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The Absolute Configuration of Boschnaloside and the Chemical Conversion of Genipin into Boschnaloside

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The absolute configuration of boschnaloside was established by chemical correlation of asperuloside tetraacetate with boschnaloside tetraacetate. During this work it was also found that catalytic reduction of asperuloside tetraacetate gave either of the two C-8 epimers (**4**) and (**5**), depending upon the kind of catalyst used, PtO_2 or Pd-C.

The absolute structure of boschnaloside was also confirmed by its degradation to 3(*R*)-*cis*, *cis*-boschnialinic acid.

Finally, conversion of genipin into boschnaloside was also achieved.

Keywords——*Boschniakia rossica* HULT.; Orobanchaceae; iridoid glucoside; boschnaloside; absolute configuration; chemical conversion; stereoselective catalytic hydrogenation

Boschniakia rossica HULT. (Orobanchaceae, Oniku in Japanese and Cao-cong-rong (草苁蓉) in Chinese) has been used in Chinese medicine as a tonic and a remedy for kidney diseases and colds. It also attracts felids. In the previous paper, we reported on the stereochemistry of boschnialactone and boschniakine, which have this activity.[2] This paper describes the elucidation of the absolute structure of boschnaloside (**1**), an iridoid glucoside of this plant, and the chemical conversion of genipin, one of the few iridoids synthesized,[3] into the glucoside (**1**).

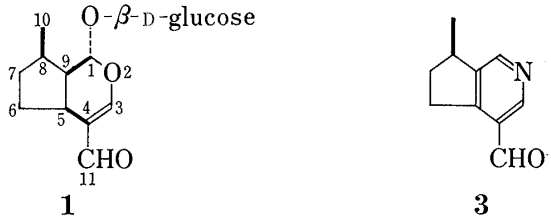


Fig. 1

Boschnaloside (**1**) was obtained from the methanolic extract of the fresh whole plant of *Boschniakia rossica* through successive chromatography on charcoal and silica gel as colorless needles, $C_{16}H_{24}O_8 \cdot H_2O$, mp 102.0—103.0° (dec.), $[\alpha]_D$ −134.5°. It showed infrared (IR) bands at 3500—3150, 2700, 1660 and 1630 cm^{-1} and ultraviolet (UV) absorption (EtOH) at 249 nm (ε 14600), attributable to an α,β-unsaturated aldehydic group. Its proton magnetic resonance (PMR) spectrum showed, beside the signals arising from glucose moiety, a doublet at δ 1.05 (J=6.0 Hz) due to the secondary methyl group, a single at δ 7.30 due to the vinyl proton, a doublet at δ 5.60 (J=3.0 Hz) due to the C-1 proton and a singlet at δ 9.07 ppm due to the aldehydic proton. Furthermore, the ^{13}C-NMR spectrum indicated the presence of an α,β-unsaturated aldehydic group, with olefinic carbon signals at 165.2 (d) and 126.5 (s) and an aldehydic carbon signal at 195.4 ppm (d). It was also apparent on detailed comparative studies with the spectrum of methyl-β-glucoside that the glucosidic linkage of **1** has the β-configuration.[4] Acetylation of **1** with acetic anhydride and pyridine afforded the corresponding tetraacetate (**2**), $C_{24}H_{32}O_{12}$, mp 144.0—145.0°, $[\alpha]_D$ −131.0°. This acetate (**2**) yielded

1) Location: *Nagakute, Aichi, 480-11, Japan.*
2) T. Sakan, F. Murai, Y. Hayashi, Y. Honda, T. Shono, M. Nakajima, and M. Kato, *Tetrahedron*, **23**, 4635 (1967).
3) G. Büchi, G. Gugler, R.S. Schmidt, and J. Wild, *J. Am. Chem. Soc.*, **89**, 2776, (1967).
4) T. Usui, N. Yamamoto, K. Katsuda, K. Tuzimura, H. Sugiyama, and S. Seto, *J. Chem. Soc.*, Perkin Trans, **1**, 2425 (1973).

boschniakine (**3**) on treatment with ammonia in methanol.[5] Consequently, the structure of boschnaloside, except for the stereochemistry, should be represented by **1.**

Boschnaloside tetraacetate (**2**) afforded on oxidation with potassium bichromate in acetic acid an α,β-unsaturated carboxylic acid (**4**), $C_{24}H_{32}O_{13}$, mp 185.0—186.0°, $[\alpha]_D$ −95.5°. The presence of a carboxylic group in this compound was indicated by the IR band at 3200 cm^{-1} and the PMR signal at δ 9.86 ppm, which disappeared on addition of D_2O. Though the melting point and the specific rotation of this acid (**4**) are very similar to those of 7-deoxyloganic acid tetraacetate (**5**) obtained through catalytic hydrogenation of asperuloside tetraacetate (**6**) using Pd-C,[6] the IR spectrum of **4** is slightly different from that of **5** in the fingerprint region. The mixed melting point of both acids also showed a depression. Furthermore, on treatment with diazomethane the acid gave the methyl esters (**7**), mp 110.0—111.0°, $[\alpha]_D$ −93.0°, and (**8**), mp 106.0—107.5°, $[\alpha]_D$ −87.4°,[6] respectively. Both esters also showed very similar IR and PMR spectra, but their IR spectra are slightly different in the fingerprint region. On catalytic reduction over PtO_2, on the other hand, asperuloside tetraacetate (**6**) gave the acid (**4**) through hydrogenolysis of the lactone and acetoxy group followed by hydrogenation of the double bond. The acid (**4**) was otherwise obtained through oxidation of **2**. The methyl ester (**7**) of the acid (**4**) was also obtained through catalytic reduction of geniposide pentaacetate (**9**) over PtO_2. The fact that both acids are derived from asperuloside tetraacetate (**6**) indicates a stereoisomeric relationship between both compounds, which differ only in the configuration at C-8. Accordingly, the absolute structure of **4** was considered to have the 8 (*R*)-configuration, since the absolute stereochemistry of **5** had already been established by Inouye.[6] It is noteworthy that reduction of asperuloside tetraacetate (**6**) gives either of the two C-8 epimers (**4**) and (**5**), depending upon the kind of catalyst used, PtO_2 or Pd-C.

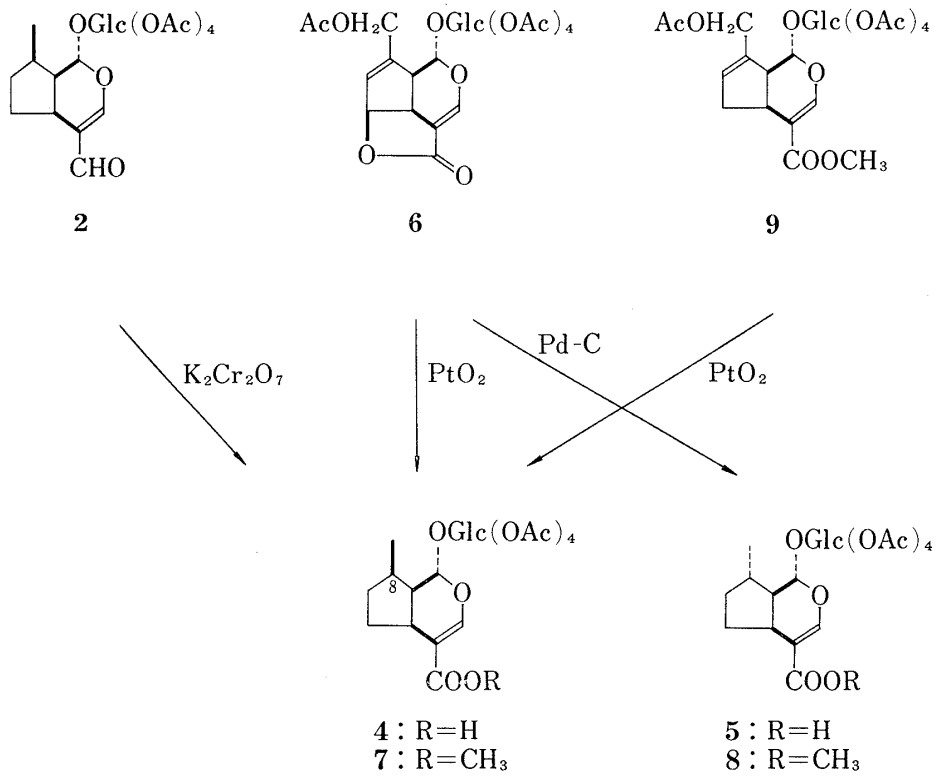


Fig. 2.

5) T. Sakan, F. Murai, S. Isoe, S. Hyeon, and Y. Hayashi, *Nippon Kagaku Zasshi*, **90**, 507 (1969).
6) H. Inouye and T. Arai, *Chem. Pharm. Bull.*, **12**, 968 (1964).

The absolute structure of **1** was also confirmed in the following way: decarboxylation of **4** with copper carbonate/quinoline gave a product (**10**), $C_{23}H_{32}O_{11}$, mp 158.0—160.0°, $[\alpha]_D$ −168.0° ($CHCl_3$), which, in turn, afforded the corresponding glucoside (**11**) on Zemplén reaction. The PMR spectrum of **11** lacked any signal due to the carboxylic product, but showed signals due to the olefinic protons on C-3 and C-4 at δ 6.14 (dd, J=6.0 and 1.0 Hz) and 6.12 ppm (d, J= 6.0 Hz), respectively. Furthermore, enzymatic hydrolysis of **11** with β-glucosidase (emulsin) gave an oily aglycone, whose IR spectrum showed, besides bands at 3400 and 1660 cm^{-1} due to an unsaturated hemiacetal structure (**12**), bands at at 2700 and 1720 cm^{-1} revealing the co-existence of the dialdehyde form (**13**). Finally, oxidation of the aglycone (**12**) with chromium trioxide-pyridine afforded a dicarboxylic acid (**14**), mp 84.0—85.0°, $[\alpha]_D$ −39.8°, along with a minute amount of its isomer (**15**), mp 107.0—108.0°, $[\alpha]_D$ −43.9°. The former was identical with an authentic sample of 3 (*R*)-*cis*, *cis*-boschnialinic acid obtained by oxidation of boschnialactone, while the latter was identical with 3 (*R*)-*trans*, *trans* boschnialinic acid obtained by epimerization of **13** at C-2.[2]

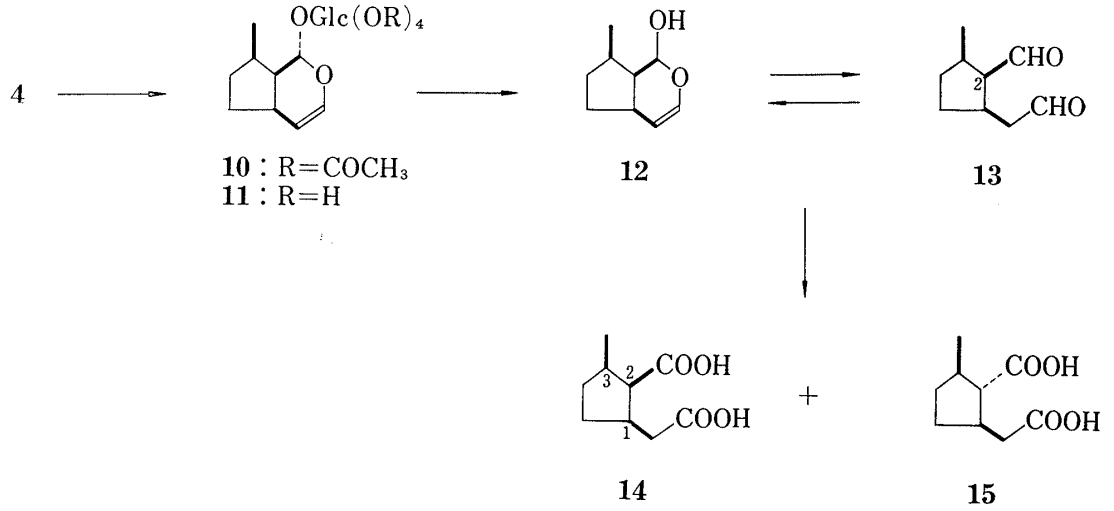


Fig. 3.

Taking into consideration the proposed cyclization mechanism of an acyclic monoterpene in the biosynthesis of loganin,[7] the formation of an iridane skeleton with 8 (*R*)-configuration leading to boschnaloside (**1**) may be depicted as shown in the Chart.

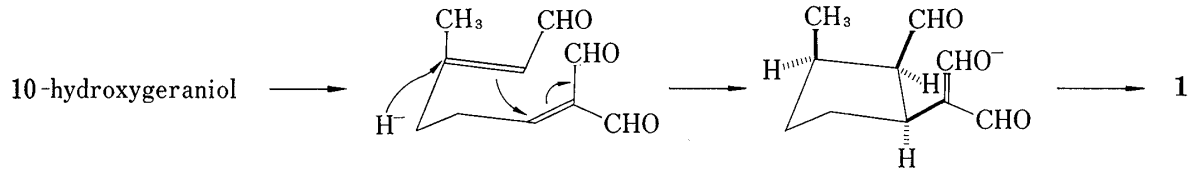
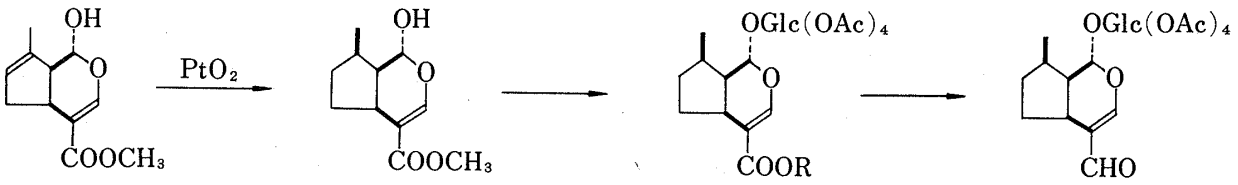


Chart 1

It is known that catalytic hydrogenation of genipin (**16**) over PtO_2 gives the compound (**17**) along with several other hydrogenation products.[8] Genipin (**16**) was next converted to boschnaloside tetraacetate (**2**) *via* **17** in the following way: reaction of **17** with α-bromo

7) *a*) S. Escher, P. Loew, and D. Arigoni, *J. Chem. Soc., Chem. Commun.*, 823 (1970); *b*) A.R. Battersby, S.H. Brown, and T.G. Payne, *ibid.*, 827 (1970).
8) C. Djerassi, T. Nakano, A.N. James, L.H. Zalkow, E.J. Eisenbrawn, and J.N. Schoolery, *J. Org. Chem.*, **26**, 1172 (1961).

glucose tetraacetate in the presence of mercurous cyanide yielded **7**, mp 109.0—110.0°, which, in turn, was subjected to hydrolysis with barium hydroxide, followed by acetylation to give the acid (**4**). On treatment with oxalyl chloride, the sodium salt of **4** gave the corresponding acid chloride, which was reduced with LiAlH $(t\text{-BuO})_3$ giving rise to the desired boschnaloside tetraacetate (**2**), mp 140.0—143.0°, $[\alpha]_D$ −105.7° ($CHCl_3$). In this way, boschnaloside (**1**) was chemically related to genipin (**16**), which has already been synthesized by Büchi and his co-workers.[3)]



16 **17** **7**: R=CH_3 **4**: R=H **2**

Fig. 4

Experimental

Melting points were determined on a Thomas Hoover capillary and are uncorrected. IR and UV spectra were recorded on a JASCO IR-G spectrophotometer and a Hitachi EPS-3T grating spectrophotometer, respectively. PMR spectra were recorded at 100 MHz on a JNM-MH-100 instrument using CD_3OD or $CDCl_3$ as a solvent with TMS as an internal standard. IR-120, IRC-50 or Dowex 50W-X8 was used for ion-exchange chromatography. Silica gel F_{25}, (Merck) plates were used for TLC with the solvent system BuOH/AcOH/H_2O (5:1:4).

Isolation Procedure——The fresh whole plants (4.0 kg), collected at Mt. Fuji in July, were extracted with hot MeOH for one hr, and the extract was concentrated *in vacuo*. The residue was diluted with H_2O and then washed with a large amount of Et_2O. The aqueous layer was concentrated *in vacuo* to afford an amber residue (400 g), which was chromatographed on charcoal (500 g), eluting successively with H_2O (30 l) and MeOH (10 l). The MeOH eluate was concentrated *in vacuo* to leave an amber residue (7.3 g), which was chromatographed on silica gel (200 g) using $CHCl_3$/EtOH as an eluent with an increasing EtOH content. The combined fractions eluted with $CHCl_3$/EtOH (22: 3 to 17: 3) were concentrated *in vacuo* to afford a crystalline solid (0.93 g, *Rf*. 0.55), which was recrystallized from Me_2CO to give boschnaloside (**1**) as colorless needles, yield 0.80 g (0.02%), mp 102.0—103.0° (dec.), $[\alpha]_D^{16}$ −134.5° (c=1, MeOH); IR ν_{max}^{Nujol} cm^{-1}: 3500—3150, 2700, 1660, 1630; UV λ_{max}^{EtOH} nm (ε): 249 (14600); PMR (CD_3OD): δ 1.05 (d, J=6.0 Hz, CH_3–C(8)), 5.60 (d, J=3.0 Hz, H–C(1)), 7.30 (s, H–C(3)), 9.07 ppm (s, H–C(11)); ^{13}C-NMR (D_2O): δ (TMS) 98.7 (d, C-1), 165.2 (d, C-3), 126.5 (s, C-4), 36.8 (d, C-5), 31.5[9)] and 34.1[9)] (t, C-6 and C-7), 31.8 (d, C-8), 44.1 (d, C-9), 17.2 (q, C-10), 195.4 (d, C-11), 100.2 (d, C-1′), 74.5 (d, C-2′), 77.5[9)] and 77.9[9)] (d, C-3′ and C-5′), 71.4 (d, C-4′), 62.7 ppm (t, C-6′). *Anal.* Calcd for $C_{16}H_{24}O_8 \cdot H_2O$: C, 53.03; H, 7.23. Found: C, 52.81; H, 7.27.

Boschnaloside Tetraacetate (2)——Boschnaloside (**1**) (200 mg) was left to stand with Ac_2O-Py at room temperature overnight. The reaction product was treated as usual and recrystallized from MeOH to afford the tetraacetate (**2**) (280 mg) as colorless needles, mp 144.0—145.0°, $[\alpha]_D^{26.5}$ −131.0° (c=1, $CHCl_3$); IR ν_{max}^{Nujol} cm^{-1}: 2755, 1760, 1750, 1673, 1638; UV λ_{max}^{EtOH} nm (ε): 247 (20000); PMR ($CDCl_3$): δ 1.01 (d, J=6.0 Hz, CH_3–C(8)), 1.94—2.07 (m, 4×$COCH_3$), 4.22 (m, 2H–C(6′)), 4.85—5.22 (m, axial-H_4 of the glucose moiety), 5.37 (dd, $^3J_{1,9}$=2.0 Hz, $^4J_{1,3}$=1.0 Hz, H–C(1)), 7.08 (s, H–C(3)), 9.21 ppm (s, H–C(11)). *Anal.* Calcd for $C_{24}H_{32}O_{12}$: C, 56.24; H, 6.29. Found: C, 56.21; H, 6.43.

Oxidation of Boschnaloside Tetraacetate (2)——A solution of **2** (200 mg) in AcOH (5 ml) was treated with a solution of $K_2Cr_2O_7$ (300 mg) in AcOH (5 ml) and the mixture was stirred at 50—60° for 1.5 hr. After cooling, the reaction mixture was poured into H_2O and extracted with Et_2O. The ethereal extract, after being washed with H_2O, was extracted with sat. $NaHCO_3$ solution. The $NaHCO_3$ solution was acidified with 3% HCl and extracted again with Et_2O. The ethereal extract was washed with H_2O, dried over Na_2SO_4 and concentrated. The remaining viscous liquid (140 mg) was chromatographed on silica gel (6 g) using $CHCl_3$/MeOH as an eluent with an increasing MeOH content. The fraction eluted with $CHCl_3$/MeOH (99: 1) afforded a crystalline solid, which was recrystallized from MeOH to yield **4** (65 mg) as colorless needles, mp 185.0—

9) These values may be reversed.

186.0°, $[\alpha]_D^{26}$ −95.5° (c=1, $CHCl_3$); IR ν_{max}^{Nujol} cm^{-1}: 3200, 1760, 1720, 1645; PMR ($CDCl_3$): δ 1.01 (d, J=5.0 Hz, CH_3–C(8)), 1.96—2.07 (m, 4×$COCH_3$), 4.17 (m, 2H–C(6′)), 4.84—5.25 (m, axial-H_4 of the glucose moiety), 7.41 (s, H–C(3)), 9.86 ppm (br.s, H–C(11)). *Anal.* Calcd for $C_{24}H_{32}O_{13}$: C, 54.54; H, 6.10. Found: C, 54.58; H, 6.16. The acid (**4**) (100 mg) was methylated with ethereal CH_2N_2 and the product was recrystallized from MeOH to afford colorless needles (64 mg) of the methyl ester (**7**), mp 110.0—111.0°, $[\alpha]_D^{26}$ −93.0° (c=1, $CHCl_3$); IR ν_{max}^{Nujol} cm^{-1}: 1760, 1710, 1700, 1640; PMR ($CDCl_3$): δ 1.02 (d, J=6.0 Hz, CH_3–C(8)), 1.94—2.07 (m, 4×$COCH_3$), 3.67 (s, $COOCH_3$), 4.17 (m, 2H-C(6′)), 4.84—5.25 (m, axial-H_4 of the glucose moiety), 7.28 ppm (d, $^4J_{1,3}$=1.0 Hz, H–C(3)). *Anal.* Calcd for $C_{25}H_{34}O_{13}$: C, 55.35; H, 6.32. Found: C, 55.30; H, 6.44.

Catalytic Hydrogenation of Asperuloside Tetraacetate (6)——The tetraacetate (**6**) (20.0 g) was dissolved in EtOH (300 ml) and hydrogenated over PtO_2 (2.50 g) at room temperature. A crystalline solid obtained by the usual work-up was recrystallized from MeOH to afford the acid (5.86 g), mp 185.0—186.0°, $[\alpha]_D^{26.5}$ −88.1° (c=1, $CHCl_3$), whose IR spectrum was superimposable on that of the oxidation product (**4**) of boschnaloside tetraacetate (**2**) with $K_2Cr_2O_7$. This substance (2.70 g) was methylated with CH_2N_2, and the reaction product was concentrated to afford an amber residue, which was dissolved in C_6H_6 and chromatographed on silica gel (60 g) using C_6H_6/Et_2O with an increasing Et_2O content. The eluate with C_6H_6/Et_2O (19: 1 to 23: 2) afforded a crystalline solid, which was recrystallized from MeOH to give colorless needles (1.41 g) of the methyl ester, mp 109.0—111.0°, $[\alpha]_D^{24}$ −66.7° (c=1.4, $CHCl_3$), whose IR spectrum was superimposable on that of **7** obtained by oxidation of **2** followed by methylation.

Catalytic Hydrogenation of Geniposide Pentaacetate (9)——The pentaacetate (**9**) (4.97 g) was dissolved in EtOH (60 ml) and hydrogenated over PtO_2 (609 mg). After the usual work-up, the resulting viscous liquid (4.95 g) was chromatographed on silica gel (175 g) using C_6H_6/Et_2O as an eluent with an increasing Et_2O content. The fraction eluted with C_6H_6/Et_2O (93: 7) afforded a crystalline solid, which was recrystallized from MeOH to yield colorless needles (2.00 g) of the methyl ester, mp 109.5—111.0°, $[\alpha]_D$ −87.1° (c=1.4, $CHCl_3$), whose IR spectrum was identical with that of **7** derived from **2**.

Decarboxylation of the Acid (4)——A mixture of **4** (1 g), quinoline (12.5 ml) and $CuCO_3 \cdot Cu(OH)_2$ (63 mg) was heated at 190—200° for 3 hr. After cooling to room temperature, the mixture was diluted with EtOH, and the EtOH solution was neutralized by passage through a column of Amberlite IR-120 (H-form, 120 ml), eluting with EtOH. The EtOH eluate (1 l) was concentrated *in vacuo* to leave an amber residue, which was dissolved in CH_2Cl_2, washed successively with sat. $NaHCO_3$ solution and H_2O, and dried over Na_2SO_4. The CH_2Cl_2 layer gave, on concentration, a viscous liquid (0.93 g), which was chromatographed on silica gel (28 g) using $CHCl_3$/MeOH as an eluent with an increasing MeOH content. The fraction eluted with $CHCl_3$/MeOH (99: 1) was concentrated to afford a crystalline solid, which, on recrystallization from EtOH, gave **10** (442 mg) as colorless needles, mp 158.0—160.0°, $[\alpha]_D$ −168.0° (c=1.2, $CHCl_3$); IR ν_{max}^{Nujol} cm^{-1}: 1754, 1656; PMR ($CDCl_3$): δ 1.02 (d, J=6.0 Hz, CH_3–C(8)), 2.00—2.06 (m, 4×$COCH_3$), 4.22 (m, 2H–C(6′)), 4.84—5.20 (m, axial-H_4 of the glucose moiety), 6.07 ppm (dd, $^3J_{3,4}$=6.0 Hz, $^4J_{1,3}$=1.0 Hz, H–C(3)). *Anal.* Calcd for $C_{23}H_{32}O_{11}$: C, 57.02; H, 6.66. Found: C, 56.92; H, 6.73.

Deacetylation of the Tetraacetate (10)——A solution of **10** (2 g) in abs. MeOH (15 ml) was refluxed with 0.1 N CH_3ONa (4 ml) at 70° for 15 min. The reaction mixture was cooled to room temperature, neutralized with Amberlite IRC-50 (H-form), and concentrated to leave a brown syrup (1.47 g), which was chromatographed on charcoal (10 g) using H_2O/MeOH as an eluent with an increasing MeOH content. The fraction eluted with H_2O/MeOH (4: 1) afforded an oil (**11**) (998 mg), which showed a single spot on TLC (Rf 0.80), IR ν_{max} cm^{-1}: 3500—3300, 1660; PMR ($CDCl_3$): δ 1.05 (d, J=6.0 Hz, CH_3–C(8)), 3.75 (m, 2H-C(6′)), 5.30 (d, J=2.0 Hz, H–C(1)), 6.12 (d, J=6.0 Hz, H–C(4)), 6.14 ppm (dd, $^3J_{3,4}$=6.0 Hz, $^4J_{1,3}$=1.0 Hz, H–C(3)).

Hydrolysis of the Glucoside (11)——A 1% aqueous β-glucosidase solution (35 ml) was added to a solution of **11** (1.60 g) in 0.1 N aqueous CH_3COONa (140 ml) and the reaction mixture was allowed to stand at 37° for 2 days. It was then extracted with Et_2O, and the ethereal extract was washed successively with sat. $NaHCO_3$ solution and H_2O, then dried over Na_2SO_4. Concentration of the ethereal layer afforded an oil (**12**) (565 mg), IR ν_{max} cm^{-1}: 3400, 2700, 1720, 1660.

Oxidation of the Aglycone (12)——A solution of **12** (480 mg) in Py (12 ml) was added to a slurry of CrO_3 (1.10 g)–Py (9 ml) complex. The reaction mixture, after stirring for 30 min, was allowed to stand at room temperature for 24 hr, then Et_2O was added to the mixture, and the ethereal layer was extracted with sat. $NaHCO_3$ solution. The $NaHCO_3$ layer was acidified with 3% HCl and extracted again with Et_2O. The ethereal extract, after being dried over Na_2SO_4, was concentrated to afford a viscous liquid (167 mg), which was chromatographed on silica gel (7.0 g) using $CHCl_3/Et_2O$ as an eluent with an increasing Et_2O content. The early eluate with $CHCl_3/Et_2O$ (99: 1) gave, on concentration, a crystalline solid, which was recrystallized from n-pentane–Et_2O (4: 1) to afford **14** (53 mg) as colorless needles, mp 84.0—85.0°, $[\alpha]_D^{20}$ −39.8° (c=1.5, $CHCl_3$), and the later eluate with the same solvent (99: 1) gave, on similar treatment, **15** (16 mg) as colorless needles, mp 107.0—108.0°, $[\alpha]_D^{20}$ −43.9° (c=1, $CHCl_3$). The two compounds (**14**) and (**15**) were identical with authentic samples of 3(*R*)-*cis*, *cis*-boschnialinic acid (obtained by oxidation of boschnialactone), and 3(*R*)-*trans*, *trans*-boschnialinic acid, respectively.

Glucosylation of Compound (17)——A mixture of a solution of **17** (500 mg) in CH_3CN (5 ml), α-bromo glucose tetraacetate (1.5 g) and $Hg(CN)_2$ (1.0 g) was stirred at room temperature for 3 hr. After addition of further α-bromo glucose tetraacetate (600 mg), the reaction mixture was stirred until disappearance of the

spot of **17** on TLC. On concentration *in vacuo*, the reaction mixture gave a residue, which was dissolved in $CHCl_3$. The insoluble material was filtered off. The filtrate was concentrated to afford a brown syrup, which was chromatographed on silica gel (30 g) using C_6H_6/EtO_2 as an eluent with an increasing Et_2O content. The crystalline residue obtained from the eluate with C_6H_6/Et_2O (97: 3) was recrystallized from MeOH to afford the glucoside tetraacetate, mp 109.0—111.0°, its IR spectrum was identical with that of an authentic sample of **7** (yield 637 mg, 52.1%).

Hydrolysis of the Glucoside Tetraacetate (7)——A suspension of **7** (2.02 g) in a sat. $Ba(OH)_2$ solution (60 ml) was stirred at room temperature for 20 hr, and then at 50° for 30 min. The reaction mixture was filtered, and the filtrate was passed through an ion-exchange column (Dowex 50W-X8, 50—80 mesh, H-form) (18 g), eluting with H_2O. The aqueous eluate afforded, on concentration *in vacuo* a viscous liquid (1.55 g). An aliquot (915 mg) of the liquid was dissolved in H_2O and chromatographed on charcoal (9 g) using H_2O/MeOH as an eluent with an increasing MeOH content. The eluate with H_2O/MeOH (19: 1) was concentrated *in vacuo* to leave a white powder (840 mg). This powder (639 mg) was left to stand with Ac_2O–Py at room temperature overnight. After treatment as usual, the product was recrystallized from MeOH to afford the tetraacetate (818 mg) as colorless needles, mp 181.5—183.0°; its IR spectrum was identical with that of **4**.

Conversion of the Acid (4) to Boschnaloside Tetraacetate (2)——A suspension of **4** (6.00 g) in a small amount of H_2O was treated dropwise with a 0.01 N NaOH solution (125 ml) with stirring. The resulting almost transparent solution was filtered to remove a minute amount of insoluble material and the filtrate was lyophilized to afford the sodium salt (5.96 g) of **4** as a white powder. After addition of 2 drops of Py to a suspension of this powder in abs. C_6H_6 (60 ml), $(COCl)_2$ (15 ml) was added dropwise at 0° then the reaction mixture was stirred at room temperature for 2 hr and filtered. The filtrate was concentrated *in vacuo* to afford the corresponding acid chloride as a crystalline solid. A solution of this chloride in diglyme (20 ml) was treated dropwise with a suspension of $LiAlH(t\text{-}BuO)_3$ (2.5 g in 43.5 g of diglyme) at −78° during one hr, and the reaction mixture was continuously stirred at the same temperature overnight. After cooling to room temperature, the reaction mixture was poured into ice H_2O and filtered, and the insoluble material was washed with EtOH. The filtrate and the washings were combined and concentrated *in vacuo* to afford an oily residue. The ethereal solution of the residue was washed successively with sat. $NaHCO_3$ solution and H_2O, then dried over Na_2SO_4. On concentration, it afforded a viscous liquid, which was chromatographed on silica gel (100 g) using C_6H_6/Et_2O as an eluent with an increasing Et_2O content. The eluate with C_6H_6/Et_2O (99: 1) was concentrated to give a residue, which was recrystallized from MeOH to afford the aldehyde glucoside tetraacetate, mp 140.0—143.0°, $[\alpha]_D^{22}$ −105.7° (c=0.38, $CHCl_3$). The IR spectrum of this substance was identical with that of boschnaloside tetraacetate (**2**) (yield 998 mg, 26.3%).

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