

**214.** *The Chemistry of Extractives from Hardwoods. Part XI.\* The Isolation of a Diterpene Ester (Methyl Vinhaticoate), and of 6 : 7 : 3' : 4'-Tetrahydroxyflavanone (Plathymenin), and 2 : 4 : 5 : 3' : 4'-Pentahydroxychalkone (neoPlathymenin), from Plathymenia reticulata.*

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The light petroleum-soluble constituents of the heartwood of *Plathymenia reticulata* include a crystalline methyl ester of a diterpene, vinhaticoic acid,  $C_{20}H_{26}O_3$ , in which the presence of a furan ring has been demonstrated. Further extraction with ether yields 6 : 7 : 3' : 4'-tetrahydroxyflavanone (plathymenin), and also the corresponding chalkone (neoplathymenin), the principal crystalline pigment of this deep yellow wood.

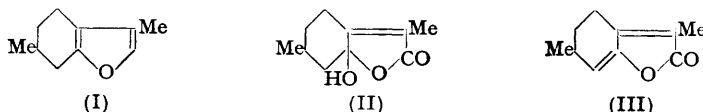
THE timber vinhatico is a brilliant yellow or brownish-yellow lustrous wood derived either from *Chloroleucon vinhatico* Record or from *Plathymenia reticulata* Benth., both of which are Brazilian trees of the family *Leguminosae*. A quantity of this timber, obtained commercially and identified in the D.S.I.R. Forest Products Research Laboratory as *P. reticulata*, has been extracted and new crystalline products have been isolated.

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When dissolved in methanol, the oil isolated by light petroleum yielded a compound  $C_{21}H_{30}O_3$ , which comprises  $1\frac{1}{2}\%$  of the weight of the wood and is the methyl ester of a diterpene acid. Hydrolysis of the carbomethoxy-group necessitated the vigorous treatment with alkali usually associated with sterically hindered, *e.g.*, tertiary, carboxylic esters. The resulting acid,  $C_{20}H_{28}O_3$ , vinhaticoic acid, sustained no further change during the hydrolysis, the original ester being recovered by treatment with diazomethane. Methyl vinhaticoate was also obtained by the action of methyl sulphate on the sodium salt, from which the ethyl ester was similarly prepared.

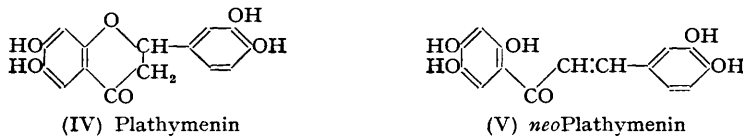
When reduced catalytically, methyl vinhaticoate absorbed two mols. of hydrogen, and the presence of two olefinic bonds was confirmed by titration with monoperphthalic acid. The preparation from the ester and maleic anhydride of an addition compound proved the diene system to be conjugated and, in view of the unreactive nature of the third oxygen atom, it suggested that the conjugated system might form part of a furan ring. In agreement with this hypothesis the maleic anhydride adduct proved to be relatively unstable, and the ultra-violet spectrum of methyl vinhaticoate exhibited an absorption maximum at  $220\text{ m}\mu$ . A ketone,  $C_{23}H_{32}O_4$ , obtained from methyl vinhaticoate by the action of acetic anhydride and stannic chloride, reagents which do not readily attack hydrocarbon nuclei, is doubtless formed as a result of acylation in the furan ring.

Evidence confirming the existence of a furan residue in vinhaticoic acid is to be found in the close resemblance between certain reactions of its methyl ester and those of the authentic furano-hydrocarbon menthofuran,  $C_{10}H_{14}O$  (I). The latter is readily oxidised



by various reagents, including hydrogen peroxide, thereby forming a weakly acidic compound  $C_{10}H_{14}O_3$ , to which Woodward and Eastman (*J. Amer. Chem. Soc.*, 1950, **72**, 399) have recently attributed the structure (II). Analogously, the perphthalic acid oxidation product of methyl vinhaticoate contains two additional oxygen atoms and is weakly acidic. Moreover, the latter yields when fused an anhydro-compound,  $C_{21}H_{28}O_4$ , thus further resembling (II), which, as Woodward and Eastman have shown, is dehydrated with potassium hydrogen sulphate to the compound (III). From other experiments shortly to be described it has been established that the furan ring of vinhaticoic acid, which is unsubstituted at positions 2 and 3, is fused to a perhydrophenanthrene nucleus.

After extraction by light petroleum the powdered wood was exhausted with boiling ether and the product separated with ethyl acetate into a cream-coloured solid  $C_{15}H_{12}O_6$  (A) comprising 5.3% of the weight of wood, and a more soluble isomer (B) amounting when crystallised to 2%. (A), termed plathymenin, formed a tetra-acetate and tetramethyl ether, and its colour reactions were indicative of a flavanone. Oxidation of the tetramethyl ether gave 2-hydroxy-4 : 5-dimethoxybenzoic acid and veratric acid, which were converted into their respective methyl esters and thus separated by alkali, so proving the constitution of plathymenin to be 6 : 7 : 3' : 4'-tetrahydroxyflavanone (IV). The tetramethyl ether, already synthesised by Bargellini and Marini-Bettolo (*Gazzetta*, 1940, **70**, 170), was oxidised by selenium dioxide to the corresponding tetramethoxyflavone.



The bright orange *neoplathymenin* (B),  $C_{15}H_{12}O_6$ , which contributes very considerably to the colour of the wood, displayed properties typical of a polyhydroxychalkone. Moreover, it formed a pentamethyl ether identical with that obtained from plathymenin by methylation in alkaline solution, thus revealing its structure as 2 : 4 : 5 : 3' : 4'-pentahydroxychalkone (V). This was confirmed when *neoplathymenin* was obtained from

plathymenin by mild alkaline hydrolysis; the action of alkali on *O*-tetramethylplathymenin gave 2-hydroxy-4 : 5 : 3' : 4'-tetramethoxychalkone, oxidised by hydrogen peroxide to 3-hydroxy-6 : 7 : 3' : 4'-tetramethoxyflavone (Bargellini and Marini-Bettolo, *loc. cit.*). *neo*Plathymenin thus resembles the isomeric 2 : 3 : 4 : 3' : 4'-pentahydroxychalkones, okanin and *isookanin* (King and King, *J.*, 1951, 569), in being a member of the comparatively rare group of naturally occurring chalkones. Both plathymenin and *neoplathymenin* contain the hydroxyquinol nucleus which though found in certain natural coumarins, *e.g.*, *æsculetin* (6 : 7-dihydroxycoumarin), has not hitherto been encountered among natural products of the flavone or isoflavone groups.

Seikel and Geissman (*J. Amer. Chem. Soc.*, 1950, **72**, 5720) have obtained a pigment (stillopsin) from *Coreopsis stillmanii* which is a hexoside of 2 : 4 : 5 : 3' : 4'-pentahydroxychalkone. The free chalkone was not isolated but was identified by ring-closure and methylation to 6 : 7 : 3' : 4'-tetramethoxyflavanone which was synthesised.

#### EXPERIMENTAL

*Methyl Vinhaticoate*.—The dark-brown oil obtained by continuous extraction of powdered *vinhatico* (2½ kg.) with boiling light petroleum (b. p. 60—80°) for 16 hours was dissolved in an equal volume of methanol, and the solution set aside at 0°. The deposit of *methyl vinhaticoate*, crystallised once again from methanol (charcoal), formed nearly colourless prisms (38—40 g.), m. p. 106°, raised by further crystallisation to 108°,  $[\alpha]_D^{18} + 66.9^\circ$  (in CHCl<sub>3</sub>) (Found : C, 76.1, 76.4; H, 9.3, 9.0; OMe, 9.9. C<sub>20</sub>H<sub>27</sub>O<sub>2</sub>·OMe requires C, 76.3; H, 9.15; OMe, 9.4%). Light absorption in *n*-hexane : max. at 220 m $\mu$  (log  $\epsilon$  = 3.88). The ester is easily soluble in most organic solvents but only sparingly in methanol and ethanol. When reduced in acetic acid containing platinum oxide the ester (32.1 mg.) absorbed 4.11 c.c. of hydrogen (theory for 2H<sub>2</sub>, 4.36 c.c.).

Methyl vinhaticoate (1 g.) and maleic anhydride (0.5 g.) in benzene (10 c.c.) at room temperature gave in 4 days an *adduct* (yield after concentration, 83%) crystallising from acetone in large hexagonal tablets, m. p. 140° (Found : C, 69.7; H, 7.4. C<sub>25</sub>H<sub>32</sub>O<sub>6</sub> requires C, 70.1; H, 7.5%). Methyl vinhaticoate was recovered when the adduct (0.2 g.) was boiled for 10 minutes with 2*N*-sodium hydroxide (10 c.c.).

*Vinhaticoic Acid*.—A solution of potassium hydroxide (10 g.) in ethanol was concentrated in a copper flask, and when the temperature reached 160°, methyl vinhaticoate (4 g.) was added and the mixture kept at 160—170° for 2 hours. After extraction with hot water (150 c.c.) and acidification, the gummy product was purified by crystallising the sodium salt (long silky needles, m. p. > 350°) from 3% aqueous sodium hydroxide. The salt with hydrochloric acid gave *vinhaticoic acid* (3.25 g.) which from 75% ethanol formed shining plates, m. p. 153—154°,  $[\alpha]_D^{18} + 73^\circ$  (in CHCl<sub>3</sub>) (Found : C, 76.3; H, 9.0%; equiv., 315. C<sub>20</sub>H<sub>22</sub>O<sub>3</sub> requires C, 75.9; H, 8.9%; equiv., 316). The acid dissolves easily in organic solvents except light petroleum.

The sodium salt (0.5 g.) in acetone with methyl sulphate gave overnight at room temperature methyl vinhaticoate (0.38 g. from methanol), m. p. 107°, also formed from the acid with ethereal diazomethane during 1 hour.

Ethyl sulphate and the sodium salt in acetone gave *ethyl vinhaticoate*, shining rods, m. p. 80—81° (from aqueous ethanol),  $[\alpha]_D + 58.7^\circ$  (in CHCl<sub>3</sub>) (Found : C, 76.5; H, 9.1. C<sub>22</sub>H<sub>32</sub>O<sub>3</sub> requires C, 76.7; H, 9.4%).

*Oxidation of Methyl Vinhaticoate with Monoperphthalic Acid*.—(a) Methyl vinhaticoate (1.0091 g.) consumed in 250 hours at 0° monoperphthalic acid equivalent to 161 c.c. of 0.0813*N*-thiosulphate, *viz.*, 2.14 mols.

(b) After 100 hours at room temperature, a solution of the methyl ester (6.5 g.) in chloroform (100 c.c.) and of *n*-ethereal perphthalic acid (150 c.c.) was filtered from precipitated phthalic acid and washed with aqueous potassium iodide and sodium thiosulphate. Evaporation left a *product* crystallising from methanol in large glistening rhombic tablets (4.75 g.), m. p. 210—212° which became opaque, gradually at room temperature, rapidly at 100° (Found : C, 65.9; H, 8.3. C<sub>21</sub>H<sub>30</sub>O<sub>5</sub>·H<sub>2</sub>O requires C, 66.3; H, 8.5. Found, in dried specimens : C, 69.5; H, 8.2; OMe, 8.7. C<sub>20</sub>H<sub>27</sub>O<sub>4</sub>·OMe requires C, 69.6; H, 8.3; OMe, 8.6%).

The oxidation product dissolved in warm aqueous sodium carbonate or hydroxide, the sodium salt separating in large plates, and it was recovered unchanged on acidification. When cautiously heated above 210° for 5 minutes the *anhydro*-derivative was obtained in needles, m. p. 142—143°, from 80% methanol (Found : C, 73.4; H, 8.1. C<sub>21</sub>H<sub>28</sub>O<sub>4</sub> requires C, 73.2; H, 8.2%), insoluble in aqueous alkalis and more readily soluble in organic solvents than its precursor.

*Methyl Acetylvinhaticoate*.—Gradual addition of stannic chloride (1 c.c.) to a mixture of methyl vinhaticoate (2 g.) and acetic anhydride (0.65 c.c.) in benzene (25 c.c.) led to an exothermic reaction. After 4 hours the purple solution was poured on ice, and the ether-soluble product isolated and dissolved in ethanol (5 c.c.). The resulting crude ketone (1.2 g.) when repeatedly crystallised from ethanol and light petroleum (charcoal) formed nearly colourless needles, m. p. 162° (Found : C, 73.7; H, 8.95.  $C_{23}H_{32}O_4$  requires C, 74.2; H, 8.7%). The semicarbazone, rhombic tablets from ethanol, had m. p. 246—248° (Found : C, 67.5; H, 7.9; N, 9.2.  $C_{24}H_{35}O_4N_3$  requires C, 67.1; H, 8.2; N, 9.8%).

*Plathymenin and neoPlathymenin*.—The powdered wood (1.7 kg.) already treated with light petroleum was continuously extracted with boiling ether (4—5 l.) for 2—3 days. The separated yellow solid (A) was collected and the solution evaporated; digestion of the residue with boiling ethyl acetate left a solid (B) which was combined with (A) and crystallised from water containing a little sulphur dioxide. 6 : 7 : 3' : 4'-Tetrahydroxyflavanone (*plathymenin*) (90 g., 5.3%) crystallised in pale cream-coloured needles, m. p. 229° (decomp.) (Found : C, 62.2; H, 4.2.  $C_{15}H_{12}O_6$  requires C, 62.5; H, 4.2%), soluble to a colourless solution in sodium hydrogen carbonate and deep red in sodium carbonate. Its solutions in concentrated hydrochloric and in sulphuric acid are bright red and its ferric reaction is green. With magnesium and hydrochloric acid the flavanone gives first a faint pink and finally an intense blue colour.

Evaporation of the ethyl acetate solution from which product (B) had been separated and extraction of the residue with boiling water gave a solution from which crystallised 2 : 4 : 5 : 3' : 4'-penta-hydroxychalkone (*neoplathymenin*) (34 g., 2%), orange plates, m. p. 232° (decomp.), from aqueous methanol (Found : C, 62.7; H, 4.5%). It dissolves in aqueous sodium hydrogen carbonate to an orange solution which with sodium hydroxide becomes deep red. The sulphuric acid solution is orange and the ferric reaction of the chalkone is dark brown. No colour is formed on reduction with magnesium and hydrochloric acid. Further small amounts of plathymenin (6 g.) and of *neoplathymenin* (3 g.) were isolated from the ethyl acetate-soluble portion of the material extracted by acetone from the wood following its treatment with ether.

*O-Tetra-acetylplathymenin*, prepared with acetic anhydride and sodium acetate, crystallised from methanol in stout rectangular prisms, m. p. 149—151° (Found : C, 60.4; H, 4.6; OAc, 39.4.  $C_{23}H_{20}O_{10}$  requires C, 60.5; H, 4.4; 4OAc, 37.7%). Plathymenin (2 g.) with ethereal diazomethane gave the tetramethyl ether (1.4 g.), needles, m. p. 161°, from methanol [Found : C, 66.4; H, 5.9; OMe, 35.9. Calc. for  $C_{15}H_{18}O_2(OMe)_4$  : C, 66.3; H, 5.85; OMe, 36.1%]. Bargellini and Marini-Bettolo (*loc. cit.*) give for 6 : 7 : 3' : 4'-tetramethoxyflavanone, m. p. 161°.

*O-Penta-acetylneoplathymenin*, from the chalkone, acetic anhydride, and perchloric acid, crystallised from ethyl acetate—light petroleum in long cream-coloured needles, m. p. 155—156° (Found : C, 60.3; H, 4.8.  $C_{25}H_{22}O_{11}$  requires C, 60.2; H, 4.45%). *O-Pentamethylneoplathymenin*, prepared by shaking a solution of either plathymenin or *neoplathymenin* (1 g.) in 30% aqueous sodium hydroxide (40 c.c.) containing sodium dithionite (0.05 g.) with methyl sulphate (12 c.c.), crystallised from aqueous methanol in yellow plates (0.6 g.), m. p. 158—159° (Found : C, 66.8; H, 6.0; OMe, 42.8. Calc. for  $C_{20}H_{22}O_6$  : C, 67.0; H, 6.2; 5OMe, 43.3%). Bargellini and Aureli (*Gazzetta*, 1910, 40, 346) give m. p. 151° for 2 : 4 : 5 : 3' : 4'-pentamethoxychalkone.

*Hydrolysis of Plathymenin with Alkali*.—A solution of plathymenin (1 g.) in 2N-sodium hydroxide (20 c.c.) under nitrogen was heated under reflux for 5 minutes. Acidification precipitated *neoplathymenin*, m. p. after crystallisation, 232° (decomp.) (Found : C, 62.2; H, 4.6%), further characterised by its penta-acetate, m. p. and mixed m. p. 155—156° (Found : C, 60.1; H, 4.9%).

*Hydrolysis of O-Tetramethylplathymenin with Alkali*.—A solution of *O*-tetramethylplathymenin (0.5 g.) in boiling alcohol (100 c.c.), treated with 2N-sodium hydroxide (2 c.c.), deposited when cold 2-hydroxy-4 : 5 : 3' : 4'-tetramethoxychalkone, *O*-tetramethylneoplathymenin, crystallising from methanol in orange plates, m. p. 174—175°, and having a brown ferric reaction (Found : C, 66.7; H, 5.9; OMe, 35.9. Calc. for  $C_{19}H_{20}O_6$  : C, 66.3; H, 5.85; 4OMe, 36.1%). Bargellini and Marini-Bettolo (*loc. cit.*) record m. p. 152°. Acetic anhydride—sodium acetate gave 2-acetoxy-4 : 5 : 3' : 4'-tetramethoxychalkone, yellow needles, m. p. 118—119°, from aqueous methanol (Found : C, 65.0; H, 5.8.  $C_{21}H_{22}O_7$  requires C, 65.3; H, 5.7%).

*Oxidation of neoPlathymenin 4 : 5 : 3' : 4'-Tetramethyl Ether*.—(a) *With potassium permanganate*. The chalkone (1 g.) was treated in acetone solution with potassium permanganate until the reaction slackened. The mixture obtained by addition of water (20 c.c.) and distillation of the acetone was saturated with sulphur dioxide, and the solution extracted with ether. The

mixed acids removed from the ethereal solution with aqueous sodium hydrogen carbonate were treated with diazomethane. From the product 2*N*-sodium hydroxide extracted methyl 2-hydroxy-4 : 5-dimethoxybenzoate, which, when sublimed under low pressure and crystallised from aqueous methanol, formed needles (0.14 g.), m. p. 94—94.5° (lit., 95°) (Found : C, 56.4; H, 5.6. Calc. for C<sub>10</sub>H<sub>12</sub>O<sub>5</sub> : C, 56.6; H, 5.7%). The acid obtained by alkaline hydrolysis had m. p. 204° (lit., from 203° to 213°) (Found : C, 54.1; H, 5.1. Calc. for C<sub>9</sub>H<sub>10</sub>O<sub>5</sub> : C, 54.5; H, 5.1%). Both acid and ester gave a bright blue ferric colour.

The alkali-insoluble ester, purified by distillation, consisted of methyl veratrate, m. p. and mixed m. p. 59—60°.

(b) *With hydrogen peroxide.* To the tetramethylchalkone (0.1 g.) dissolved in warm *N*-sodium hydroxide (40 c.c.), 30% hydrogen peroxide (2 c.c.) was added. 3-Hydroxy-6 : 7 : 3' : 4'-tetramethoxyflavone separated in the cold and crystallised from aqueous methanol in yellow plates, m. p. 226° (Found : C, 63.5; H, 5.2; OMe, 34.0. Calc. for C<sub>19</sub>H<sub>18</sub>O<sub>7</sub> : C, 63.7; H, 5.1; 4OMe, 34.6%). Bargellini and Marini-Bettolo (*loc. cit.*) found m. p. 228°.

6 : 7 : 3' : 4'-*Tetramethoxyflavone.*—*O*-Tetramethylplathymenin (1 g.) was heated with selenium dioxide (0.5 g.) under reflux in *iso*amyl alcohol (20 c.c.). The product which was deposited in the cold was separated from selenium by recrystallisation, 6 : 7 : 3' : 4'-tetramethoxyflavone being obtained as long needles, m. p. 215—216° (lit., 219°), from methanol (Found : C, 66.8; H, 5.4; OMe, 35.9. Calc. for C<sub>19</sub>H<sub>18</sub>O<sub>6</sub> : C, 66.7; H, 5.3; 4OMe, 36.2%).

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