute hydrochloric acid, dilute sodium hydroxide solution, and water. The cyclic ketone (I; R = R′ = R″ = OMe) was obtained from the benzene layer, and crystallised from *cyclo*hexane in colourless rhombs (7·8 g.), m. p. 102°. The 2 : 4-*dinitrophenylhydrazone* crystallised from ethyl acetate in orange prisms, m. p. 186° (Found: C, 55·8; H, 5·2; N, 13·0. $C_{22}H_{22}O_7N_4$ requires C, 56·0; H, 5·3; N, 13·1%). In Part I the m. p. was recorded as 176—177°. The *semicarbazone* crystallised from methyl alcohol in colourless needles, m. p. 165—166° (Found: C, 58·5; H, 6·9. $C_{15}H_{21}O_4N_3$ requires C, 58·6; H, 6·9%).

1′-*Bromo*-2′ : 3′ : 4′-*trimethoxybenz*cyclo*hepten*-3-*one* [by P. L. Pauson].—The cyclic ketone (I; R = R′ = R″ = OMe) (0·25 g.) was gently warmed with pyridine hydrobromide perbromide (Dierassi and Scholz, *J. Amer. Chem. Soc.*, 1948, **70**, 417) (0·32 g.) in acetic acid (10 c.c.). The *bromo*-compound, precipitated by addition of water as a brown oil which solidified during several weeks, crystallised from methyl alcohol in colourless needles, m. p. 79° (Found: C, 50·7; H, 5·2. $C_{14}H_{17}O_4Br$ requires C, 51·0; H, 5·2%), which were unaffected when boiled with potassium acetate in acetic acid. Pure products were not obtained during attempted bromination of the ketone with *N*-bromosuccinimide in carbon tetrachloride or with bromine in chloroform.

Ethyl 3-*Keto*-2′ : 3′ : 4′-*trimethoxybenz*cyclo*heptene*-4-*glyoxylate* [by P. L. Pauson].—2′ : 3′ : 4′-Trimethoxybenz*cyclo*hepten-3-one (I; R = R′ = R″ = OMe) (0·5 g.) was added to the solution obtained by adding ethyl oxalate (0·7 g.) in ether (5 c.c.) to a suspension of potassium ethoxide, prepared from potassium (0·16 g.) and ethyl alcohol (0·2 g.) in ether (15 c.c.). After 2 hours at room temperature, the mixture was decomposed with ice, the combined aqueous layers were acidified with ice-cold dilute hydrochloric acid, and the product was collected; it crystallised from ethyl alcohol in pale yellow prisms, m. p. 120° (Found: C, 61·6; H, 6·3. $C_{18}H_{22}O_7$ requires C, 61·7; H, 6·3%).

2′ : 3′ : 4′-*Trimethoxybenz*cyclo*heptene*-3 : 4-*dione* (III; R = R′ = R″ = OMe).—2′ : 3′ : 4′-Trimethoxybenz*cyclo*hepten-3-one (I; R = R′ = R″ = OMe) (5 g.) was refluxed with *n*-butyl alcohol (60 c.c.) and selenium dioxide (2·3 g.) for 3 hours. After cooling, the mixture was filtered from selenium, the filtrate evaporated under reduced pressure, and the residue taken up in ether. Removal of the ether and distillation of the residue yielded unchanged benzsuberone (I; R = R′ = R″ = OMe) (2·7 g.), b. p. 175—180°/0·2 mm., and the *dione* (III; R = R′ = R″ = OMe) (12·2 g.), a pale yellow oil, b. p. 200—210°/0·2 mm. (Found: C, 63·6; H, 6·3. $C_{14}H_{16}O_5$ requires C, 63·6; H, 6·1%), which gave a *mono*-2 : 4-*dinitrophenylhydrazone* crystallising from ethyl acetate in yellow prisms, m. p. 181° (Found: C, 54·1; H, 4·5; N, 12·6. $C_{20}H_{20}O_8N_4$ requires C, 54·1; H, 4·5; N, 12·6%).

4 : 4′-*Dihydroxy*-2′ : 3′-*dimethoxybenz*cyclo*heptatrien*-3-*one* (II; R = OH, R′ = R″ = OMe).—The above dione (1 g.) was dehydrogenated in boiling trichlorobenzene as described above for the dimethoxy-analogue, the sodium hydroxide extract was acidified at 50°, and the product isolated with ether. The red solid, crystallised first from *cyclo*hexane and then from methyl alcohol, gave orange plates (0·09 g.), m. p. 156°, identical with purpurogallin dimethyl ether described in Part I (*loc. cit.*, p. 1049). This ether (0·08 g.) in dioxan (5 c.c.) with diazomethane (0·02 g.) in ether (500 c.c.) gave

4′-hydroxy-2′ : 3′ : 4-trimethoxybenz*cyclo*heptatrien-3-one, as yellow prisms (from alcohol), m. p. 176°, identical with purpurogallin trimethyl ether. Further methylation to purpurogallin tetramethyl ether, m. p. 94°, with methyl sulphate and potassium hydroxide was accomplished as described in Part I (*loc. cit.*, p. 1049).

Demethylation of Purpurogallin 2′ : 3′ : 4′-Trimethyl Ether.—The synthetic trimethyl ether (0·06 g.) described above was heated for 1 hour with hydrobromic acid (5 c.c.; *d* 1·45). The solution was evaporated to dryness under reduced pressure and the product, after dissolution in and recovery from dioxan, was sublimed at 0·02 mm. and separated into three fractions characterised by the sublimation bath-temperatures of (*a*) 150—185°, (*b*) 185—210°, and (*c*) 210—290°. Resublimation of fraction (*c*) yielded a fraction (*d*) subliming at 265—285°, which yielded purpurogallin (0·015 g.) as red prisms, m. p. 276°, undepressed on admixture with an authentic specimen, after crystallisation from anisole.

Fraction (*b*), crystallised from chloroform, yielded purpurogallin 2′-monomethyl ether as orange prisms (0·002 g.), m. p. 193°, identical with a sample prepared from pyrogallol and 3-methoxycatechol (Willstatter and Heiss, *loc. cit.*, give m. p. 183°, but this has been raised to 193° by sublimation).

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