293. *Purpurogallin. Part VII. Constitution of Purpurogallin-carboxylic Acid.*

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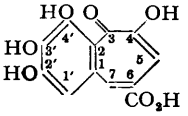
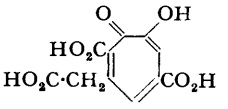
An improved preparation of purpurogallin-carboxylic acid (I) from a mixture of gallic acid and pyrogallol is described, and the structure of the acid has been established (*a*) by oxidation of its tetramethyl ether with permanganate to 3 : 4 : 5-trimethoxyphthalic anhydride and (*b*) by oxidation with alkaline hydrogen peroxide to αβ′-dicarboxy-β-carboxymethyltropolone (II). The latter acid on decarboxylation gave β-methyltropolone-β′-carboxylic acid (III), which was converted into uvitic acid (IV) by fusion with potassium hydroxide.

Oxidation of gallic acid with potassium ferricyanide in presence of aqueous sodium acetate, or preferably electrolytically in sodium sulphate or acetate solution has been shown to give purpurogallin-carboxylic acid, $C_{12}H_8O_7$ (Perkin and Stevens, *J.*, 1903, **83**, 192; Perkin and Perkin, *J.*, 1904, **85**, 243; 1908, **93**, 1188). Although a number of ethers and esters of the acid have been described by Perkin *et al.* (*locc. cit.*) and Willstätter and Heiss (*Annalen*, 1923, **433**, 17), no experimental evidence leading to a structural formula for the acid or establishing a relationship with purpurogallin has been published. No doubt the inaccessibility of the acid has handicapped investigation, and in our hands the methods previously reported gave extremely poor yields. Hooker (*Ber.*, 1887, **20**, 3073) obtained a small yield of purpurogallin by the action of sodium nitrite on a solution of gallic acid in aqueous acetic acid, but we failed to confirm this observation, and the action of potassium iodate on gallic acid or ethyl gallate was equally disappointing; some iodine was liberated unless the acid was neutralised before the addition of the iodate, but we failed to discover experimental conditions for the production of purpurogallin-carboxylic acid or its ethyl ester. New views (Part VI, preceding paper) concerning the

mechanism of purpurogallin formation not only explained the difficulties experienced but they indicated (*a*) that purpurogallin-carboxylic acid was probably 4 : 2′ : 3′ : 4′-tetrahydroxybenzo*cyclo*heptatrien-3-one-6-carboxylic acid (I) and (*b*) that a useful preparation might be found in the oxidation of a mixture of pyrogallol and gallic acid with potassium iodate. In practice this reaction proceeded smoothly and after some preliminary experiments concerning the quantities and mode of addition of the reagents it was possible to obtain 22% yields (calculated on the amount of gallic acid employed).



(I.)



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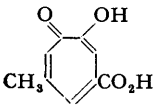
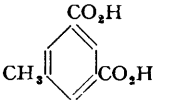


(III.)



(IV.)

Purpurogallin-carboxylic acid (I), when warmed with methyl alcohol and sulphuric acid, gave a methyl ester, m. p. 267—268° [Willstätter and Heiss, *loc. cit.*, gave m. p. 260—270° (decomp.)], and with methyl sulphate and potassium carbonate in acetone yielded methyl 4 : 2′ : 3′ : 4′-tetramethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate, m. p. 122°, which was hydrolysed by alcoholic potassium hydroxide to the corresponding 4 : 2′ : 3′ : 4′-tetramethoxy-acid, m. p. 185—186° (Perkin and Perkin, *J.*, 1908, **93**, 1188, gave m. p. 182—183°). Methylation with diazomethane gave a phenolic product, probably methyl 4′-hydroxy-2′ : 3′ : 4-trimethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate, m. p. 156—157°, which was hydrolysed to the corresponding acid, m. p. 275—276°, with alcoholic potassium hydroxide. Purpurogallin-carboxylic acid (I) was decarboxylated in boiling quinoline in presence of copper powder, and the product, m. p. 275° (decomp.), was identified as purpurogallin, thus establishing the benzotropolone structure of the acid. The determination of the position of the carboxyl group occupied two stages. First, oxidation of methyl 4 : 2′ : 3′ : 4′-tetramethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate with potassium permanganate gave 3 : 4 : 5-trimethoxyphthalic acid, which we identified by means of the anhydride and *N*-methylimide, and consequently the carboxyl group must reside in the tropolone ring. This was fully confirmed by oxidation of purpurogallin-carboxylic acid (I) with hydrogen peroxide, which gave αβ′-dicarboxy-β-carboxymethyltropolone (II) in 35% yield. This pale yellow acid was easily decarboxylated either by heating it to its melting point or better by heating it at 250° for a few minutes with a trace of copper powder in dibutyl phthalate. β-Methyltropolone-β′-carboxylic acid (III), m. p. 220—221°, thus obtained, had all the properties of a tropolone derivative, giving a blood-red ferric test, and crimson azo-dyes when coupled with diazo-compounds. When β-methyltropolone-β′-carboxylic acid was heated at 250° with potassium hydroxide it was converted into uvitic acid (IV) which was identified by comparison with an authentic specimen prepared from mesitylene (Fittig and Furtenbach, *Annalen*, 1868, **147**, 296). The yield of uvitic acid was poor (8·4%) but its formation provided rigid proof of the structure of purpurogallin-carboxylic acid (I) and the degradation products (II) and (III).

Experimental.

Purpurogallin-carboxylic Acid (I).—Aqueous solutions of pyrogallol (31 g. in 250 c.c.) and potassium iodate (53 g. in 500 c.c.) were added simultaneously with stirring and ice-cooling to the slurry of sodium gallate obtained by adding gallic acid (47 g.) to a solution of sodium hydrogen carbonate (21 g.) in water (300 c.c.) so that addition of each solution was completed in 45 minutes. After another 15 minutes' stirring, the mixture was acidified with 10N-hydrochloric acid (25 c.c.), set aside overnight, and filtered, and the filtrate extracted thrice with ether (total, 1 l.). The air-dried precipitate was extracted several times with hot methyl alcohol (total, 1 l.), the ethereal and alcoholic extracts were combined, and the whole was concentrated until precipitation commenced. The solid was removed, the process was repeated on the filtrate, and the combined solids were washed with methyl alcohol. The air-dried product (29 g.) was an orange microcrystalline powder, recrystallising from dioxan in small orange needles, m. p. above 320° (decomp.) (Found : C, 54·3; H, 3·4. Calc. for $C_{12}H_8O_7$: C, 54·6; H, 3·1%). The acid (I) was readily soluble in sodium hydroxide solution and slowly in sodium hydrogen carbonate solution, to give red solutions which became blue on exposure to air, and was sparingly soluble after drying, in the usual solvents. An alcoholic solution gave a black ferric test. The *methyl* ester, prepared by refluxing the acid (I) (0·5 g.) for 30 minutes with methyl alcohol (25 c.c.) and concentrated sulphuric acid (2 c.c.), crystallised from acetone in dark red needles (0·45 g.), m. p. 267—268° (Found : C, 56·4; H, 3·7; MeO, 11·5. Calc. for $C_{13}H_{10}O_7$: C, 56·1; H, 3·6; MeO, 11·2%).

Decarboxylation of Purpurogallin-carboxylic Acid (with D. Caunt).—The acid (1·5 g.) was heated under reflux for 1 hour in quinoline (7·5 c.c.) with copper powder (0·75 g.). The mixture was diluted with ether (100 c.c.) and extracted with hydrochloric acid, and the ethereal layer washed, dried, and

evaporated. The residue (0·5 g.) crystallised from acetic acid in red needles, m. p. 274—276°, and was identified as purpurogallin by comparison of the phenol, the tetra-acetate, m. p. 186°, and the trimethyl ether, m. p. 176°, with authentic specimens.

*Methyl 4′-Hydroxy-2′ : 3′ : 4-trimethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate.*—A suspension of purpurogallin-carboxylic acid (I) (1·0 g.) in ether (25 c.c.) was treated with excess of ethereal diazomethane, the ether removed after several hours, and the product crystallised from alcohol, giving yellow needles (0·9 g.), m. p. 156—157° (Found : C, 60·0; H, 5·1; MeO, 37·8. $C_{16}H_{16}O_7$ requires C, 60·0; H, 5·0; MeO, 38·8%). The *ester* was soluble in sodium hydroxide solution to give a yellow colour, but insoluble in sodium hydrogen carbonate solution, and gave a red colour with ferric chloride.

*4′-Hydroxy-2′ : 3′ : 4-trimethoxybenzo*cyclo*heptatrien-3-one-6-carboxylic Acid.*—The ester described above (0·2 g.) was heated on the water-bath for 30 minutes with 10% methanolic potassium hydroxide (25 c.c.). After dilution the solution was acidified and the *acid*, isolated by extraction with chloroform, crystallised from dioxan in red prisms (0·1 g.), m. p. 275—276° (Found : C, 58·7; H, 4·6; MeO, 28·7. $C_{15}H_{14}O_7$ requires C, 58·8; H, 4·6; MeO, 30·4%). The product was readily soluble in sodium hydrogen carbonate solution and gave a reddish-brown ferric test in alcoholic solution.

*4 : 2′ : 3′ : 4′-Tetramethoxybenzo*cyclo*heptatrien-3-one-6-carboxylic Acid and its Methyl Ester.*—Methyl 4′-hydroxy-2′ : 3′ : 4-trimethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate (3·0 g.), methyl sulphate (10 c.c.), and anhydrous potassium carbonate (50 g.) in acetone (150 c.c.) were refluxed for 3 hours. The mixture was filtered, the solid was washed with acetone, and the combined filtrate and washings were evaporated to dryness, shaken with 10% sodium hydroxide solution to remove methyl sulphate, and extracted with ether. Evaporation and crystallisation of the residue from alcohol gave the methyl ester (2·3 g.) as colourless needles, m. p. 121—122° (Found : C, 61·4; H, 5·4; MeO, 43·5. Calc. for $C_{17}H_{18}O_7$: C, 61·1; H, 5·4; MeO, 46·4%). The aqueous layer was combined with the potassium carbonate residues, acidified, and extracted with ether. Evaporation and crystallisation of the residue from dioxan–light petroleum (b. p. 60—80°) gave the acid (0·6 g.) as pale yellow needles, m. p. 185—186° (Found : C, 59·8; H, 5·2; MeO, 38·1. Calc. for $C_{16}H_{16}O_7$: C, 60·0; H, 5·0; MeO, 38·8%). This acid, which was readily soluble in sodium hydrogen carbonate solution, was also formed by hydrolysis of the methyl ester, m. p. 121—122°, with methanolic potassium hydroxide.

3 : 4 : 5-Trimethoxyphthalic Anhydride.—Methyl 4′ : 2′ : 3′ : 4′-tetramethoxybenzo*cyclo*heptatrien-3-one-6-carboxylate, m. p. 121—122° (1·0 g.), in pure acetone (25 c.c.) was shaken at room temperature with 5% aqueous potassium permanganate (100 c.c.). After 2 hours the mixture was clarified with sulphur dioxide, rendered alkaline, and evaporated to dryness under reduced pressure. The residue was acidified with hydrochloric acid, then continuously extracted with ether, the extract was evaporated, and the residue distilled at 0·1 mm. Crystallisation of the distillate from absolute ether gave 3 : 4 : 5-trimethoxyphthalic anhydride (0·05 g.), m. p. 141—142°, not depressed on admixture with an authentic specimen. The *N*-methylimide crystallised from methyl alcohol in colourless needles, m. p. 127°; Manske and Holmes (*J. Amer. Chem. Soc.*, 1945, **67**, 98) give m. p. 127°.

Oxidation of Purpurogallin-carboxylic Acid with Alkaline Hydrogen Peroxide.—30% Hydrogen peroxide (40 c.c.) was added during 1 minute to a solution of purpurogallin-carboxylic acid (I) (20 g.) in sodium hydroxide (170 g.) and water (1000 c.c.) at 90°. After the intial effervescence had subsided, sodium metabisulphite (10 g.) was added, and the cooled mixture was acidified to Congo-red with 40% sulphuric acid and continuously extracted with ether for 20 hours. The extract on concentration to small bulk deposited *αβ′-dicarboxy-β-carboxymethyltropolone* (II) (7·5 g.) which crystallised from acetic acid as pale yellow needles, m. p. 230° (decomp.; rapid heating) (Found : C, 48·9; H, 3·3. $C_{11}H_8O_8$ requires C, 49·3; H, 3·0%), and gave a red ferric test in alcoholic solution.

β-Methyltropolone-β′-carboxylic Acid (III).—The above acid (II) (5·0 g.), when heated for 10 minutes at 250° in dibutyl phthalate (100 c.c.) containing a little copper powder, gave a dark solution, which was cooled, diluted with ether, and filtered. The acids were taken up in sodium hydroxide solution, recovered, and extracted several times with ethyl methyl ketone, and the solvent was removed. The residue was dissolved in dioxan (charcoal) and diluted with benzene; *β-methyltropolone-β′-carboxylic acid* (III) separated in yellow prisms (3·2 g.), m. p. 223—224°, containing solvent of crystallisation which was removed at 100°/0·1 mm. (Found : C, 59·8; H, 4·5. $C_9H_8O_4$ requires C, 60·0; H, 4·5%). The acid (III) gave a blood-red ferric test, and a crimson product with diazotised *p*-toluidine.

The acid (III) (1·0 g.) was heated to 250° with potassium hydroxide (10 g.) moistened with water, and this temperature maintained for 5 minutes. The reaction mixture was dissolved in water, then acidified, and the product isolated with ether and sublimed at 0·1 mm. Uvitic acid (0·075 g.), m. p. 290—292° not depressed on admixture with an authentic specimen (Fittig and Furtenbach, *loc. cit.*), was obtained. The methyl ester was obtained by the action of diazomethane as cream-coloured needles, m. p. 95°, undepressed by an authentic specimen.

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