THE CHEMICAL CONSTITUENTS OF AUSTRALIAN *ZANTHOXYLUM* SPECIES

III.* THE CONSTITUENTS OF *Z. PARVIFLORUM* BENTH.; THE STRUCTURE OF PARVIFLORAL; SOME OBSERVATIONS ON THE BIOGENESIS OF FUROQUINOLINE ALKALOIDS

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Summary

The leaves of *Zanthoxylum parviflorum* Benth. yielded lupeol, sitosterol, and skimmianine; the bark gave sucrose, hesperidin, lupeol, skimmianine, chelerythrine chloride, (−)-α-canadine methiodide, and magnoflorine iodide. From the wood there were isolated hesperidin, sitosterol, dictamnine, skimmianine, platydesmine, and a new phenolic aldehyde, parvifloral.

Spectroscopic data and biogenetic considerations suggested that parvifloral was 5-prenylconiferaldehyde, and the assignment of structure was confirmed by a rational synthesis.

Oxidation of platydesmine with iodine/lead tetraacetate gave dictamnine. The significance of this result to the biogenesis of furoquinoline alkaloids is discussed.

INTRODUCTION

In previous papers[1,2] in this series it was reported that *Zanthoxylum brachyacanthum* F. Muell. (syn. *Z. veneficum* F. M. Bail.) yielded hesperidin, lupeol, (−)-α-canadine methiodide, α-allocryptopine, chelerythrine, and isocorydine methiodide, and that *Z. suberosum* C. T. White contained suberosin and canthin-6-one. The present paper is concerned with *Z. parviflorum* Benth., a small tree found on islands in the Gulf of Carpentaria and off the coast of north-western Australia.

By conventional procedures there were isolated from the leaves lupeol, sitosterol, and skimmianine; the bark gave sucrose, hesperidin, lupeol, skimmianine, chelerythrine chloride, (−)-α-canadine methiodide, and magnoflorine iodide. In view of the specific name of the plant the occurrence of the latter substance is of some interest. The wood furnished hesperidin, sitosterol, dictamnine, skimmianine, the recently described[3–5] alkaloid, platydesmine, and a new phenolic aldehyde, parvifloral.

* Part II, *Aust. J. Chem.*, 1953, **6**, 86.

† Department of Organic Chemistry, University of Sydney.

[1] Ewing, J., Hughes, G. K., and Ritchie, E., *Aust. J. scient. Res.* A, 1950, **3**, 342.

[2] Cannon, J. R., Hughes, G. K., Ritchie, E., and Taylor, W. C., *Aust. J. Chem.*, 1953, **6**, 86.

[3] Werney, E., and Scheuer, P. J., *Tetrahedron*, 1963, **19**, 1293.

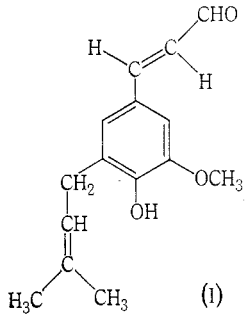
[4] Bowman, R. M., and Grundon, M. F., *J. chem. Soc.* C, 1966, 1504.

[5] Johns, S. R., and Lamberton, J. A., *Aust. J. Chem.*, 1966, **19**, 1991.

The Structure of Parvifloral

The molecular formula of parvifloral, $C_{15}H_{18}O_3$, was established by elementary analysis and by the molecular weight determined by mass spectrometry. The structural features of the molecule were readily revealed by spectroscopic methods and biogenetic considerations then allowed the structure (I) to be deduced.

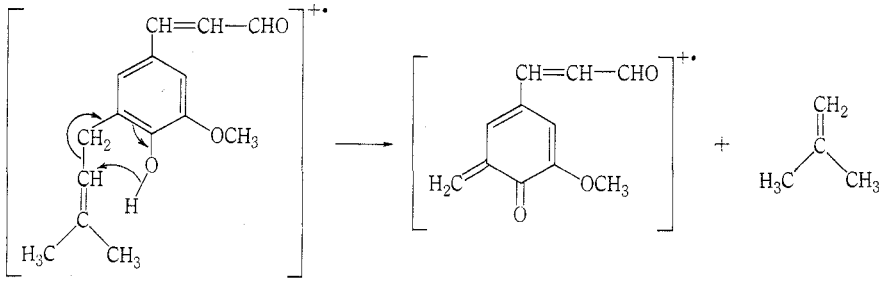
The i.r. spectrum (ν_{max} 3325, 1655 cm^{-1}) indicated the presence of a phenolic hydroxyl group and a conjugated carbonyl group. The u.v. spectra in neutral solution and the large bathochromic shift observed on the addition of alkali, together with the n.m.r. spectrum, showed the presence of an *o*- or *p*-hydroxycinnamaldehyde residue. In the n.m.r. spectrum the signals from all protons were clearly resolved and susceptible to a first-order analysis. A three-proton singlet at δ 3·90 proved the presence of a methoxyl group and a six-proton broadened singlet at δ 1·72 [$(CH_3)_2C{=}C$], together with one-proton triplet (J 7 c/s) at δ 5·33 (C=C–H) and a two-proton doublet (J 7 c/s) at δ 3·37, showed that a prenyl group was attached directly to an aryl residue. The three protons of the α,β-unsaturated aldehyde grouping, $-CH_M{=}CH_X{-}CH_AO$, formed an AMX system: a doublet (J_{AX} 7·3 c/s) at δ 9·65, a doublet (J_{MX} 16 c/s) at δ 7·4, and a quartet at about δ 6·35; the magnitude of J_{MX} established that the double bond was *trans*-substituted. The signal from the proton of the hydroyxl group, which disappeared on deuteration, appeared at δ 6·35; and that from the aromatic protons as a close AB quartet centred at about δ 6·9, with J 2 c/s indicating a *meta* relationship.



(I)

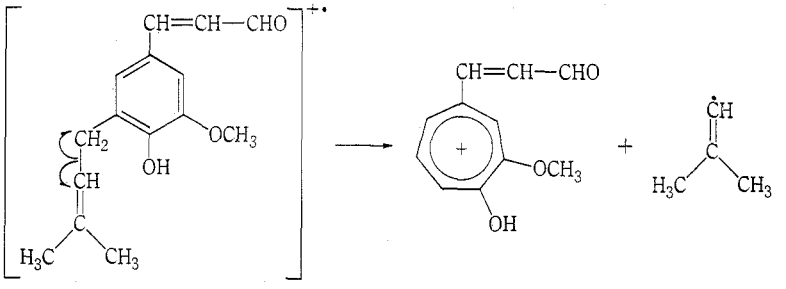
It was possible to write several structures in which the four substituents were attached to different positions in the ring and in which the two aryl protons were *meta* to one another, but biogenetic considerations suggested that parvifloral would be a derivative of coniferaldehyde and that the prenyl group would be *ortho* to the hydroxyl group; that is, that the structure of parvifloral was (I).

Some support was obtained from the mass spectrum of parvifloral. Apart from the molecular ion peak at *m/e* 246 there were only three prominent peaks in the spectrum. One at *m/e* 177 was clearly due to the loss of the prenyl chain, and a second at *m/e* 190 corresponded to the loss of isobutylene. As in a similar structure[6] this was interpreted by the process:



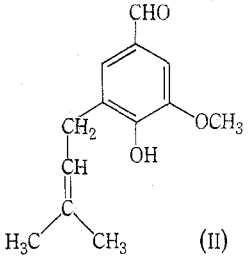
[6] Ritchie, E., Taylor, W. C., and Shannon, J. S., *Tetrahedron Lett.*, 1964, 1437.

Together, the results constituted strong evidence that the hydroxyl group and the prenyl chain were attached to adjacent carbon atoms. In harmony with these conclusions was the fact that after *O*-deuteration the first peak shifted to *m/e* 178 but the second remained at *m/e* 190. The third prominent peak was at *m/e* 191. It was tempting to assign its origin to the process:



but since the peak did not move to *m/e* 192 on *O*-deuteration this explanation could not be valid. It is possible to suggest fragmentations and rearrangements which account for the results but without further evidence speculation seems unwarranted.

The structure proposed for parvifloral was confirmed by a synthesis which depended upon the *ortho* alkylation of the sodium salt of a phenol in a hydrocarbon solvent (see e.g. Späth and Holzen[7]). Thus prenyl bromide and the dry sodium salt of vanillin in refluxing xylene gave (II). Yields on runs conducted under apparently identical conditions were very variable and usually low, but the availability of the starting materials compensated for these disadvantages. The structure of (II) was supported by its spectral properties and its acid-catalysed conversion into the chroman derivative (III). Condensation of (II) with malonic acid followed by acetylation gave the acid (IV), the acid chloride of which was reduced by lithium tri-t-butoxyaluminium hydride[8] to the acetyl derivative of parvifloral. Mild base-catalysed methanolysis then yielded parvifloral itself.



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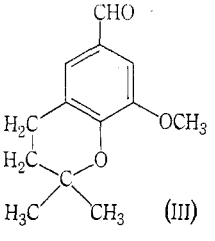

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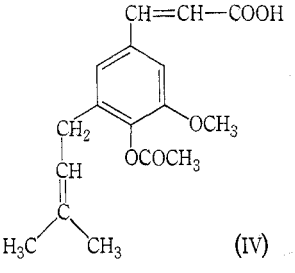


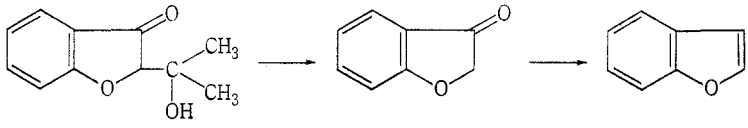
(IV)

Parvifloral provides a further striking example of the variety of prenylated structures occurring in members of the Rutaceae. Its closest relative appears to be the recently described zanthoxylol[9] from *Fagara zanthoxyloides* (Lam.).

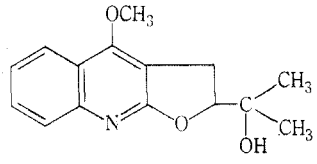
[7] Späth, E., and Holzen, H., *Ber. dt. chem. Ges.*, 1934, **67**, 264.
[8] Pearl, I. A., and Darling, S. F., *J. org. Chem.*, 1957, **22**, 1266.
[9] Eshiet, I. T., and Taylor, D. A. H., *Chem. Commun.*, 1966, 467.

Some Observations on the Biogenesis of Furoquinoline Alkaloids

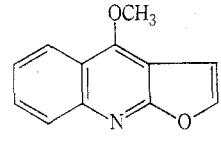
The hypothesis that the two-carbon fragment of the furan ring of furoquinoline alkaloids represented a degraded prenyl residue was first expressed by Price[10] in 1948. Birch and Smith[11] and also Aneja, Mukerjee, and Seshadri[12] arrived at the same idea, and the former authors further suggested that benzofurans were formed by a retro-aldol reaction followed by a reduction as shown:



This scheme appears to have been generally accepted (e.g. by Ollis and Sutherland[13]) and preferred to the hypotheses that the four carbon atoms of the furan ring stem from succinic acid[14] or from α-oxoglutaric acid.[15] However, until recently there was no evidence on the question, apart from the statistics of occurrences of prenyl-, furo-, and pyrano-derivatives cited by Birch and Smith. Some chemical support for the scheme was obtained by Bowman and Grundon[4] by their synthesis of platydesmine (V) in which the cyclization reaction may well parallel the biosynthetic pathway (see also King, Housley, and King[16]). Also Monković and Spenser[17] have reported some preliminary results on the biosynthesis of dictamnine (VI) involving feeding experiments with ^{14}C-labelled substances. They found that the succinic acid and α-oxoglutaric acid hypotheses were untenable and that although no evidence for the participation of a prenyl (or mevalonic acid) unit emerged from their experiments, this possibility still remained open.



(V)

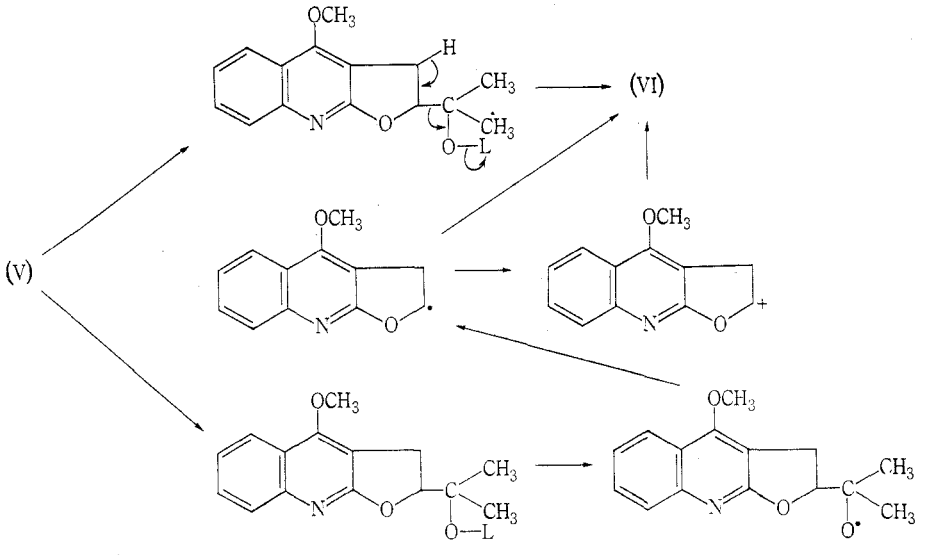


(VI)

The co-occurrence of platydesmine and dictamnine in *Z. parviflorum* is evidence for Price's hypothesis, and moreover suggested that the latter alkaloid might be derived directly from the former by an oxidative process without the intervention of

[10] Price, J. R., *Pure appl. Chem.*, 1961, **2**, 367.
[11] Birch, A. J., and Smith, H., Spec. Publ. Chem. Soc., No. 17, p. 4 (1958).
[12] Aneja, R., Mukerjee, S. K., and Seshadri, T. S., *Tetrahedron*, 1958, **4**, 256.
[13] Ollis, W. D., and Sutherland, I. O., in "Chemistry of Natural Phenolic Compounds." (Ed. W. D. Ollis.) p. 74. (Pergamon: Oxford 1961.)
[14] Boit, H. G., "Ergebnisse der Alkaloid-Chemie bis 1960." p. 715. (Akademie-Verlag: Berlin 1961.)
[15] Ghosal, S., *Sci. Cult.*, 1964, **30**, 142.
[16] King, F. E., Housley, J. R., and King, T. J., *J. chem. Soc.*, 1954, 1392.
[17] Monković, I., and Spenser, I. D., *Chem. Commun.*, 1966, 204.

the two intermediates postulated by Birch and Smith. Several plausible routes by which this transformation could proceed are readily envisaged and a few are set out below:



L = leaving group

In the event, it has now been found that although platydesmine was unaffected by chromic acid under mild conditions it was converted into dictamnine by iodine/lead tetraacetate in the presence of calcium carbonate and under irradiation. The yield was low and other products as yet unidentified were formed. The route by which the reaction proceeds has not been established (for a review of the reaction see Heusler and Kalvoda[18]), since shortage of material has precluded a full examination, but it is intended to pursue the matter.

It must be emphasized that this result is merely indicative of a possibility and does no more than demonstrate the chemical feasibility of converting substances of type (V) directly into those of type (VI).

Experimental

Melting points are uncorrected. Light petroleum had b.p. 40–60°. I.r. spectra were measured in Nujol mulls and u.v. spectra in ethanol. Analyses were carried out by Miss B. J. Stevenson of this Department and by the Australian Microanalytical Service, Melbourne. Mass spectra were determined by an AEI MS9 instrument and n.m.r. spectra on a Varian A60 spectrometer in deuterochloroform solution with tetramethylsilane as internal reference. Each signal is described in terms of multiplicity, intensity, chemical shift in p.p.m., assignment, and coupling constant in c/s in that order, with the use of the following abbreviations: s, singlet; d, doublet; t, triplet; (b), broad.

[18] Heusler, K., and Kalvoda, J., *Angew. Chem. int. Edn*, 1964, **3**, 525.

Extraction of the Bark

The dried milled bark (5·2 kg) (collected from Melville Island) was extracted at room temperature in turn with light petroleum, ether, and methanol. Each extract was refrigerated after concentration to a small bulk.

The light petroleum extract deposited a waxy solid which on repeated recrystallization from methanol gave lupeol (6 g), identified by m.p. 213–214°, and mixed m.p. with an authentic specimen, and comparison of i.r. spectra. Light petroleum was removed from the filtrate and a solution of the residue in ether extracted in turn with 3% HCl, 5% $NaHCO_3$, 5% Na_2CO_3, and 5% NaOH. The small crude dark basic fraction was worked up with the basic fraction of the methanol extract. The acidic fractions which were small and dark were discarded. The neutral fraction gave more lupeol (30 g) on crystallization from methanol and a further quantity (15 g) was isolated by chromatographing the material in the filtrates on alumina.

The ether extract contained only traces of basic and acidic substances. Chromatography yielded additional lupeol (4 g), which brought the total to 55 g (1·06%).

The methanol extract deposited cubes (3 g), which after recrystallization from methanol/water had m.p. 182° (dec.), $[\alpha]_D$ +68° (*c*, 0·2 in water), and were identified as sucrose (lit. m.p. 185° (dec.), $[\alpha]_D$ +63°). The identification was confirmed by comparison of i.r. spectra. The filtrate was divided into two equal portions which were worked up separately.

The first portion, with which was combined the basic fraction of the light petroleum extract, was diluted with water and the methanol removed. The residue was stirred vigorously with phosphoric acid (3000 ml of 0·2M) and the suspension filtered. The solid material was washed thoroughly with acid and then with chloroform. Recrystallization from methanol gave hesperidin (10 g), m.p. and mixed m.p. with an authentic specimen, 260° (dec.); the i.r. spectra also were identical. The acid solution was washed thoroughly with ether, made 4M with respect to potassium iodide, and extracted several times with chloroform. The aqueous layer was basified with ammonia and extracted again with chloroform. The residues obtained on evaporation of the chloroform extracts were combined, and dissolved in 3% HCl. The solution was basified with ammonia and extracted with chloroform to yield a crude tertiary base fraction, which on chromatography on alumina afforded skimmianine (0·1 g), m.p. 174°, identified by direct comparison (mixed m.p. and i.r. spectra) with an authentic specimen. From the aqueous solution the quaternary bases were recovered by acidification, addition of KI, and extraction with chloroform in the usual manner. The fraction was worked up with the corresponding fraction from the second portion of the methanol extract.

The methanol was removed from the second portion of the methanol extract and the residue was extracted with hot 5% HCl (4000 ml). The insoluble material was crude hesperidin (11 g). The hot solution on cooling deposited a dark gum which was extracted with boiling chloroform. The soluble portion after recrystallization from acetic acid and then dilute HCl afforded chelerythrine chloride (0·25 g), m.p. 200–203° (dec.) (hydrated) identified by comparison with an authentic specimen. The aqueous acid solution was basified with ammonia and extracted with chloroform to yield the tertiary base fraction, then acidified, treated with excess KI, and extracted again with chloroform to furnish the quaternary base fraction. The tertiary base fraction, which thin-layer chromatography revealed as a very complex mixture, was extensively examined but only traces of crystalline alkaloids could be separated.

The combined quaternary base iodide fraction was fractionally crystallized from methanol. The operation, which was attended with much loss of material, eventually yielded (−)-α-canadine methiodide (1·5 g), m.p. 218° from acetonitrile, as the less soluble component and magnoflorine iodide (0·15 g), m.p. 250°–260° (depending on the rate of heating), $[\alpha]_D^{30}$ +193° (*c*, 0·6 in CH_3OH) as the more soluble component. Each was identified by comparison with an authentic specimen (mixed m.p. and i.r. spectra).

Extraction of the Leaves

The dried milled leaves (1·6 kg) were extracted at room temperature in turn with light petroleum, ether, and methanol.

The light petroleum extract was evaporated, the residue dissolved in ether, and the solution extracted thoroughly with 3% HCl and then 3% NaOH. The basic fraction, after recovery in the usual way, on crystallization from benzene yielded skimmianine (0·2 g). The acidic fraction, a wax apparently consisting chiefly of saturated aliphatic acids, was not further examined. The neutral fraction, on chromatography on alumina, gave lupeol (0·35 g) and sitosterol (0·15 g).

The ether extract on treatment as above afforded skimmianine (0·625 g) and sitosterol (0·2 g).

The methanol extract was concentrated and the residue dissolved in ether. The only substance isolable was skimmianine (0·5 g).

Extraction of the Wood

The milled wood (5·3 kg) was extracted with ether and then with methanol at room temperature.

The ether extract was concentrated and then washed thoroughly with 3% HCl and 3% NaOH to give basic, acidic, and "neutral" fractions. The basic fraction on chromatography on alumina afforded skimmianine (2 g). The acidic fraction yielded no pure substance. The "neutral" fraction on chromatography on alumina gave dictamnine (0·15 g), m.p. 134–135°, identified by comparison with an authentic specimen, and sitosterol (0·1 g).

The methanol extract was freed of solvent and the residue extracted with chloroform. The insoluble fraction after crystallization from methanol was identified as hesperidin (10·5 g). The chloroform solution was extracted with 3% HCl and then with 3% NaOH to yield basic, acidic, and "neutral" fractions. The basic fraction on crystallization from benzene gave skimmianine (0·3 g); chromatography of the mother liquors on alumina gave dictamnine (0·15 g), skimmianine (0·3 g), and platydesmine (2·1 g). The latter substance after crystallization from ethyl acetate had m.p. 136–137°, $[\alpha]_{589}^{25}$ +44°, $[\alpha]_{500}^{25}$ +59°, $[\alpha]_{400}^{25}$ +90° (*c*, 3·2 in CH_3OH), (lit.[3] m.p. 137–138°); its i.r. spectrum was identical with that published.[3] The identity of the alkaloid was confirmed by direct comparison of its picrate, m.p. 105–109°, with an authentic specimen (mixed m.p. and i.r. spectrum). The acidic fraction was chromatographed on silica gel; elution with benzene/ether gave crude *parvifloral* (0·4 g). The "neutral" fraction was chromatographed on alumina; the only substance isolated was skimmianine (3 g).

Parvifloral

The pure substance crystallized from a little methanol as very pale yellow needles, m.p. 124–125° (Found: C, 72·4; H, 7·2; O, 19·3. $C_{15}H_{18}O_3$ requires C, 73·1; H, 7·4; O, 19·5%); λ_{max} 228, 245, 343 mμ, log ϵ 4·12, 4·18, 4·43; λ_{max} (NaOH/EtOH) 267, 425 mμ, log ϵ 4·02, 4·57; ν_{max} 3325, 1655, 1615, 1585 cm^{-1}.

The *acetate*, prepared by the acetic anhydride/pyridine method, separated from cyclohexane as colourless needles, m.p. 112–113° (Found: C, 69·8; H, 7·1; mol. wt., 288 (mass spectrometry). $C_{17}H_{20}O_4$ requires C, 70·2; H, 7·0%; mol. wt., 288); λ_{max} 245sh, 295, log ϵ 3·89, 4·09; ν_{max} 1760, 1660, 1240 cm^{-1}. The n.m.r. spectrum was essentially the same as that of parvifloral except for the disappearance of the hydroxyl proton signal and the appearance of a three-proton singlet at δ 2·3; the two aromatic proton signals moved downfield to about δ 7·04.

Synthesis of Parvifloral

(i) *5-Prenylvanillin.*—The thoroughly dried and ground sodium salt of vanillin (93 g) (which had been prepared by adding methanolic NaOH to a solution of vanillin in methanol, collecting the precipitate, and washing it thoroughly with methanol and ether) was heated under reflux with dry xylene (1200 ml) and prenyl bromide (40 g). After 12 hr, more prenyl bromide (40 g) was added and heating continued for a further 24 hr. The reaction mixture was cooled and shaken with water and then 10% NaOH (3 × 500 ml). Phenolic material was recovered from the combined aqueous extracts and chromatographed on silica gel (1500 g). Elution with ether/benzene (1 : 50) gave the required product (29 g; 40%); unchanged vanillin (35 g) was eluted by ether/benzene (1 : 9).

The above experiment was the best of several; others gave yields as low as 2%. Benzene was somewhat less efficient as the reaction solvent. Recrystallization of the product from benzene/light petroleum gave *5-prenylvanillin* as needles, m.p. 64–65° (Found: C, 71·1; H, 7·3. $C_{13}H_{16}O_3$ requires C, 70·9; H, 7·3%). λ_{max} 233, 305 mμ, log ε 4·02, 4·21; λ_{max} (NaOH/EtOH) 255, 360 mμ, log ε 4·18, 4·51; ν_{max} 3310, 1675 cm^{-1}; n.m.r. spectrum: s(b), 6, 1·72 [$(CH_3)_2C$=C]; d(b), 2, 3·33 (Ar–CH_2–C=C), 8; s, 3, 3·87 (OCH_3); t(b), 1, 5·30 (C=C–H), 8; s, 1, 6·62 (OH), disappearing on exchange with deuterium oxide; s(b), 2, 7·20 (Ar–H); s, 1, 9·70 (CHO).

(ii) *7-Formyl-8-methoxy-2,2-dimethylchroman* (*III*).—A solution of the prenylvanillin (1·5 g) in glacial acetic acid (25 ml) and conc. HCl (5 ml) was heated on the steam-bath for 1 hr and then evaporated under reduced pressure. The residue was dissolved in ether, the solution washed thoroughly with aqueous NaOH, then with water, dried, and evaporated. The gum was taken up in benzene, and the solution filtered through a column of alumina. The recovered material on recrystallization from cyclohexane afforded the *chroman* (III) (0·85 g) as colourless needles, m.p. 64–65°, depressed to about 30° on admixture with starting material (Found: C, 71·1; H, 7·4. $C_{13}H_{16}O_3$ requires C, 70·9; H, 7·3%). λ_{max} 236, 298 mμ, log ε 4·19, 4·10; ν_{max} 1680 cm^{-1}; n.m.r. spectrum: s, 6, 1·42 ($OC(CH_3)_2$); t, 2, 1·86 (CH_2), 7; t, 2, 2·87 ($ArCH_2$), 7; s, 3, 3·9 (OCH_3); s(b), 2, 7·27 (Ar–H); s, 1, 9·83 (CHO).

(iii) *4-Acetoxy-3-methoxy-5-prenylcinnamic Acid* (*IV*).—A mixture of prenylvanillin (2 g), malonic acid (2 g), pyridine (10 ml), and piperidine (0·3 ml) was heated on the steam-bath for 8 hr and then refluxed for 0·25 hr. After cooling, acetic anhydride (5 ml) was added, the mixture kept overnight and then decomposed by ice and dil. HCl. The product, which solidified slowly, was collected, washed, dried, and recrystallized from ethyl acetate/cyclohexane. The *cinnamic acid* (IV) (0·95 g) formed colourless prisms, m.p. 177–178° (Found: C, 67·2; H, 6·7. $C_{17}H_{20}O_5$ requires C, 67·1; H, 6·6%). λ_{max} 275 mμ, log ε 4·24; ν_{max} 1750, 1695 cm^{-1}; n.m.r. spectrum: s(b), 6, 1·73 (C–$(CH_3)_2$); s, 3, 2·32 ($OCOCH_3$); t, 1, 5·26 (–CH_2–CH=C), 7; d, 1, 6·38 (–CH=CHCOOH), 16; s(b), 2, 7·02 (Ar–H); d, 1, 7·75 (CH=CHCOOH), 16; s, 1, 10·1 (COOH).

(iv) *4-Acetoxy-3-methoxy-5-prenylcinnamaldehyde*.—The above acid (0·2 g) was heated at 70° with excess oxalyl chloride for 4 hr and then unchanged reagent was removed under reduced pressure. A stirred solution of the residue in tetrahydrofuran (20 ml) was cooled to −65° and treated dropwise with a solution of lithium tri-t-butoxyaluminium hydride (2·0 g) in tetrahydrofuran (15 ml), in an atmosphere of nitrogen. After the addition was complete, the mixture was allowed to warm to room temperature and then decomposed with ice-water. Solvent was removed under reduced pressure and the precipitated product collected. Purification by extraction with ether and recrystallization of the soluble portion from cyclohexane gave parvifloral acetate (0·1 g), m.p. 111°, identical with the natural derivative (mixed m.p. and i.r. spectra).

On one occasion the product was contaminated by a small amount of another *compound* which was separated by virtue of its lower solubility in cyclohexane. It crystallized from this solvent in needles, m.p. 135–136° (Found: C, 63·3; H, 6·5. $C_{15}H_{19}ClO_3$ requires C, 63·6; H, 6·7%). It contained chlorine (qualitative test) and its n.m.r. spectrum, otherwise similar to that of parvifloral acetate, showed no signal from an olefinic proton at about δ 5·3, but two ill-defined triplets (due to the small quantity available) at δ 1·9 and δ 2·8, and signals from the methyl protons at δ 1·63. It was apparently formed by the addition of hydrogen chloride to the prenyl residue of the above aldehyde.

(v) *Parvifloral*.—Methanolysis of the synthetic acetate (0·05 g) was effected by treating its solution in chloroform (2 ml) with a solution of sodium (0·2 g) in methanol (2 ml). After 0·5 hr at room temperature the mixture was shaken with water (50 ml). The aqueous layer was separated and the product recovered from it by acidification and extraction with chloroform. The synthetic material (0·03 g), m.p. 123° after recrystallization from methanol, was identical with the natural product (mixed m.p. and i.r. spectra).

Conversion of Platydesmine into Dictamnine

A mixture of purified lead tetraacetate (0·19 g), calcium carbonate (0·05 g), and cyclohexane (50 ml) was heated under reflux for 10 min. After cooling slightly, iodine (0·1 g) and then platydesmine (0·1 g) were added and the mixture refluxed for 2 hr under irradiation by

a 500-W tungsten lamp. The mixture was cooled, treated with a few drops of conc. HCl, and filtered. The residue was washed with ether and chloroform and the combined filtrates evaporated under reduced pressure. The remaining material was extracted with ether and the extract washed thoroughly with water, dil. $Na_2S_2O_3$, and water, dried, and evaporated. The residue in light petroleum was chromatographed on alumina (15 g). Elution with benzene/ether gave dictamnine (0·008 g; 10% yield), m.p. 133–135°, identical with an authentic specimen (mixed m.p. and i.r. spectra).

In some other experiments the reaction was followed by thin-layer chromatography. Lead tetraacetate alone effected the conversion very slowly and in lower yield. Lead tetraacetate and iodine without irradiation by the lamp yielded dictamnine in about 10% yield but only after refluxing for 6 hr. Dictamnine itself was not appreciably changed by the reaction conditions.

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