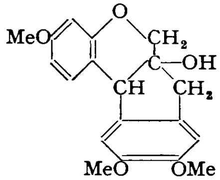
488. *Furano-compounds. Part XI. The Synthesis of α-Anhydro-O-trimethylbrazilone and Related Compounds.*

By P. C. Johnson and Alexander Robertson.

A series of 4′- and 3′-hydroxynaphtho(2′ : 1′-2 : 3)coumarones of the α-anhydrobrazilone type has been synthesised. 3-(3 : 4-Dimethoxyphenyl)-6-methoxycoumarone (VI; R = H) was prepared from 5-methoxy-2-veratroylphenoxyacetic acid (V; R = H), and its 2-formyl derivative (VI; R = CHO) was converted by the azlactone method into 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-acetic acid (VIII) which on cyclisation gave 4′-hydroxy-6 : 6′ : 7′-trimethoxynaphtho(2′ : 1′-2 : 3)coumarone (IX). 4′-Hydroxy-6 : 6′- and -6 : 7′-dimethoxynaphtho(2′ : 1′-2 : 3)coumarone were also synthesised by the same general route.

3-*o*-Carboxyphenyl-6-methoxycoumarone (XII; R = OH, R′ = H) was prepared from 2-*o*-carboxybenzoyl-5-methoxyphenoxyacetic acid (XI; R = R′ = H), and converted into the acetic acid (XIII; R = H) which on cyclisation gave 3′-hydroxy-6-methoxynaphtho(2′ : 1′-2 : 3)coumarone (XIV). By the same route α-anhydro-*O*-trimethylbrazilone (IV) was synthesised from brazilinic acid (XI; R = H, R′ = OMe).

By the oxidation of *O*-trimethylbrazilin (I) with chromic acid Gilbody and Perkin (*J.*, 1902, **81**, 1008; cf. *Proc. Chem. Soc.*, 1899, **15**, 27) obtained *O*-trimethylbrazilone which by loss of water under comparatively mild conditions gave α-anhydro-*O*-trimethylbrazilone. Subsequently Perkin and Robinson (*J.*, 1908, **93**, 498) formulated *O*-trimethylbrazilone as (III), a constitution which explains the majority of the remarkable reactions of this compound. These authors also suggested that the primary oxidation product of *O*-trimethylbrazilin was the diketone (II) which immediately undergoes an intramolecular aldol condensation giving (III), and from an examination of the properties and reactions of α-anhydro-*O*-trimethylbrazilone they concluded that it was a β-naphthol derivative (IV) (*loc. cit.*; *J.*, 1909, **95**, 381).



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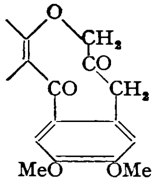

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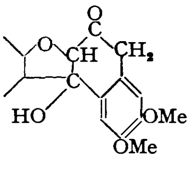

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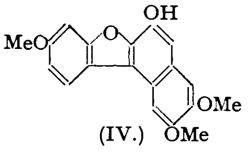

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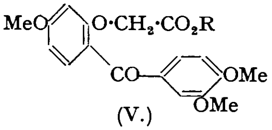

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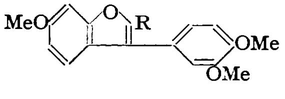

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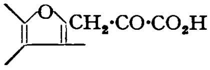

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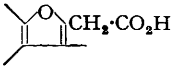

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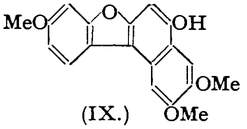


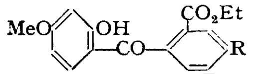
(IX.)

For the synthesis of α-anhydro-*O*-trimethylbrazilone (IV) there appeared to be two promising routes, *viz.*, the preparation and cyclisation (*a*) of the diazo-ketone (VI; R = $CO{\cdot}CHN_2$) according to the method of Cook and Schoental (*J.*, 1945, 288) and (*b*) of the acid (XIII; R = OMe) which from the established reactivity of the α-position of the coumarone residue would be expected to give (IV) (Robertson *et al.*, Part VII, *J.*, 1948, 2254; Part X, *J.*, 1949, 2057). Naphtho(2′ : 1′-2 : 3)coumarone derivatives of the α-anhydrobrazilone type do not appear to have been synthesised and, before proceeding to the synthesis of (IV), exploratory experiments on the preparation of typical 3-phenylcoumarone-2-acetic acids and their conversion into α-naphthol derivatives analogous to (IV) were carried out.

Ethyl 5-methoxy-2-veratroylphenoxyacetate (V; R = Et) was prepared from 2-hydroxy-4 : 3′ : 4′-trimethoxybenzophenone and ethyl bromoacetate by the potassium carbonate–acetone method, and gave on hydrolysis the acid (V; R = H) which was cyclised with sodium acetate and hot acetic anhydride to 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone (VI; R = H). 3-(3 : 4-Dimethoxyphenyl)-2-formyl-6-methoxycoumarone (VI; R = CHO) was obtained from (VI; R = H) by Gattermann's method, and its orientation established by oxidation with potassium permanganate in acetone to 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-carboxylic acid (VI; $R = CO_2H$), identical with a specimen prepared by the hydrolysis of the ester (VI; $R = CO_2Et$) which was formed by the cyclisation of (V; R = Et) with alcoholic sodium ethoxide. Condensation of the aldehyde (VI; R = CHO) with hippuric acid in the usual manner gave the azlactone, and on hydrolysis this compound yielded 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-pyruvic acid (VII) which was oxidised with alkaline hydrogen peroxide, giving 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-acetic acid (VIII). Attempts to cyclise the acid (VIII) to 4′-hydroxy-6 : 6′ : 7′-trimethoxynaphtho(2′ : 1′-2 : 3)-coumarone (IX) by sulphuric acid or by an intramolecular Friedel–Crafts reaction on the acid chloride with aluminium chloride in nitrobenzene were unsuccessful but treatment with phosphoric oxide in boiling benzene gave the naphthol in small yield.

From the requisite benzophenones, 4′-hydroxy-6 : 7′- and -6 : 6′-dimethoxynaphtho(2′ : 1′-2 : 3)coumarone were prepared by the same general method; however, in the synthesis of the last-mentioned compound hydrolysis of the azlactone obtained from 2-formyl-6-methoxy-3-*m*-methoxyphenylcoumarone gave a poor yield of the pyruvic acid, and the required acetic acid was prepared in quantity by way of its amide from 6-methoxy-3-*m*-methoxyphenylcoumarone-2-carboxylic acid, according to the procedure of Arndt and Eistert. The 4′-hydroxynaphtho-(2′ : 1′-2 : 3)coumarones resemble α-anhydro-*O*-trimethylbrazilone (IV) in readily forming azo-dyes with diazonium chlorides but can be readily distinguished from it by their failure to give the striking blue colour with warm alcoholic potassium hydroxide containing a little chloroform, characteristic of (IV) as well as of (XIV).

The well-crystallised diazo-ketone (VI; $R = CO{\cdot}CHN_2$) was prepared from 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-carboxylic acid in the usual manner but our attempts to induce this compound to undergo the Cook–Schoental cyclisation (*loc. cit.*) and thus give α-anhydro-*O*-trimethylbrazilone were unsuccessful. The alternative route to the last-mentioned compound was therefore explored.



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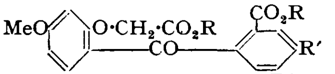
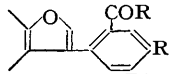
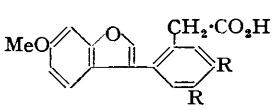


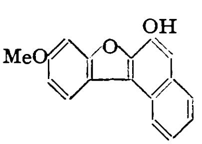
(XI.)



(XII.)

(XIII.)





(XIV.)

Before we attempted the synthesis of the intermediate acid (XIII; R = OMe) which on cyclisation would be expected to give α-anhydro-*O*-trimethylbrazilone, model experiments were carried out with (XIII; R = H). 2-*o*-Carboxybenzoyl-5-methoxyphenoxyacetic acid (XI; R = R′ = H) was prepared by the interaction of 2′-carbethoxy-2-hydroxy-4-methoxybenzophenone (X; R = H) with ethyl bromoacetate and potassium carbonate in boiling acetone, followed by hydrolysis of the resulting ester (XI; R = Et, R′ = H) and, on treatment with boiling acetic anhydride containing sodium acetate, this acid was converted into 3-*o*-carboxyphenyl-6-methoxycoumarone (XII; R = OH, R′ = H). With diazomethane the acid chloride of (XII; R = OH, R′ = H) gave the diazo-ketone (XII; $R = CHN_2$, R′ = H) from which the 2′-acetic acid (XIII; R = H) was prepared by way of the amide (Arndt–Eistert). On cyclisation with sulphuric acid (XIII; R = H) yielded 3′-hydroxy-6-methoxynaphtho(2′ : 1′-2 : 3)coumarone, the properties of which closely resemble those of α-anhydro-*O*-

trimethylbrazilone. Similarly, brazilinic acid has been prepared by a new route from 2′-carbethoxy-2-hydroxy-4 : 4′ : 5′-trimethoxybenzophenone (X; R = OMe) (cf. Perkin and Robinson, *loc. cit.*; Rây *et al.*, *J. Indian Chem. Soc.*, 1933, **10**, 617), and on treatment with boiling acetic anhydride and potassium acetate gave 3-(2′-carboxy-4′ : 5′-dimethoxyphenyl)-6-methoxycoumarone (XII; R = OH, R′ = OMe) from which the acetic acid (XIII; R = OMe) was prepared by way of the diazo-ketone (XII; R = CHN_2, R′ = OMe). When cyclised with sulphuric acid, the acid (XIII; R = OMe) furnished 3′-hydroxy-6 : 6′ : 7′-trimethoxynaphtho(2′ : 1′-2 : 3)coumarone, the properties and derivatives of which were identical with those of α-anhydro-*O*-trimethylbrazilone from natural sources.

EXPERIMENTAL.

2 : 4-*Dihydroxy*-3′ : 4′-*dimethoxybenzophenone*.—Attempts to prepare this compound by the condensation of veratronitrile and resorcinol by the method of Hoesch were unsuccessful. It was obtained by the following methods.

(*a*) An intimate mixture of resorcinol (2 g.), veratric acid (3 g.), and powdered zinc chloride (3 g.) was heated at 160° (oil-bath) for 7 minutes, cooled, and treated with hot water (50 ml.). Crystallisation of the orange residue from dilute alcohol gave 2 : 4-*dihydroxy*-3′ : 4′-*dimethoxybenzophenone* in pale yellow rhombic plates (1·1 g.), m. p. 177°, having a red-brown ferric reaction in alcohol (Found : C, 65·8; H, 5·0. $C_{15}H_{14}O_5$ requires C, 65·7; H, 5·1%). This ketone was readily soluble in acetone and almost insoluble in benzene.

(*b*) Aluminium chloride (16 g.) was added gradually to a mixture of resorcinol (9 g.), veratroyl chloride (16 g.), and nitrobenzene (120 ml.) during 30 minutes, and 3 days later the reaction mixture was poured on ice (100 g.) and hydrochloric acid (200 ml.). After the removal of the nitrobenzene with steam the residual solid was triturated with aqueous sodium hydrogen carbonate, washed with water and then with cold methanol (100 ml.) to remove tarry impurities, and crystallised from dilute methanol, giving 2 : 4-dihydroxy-3′ : 4′-dimethoxybenzophenone in pale yellow rhombic plates (13—14 g.), m. p. and mixed m. p. 177°.

Methylation of this ketone (10 g.) with methyl iodide (2·7 ml.) and potassium carbonate (15 g.) in boiling acetone (100 ml.) during 1½ hours gave 2-hydroxy-4 : 3′ : 4′-trimethoxybenzophenone which formed clusters of pale yellow needles (9·4 g.), m. p. 140°, from carbon tetrachloride, having a red-brown ferric reaction in alcohol (Found : C, 66·2; H, 5·8. Calc. for $C_{16}H_{16}O_5$: C, 66·7; H, 5·6%) (compare Appel *et al.*, *J.*, 1937, 738, and Rây *et al.*, *loc. cit.*). The 2 : 4-*dinitrophenylhydrazone* separated from ethyl acetate in deep-red prisms, m. p. 231° (Found : N, 12·0. $C_{22}H_{20}O_8N_4$ requires N, 11·9%).

5-*Methoxy*-2-*veratroylphenoxyacetic Acid* (V; R = H).—A mixture of 2-hydroxy-4 : 3′ : 4′-trimethoxybenzophenone (25 g.), ethyl bromoacetate (16 ml.), potassium carbonate (70 g.), and acetone (300 ml.) was heated under reflux for 8 hours. On isolation the resulting *ethyl* 5-*methoxy*-2-*veratroylphenoxyacetate* (V; R = Et) crystallised from dilute alcohol in colourless needles (31 g.), m. p. 80°, having a negative ferric reaction (Found : C, 63·8; H, 5·9. $C_{20}H_{22}O_7$ requires C, 64·2; H, 5·9%). This compound was readily soluble in alcohol, methanol, benzene, or ethyl acetate and sparingly soluble in light petroleum.

A solution of this ester (32 g.) and potassium hydroxide (30 g.) in alcohol (150 ml.) containing water (100 ml.) was heated under reflux for ½ hour, the greater part of the alcohol was removed in a vacuum, the residue was diluted with water (500 ml.), and the resulting *acid* precipitated with dilute hydrochloric acid. Crystallised from ethyl acetate–light petroleum (b. p. 60—80°), this acid formed clusters of colourless needles (27 g.), m. p. 149°, readily soluble in alcohol, acetic acid, or ethyl acetate (Found : C, 62·3; H, 5·3. $C_{18}H_{18}O_7$ requires C, 62·4; H, 5·2%).

3-(3 : 4-*Dimethoxyphenyl*)-6-*methoxycoumarone* (VI; R = H).—A mixture of 5-methoxy-2-veratroylphenoxyacetic acid (6 g.), sodium acetate (12 g.), and acetic anhydride (60 ml.) was heated at 150—160° (oil-bath) for ½ hour and poured into water (600 ml.). Next day the solid was collected, well washed with aqueous sodium hydrogen carbonate, and crystallised from dilute acetic acid (charcoal), yielding 3-(3 : 4-*dimethoxyphenyl*)-6-*methoxycoumarone* in colourless plates (4·2 g.), m. p. 74°, which gave a bright red colour with concentrated sulphuric acid (Found : C, 71·4; H, 5·5. $C_{17}H_{16}O_4$ requires C, 71·8; H, 5·6%). This compound is easily soluble in the usual organic solvents except light petroleum.

3-(3 : 4-*Dimethoxyphenyl*)-2-*formyl*-6-*methoxycoumarone* (VI; R = CHO).—A solution of 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone (5 g.) and hydrogen cyanide (7 ml.) in ether (150 ml.) containing zinc chloride (2 g.) was saturated with hydrogen chloride at 0° and next day the product, which had separated in orange-yellow needles, was washed with ether and hydrolysed with water (250 ml.) on the steam-bath for 25 minutes. On isolation from the cooled hydrolysate the resulting *aldehyde* formed pale yellow needles (5 g.), m. p. 158°, from alcohol (Found : C, 69·3; H, 5·1. $C_{18}H_{16}O_5$ requires C, 69·2; H, 5·1%). On being diluted with water the bright red solution of this compound in warm concentrated sulphuric acid became green and then bright blue. The 2 : 4-*dinitrophenylhydrazone* separated from nitrobenzene–alcohol in crimson needles, m. p. 260° after sintering at 255° (Found : N, 11·3. $C_{24}H_{20}O_8N_4$ requires N, 11·4%).

3-(3 : 4-*Dimethoxyphenyl*)-6-*methoxycoumarone*-2-*carboxylic Acid* (VI; R = CO_2H).—(*a*) A solution of ethyl 5-methoxy-2-veratroylphenoxyacetate (14·1 g.) and sodium ethoxide (from 1·15 g. of sodium) in absolute alcohol (90 ml.) was heated under reflux for 1 hour and then treated with water (800 ml.). Next day the resulting *ethyl* 3-(3 : 4-*dimethoxyphenyl*)-6-*methoxycoumarone*-2-*carboxylate* (VI; R = CO_2Et) was isolated and purified from dilute alcohol, forming elongated, pale yellow needles (5·8 g.), m. p. 134°, having a bright red sulphuric acid reaction (Found : C, 67·2; H, 5·7. $C_{20}H_{20}O_6$ requires C, 67·5; H, 5·6%).

On being acidified with dilute hydrochloric acid the alkaline liquors left after the separation of the crude ester deposited a solid which, on crystallisation from acetic acid, gave 3-(3 : *4-dimethoxyphenyl*)-6-*methoxycoumarone*-2-*carboxylic acid* in colourless prismatic needles (1·5 g.), m. p. 204° (decomp.) (Found : C, 65·9; H, 5·1. $C_{18}H_{16}O_6$ requires C, 65·9; H, 4·9%), identical with a specimen (6·5 g.) prepared by the hydrolysis of the foregoing ethyl ester (8 g.) with a boiling solution of potassium hydroxide (10 g.) in water (80 ml.) and alcohol (120 ml.) during ½ hour. This compound, which is soluble in alcohol, ethyl acetate, or acetone and almost insoluble in benzene, gave a red colour with cold sulphuric acid changing to deep violet in warm acid.

From the acetic acid liquors left from the purification of the crude 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-carboxylic acid mixture, 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone (1·8 g.) and 5-methoxy-2-veratroylphenoxyacetic acid (1·3 g.) were isolated and separated by fractional crystallisation from dilute acetic acid.

(*b*) A solution of potassium permanganate (1 g.) in water (20 ml.) at 50° was gradually added during ½ hour to 3-(3 : 4-dimethoxyphenyl)-2-formyl-6-methoxycoumarone (0·4 g.), dissolved in acetone (20 ml.), and 1 hour later the mixture was cooled, cleared with sulphur dioxide, and diluted with water, giving a precipitate of 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-carboxylic acid which formed colourless prismatic needles, m. p. and mixed m. p. 204° (decomp.), from acetic acid.

On treatment with phosphorus pentachloride (2·6 g.) in chloroform (130 ml.) for ½ hour at room temperature and then at 50° for 10 minutes, this acid (4 g.) was converted into the acid chloride which was left as a light-green solid after the evaporation of the solvent and phosphoryl chloride in a vacuum. A suspension of this product in ether (100 ml.) was slowly added to ethereal diazomethane (from 20·6 g. of nitrosomethylurea and 250 ml. of ether) at 0°, the mixture was kept at room temperature for 48 hours, and the resulting crystalline *diazo-ketone* was isolated and recrystallised from benzene–light petroleum (b. p. 40—60°), forming yellow prisms (2·4 g.), m. p. 159° (decomp.) (Found : N, 7·5. $C_{19}H_{16}O_5N_2$ requires N, 8·0%). A further 0·4 g. of less pure product was obtained by evaporation of the ethereal liquor in a vacuum.

3-(3 : 4-*Dimethoxyphenyl*)-6-*methoxycoumarone*-2-*acetic Acid* (VIII).—An intimate mixture of 3-(3 : 4-dimethoxyphenyl)-2-formyl-6-methoxycoumarone (10 g.), hippuric acid (6 g.), sodium acetate (5 g.), and acetic anhydride (50 ml.) was heated on the steam-bath for 15 minutes, cooled, and treated with 50% alcohol (200 ml.). ½ Hour later the resulting *azlactone* was collected, well washed with cold 95% alcohol, and crystallised from benzene, forming small brilliant red needles (13·9 g.), m. p. 219° (Found : N, 3·4. $C_{27}H_{21}O_6N$ requires N, 3·1%). This compound (10 g.) was hydrolysed with boiling 10% aqueous sodium hydroxide (180 ml.) for 5 hours and the orange-brown hydrolysate cooled, diluted with water (120 ml.), and saturated with sulphur dioxide at room temperature. Next day the precipitate of benzoic acid was removed and the aqueous liquor mixed with concentrated hydrochloric acid (50 ml.) and heated on the steam-bath for 2 hours. On cooling, the reaction mixture deposited 3-(3 : 4-*dimethoxyphenyl*)-6-*methoxycoumarone*-2-*pyruvic acid* (VII) which separated from dilute methanol as a *hydrate* in tiny yellow needles (5 g.), m. p. 195—196° (decomp.), having a violet ferric reaction in alcohol (Found : C, 62·3; H, 5·1. $C_{20}H_{18}O_7,H_2O$ requires C, 61·9; H, 5·2. Found, in a specimen dried in a high vacuum at 100° : C, 64·8; H, 4·9. $C_{20}H_{18}O_7$ requires C, 64·9; H, 4·9%). The *oxime* of this pyruvic acid formed clusters of colourless needles, m. p. 146°, from dilute methanol (Found : N, 3·5. $C_{20}H_{19}O_7N$ requires N, 3·6%).

10% Hydrogen peroxide (15 ml.) was added dropwise to a stirred solution of 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-pyruvic acid (5 g.) in 5% aqueous sodium hydroxide (100 ml.) maintained at 0° and the mixture then kept at room temperature for 20 minutes, cooled to 0°, and acidified with dilute hydrochloric acid, giving a precipitate of 3-(3 : *4-dimethoxyphenyl*)-6-*methoxycoumarone*-2-*acetic acid* (VIII) which crystallised from dilute alcohol (charcoal) in almost colourless needles (3·5 g.), m. p. 178°, and had a deep-red sulphuric acid reaction. Sublimation of this material at 170°/0·2 mm. gave the colourless acid, m. p. 178° (Found : C, 66·3; H, 5·3. $C_{19}H_{18}O_6$ requires C, 66·7; H, 5·3%). It is readily soluble in alcohol, acetone, ethyl acetate, benzene, or chloroform and insoluble in light petroleum. Treatment of the compound (3·3 g.) with phosphorus pentachloride (2·1 g.) in chloroform (150 ml.) at room temperature with subsequent removal of the solvent and phosphoryl chloride in a vacuum gave the acid chloride which reacted with ammonia to give the *amide*, forming colourless prismatic needles, m. p. 190°, from dilute alcohol (Found : N, 4·2. $C_{19}H_{19}O_5N$ requires N, 4·1%).

4′-*Hydroxy*-6 : 6′ : 7′-*trimethoxynaphtho*(2′ : 1′-2 : 3)*coumarone* (IX).—Phosphoric oxide (5 g.) was added portion-wise to a solution of 3-(3 : 4-dimethoxyphenyl)-6-methoxycoumarone-2-acetic acid (1 g.) in hot benzene (30 ml.) during 3 minutes and the mixture then heated under reflux for 3 hours, cooled, treated with ice (150 g.), and extracted with ether (150 ml. × 3). After having been washed with aqueous sodium hydrogen carbonate and then water, the combined extracts were dried and evaporated, leaving 4′-*hydroxy*-6 : 6′ : 7′-*trimethoxynaphtho*(2′ : 1′-2 : 3)*coumarone* as a pale brown crystalline solid. Recrystallised from ethyl acetate, this compound was obtained in almost colourless prisms (0·25 g.), m. p. 195—196°, soluble in warm benzene or ethyl acetate, sparingly soluble in hot alcohol, and giving a deep-red and a green colour respectively with cold and warm concentrated sulphuric acid (Found : C, 70·2; H, 5·1. $C_{19}H_{16}O_5$ requires C, 70·4; H, 4·9%). In alkaline solution the naphthol readily reacted with benzene- and with α-naphthalene-diazonium chloride to give red azo-dyes. The p-*nitrobenzoate* crystallised from acetic acid in clusters of yellow, elongated rectangular plates, m. p. 193° (Found : N, 3·1. $C_{26}H_{19}O_8N$ requires N, 3·0%).

2-*Hydroxy*-4 : 4′-*dimethoxybenzophenone*.—2 : 4-Dihydroxy-4′-methoxybenzophenone was prepared by the condensation of resorcinol (16 g.) and anisoyl chloride (25 g.) with aluminium chloride (27 g.) in nitrobenzene (250 ml.) during 48 hours and, on isolation in the usual manner, crystallised from dilute alcohol in pale yellow needles (26 g.), m. p. 160°, identical with a specimen, m. p. 160°, obtained in poor yield by the method of Komarowsky and Kostanecki (*Ber.*, 1894, **27**, 2000) who, however, give m. p. 165°. The ketone had an intense red-brown ferric reaction in alcohol. The 2 : 4-*dinitrophenylhydrazone* separated from ethyl acetate–light petroleum in small orange-red prisms, m. p. 264—265° (Found : N, 13·6. $C_{20}H_{16}O_7N_4$ requires N, 13·2%).

Methyl iodide (5·5 ml.) was added portion-wise to a solution of 2 : 4-dihydroxy-4′-methoxybenzophenone (20 g.) and potassium carbonate (30 g.) in boiling acetone (120 ml.) during 1 hour and the mixture then heated under reflux for 45 minutes. On isolation, the resulting 2-*hydroxy*-4 : 4′-*dimethoxybenzophenone* formed very pale yellow needles (18·7 g.), m. p. 118°, from light petroleum (b. p. 80—100°) or dilute acetone, having an intense red-brown ferric reaction in alcohol (Found : C, 69·4; H, 5·4. $C_{15}H_{14}O_4$ requires C, 69·8; H, 5·4%). The 2 : 4-*dinitrophenylhydrazone* separated from ethyl acetate in deep-red prisms, m. p. 238° (Found : N, 13·2. $C_{21}H_{18}O_7N_4$ requires N, 12·8%).

2-*Anisoyl*-5-*methoxyphenoxyacetic Acid.*—The interaction of 2-hydroxy-4 : 4′-dimethoxybenzophenone (10 g.) and ethyl bromoacetate (8 ml.) in boiling acetone containing potassium carbonate (25 g.) in the course of 6 hours gave rise to *ethyl* 2-*anisoyl*-5-*methoxyphenoxyacetate* which crystallised from light petroleum (b. p. 60—80°) or dilute alcohol in long colourless needles (12·2 g.), m. p. 80°, having a negative ferric reaction in alcohol (Found : C, 66·5; H, 5·9. $C_{19}H_{20}O_6$ requires C, 66·3; H, 5·8%). On hydrolysis with a boiling solution of potassium hydroxide (20 g.) in methanol (100 ml.) and water (60 ml.) during 30 minutes, followed by removal of the greater part of the methanol in a vacuum and acidification of the cooled residue with dilute hydrochloric acid, this ester (33 g.) gave rise to 2-*anisoyl*-5-*methoxyphenoxyacetic acid* which formed colourless needles (27 g.), m. p. 139°, from dilute alcohol or benzene–light petroleum (b. p. 60—80°) (Found : C, 64·4; H, 4·8. $C_{17}H_{16}O_6$ requires C, 64·6; H, 5·1%).

6-*Methoxy*-3-p-*methoxyphenylcoumarone.*—A mixture of 2-anisoyl-5-methoxyphenoxyacetic acid (10 g.), sodium acetate (20 g.), and acetic anhydride (100 ml.) was heated at 160° for ½ hour and poured into water (500 ml.). Next day the solid was collected, thoroughly triturated with aqueous sodium hydrogen carbonate, and crystallised from dilute acetic acid (charcoal), giving 6-*methoxy*-3-p-*methoxyphenylcoumarone* in long colourless needles (6·3 g.), m. p. 60°, having a red-brown sulphuric acid reaction (Found : C, 75·4; H, 5·7. $C_{16}H_{14}O_3$ requires C, 75·6; H, 5·5%).

2-*Formyl*-6-*methoxy*-3-p-*methoxyphenylcoumarone.*—Prepared by the interaction of 6-methoxy-3-*p*-methoxyphenylcoumarone (5 g.), hydrogen cyanide (7·5 ml.), and zinc chloride (2 g.) in ether (100 ml.), saturated at 0° with hydrogen chloride, the crystalline aldimine derivative was hydrolysed with water (200 ml.) on the steam-bath for ½ hour, giving 2-*formyl*-6-*methoxy*-3-p-*methoxyphenylcoumarone* which separated from alcohol in colourless needles (5 g.), m. p. 167° (Found : C, 72·5; H, 5·0. $C_{17}H_{14}O_4$ requires C, 72·3; H, 5·0%). The brown-red solution of this aldehyde in concentrated sulphuric acid rapidly changed to yellow-green and on being warmed and diluted with water it then became green and then deep blue. The 2 : 4-*dinitrophenylhydrazone* formed dull red needles, m. p. 255° after sintering at 230°, from nitrobenzene–alcohol (Found : N, 12·0. $C_{23}H_{18}O_7N_4$ requires N, 12·1%).

6-*Methoxy*-3-p-*methoxyphenylcoumarone*-2-*carboxylic Acid.*—(*a*) Cyclisation of ethyl 2-anisoyl-5-methoxyphenoxyacetate (5 g.) with sodium ethoxide (from 0·4 g. of sodium) in boiling alcohol (50 ml.) during 1 hour followed by dilution of the reaction mixture with water (300 ml.) gave *ethyl* 6-*methoxy*-3-p-*methoxyphenylcoumarone*-2-*carboxylate* which separated from alcohol in long colourless needles (1·4 g.), m. p. 98°, having a reddish-orange sulphuric acid reaction (Found : C, 69·7; H, 5·8. $C_{19}H_{18}O_5$ requires C, 70·0; H, 5·5%). On hydrolysis with boiling 5% aqueous-methanolic potassium hydroxide (10 ml.) for ½ hour this ester (0·3 g.) gave rise to 6-*methoxy*-3-p-*methoxyphenylcoumarone*-2-*carboxylic acid*, forming colourless needles (0·2 g.), m. p. 223° (decomp.), from ethyl acetate (Found : C, 68·6; H, 4·8. $C_{17}H_{14}O_5$ requires C, 68·5; H, 4·7%). A mixture of this acid (0·5 g.), m. p. and mixed m. p. 223° (decomp.), and 6-methoxy-3-*p*-methoxyphenylcoumarone (1·1 g.) was obtained by the addition of an excess of dilute hydrochloric acid to the alkaline filtrate from the crude ester. The compounds were separated by fractional crystallisation from alcohol and ethyl acetate.

(*b*) A mixture of 2-formyl-6-methoxy-3-*p*-methoxyphenylcoumarone (0·5 g.), 30% hydrogen peroxide (5 ml.), 5% aqueous sodium hydroxide (10 ml.), and acetone (50 ml.) was kept at 40° for 75 minutes with the addition of more 30% hydrogen peroxide (5 ml.) after 1 hour. After the removal of the acetone, the cooled reaction mixture was diluted with water (50 ml.), filtered to remove a little tarry material, and acidified with dilute hydrochloric acid, giving a precipitate of 6-methoxy-3-*p*-methoxyphenylcoumarone-2-carboxylic acid, m. p. and mixed m. p. 223° (decomp.) after purification.

6-*Methoxy*-3-p-*methoxyphenylcoumarone*-2-*acetic Acid.*—An intimate mixture of 2-formyl-6-methoxy-3-*p*-methoxyphenylcoumarone (10 g.), hippuric acid (6·5 g.), sodium acetate (3 g.), and acetic anhydride (50 ml.) was heated on the steam-bath for 20 minutes, cooled, and treated with 50% alcohol (100 ml.). ½ Hour later the *azlactone* was collected and crystallised from benzene, forming bright orange needles (12·4 g.), m. p. 226° (Found : N, 3·4. $C_{26}H_{19}O_5N$ requires N, 3·3%). This compound (10 g.) was hydrolysed with boiling 10% aqueous potassium hydroxide (150 ml.) for 5½ hours and the resulting 6-*methoxy*-3-p-*methoxyphenylcoumarone*-2-*pyruvic acid* isolated by the sulphur dioxide method and crystallised from dilute acetic acid, forming pale yellow, elongated rectangular prisms (7 g.), m. p. 225—226° (decomp.), which gave a violet ferric reaction in alcohol (Found : C, 66·7; H, 4·8. $C_{19}H_{16}O_6$ requires C, 67·1; H, 4·7%). The *oxime* separated from ethyl acetate–light petroleum (b. p. 60—80°) in small colourless rods, m. p. 164° (decomp.) (Found : N, 4·0. $C_{19}H_{17}O_6N$ requires N, 3·9%).

Oxidation of this pyruvic acid (5 g.), dissolved in 5% aqueous sodium hydroxide (100 ml.), with 30% hydrogen peroxide (10 ml., added during 15 minutes) at room temperature, followed by acidification of the solution with dilute hydrochloric acid gave 6-*methoxy*-3-p-*methoxyphenylcoumarone*-2-*acetic acid* which separated from dilute alcohol and then benzene–light petroleum (b. p. 60—80°) in almost colourless needles (3·7 g.), m. p. 169—170°, having a deep orange-brown sulphuric acid reaction (Found : C, 69·2; H, 5·1. $C_{18}H_{16}O_5$ requires C, 69·2; H, 5·1%). It is readily soluble in ethyl acetate or acetone and moderately soluble in methanol, acetic acid, or benzene. Interaction of the acid with a molecular proportion of phosphorus pentachloride in chloroform furnished the acid chloride as a solid which on treatment with ammonia yielded the *amide*, forming tiny colourless prisms, m. p. 210°, from benzene–light petroleum (b. p. 60—80°) (Found : N, 4·8. $C_{18}H_{17}O_4N$ requires N, 4·5%).

*4′-Hydroxy-*6 : *6′-dimethoxynaphtho*(*2′* : *1′-*2 : 3)*coumarone.*—Cyclisation of 6-methoxy-3-*p*-methoxyphenylcoumarone-2-acetic acid (0·8 g.) with phosphoric oxide (4 g.) in boiling benzene (20 ml.) during 5 hours and subsequent treatment of the reaction mixture with ice (200 g.), gave the desired *naphthol* which was isolated with chloroform and crystallised from acetic acid, forming colourless tiny needles (0·2 g.), m. p. 179—180° and giving a deep-red and a green colour with cold and warm concentrated sulphuric acid respectively (Found : C, 73·4; H, 4·9. $C_{18}H_{14}O_4$ requires C, 73·5; H, 4·8%). In alkaline solution this naphthol gave red azo-dyes with benzene- and α-naphthalene-diazonium chloride.

2-*Hydroxy-*4 : 3′*-dimethoxybenzophenone.*—A mixture of resorcinol (9 g.), *m*-anisoyl chloride (13 g.), aluminium chloride (15 g.), and nitrobenzene (120 ml.) was kept at room temperature for 48 hours, and then treated with ice (100 g.) and concentrated hydrochloric acid (200 ml.). After the removal of the nitrobenzene with steam 2 : 4*-dihydroxy-*3′*-methoxybenzophenone* remained in the acidic liquor as a solid and, on crystallisation from dilute alcohol, formed pale yellow, elongated rectangular prisms (16 g.), m. p. 176°, having a red-brown ferric reaction (Found : C, 69·2; H, 5·0. $C_{14}H_{12}O_4$ requires C, 68·9; H, 4·9%). The condensation of *m*-anisic acid (5 g.) and resorcinol (4 g.) with zinc chloride (5 g.) at 160° for 10 minutes, according to the method of Nencki, gave a poor yield of the same benzophenone (0·3 g.), m. p. and mixed m. p. 176°, after purification. The 2 : 4*-dinitrophenylhydrazone* separated from ethyl acetate in masses of orange prisms, m. p. 285—287° (Found : N, 13·1. $C_{20}H_{16}O_7N_4$ requires N, 13·2%).

A solution of methyl iodide (9 ml.) was added dropwise in the course of 1 hour to a boiling solution of the ketone (30 g.) in acetone (200 ml.) containing potassium carbonate (45 g.), and the mixture then heated under reflux for 1 hour. On isolation the resulting 2*-hydroxy-*4 : 3′*-dimethoxybenzophenone* crystallised from methanol in cream needles (22 g.), m. p. 66°, having a red-brown ferric reaction (Found : C, 69·8; H, 5·7. $C_{15}H_{14}O_4$ requires C, 69·8; H, 5·4%). This compound is readily soluble in acetone, ethyl acetate, benzene, or carbon tetrachloride and sparingly soluble in boiling light petroleum. The 2 : 4*-dinitrophenylhydrazone* formed clusters of brilliant red, tiny, elongated prims, m. p. 204°, from ethyl acetate (Found : N, 12·6. $C_{21}H_{18}O_7N_4$ requires N, 12·8%).

2-m-*Anisoyl-*5*-methoxyphenoxyacetic Acid.*—The interaction of 2-hydroxy-4 : 3′-dimethoxybenzophenone (20 g.) and ethyl bromoacetate (16 ml.) in boiling acetone (200 ml.) containing potassium carbonate (50 g.) during 5 hours gave rise to *ethyl* 2-m-*anisoyl-*5*-methoxyphenoxyacetate*, forming colourless irregular prisms (24 g.), m. p. 76°, from dilute methanol, soluble in the usual organic solvents except light petroleum (Found : C, 66·6; H, 6·0. $C_{19}H_{20}O_6$ requires C, 66·3; H, 5·8%). On hydrolysis with 10% aqueous-methanolic potassium hydroxide (20 ml.) during ½ hour this ester (4·5 g.) yielded the corresponding *acid* which separated from ethyl acetate–light petroleum (b. p. 60—80°) in long needles (4 g.), m. p. 80—81°, easily soluble in alcohol, acetone, or ethyl acetate and sparingly soluble in warm water (Found : C, 64·5; H, 5·2. $C_{17}H_{16}O_6$ requires C, 64·6; H, 5·1%).

6-*Methoxy-*3-m-*methoxyphenylcoumarone.*—Cyclisation of the foregoing phenoxyacetic acid (6 g.) with acetic anhydride (60 ml.) and sodium acetate (12 g.) at 150° for ½ hour gave rise to 6-*methoxy-*3-m-*methoxyphenylcoumarone* which crystallised from methanol in long, colourless needles (4 g.), m. p. 55°, having a yellow orange sulphuric acid reaction (Found : C, 75·8; H, 5·7. $C_{16}H_{14}O_3$ requires C, 75·6; H, 5·5%).

Prepared from this coumarone (5 g.), hydrogen cyanide (7 ml.) and zinc chloride (2 g.) in ether (70 ml.) saturated with hydrogen chloride during 24 hours, the crystalline aldimine complex was hydrolysed with water (250 ml.) on the steam-bath for ½ hour, giving 2*-formyl-*6*-methoxy-*3-m-*methoxyphenylcoumarone* which formed yellow irregular prisms (4·1 g.), m. p. 92°, from alcohol (Found : C, 72·0; H, 4·8. $C_{17}H_{14}O_4$ requires C, 72·3; H, 5·0%). The yellow solution of this compound in concentrated sulphuric acid became darker on warming and then on dilution with water changed to blue-green. The 2 : 4*-dinitrophenylhydrazone* separated from acetic acid in dull red needles, m. p. 226—227° after sintering at 220° (Found : N, 12·0. $C_{23}H_{18}O_7N_4$ requires N, 12·1%).

6-*Methoxy-*3-m-*methoxyphenylcoumarone-*2*-acetic Acid.*—(*a*) A mixture of the aforementioned aldehyde (3 g.), hippuric acid (2 g.), sodium acetate (1 g.), and acetic anhydride (20 ml.) was heated on the steam-bath for ½ hour, cooled, and diluted with 50% alcohol (80 ml.). Crystallised from benzene, the resulting *azlactone* formed small, bright orange, rectangular prisms (3·3 g.), m. p. 226° (Found : N, 3·6. $C_{26}H_{19}O_5N$ requires N, 3·3%). On hydrolysis with boiling 10% aqueous sodium hydroxide (120 ml.) for 5½ hours this compound (9 g.) gave 6-*methoxy-*3-m-*methoxyphenylcoumarone-*2*-pyruvic acid* which was isolated by the sulphur dioxide method and crystallised from ethyl acetate–light petroleum (b. p. 60—80°), forming yellow prisms (1 g.), m. p. 170—172° (decomp.), and giving a violet ferric reaction in alcohol (Found : C, 66·9; H, 4·5. $C_{19}H_{16}O_6$ requires C, 67·1; H, 4·7%). Oxidation of the pyruvic acid (0·1 g.), dissolved in 5% sodium hydroxide (5 ml.), with 10% hydrogen peroxide (5 ml.) at room temperature in the course of 1 hour furnished 6-*methoxy-*3-m-*methoxyphenylcoumarone-*2*-acetic acid* which separated from light petroleum (b. p. 80—100°) in colourless needles, m. p. 141—142° (Found : C, 69·2; H, 5·1. $C_{18}H_{16}O_5$ requires C, 69·2; H, 5·1%). On being warmed the deep-yellow solution of the acid in concentrated sulphuric acid became deep green.

(*b*) A mixture of ethyl 2-*m*-anisoyl-5-methoxyphenoxyacetate (18 g.), alcohol (100 ml.), and sodium ethoxide (from 1·4 g. of sodium) was heated under reflux for 45 minutes and diluted with water (400 ml.). Next day 6-*methoxy-*3-m-*methoxyphenylcoumarone-*2*-carboxylic acid* was precipitated from the solution with dilute hydrochloric acid and crystallised from benzene, forming small, colourless prisms (7·5 g.),

m. p. 192° (decomp.), which with concentrated sulphuric acid gave a deep yellow colour which changed to a deep green on warming (Found : C, 68·2; H, 4·6. $C_{17}H_{14}O_5$ requires C, 68·5; H, 4·7%). This acid (5 g.) was converted into the acid chloride by means of phosphorus pentachloride (3·7 g.) in chloroform (100 ml.) and, after the removal of the solvent and phosphoryl chloride, the product was obtained as a solid which was immediately dissolved in benzene (50 ml.) and treated with an excess of ethereal diazomethane (from 20·6 g. of nitrosomethylurea) at 0°. Next day the solution was filtered to remove traces of solid, the solvents were removed in a vacuum, and the residual *diazo-ketone* recrystallised from benzene–light petroleum (b. p. 40—60°), forming yellow elongated prisms, m. p. 124—126° (decomp.) (Found : N, 8·4. $C_{18}H_{14}O_4N_2$ requires N, 8·7%). A solution of the diazo-ketone in dioxan (100 ml.) was added drop-wise to a well-stirred mixture of 10% aqueous silver nitrate (40 ml.) and concentrated aqueous ammonia (25 ml.) kept at 70°. After having been kept at this temperature for 1 hour the reaction mixture was allowed to cool and next day *6-methoxy-3-*m*-methoxyphenylcoumarone-2-acetamide* was isolated from the reaction mixture with ether and crystallised from ethyl acetate–light petroleum (b. p. 60—80°) and then benzene, forming colourless needles (1·8 g.), m. p. 153°, readily soluble in alcohol, ethyl acetate, or chloroform (Found : N, 4·2. $C_{18}H_{17}O_4N$ requires N, 4·5%). This amide (1·5 g.) was hydrolysed with boiling 10% aqueous-alcoholic potassium hydroxide (15 ml.) during 9 hours and the cooled solution was diluted with water (100 ml.), extracted with ether to remove traces of non-acidic impurities, and acidified with hydrochloric acid, giving 6-methoxy-3-*m*-methoxyphenylcoumarone-2-acetic acid (1·3 g.), m. p. and mixed m. p. 141—142° after recrystallisation.

4′-Hydroxy-6 : 6′-dimethoxynaphtho(2′ : 1′-2 : 3)coumarone.—On being heated with phosphoric oxide (4 g.) in boiling benzene (30 ml.) during 3 hours 6-methoxy-3-*m*-methoxyphenylcoumarone-2-acetic acid (0·8 g.) gave rise to *4′-hydroxy-6 : 6′-dimethoxynaphtho(2′ : 1′-2 : 3)coumarone* which was isolated with ether and freed from traces of acidic material by means of aqueous sodium hydrogen carbonate. Recrystallised from benzene–light petroleum (b. p. 60—80°), this compound formed pale yellow, elongated prisms (0·3 g.), m. p. 158—159°, easily soluble in chloroform and moderately soluble in benzene, acetic acid, or warm alcohol (Found : C, 73·4; H, 4·8. $C_{18}H_{14}O_4$ requires C, 73·5; H, 4·8%). In alkaline solution the naphthol reacted with benzene- and α-naphthalene-diazonium chloride, forming red azo-dyes. With sulphuric acid it gave a deep-red and then a green colour.

2′-Carboxy-2-hydroxy-5-methoxybenzophenone.—Methyl iodide (7·5 ml.) was added during 1 hour to a boiling solution of 2′-carbethoxy-2 : 4-dihydroxybenzophenone (Desai and Figueredo, *Proc. Indian Acad. Sci.*, 1941, **14**, *A*, 605; Tambor, *Ber.*, 1910, **43**, 1882) (25 g.) in acetone (200 ml.) containing potassium carbonate (40 g.), and the mixture then heated under reflux for 1 hour. On isolation, *2′-carbethoxy-2-hydroxy-4-methoxybenzophenone* (X; R = H) crystallised from light petroleum (b. p. 80—100°) in yellow irregular prisms (23·8 g.), m. p. 100°, having a red-brown ferric reaction in alcohol (Found : C, 67·8; H, 5·2. $C_{17}H_{16}O_5$ requires C, 68·0; H, 5·3%). Hydrolysis of this compound with 10% aqueous methanolic potassium hydroxide for ½ hour gave rise to 2′-carboxy-2-hydroxy-4-methoxybenzophenone, m. p. 165°, identical with a specimen prepared by the method of Desai and Figueredo (*loc. cit.*).

*2-*o*-Carboxybenzoyl-5-methoxyphenoxyacetic Acid* (XI; R = R′ = H).—A mixture of 2′-carbethoxy-2-hydroxy-4-methoxybenzophenone (22 g.), ethyl bromoacetate (16 ml.), potassium carbonate (70 g.), and acetone (200 ml.) was heated under reflux for 5 hours. On isolation the resulting product was obtained as a yellow syrup which was hydrolysed with boiling 10% aqueous-methanolic potassium hydroxide (200 ml.) for ½ hour. After the removal of the greater part of the methanol and the dilution of the residual hydrolysate with water, *2-*o*-carboxybenzoyl-5-methoxyphenoxyacetic acid* was precipitated with hydrochloric acid and crystallised from alcohol–light petroleum (b. p. 60—80°), forming colourless flat prisms (23 g.), m. p. 177—178° (Found : C, 62·0; H, 4·4. $C_{17}H_{14}O_7$ requires C, 61·8; H, 4·2%), soluble in the usual organic solvents except light petroleum.

*3-*o*-Carboxyphenyl-6-methoxycoumarone* (XII; R = OH, R′ = H).—On being heated with sodium acetate (30 g.) and acetic anhydride (100 ml.) at 160° for ½ hour 2-*o*-carboxybenzoyl-5-methoxyphenoxyacetic acid (10 g.) gave rise to *3-*o*-carboxyphenyl-6-methoxycoumarone* which was extracted from the crude reaction product with hot light petroleum (b. p. 80—100°) and then crystallised from the same solvent, forming colourless rectangular prisms (3·8 g.), m. p. 135°, having a deep blue-green sulphuric acid reaction (Found : C, 71·6; H, 4·5. $C_{16}H_{12}O_4$ requires C, 71·7; H, 4·5%).

*3-*o*-Carboxymethylphenyl-6-methoxycoumarone* (XIII; R = H).—The foregoing acid (5 g.) was added in portions to a mixture of benzene (50 ml.), thionyl chloride (2·6 ml.), and pyridine (3 drops) at room temperature during 15 minutes. ½ Hour later the reaction mixture was warmed to 40—45° for 15 minutes and then evaporated in a vacuum with the addition of more benzene (20 ml.) to remove traces of residual thionyl chloride. A solution of the residual acid chloride in benzene (50 ml.) was added drop-wise during 30 minutes to well-stirred ethereal diazomethane (from 20·6 g. of nitrosomethylurea and 200 ml. of ether) kept at 0° and, after having been kept at room temperature for 24 hours, the reaction mixture was evaporated in a vacuum, leaving the *diazo-ketone* (XII; R = CHN_2, R′ = H) as a yellow crystalline mass. Recrystallised from benzene–light petroleum (b. p. 60—80°), this compound formed pale yellow needles, m. p. 85—87° (Found : N, 9·8. $C_{17}H_{12}O_3N_2$ requires N, 9·6%).

A solution of this diazo-ketone in dioxan (50 ml.) was added drop-wise during 35 minutes to a well-stirred mixture of 10% silver nitrate (40 ml.) and concentrated aqueous ammonia (25 ml.) at 60—70° and, after having been kept at this temperature for 1½ hours, the reaction mixture was filtered and allowed to cool, depositing *3-*o*-carbamylmethylphenyl-6-methoxycoumarone* which formed colourless needles (3 g.), m. p. 148°, from benzene–light petroleum (b. p. 60—80°) (Found : N, 4·9. $C_{17}H_{15}O_3N$ requires N, 5·0%). Hydrolysis of this amide (2 g.) with boiling 10% alcoholic potassium hydroxide (20 ml.) for 16 hours, followed by dilution of the hydrolysate with water (100 ml.) and acidification with dilute hydrochloric acid, gave *3-*o*-carboxymethylphenyl-6-methoxycoumarone* which separated from dilute methanol in colourless needles (2 g.), m. p. 125°, having a deep red sulphuric acid reaction (Found : C, 72·3; H, 5·1. $C_{17}H_{14}O_4$ requires C, 72·4; H, 5·0%). This acid was soluble in alcohol, ethyl acetate, or benzene and sparingly soluble in light petroleum.

3′-Hydroxy-6-methoxynaphtho(2′ : 1′-2 : 3)*coumarone* (XIV).—A solution of the foregoing acetic acid (1 g.) in concentrated sulphuric acid (20 ml.) was kept at room temperature for ½ hour and poured on ice (100 g.). Crystallised from benzene or dilute alcohol, the resulting precipitate gave the *naphthocoumarone* in colourless prismatic needles (0·5 g.), m. p. 163°, readily soluble in alcohol or acetic acid and moderately soluble in ethyl acetate or benzene (Found : C, 77·2; H, 4·7. $C_{17}H_{12}O_3$ requires C, 77·3; H, 4·5%). On being warmed with alcoholic potassium hydroxide and a drop of chloroform this phenol gave a deep-blue colour which slowly became green and then yellow. With benzene- and α-naphthalenediazonium chloride it gave red azo-dyes. The p-*nitrobenzoate* crystallised from ethyl acetate in yellow plates, m. p. 191° (Found : N, 3·4. $C_{24}H_{15}O_6N$ requires N, 3·4%).

2′-Carbethoxy-2-hydroxy-4 : 4′ : 5′-trimethoxybenzophenone (X; R = OMe).—Prepared by the interaction of resorcinol (5 g.), *m*-hemipinic anhydride (Perkin *et al.*, *J.*, 1925, **127**, 195; Perkin, *J.*, 1916, **109**, 889) (8 g.), and aluminium chloride (10 g.) in nitrobenzene (100 ml.) at room temperature for 48 hours, then at 60° for 1½ hours, and finally at 100° for 10 minutes, *2′-carboxy-2 : 4-dihydroxy-4′ : 5′-dimethoxybenzophenone* separated from ethyl acetate–light petroleum (b. p. 60—80°) in pale yellow prisms (10 g.), m. p. 255° (decomp.), having a red-brown ferric reaction in alcohol (Found : C, 60·4; H, 4·5. $C_{16}H_{14}O_7$ requires C, 60·4; H, 4·4%). Esterification of this acid (9·5 g.) with boiling alcohol (50 ml.) containing concentrated sulphuric acid during 4 hours yielded the *ethyl* ester which formed yellow needles (7·5 g.), m. p. 171°, from dilute alcohol, having a red-brown ferric reaction (Found : C, 62·5; H, 5·3. $C_{18}H_{18}O_7$ requires C, 62·4; H, 5·2%). The ester is readily soluble in the usual organic solvents except light petroleum.

Methyl iodide (3 ml. in 20 ml. of acetone) was added gradually during 45 minutes to a solution of this ester (8·5 g.) in boiling acetone (100 ml.), containing potassium carbonate (15 g.), and the mixture then heated for 1 hour. On isolation the resulting *2′-carbethoxy-2-hydroxy-4 : 4′ : 5′-trimethoxybenzophenone* (X; R = OMe) crystallised from dilute alcohol in yellow irregular prisms (8 g.), m. p. 119°, having a red-brown ferric reaction (Found : C, 63·6; H, 5·8. $C_{19}H_{20}O_7$ requires C, 63·4; H, 5·6%). Hydrolysis of this ester (0·3 g.) with boiling 5% aqueous-methanolic potassium hydroxide (10 ml.) for 15 minutes gave rise to 2′-carboxy-2-hydroxy-4 : 4′ : 5′-trimethoxybenzophenone which separated from ethyl acetate–light petroleum (b. p. 60—80°) in masses of pale yellow prisms (0·2 g.), m. p. 212° (Found : C, 61·4; H, 4·7. Calc. for $C_{17}H_{16}O_7$: C, 61·5; H, 4·8%) (compare Rây *et al.*, *loc. cit.*, who give m. p. 203°).

Brazilinic Acid (XI; R = H, R′ = OMe).—A mixture of 2′-carbethoxy-2-hydroxy-4 : 4′ : 5′-trimethoxybenzophenone (8 g.), ethyl bromoacetate (5 ml.), potassium carbonate (24 g.), and acetone (100 ml.) was heated under reflux for 5 hours. On isolation the resulting ethyl brazilinate was obtained as a yellow syrup which was hydrolysed with boiling 10% aqueous-methanolic potassium hydroxide (100 ml.) during ½ hour. After the removal of the methanol in a vacuum the residue was mixed with ice-water (200 ml.) and acidified with dilute hydrochloric acid, giving a precipitate of brazilinic acid (8·2 g.) which was collected 48 hours later. Crystallised from dilute acetic acid, the compound formed colourless prisms, m. p. 208—209° (Found : C, 58·3; H, 4·6. Calc. for $C_{19}H_{18}O_9$: C, 58·5; H, 4·6%) (cf. Perkin and Robinson, *J.*, 1908, **93**, 515; Rây *et al.*, *loc. cit.*).

3-(2-Carboxymethyl-4 : 5-dimethoxyphenyl)-6-methoxycoumarone (XIII; R = OMe).—A mixture of brazilinic acid (9 g.), potassium acetate (27 g.), and acetic anhydride (90 ml.) was kept at 150° for 45 minutes, cooled, and treated with water (500 ml.). Next day the precipitated 3-(*2-carboxy-4 : 5-dimethoxyphenyl*)*-6-methoxycoumarone* (XII; R = OH, R′ = OMe) was collected and crystallised from acetic acid, forming pale yellow prismatic needles (4·9 g.), m. p. 210°, easily soluble in chloroform, warm alcohol, or ethyl acetate (Found : C, 65·7; H, 4·9. $C_{18}H_{16}O_6$ requires C, 65·9; H, 4·9%). This acid (5 g.) was converted into the acid chloride by treatment with thionyl chloride (2·5 ml.) and pyridine (3 drops) in benzene (150 ml.) at room temperature for 35 minutes and then on the steam-bath for 15 minutes. After the evaporation of the reaction mixture in a vacuum the residue was dissolved in benzene (30 ml.) and the solution evaporated. Repetition of this process finally gave the acid chloride as a red viscous liquid. A solution of this compound in benzene (50 ml.) was added drop-wise to ethereal diazomethane (from 20 g. of nitrosomethylurea and 200 ml. of ether) at 0° and, after having been kept at room temperature for 24 hours, the reaction mixture was evaporated, leaving the *diazo-ketone* (XII; R = CHN_2, R′ = OMe) as an orange-yellow crystalline solid which formed large orange-yellow prisms, m. p. 86—88°, from benzene–light petroleum (b. p. 40—60°) (Found : N, 7·9. $C_{19}H_{16}O_5N_2$ requires N, 8·0%). A solution of this compound in dioxan (50 ml.) was added drop-wise to a well-stirred mixture of 10% silver nitrate (50 ml.) and concentrated aqueous ammonia (25 ml.) kept at 65—70° during 15 minutes and the mixture then kept at this temperature for 2½ hours. From the cooled, filtered reaction mixture 3-(*2-carbamylmethyl-4 : 5-dimethoxyphenyl*)*-6-methoxycoumarone* was isolated with chloroform (100 ml. × 3) and crystallised from dilute methanol, forming colourless prisms (2·2 g.), m. p. 143° (Found : N, 4·4. $C_{19}H_{19}O_5N$ requires N, 4·1%). On hydrolysis with boiling 15% alcoholic potassium hydroxide (50 ml.) for 14 hours, this amide gave rise to 3-(*2-carboxymethyl-4 : 5-dimethoxyphenyl*)*-6-methoxycoumarone* which separated from benzene–light petroleum (b. p. 60—80°) and then dilute methanol in colourless needles (1·7 g.), m. p. 148·5—149·5°, having a deep red sulphuric acid reaction (Found : C, 66·6; H, 5·0. $C_{19}H_{18}O_6$ requires C, 66·9; H, 5·3%).

3′-Hydroxy-6 : 6′ : 7′-trimethoxynaphtho(2′ : 1′-2 : 3)*coumarone* (*α-Anhydro-*O*-trimethylbrazilone*) (IV).—Cyclised by means of concentrated sulphuric acid (25 ml.) at room temperature during ½ hour, the foregoing acetic acid (1·2 g.) furnished α-anhydro-*O*-trimethylbrazilone which was precipitated from the reaction mixture with ice (75 g.) and crystallised from acetic acid, forming large pale brown prisms. Recrystallised from alcohol, this specimen then formed yellow plates (0·8 g.), m. p. 198°, identical with the compound from natural sources (Found : C, 70·2; H, 5·0. Calc. for $C_{19}H_{16}O_5$: C, 70·4; H, 4·9%). On being warmed with a little alcoholic potassium hydroxide containing a drop of chloroform, the synthetic naphthol gave an intense blue colour which slowly changed to green and then yellow-brown. On being warmed the orange-red solution of the naphthol in concentrated sulphuric acid became deep red. With benzene- and α-naphthalene-diazonium chloride an alkaline solution of the compound gave red azo-dyes. The acetate crystallised from benzene in clusters of colourless elongated plates, m. p. 174—175° (Found: C, 69·0; H, 5·0. Calc. for $C_{21}H_{18}O_6$: C, 68·8; H, 4·9%) (Perkin and Robinson, *J.*, 1909, **95**, 393). Prepared by the method employed by Perkin and Robinson (*loc. cit.*) for the natural derivative, synthetical acetyl-nitro-α-anhydro-*O*-trimethylbrazilone separated from acetic acid in bright yellow needles, m. p. 235° (decomp.) after sintering at 222°, and with concentrated sulphuric acid gave a purple colour which became yellow-brown on the addition of water (Found: N, 3·3. Calc. for $C_{21}H_{17}O_8N$: N, 3·4%).

The p-*nitrobenzoate* of α-anhydro-*O*-trimethylbrazilone formed bright yellow, elongated prisms, m. p. 233—234°, from acetic acid (Found: N, 2·9. $C_{26}H_{19}O_8N$ requires N, 3·0%).

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