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A BITTER MONOTERPENE DIGLYCOSIDE FROM *VIBURNUM URCEOLATUM*

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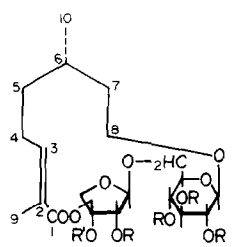
Key Word Index—*Viburnum urceolatum*, Caprifoliaceae, monoterpene diglycoside, urceolide

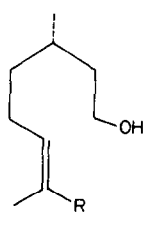
Abstract—From the methanolic extract of the leaves of *Viburnum urceolatum* a new bitter monoterpene diglycoside, urceolide, has been isolated in addition to several known compounds The structures were elucidated by spectroscopic and chemical methods

INTRODUCTION

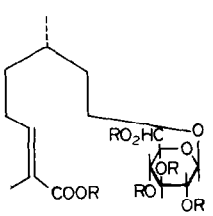
The deciduous shrub *Viburnum urceolatum* is widely distributed in the mountains of Japan and its leaves are remarkably bitter In the course of an investigation of the bitter constituents of *V urceolatum* four new iridoid and bis-iridoid glucosides were isolated and their structures were elucidated [Hase T and Iwagawa, T , unpublished results] Further investigations on the bitter principles of the plant led the isolation of a new monoterpene diglycoside which was named urceolide (1) together with α-amyrin palmitate, lupeol palmitate, β-amyrin acetate, ursolic acid and sitosteryl-β-D-glucoside



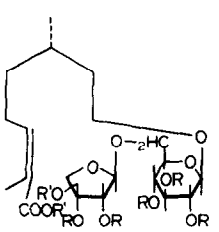
1 R = R' = H
2 R = Ac, R = H
3 R = Ac, R' = Ac



4 R = COOH
5 R = Me
6 R = CHO
7 R = COOMe



8 R = H
10 R = Me



9 R = R' = H
11 R = R' = Me
12 R = Me, R' = H

RESULTS AND DISCUSSION

The diglycoside (1) was obtained by ether extraction of the methanolic extract of fresh leaves and subsequent fractionation by Si gel CC Compound 1 was crystallized as colorless prisms or plates, mp 155–156°, $[\alpha]_D^{26}$ −45 4° (MeOH, *c* 0 4), and had the molecular formula $C_{21}H_{34}O_{11}$ H_2O The IR spectrum showed absorption bands of a hydroxyl group at 3300 cm^{-1}, and an α, β-unsaturated ester at 1715 and 1625 cm^{-1} The presence of the α, β-unsaturated ester was also supported by the absorption maximum at 218 nm (ϵ 14000) in the UV spectrum The ^1H NMR spectrum confirmed the presence of a secondary methyl group δ 0 86 (3H, *d*, J = 5 Hz) and an olefinic methyl group δ 1 86 (3H, *brs*) A β-proton on the α, β-unsaturated ester gave rise to a broad triplet at δ 6 97 (1H, J = 7 Hz) coupled to allylic methylene protons

Acetylation of **1** with acetic anhydride in pyridine gave a tetra-acetate (**2**), $C_{29}H_{42}O_{15}$ and a penta-acetate (**3**), $C_{31}H_{44}O_{16}$ The IR spectrum of **2** showed an absorption band typical of a tertiary hydroxyl group at 3450 cm^{-1}

On hydrolysis with 2 N HCl, compound **1** afforded a monoterpenoid acid (**4**), $C_{10}H_{18}O_3$, $[\alpha]_D^{26}$ − 14 6° ($CHCl_3$, *c* 0 24), D-apiose and D-glucose The IR spectrum of **4** indicated a hydroxyl absorption at 3400 cm^{-1} together with the absorption of an α, β-unsaturated acid at 1680 and 1640 cm^{-1} In the ^1H NMR spectrum of **4** signals were observed at δ 0 95 (3H, *d*, J = 6 Hz) due to a secondary methyl group (H-10) and at 1 82 (*brs*) due to an olefinic methyl group (H-9) A quartet-like signal at 2 22 (2H, J = 8 Hz, H-4) and a multiplet at *ca* 3 83 (2H, H-8) were assigned to allylic methylene protons and methylene protons adjacent to a hydroxyl group, respectively A β-proton (H-3) on the α, β-unsaturated carboxylic acid appeared at 6 93 as triplet-like (1H, *d*, J = 7 Hz) The *E*-stereochemistry of the 2, 3-double bond was defined from the olefinic proton (H-3) shift at δ 6 92 [1] From these data, and biogenetic considerations,

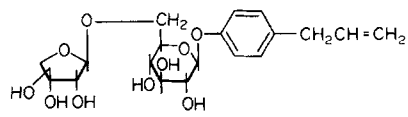
the monoterpenoid acid (**4**) was assumed to be 8-hydroxy-2, 6-dimethyl-2(*E*)-octenoic acid

To confirm the structure, the acid **4** was prepared from (−)-citronellol (**5**), $[\alpha]_D$ −3 4° (see Experimental) Compound **5** was oxidized with selenium dioxide in ethanol to give an aldehyde (**6**) The IR spectrum of the aldehyde had absorption bands at 1700 and 1640 cm^{-1} for an α,β-unsaturated aldehyde The ^1H NMR chemical shift of the aldehyde proton at δ 9 59 (*s*) in the ^1H NMR spectrum revealed that the methyl group with *E* geometry was oxidized selectively [2] Further oxidation of the aldehyde led to a methyl ester (**7**) [3], which gave an acid on treatment with 1N sodium hydroxide The synthetic acid was identified by comparison of its IR spectrum with that of the natural monoterpenoid acid (**4**) The configuration of the assymmetric carbon at C-6 was determined as the *S*-form, because of the sign of the specific rotation of **4** ($[\alpha]_D^{26}$ −14 6°), which was in agreement with that of the synthetic acid ($[\alpha]_D^{26}$ −6°)

On alkaline hydrolysis, compound **1** provided a mixture of two acids, **8** and **9**, which were hydrolysed with β-glucosidase to afford the aglycone (**4**) and D-glucose in low yield This proved that the compound is a β-D-glucoside The above mixture was permethylated and separated by Si gel chromatography to give a pentamethylether (**10**) and a heptamethylether (**11**) The ^1H NMR spectrum of **10** in deuterochloroform showed signals arising from the monoterpenoid moiety at δ 0 89 (3H, *d*, *J* = 6 Hz), 1 80 (3H, *brs*), 2 14 (2H, *m*) and 6 72 (1H, *br t*, *J* = 7 Hz) together with signals from the five methyl groups at 3 36–3 69 (3H × 5, *s*) and an anomeric proton of glucose at 4 16 (1H, *d*, *J* = 8 Hz) Signals due to apiose were absent from the ^1H NMR spectrum Thus, compound **8** must be a glucoside of the monoterpenoid acid (**4**) On the other hand, the heptamethylether (**11**) was hydrolysed with 2N hydrochloric acid to give 2, 3, 3′-tri-*O*-methyl-D-apio-D-furanose, $[\alpha]_D^{18}$ −5 6° (MeOH, *c* 0.09), which was identified by comparing the IR spectrum with that of methylated apiose from apiin [4], and 2, 3, 4-tri-*O*-methyl-D-glucopyranose These results, and the chemical shift of the methylene protons at δ 4 57 (AB*q*, *J* = 11 Hz) in the ^1H NMR spectrum of **1**, suggested that the hydroxyl group at C-3′ of apiose was esterified in compound **1**

Permethylation of **1** by the Purdie method followed by alkaline and then acid hydrolysis gave the aglycone **4** and a mixture of two methylated sugars Only a small amount of 2, 3, 4-tri-*O*-methyl-D-glucopyranose could be separated from the mixture by repeated chromatography

On the basis of the above results the mixture of methylated sugars was deduced to be composed of 2, 3′-*O*-methyl-D-apiose and 2, 3, 4-tri-*O*-methyl-D-glucopyranose, and it was considered to be possible to prepare the mixture from furcatin (**13**) which has the structure *p*-allylphenol 4-*O*-β-D-apio-D-furanosyl-(1→6)-β-D-glucopyranoside [5, 6] To protect the primary hydroxyl group at C-3′ of apiose, tritylation of **13** under various conditions was attempted without success However, compound **13** was silylated successfully with *t*-butyldimethylsilyl chloride to give a monosilylate (**14**), mp 65–67°, $C_{26}H_{42}O$ Si H_2O Compound **14** was permethylated to afford a



13

monosilylpentamethylether (**15**), which gave a pentamethylalcohol (**16**) by means of hydrolysis under mild conditions On acetylation with acetic anhydride in pyridine, compound **16** produced a monoacetate (**17**), $C_{27}H_{40}O_{11}$ The difference in the chemical shifts of the methylene protons at C-3′ of apiose between the monoalcohol (**16**) and the monoacetate (**17**) was at least 0 5 ppm, showing that the primary hydroxyl group of apiose was silylated in **14** The methylated monosilylate (**15**) on hydrolysis with 2N hydrochloric acid gave a mixture of 2, 3-di-*O*-methyl-D-apiose and 2, 3, 4-tri-*O*-methyl-D-glucopyranose as well as *p*-allylphenol The GC/MS analysis of the alditol acetates of the mixture gave results which were identical with those of the alditol acetates formed from the permethylether of **1**

The coupling constants of the anomeric protons at δ 4 78 (*J* = 8 Hz) and at 5 62 (*J* = 2 Hz) in the ^1H NMR spectrum of **1** showed that both glucose and apiose were in the β-configurations [7] Therefore, the bitter monoterpene diglycoside was shown to have the structure **1**

The acids **8** and **9** resulting from the basic hydrolysis of **1** were probably produced by the strongly acidic Amberlite IR-120 used for neutralization

EXPERIMENTAL

Extraction and isolation Plant material was collected in Miyazaki prefecture and identified by Dr S Sako (Herbarium sample No 26132) The fresh leaves of *V urcolatum* Sieb et Zucc (2 1 kg) were extracted with MeOH (10 l × 2) The combined MeOH solns were concd to dryness to afford a dark green residue (210 g) The residue was diluted with H_2O and extracted with Et_2O The Et_2O extract (30 g) was chromatographed on Si gel and eluted with $CHCl_3$–MeOH The fractions eluted with $CHCl_3$ were combined and rechromatographed on Si gel with hexane to give α-amyrin palmitate (1 2 g), lupeol palmitate (64 mg) and β-amyrin acetate (9 mg) Elution with $CHCl_3$–MeOH (95 5) gave ursolic acid (251 mg) From the fraction eluted with $CHCl_3$–MeOH (90 10), a crude bitter principle and sitosteryl-β-D-glucoside (154 mg) were obtained Known compounds were identified by their IR and ^1H NMR spectra The crude bitter principle was crystallized from Me_2CO or H_2O to give compound **1** as prisms or plates (230 mg), $[\alpha]_D^{26}$ −45 4° (MeOH, *c* 0 4) UV λ_{max}^{MeOH} nm (ϵ) 218 (14000), IR ν_{max}^{nujol} cm^{-1} 3300, 1625, ^1H NMR (360 MHz, C_5D_5N) δ 0 86 (3H, *d*, *J* = 7 Hz, H-10), 1 82 (3H, *br s*, H-9), 1 97, 2 20 (1H each, *m*, H-4), 4 51, 4 63 (1H each, AB*q*, *J* = 11 Hz, H-3′ of apiose), 4 78 (1H, *d*, *J* = 8 Hz, H-1 of glucose), 5 62 (1H, *d*, *J* = 2 Hz, H-1 of apiose), 6 93 (1H, *br t*, *J* = 7 Hz, H-3), MS *m/z* (rel int) 462 $[M]^+$ (0 8), 444 (0 5), 431 (0 3), 359 (0 4), 197 (52), 169 (55), 97 (100), 95 (37) (Found C, 52 52, H, 7 67% Calc for $C_{21}H_{34}O_{11}$ H_2O C, 52 49, H, 7 57%) Compound **1** (120 mg) was also isolated from the EtOAc extract of the remaining aq soln

Acetylation of **1** A soln of **1** (60 mg) in Ac_2O and pyridine was allowed to stand at room temp overnight The crude product was chromatographed on Si gel with $CHCl_3$–MeOH (99 1) The faster eluting compound was an amorphous

powder (**2**) (22 mg), IR ν_{max}^{nujol} cm^{-1} 1755, 1710, 1650, 1240, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 96 (3H, *d*, J = 6 Hz), 1 85 (3H, *br s*), 1 99–2 09 (3H × 5, *s*), 6 89 (1H, *br t*, J = 8 Hz) (Found 672 2622 Calc for $C_{31}H_{44}O_{16}$ 672 2628) The slower eluting compound was also an amorphous powder (**3**) (14 mg), IR ν_{max}^{KBr} cm^{-1} 3450, 1750, 1710, 1630, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 93 (3H, *d*, J = 6 Hz), 1 86 (3H, *s*), 2 00–2 16 (3H × 4, *s*), 2 88 (1H, *br s*, OH), 6 88 (1H, *br t*, J = 8 Hz) (Found 630 2558 Calc for $C_{29}H_{42}O_{15}$ 630 2525)

Hydrolysis of **1** Compound **1** (50 mg) was dissolved in MeOH (0 5 ml) and to this soln was added 2N HCl (2 ml) After refluxing for 2 5 hr, the reaction soln was added to H_2O and extracted with Et_2O The extract was washed with H_2O and brine, dried over Na_2SO_4 and concd The residue was chromatographed on Si gel with $CHCl_3$–MeOH (97 3) to afford an oil (**4**) (9 mg), $[\alpha]_D^{26}$ −14 6° ($CHCl_3$, *c* 0 24), IR ν_{max}^{film} cm^{-1} 3350, 2600, 1680, 1640, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 95 (3H, *d*, J = 6 Hz, H-10), 1 82 (3H, *br s*, H-9), 2 22 (2H, *q*-like, J = 8 Hz, H-4), 3 83 (2H, *m*, H-8), 5 68 (2H, *m*, OH and COOH), 6 95 (1H, *br t*, J = 7 Hz, H-3), MS *m/z* (rel int) 168 [M − H_2O]$^+$ (69), 112 (32), 111 (38), 95 (100), 87 (37), 82 (69), 69 (51), 67 (77) (Found 168 1140 Calc for $C_{10}H_{18}O_3$ H_2O 168 1148)

The aq soln was neutralized with Amberlite IR-45 (6 g) and evaporated to dryness *in vacuo* The presence of D-glucose and D-apiose in the residue was confirmed by co-PC with authentic samples (solvent system EtOAc–pyridine–H_2O – HOAc, 5 5 3 1)

Oxidation of (−)-*citronellol* (**5**) *with* SeO_2 A soln of freshly sublimed SeO_2 (147 mg) in EtOH (1 ml) was added over a period of 2 5 hr to (−)-citronellol, $[\alpha]_D$ −3 4°, (205 mg) dissolved in EtOH (2 ml) at 50° The mixture was refluxed for 17 hr, cooled, the selenium was filtered and the solvent removed *in vacuo* The residue was taken up in Et_2O, washed with $NaHCO_3$ soln and brine and dried over Na_2SO_4 Evaporation of the Et_2O left a dark orange oil, which was subjected to CC on Si gel with $CHCl_3$ to give an aldehyde (**6**) (54 mg) IR ν_{max}^{film} cm^{-1} 3400, 2700, 1680, 1640, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 95 (3H, *d*, J = 6 Hz, H-10), 1 76 (3H, *br s*, H-9) 240 (2H, *q*-like, J = 8 Hz, H-4), 3 74 (2H, *t*, J = 6 Hz, H-8), 6 62 (1H, *tq*, J = 1 and 7 Hz, H-3), 9 59 (1H, *s*, H-1) MS *m/z* 170 [M]$^+$

Conversion of the aldehyde (**6**) *to the methylester* (**7**) The aldehyde (**6**) (53 mg) was stirred with a mixture of NaCN (85 mg), Ac_2O (35 mg) and MnO_2 (575 mg) in MeOH (3 ml) at room temp After 12 hr, the mixture was filtered and the filtrate was evaporated *in vacuo* The residue was taken up in Et_2O, washed with H_2O and brine, dried over Na_2SO_4 and the solvent was removed CC of the residual oil on Si gel with $CHCl_3$ gave the methylester (**7**) (25 mg), $[\alpha]_D^{26}$ −4 8° ($CHCl_3$, *c* 0 833), IR ν_{max}^{film} cm^{-1} 3400, 1710, 1640, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 94 (3H, *d*, J = 6 Hz), 1 79 (3H, *br s*), 2 17 (2H, *q*-like, J = 8 Hz), 3 77 (3H, *s*, COOMe), 6 85 (1H, *tq* J = 1 and 8 Hz), MS *m/z* 200 [M]$^+$

Hydrolysis of the methylester (**7**) Compound **7** (25 mg) was dissolved in MeOH (1 ml) and to this soln 1N NaOH (0 5 ml) was added After stirring at 80° for 45 min, the reaction soln was diluted with H_2O and extracted with Et_2O to remove the neutral material The aq soln was acidified with dil HCl and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 The Et_2O was evaporated to afford an oil, which was chromatographed on Si gel with $CHCl_3$–MeOH (97 3) to give the acid, **4** (17 mg), $[\alpha]_D^{26}$ −6 0° ($CHCl_3$, *c* 0 557), IR ν_{max}^{film} cm^{-1} 3350, 2650, 1680, 1640, ^{1}H NMR (100 MHz, $CHCl_3$) δ 0 95 (3H, *d*, J = 6 Hz), 1 86 (3H, *br s*), 2 20 (2H, *m*), 3 76 (2H, *m*), 6 29 (2H, *m*), 7 00 (1H, *br t*, J = 6 Hz), MS *m/z* 168 [M − H_2O]$^+$ The IR spectrum of the acid was in good agreement with that of the aglycone (**4**)

Alkaline hydrolysis of **1** To a soln of **1** (97 mg) in MeOH (0 5 ml), was added 1N NaOH (1 ml) and the soln was refluxed for 1 hr The reaction soln was neutralized with Amberlite IR-120 (10 g) and evaporated to dryness *in vacuo* CC of the crude product, which gave a negative Fehling test, on Si gel with $CHCl_3$–MeOH (80 20) afforded a mixture of two acids, **8** and **9** (59 mg) (a) *Enzymatic hydrolysis of the mixture of* **8** *and* **9** To a soln of β-glucosidase (7 mg) in acetate buffer soln (pH 4 9, 2 5 ml), was added the mixture of **8** and **9** (27 mg) After stirring at 38° for 24 hr, the soln was extracted with Et_2O The extract was washed with H_2O, dried over Na_2SO_4 and the solvent was evaporated to give an oil (4 mg) The IR spectrum of the oil was identical with that of the aglycone (**4**) The aq soln was evaporated to dryness *in vacuo* The presence of D-glucose was confirmed by PC (b) *Methylation of the mixture of* **8** *and* **9** A soln of the mixture of **8** and **9** (100 mg) in DMF (1 5 ml) was treated with Ag_2O (220 mg) and MeI (1 ml) and stirred at 5° After the usual work-up, the crude product was methylated again in the same way and the final product was chromatographed on Si gel with $CHCl_3$–MeOH (99 1) The faster eluting compound was the pentamethylether (**10**) (19 mg), IR ν_{max}^{film} cm^{-1} 1720, 1650, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 89 (3H, *d*, J = 6 Hz), 1 80 (3H, *br s*), 2 14 (2H, *m*), 3 36, 3 48, 3 51, 3 59, 3 69 (3H each, *s*), 4 16 (1H, *d*, J = 8 Hz, H-1 of glucose), 6 72 (1H, *br t*, J = 7 Hz, H-3), MS *m/z* 387 [M]$^+$ The slower eluting compound was the heptamethylether (**11**) (65 mg), IR ν_{max}^{film} cm^{-1} 1710, 1650, ^{1}H NMR (100 MHz, $CDCl_3$), δ 0 96 (3H, *d*, J = 6 Hz), 1 81 (3H, *br s*), 2 17 (2H, *m*), 3 43, 3 48, 3 52, 3 58, 3 69 (3H, *s*), 4 18 (1H, *d*, J = 7 Hz, H-1 of glucose), 5 07 (1H, *d*, J = 2 Hz, H-1 of apiose), 6 71 (1H, *br t*, J = 8 Hz, H-3)

Hydrolysis of the heptamethylether (**11**) To a soln of **11** (62 mg) in MeOH (1 ml) was added 2N HCl (0 5 ml) and the mixture was refluxed for 4 hr The reaction mixture was diluted with H_2O and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 The solvent was removed and chromatographed on Si gel with $CHCl_3$–MeOH mixtures Elution with $CHCl_3$–MeOH (99 1) gave the starting material (**11**) (8 mg) Elution with $CHCl_3$–MeOH (97 3) gave the aglycone (**4**) (2 5 mg) The aq soln was neutralized with Amberlite IR-45 (6 g) and evaporated to dryness *in vacuo* The crude product was subjected to CC on Si gel with $CHCl_3$–MeOH (96 4) The faster eluting compound was 2, 3, 3′-tri-*O*-methyl-D-apio-D-furanose (10 mg), $[\alpha]_D^{18}$ −5 6° (MeOH, *c* 0 09) whose IR spectrum was identical with that of 2, 3, 3′-tri-*O*-methyl-D-apio-D-furanose from apiin permethylate The slower eluting compound was 2, 3, 4-tri-*O*-methyl-D-glucopyranose (6 mg), which was identified by comparison of its IR spectrum with that of an authentic sample

Methylation of **1** *followed by alkaline and acid hydrolysis* A soln of **1** (100 mg) in DMF (1 ml) was treated with Ag_2O (220 mg) and MeI (1 ml) and the reaction mixture was stirred at 5° for 2 days After usual work-up, the crude product was chromatographed on Si gel with $CHCl_3$–MeOH (99 1) to give a methylate (72 mg), IR ν_{max}^{film} cm^{-1} 1720, 1640, ^{1}H NMR (100 MHz, $CDCl_3$) δ 0 95 (3H, *d*, J = 5 Hz), 1 87 (3H, *br s*), 3 47, 3 52, 3 56, 3 58, 3 64 (3H each, *s*), 5 11 (1H, *d*, J = 2 Hz), 6 82 (1H, *br t*, J = 8 Hz), MS *m/z* 532 [M]$^+$

To a soln of the methylate (62 mg) in MeOH (4 ml), was added 1N NaOH (1 ml) and the soln was refluxed for 1 hr The reaction soln was diluted with H_2O and extracted with

Et_2O to remove the neutral material The aq soln was acidified with dil HCl and extracted with Et_2O The Et_2O was washed with H_2O and brine and dried over Na_2SO_4 Removal of the solvent followed by CC of the residual oil on Si gel with $CHCl_3$–MeOH (99 1) gave an acid (**12**) (30 mg), IR ν_{max}^{film} cm^{-1} 3450, 1710, 1680, 1640, ^1H NMR (100 MHz, $CDCl_3$) δ 0 93 (3H, *d*, $J = 5$ Hz), 1 83 (3H, *s*), 3 46, 3 48, 3 53, 3 58, 3 63 (3H each, *s*), 3 91, 4 12 (1H each, AB*q*, $J = 10$ Hz), 4 26 (1H, *d*, $J = 7$ Hz), 5 18 (1H, *d*, $J =$ 2 Hz), 6 91 (1H, *t*-like, $J = 4$ Hz) The acid (22 mg) was dissolved in EtOH (1 ml) and treated with 2N HCl (0 5 ml) at 100° for 4 hr The reaction soln was diluted with H_2O and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 The solvent was evaporated and the residue was chromatographed on Si gel with $CHCl_3$–MeOH (97 3) to give the aglycone (**4**) (2 mg)

The aq soln was neutralized with Amberlite IR-45 (6 g) and evaporated to dryness *in vacuo* The crude product was subjected to CC on Si gel with $CHCl_3$–MeOH (96 4) to give a mixture of two methylated sugars (6 mg), from which only a small amount of 2, 3, 4-tri-*O*-methyl-D-glucopyranose (0 5 mg) was separated by repeated CC A soln of the mixture (9 mg) in MeOH (3 ml) was reduced with $NaBH_4$ (15 mg) followed by acetylation with Ac_2O in pyridine to give alditol acetates (9 mg), GC/MS 22 V, column, 3% ECNSS-M/Chromosorb W-HP (80–100 mesh), 2 m × 2 mm, temp 180°, He, 32 ml/min 1, 3′, 4-tri-*O*-acetyl-2, 3-di-*O*-methyl-D-apiitol, *m/z* (rel int) 233 (8), 189 (43), 173 (10), 129 (66), 117 (100), 99 (28), 87 (25), 1, 5, 6-tri-*O*-acetyl-2, 3, 4-tri-*O*-methyl-D-glucitol, *m/z* (rel int) 291 (1), 233 (20), 189 (46), 173 (27), 129 (64), 117 (100), 99 (33), 87 (28) The mass spectra were in good agreement with those of authentic samples of 1, 3′, 4-tri-*O*-acetyl-2, 3-di-*O*-methyl-D-apiitol and 1, 5, 6-tri-*O*-acetyl- 2, 3, 4-tri-*O*-methyl-D-glucitol which will be described later

Silylation of furcatin (**13**) To a soln of furcatin (2 g) in DMF (4 ml), were added TBDMSCl (900 mg) and imidazole (320 mg) and the soln was stirred at 0° for 2 hr The reaction mixture was diluted with H_2O and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 CC of the crude product on Si gel with $CHCl_3$–MeOH (95 5) gave the monosilylate (**14**) (685 mg) after crystallization from Et_2O–hexane, plates, mp 65–67°, IR ν_{max}^{nujol} cm^{-1} 3450, 3400, 3300, 1640, 1620, 1510, 920, 875, 835, 820, 780, ^1H NMR (100 MHz, $CDCl_3$) δ 0 89 (9H, *s*), 3 24 (2H, *d*, $J = 7$ Hz), 7 02 (4H, *m*), MS *m/z* 409 $[M - t\text{-}BuSiMe_2 - H_2O]^+$ (Found C, 55 75, H, 7 94% Calc for $C_{26}H_{42}O_{10}Si \cdot H_2O$ C, 55 69, H, 7 91%)

Methylation of the monosilylate (**14**) A soln of **14** (105 mg) in DMF (1 ml) was treated with Ag_2O (220 mg) and MeI (1 ml) and the reaction mixture was stirred at 5° for 3 days After the usual work-up, the crude product was chromatographed on Si gel with $CHCl_3$ to give the monosilylpentamethylate (**15**) (99 mg), IR ν_{max}^{film} cm^{-1} 1640, 1610, 1590, 1510, 840, ^1H NMR (100 MHz, $CDCl_3$) δ 0 82 (9H, *s*), 3 28, 3 32, 3 45, 3 56 (3H × 5, *s*), 6 84, 6 98 (2H each, A_2B_2q, $J = 8$ Hz), MS *m/z* 569 $[M - 43]^+$

Desilylation of the monosilylpentamethylate (**15**) To a soln of **14** (126 mg) in EtOH (2 ml), was added 2 N HCl (0 5 ml) and the soln was stirred at room temp overnight The reaction mixture was diluted with H_2O and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 CC of the crude product on Si gel with $CHCl_3$ gave the pentamethylmonoalcohol (**16**) (87 mg), IR ν_{max}^{film} cm^{-1} 3500, 1640, 1615, 1590, 1510, ^1H NMR (100 MHz, $CDCl_3$) δ 3 36, 3 40, 3 52, 3 62 (3H × 5, *s*), 3 72 [inside peak of B proton (in lower field) in AB system] (the peaks of the A proton in the AB system were obscured by the signals of other protons), MS *m/z* 498 $[M]^+$

Acetylation of the monoalcohol (**16**) Compound **16** (53 mg) was acetylated with Ac_2O in pyridine After the usual work-up, the crude product was subjected to CC on Si gel with $CHCl_3$ to give the pentamethylmonoacetate (**17**) (28 mg), IR ν_{max}^{film} cm^{-1} 1740, 1618, 1590, 1510, 1230, ^1H NMR (100 MHz, $CDCl_3$) δ 2 04 (3H, *s*), 3 31, 3 42, 3 47, 3 58 (3H × 5, *s*), 4 22 (2H, AB*q*, $J = 12$ Hz), 6 84, 7 00 (2H each, A_2B_2q, $J = 8$ Hz), MS *m/z* 540 $[M]^+$ (Found 540 2560 Calc for $C_{27}H_{40}O_{11}$ 540 2568)

Hydrolysis of the monosilylpentamethylether (**15**) To a soln of **15** (99 mg) in EtOH (0 5 ml), was added 2 N HCl (0 5 ml) and the soln was refluxed for 2 hr The reaction mixture was diluted with H_2O and extracted with Et_2O The extract was washed with H_2O and brine and dried over Na_2SO_4 The solvent was removed to give *p*-allylphenol (21 mg) The aq soln was neutralized with Amberlite IR-45 (10 g) and evaporated to dryness *in vacuo* to give a mixture of 2, 3-di-*O*-methyl-D-apiose and 2, 3, 4-tri-*O*-methyl-D-glucopyranose (37 mg), from which the latter (4 mg) was separated by repeated CC

Conversion of the mixture of methylated sugars to the alditol acetates A soln of the methylated sugars (7 mg) in MeOH (3 ml) was reduced with $NaBH_4$ (15 mg) and acetylated with Ac_2O in pyridine to give the alditol acetates (6 mg) GC/MS 1, 3′, 4-tri-*O*-acetyl-2-3-di-*O*-methyl-D-apiitol *m/z* (rel int) 233 (5), 189 (31), 173 (10), 129 (67), 117 (100), 99 (29), 87 (24), 1, 5, 6-tri-*O*-acetyl-2, 3, 4-tri-*O*-methyl-D-glucitol *m/z* (rel int) 291 (1), 233 (26), 189 (51), 173 (29), 129 (69), 117 (100), 99 (46), 87 (33)

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