

Three New Glycosides from *Viburnum plicatum* THUNB. var. *tomentosum* MIQ.

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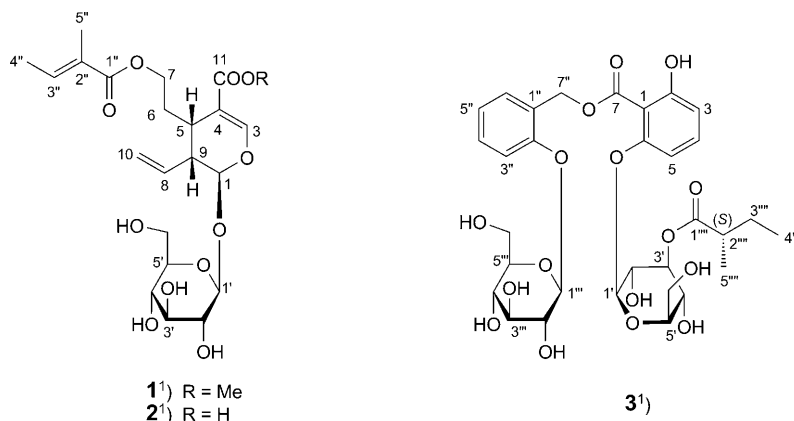
Three new glycosides, 7-*O*-tigloylsecologanol (**1**), 7-*O*-tigloylsecologanolic acid (**2**), and 3'-*O*-[(2*S*)-2-methylbutanoyl]henryoside (**3**), together with seven known ones, were isolated from the leaves of *Viburnum plicatum* THUNB. var. *tomentosum* MIQ. Their structures were established on the basis of spectral and chemical data.

Introduction. – The deciduous shrub *Viburnum plicatum* THUNB. var. *tomentosum* MIQ. (Caprifoliaceae) is widely distributed in Japan and China. This plant has been utilized in traditional Chinese medicine (Chinese name, hú dié shù) for lymphadenitis, ringworm, and infantile tantrum [1]. In a continuation of our investigation of the chemical constituents from plants of the genus *Viburnum* species [2–9], we have now examined the chemical constituents of the leaves of *V. plicatum* THUNB. var. *tomentosum* MIQ. As far as we know, there is no report regarding the chemical constituents of this plant. In this article, we describe the isolation and structure elucidation of three new glycosides, named 7-*O*-tigloylsecologanol¹⁾ (**1**), 7-*O*-tigloylsecologanolic acid¹⁾ (**2**), and 3'-*O*-[(2*S*)-2-methylbutanoyl]henryoside¹⁾ (**3**), together with seven known ones, which were isolated from the leaves of this plant. This article deals with the structural elucidation and identification of these compounds.

Results and Discussion. – The MeOH extract of the leaves of *V. plicatum* THUNB. var. *tomentosum* MIQ. was partitioned with CHCl₃, AcOEt, BuOH, and H₂O. The BuOH- and AcOEt-soluble fractions were each subjected to separation by a combination of chromatographic procedures. From the BuOH-soluble fraction, compounds **1–3** and **4**²⁾ were isolated, while compounds **5–10**²⁾ were isolated from the AcOEt-soluble fraction. The known compounds **4–10**²⁾ were identified as (4*R*)- α -terpineol *O*- β -D-glucopyranoside²⁾ (**4**) [10], (7*S*,8*R*)-dihydrodehydrodiconiferyl alcohol 9-*O*- β -D-glucopyranoside²⁾ (**5**) [11], (7*R*,8*S*)-dihydrodehydrodiconiferyl alcohol 9-*O*- β -D-glucopyranoside²⁾ (**6**) [12], quercetin 3-*O*-robinobioside²⁾ (**7**) [13], quercetin 3-*O*-rutinoside²⁾ (**8**) [13], kaempferol 3-*O*-robinobioside²⁾ (**9**) [13], and kaempferol 3-*O*-rutinoside²⁾ (**10**) [13], respectively, by comparison of their spectroscopic data with those previously described in the literatures.

¹⁾ Arbitrary atom numbering; for systematic names, see *Exper. Part*.

²⁾ For formulas, see corresponding references.



Compound **1** was obtained as an optically active amorphous powder. The molecular formula of **1**, $\text{C}_{22}\text{H}_{32}\text{O}_{11}$, was confirmed by HR-FAB-MS (m/z 495.1855 ($[M + \text{Na}]^+$)). The ^1H -NMR spectrum of **1** (Table 1) showed signals due to one olefinic H-atom at

Table 1. ^1H - and ^{13}C -NMR Data (400 and 100 MHz, resp.; in CD_3OD) of **1** and **2**. δ in ppm, J in Hz.

	1		2	
	$\delta(\text{H})$	$\delta(\text{C})$	$\delta(\text{H})$	$\delta(\text{C})$
H–C(1)	5.56 (<i>d</i> , $J = 6.6$)	97.7	5.53 (<i>d</i> , $J = 6.3$)	97.6
H–C(3)	7.47 (<i>s</i>)	153.7	7.46 (<i>s</i>)	153.2
C(4)	–	111.5	–	112.1
H–C(5)	2.91 (<i>br. dd</i> , $J = 6.6, 6.0$)	31.5	2.89 (<i>br. dd</i> , $J = 6.6, 5.9$)	31.3
CH ₂ (6)	1.86 (<i>br. ddd</i> , $J = 13.7, 6.6, 6.0$), 2.03 (<i>br. ddd</i> , $J = 13.7, 7.3, 6.0$)	30.2	1.84 (overlapped), 2.08 (<i>br. ddd</i> , $J = 13.9, 7.1, 5.9$)	30.1
CH ₂ (7)	4.14 (<i>br. dt</i> , $J = 11.2, 6.6$), 4.16 (<i>ddd</i> , $J = 11.2, 7.3, 6.0$)	64.2	4.14 (<i>br. dt</i> , $J = 11.0, 6.6$), 4.19 (<i>ddd</i> , $J = 11.0, 7.1, 5.9$)	64.3
H–C(8)	5.79 (<i>ddd</i> , $J = 17.3, 10.5, 8.5$)	135.8	5.79 (<i>ddd</i> , $J = 17.3, 10.5, 8.5$)	135.9
H–C(9)	2.65 (<i>ddd</i> , $J = 8.5, 6.6, 6.0$)	45.6	2.65 (<i>ddd</i> , $J = 8.5, 6.3, 5.9$)	45.5
CH ₂ (10)	5.25 (<i>dd</i> , $J = 10.5, 1.0$), 5.30 (<i>dd</i> , $J = 17.3, 1.0$)	119.6	5.25 (<i>dd</i> , $J = 10.5, 1.2$), 5.29 (<i>dd</i> , $J = 17.3, 1.2$)	119.5
C(11)	–	169.2	–	171.2
MeO–C(11)	3.67 (<i>s</i>)	51.8	–	–
H–C(1')	4.69 (<i>d</i> , $J = 7.8$)	100.2	4.69 (<i>d</i> , $J = 7.8$)	100.2
H–C(2')	3.18 (<i>dd</i> , $J = 9.0, 7.8$)	74.7	3.19 (<i>dd</i> , $J = 9.0, 7.8$)	74.7
H–C(3')	3.30 (overlapped)	78.5	3.30 (overlapped)	78.5
H–C(4')	3.30 (overlapped)	71.6	3.30 (overlapped)	71.6
H–C(5')	3.30 (overlapped)	78.1	3.30 (overlapped)	78.0
CH ₂ (6')	3.66 (overlapped), 3.90 (<i>dd</i> , $J = 12.0, 2.0$)	62.8	3.66 (<i>dd</i> , $J = 12.0, 5.9$), 3.90 (<i>dd</i> , $J = 12.0, 2.0$)	62.8
C(1'')	–	169.6	–	169.7
C(2'')	–	129.7	–	129.7
H–C(3'')	6.85 (<i>br. dq</i> , $J = 7.3, 1.2$)	138.7	6.86 (<i>br. dq</i> , $J = 7.0, 1.2$)	138.6
Me(4'')	1.80 (<i>br. d</i> , $J = 7.3$)	14.4	1.79 (<i>br. dd</i> , $J = 7.0, 1.2$)	14.4
Me(5'')	1.81 (<i>br. s</i>)	12.1	1.81 (<i>br. q</i> , $J = 1.2$)	12.1

$\delta(\text{H})$ 7.47 (s, H-C(3)¹), vinyl H-atoms at $\delta(\text{H})$ 5.25 (dd, $J = 10.5, 1.0$ Hz, H_a-C(10)), 5.30 (dd, $J = 17.3, 1.0$ Hz, H_b-C(10)), and 5.79 (ddd, $J = 17.3, 10.5, 8.5$ Hz, H-C(8)), two acetal H-atoms at $\delta(\text{H})$ 4.69 (d, $J = 7.8$ Hz, H-C(1')) and 5.56 (d, $J = 6.6$ Hz, H-C(1)), one MeO group at $\delta(\text{H})$ 3.67 (s, MeO-C(11)), two CH₂ groups at $\delta(\text{H})$ 1.86 (br. ddd, $J = 13.7, 6.6, 6.0$ Hz, H_a-C(6)), 2.03 (br. ddd, $J = 13.7, 7.3, 6.0$ Hz, H_b-C(6)), 4.14 (br. dt, $J = 11.2, 6.6$ Hz, H_a-C(7)), and 4.16 (ddd, $J = 11.2, 7.3, 6.0$ Hz, H_b-C(7)), and two CH groups at $\delta(\text{H})$ 2.91 (br. dd, $J = 6.6, 6.0$ Hz, H-C(5)) and 2.65 (ddd, $J = 8.5, 6.6, 6.0$ Hz, H-C(9)). The ¹H,¹H-COSY experiment of **1** in combination with the HMQC spectrum revealed the partial structures shown by the bold lines in Fig. 1. Acid hydrolysis of **1** yielded D-glucose which was identified by its retention time and optical rotation by means of chiral detection in HPLC analysis. The ¹H- and ¹³C-NMR data (Table 1) were closely related to those of secologanol = (2*S*,3*R*,4*S*)-3-ethenyl-2-(β-D-glucopyranosyloxy)-3,4-dihydro-4-(2-hydroxyethyl)-2*H*-pyran-5-carboxylic acid methyl ester [14], except for the presence of signals due to a tigloyl group ($\delta(\text{H})$ 6.85 (dq, $J = 7.3, 1.2$ Hz, H-C(3'')), 1.81 (br. s, Me(5'')), and 1.80 (br. d, $J = 7.3$ Hz, Me(4'')); $\delta(\text{C})$ 169.6 (C(1'')), 138.7 (C(3'')), 129.7 (C(2'')), 14.4 (C(4'')), and 12.1 (C(5'')). Furthermore, the ¹H- and ¹³C-NMR chemical shifts of the CH₂(7) moiety of **1** were shifted downfield by +0.6 ppm (2 H-C(7)) and +2.9 ppm (C(7)) compared with those of secologanol, suggesting that the additional tigloyl group in **1** is located at OH-C(7) of secologanol. This finding was supported by the HMBC cross-peaks between CH₂(7) and C(1''). Other HMBC and ¹H,¹H-COSY (Fig. 1), and NOESY (H-C(1)/H-C(8), H-C(5)/H-C(9)) correlations of **1** confirmed the proposed structure. The absolute configuration of the aglycone of **1** was not determined. From the above data, the structure of **1** was established as *rel*-(2*R*,3*S*,4*R*)-3-ethenyl-2-(β-D-glucopyranosyloxy)-3,4-dihydro-4-[2-(2-methylbut-2-enoyl)oxy]ethyl)-2*H*-pyran-5-carboxylic acid methyl ester, and named 7-*O*-tigloylsecologanol.

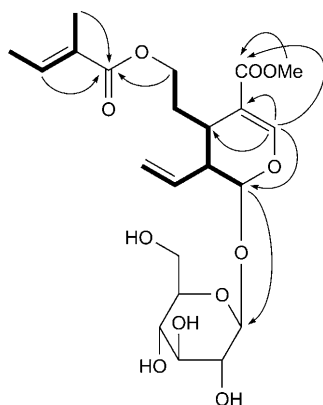


Fig. 1. ¹H,¹H-COSY Correlations (bold line) and key HMBCs (full-line arrows) of **1**

Compound **2** was obtained as an optically active amorphous powder. In the HR-FAB-MS, the m/z at 481.1671 ($[M + \text{Na}]^+$) indicated the molecular formula of **2** as C₂₁H₃₀O₁₁. Acid hydrolysis of **2** in the above described manner gave only D-glucose. The ¹H- and ¹³C-NMR spectra of **2** (Table 1) closely resembled those of **1**, except for

the absence of signals for a MeO group. A comparison of the ^{13}C -NMR chemical shifts of **1** and **2** indicated that the $\text{C}(11)=\text{O}$ group ($\delta(\text{C})$ 171.2) of **2** was deshielded by 2.0 ppm with respect to that of **1**. The molecular formula of **2** represented a loss of a CH_2 unit compared to that of **1**. These findings suggested that **2** is the de-*O*-methyl analogue of **1**. The complete assignments of the ^1H - and ^{13}C -NMR signals of **2** were confirmed by the ^1H , ^1H -COSY, HMQC, and HMBC experiments (Fig. 2). The absolute configuration of the aglycone of **2** was not determined. From the above data, the structure of **2** was established as *rel*-(2*R*,3*S*,4*R*)-3-ethenyl-2-(β -D-glucopyranosyloxy)-3,4-dihydro-4-[2-[(2-methylbut-2-enoyl)oxy]ethyl]-2*H*-pyran-5-carboxylic acid, and named 7-*O*-tigloylsecologanolic acid.

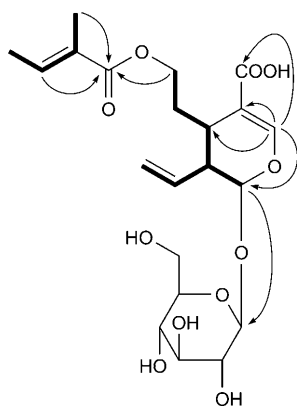


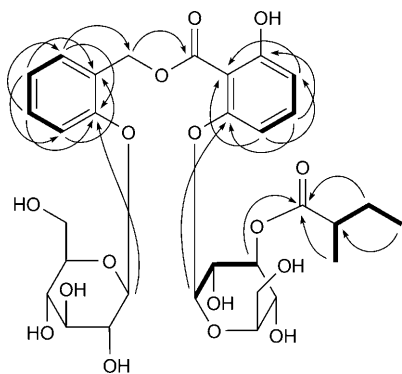
Fig. 2. ^1H , ^1H -COSY Correlations (bold line) and key HMBCs (full-line arrows) of **2**

Compound **3** was obtained as an optically active amorphous powder. The molecular formula of **3**, $\text{C}_{31}\text{H}_{40}\text{O}_{16}$, was confirmed by HR-FAB-MS (m/z 691.2207 ($[M + \text{Na}]^+$)). The ^1H -NMR spectrum of **3** (Table 2) showed the signals due to one 1,2,6-trisubstituted aromatic ring at $\delta(\text{H})$ 6.60 (*dd*, $J = 8.5, 1.0$ Hz, $\text{H}-\text{C}(5)$), 6.74 (*dd*, $J = 8.3, 1.0$ Hz, $\text{H}-\text{C}(3)$), and 7.28 (*dd*, $J = 8.5, 8.3$ Hz, $\text{H}-\text{C}(4)$), one *ortho*-disubstituted aromatic ring at $\delta(\text{H})$ 7.06 (*dt*, $J = 7.6, 1.0$ Hz, $\text{H}-\text{C}(5'')$), 7.21 (*dd*, $J = 8.3, 1.0$ Hz, $\text{H}-\text{C}(3'')$), 7.32 (*ddd*, $J = 8.3, 7.6, 1.5$ Hz, $\text{H}-\text{C}(4'')$), and 7.54 (*dd*, $J = 7.6, 1.5$ Hz, $\text{H}-\text{C}(6'')$), one CH_2 as an *AB* system at $\delta(\text{H})$ 5.48 (*d*, $J = 13.0$ Hz, $\text{H}_a-\text{C}(7'')$) and 5.53 (*d*, $J = 13.0$ Hz, $\text{H}_b-\text{C}(7'')$), and two anomeric H-atoms at $\delta(\text{H})$ 4.94 (*d*, $J = 7.8$ Hz, $\text{H}-\text{C}(1''')$) and 5.03 (*d*, $J = 7.8$ Hz, $\text{H}-\text{C}(1')$). Acid hydrolysis of **3** in the above described manner gave only D-glucose. The coupling constants of the two anomeric H-atoms indicated that the glycosyl linkages are of β -configuration. These spectral features were almost identical to those of henryoside = 2-[[2-(β -D-glucopyranosyloxy)-6-hydroxybenzoyl]oxy]methyl]phenyl β -D-glucopyranoside isolated from *V. henryi* [15]. This was also supported by the HMBC correlations shown in Fig. 3.

The ^1H - and ^{13}C -NMR spectra of **3** (Table 2), however, showed the presence of additional signals due to one $\text{C}=\text{O}$ group ($\delta(\text{C})$ 178.1 ($\text{C}(1''''')$)), one primary Me group ($\delta(\text{H})$ 0.98 (*t*, $J = 7.1$ Hz, $\text{Me}(4''''')$; $\delta(\text{C})$ 12.0 ($\text{C}(4''''')$)), one secondary Me group ($\delta(\text{H})$ 1.19 (*d*, $J = 7.1$ Hz, $\text{Me}(5''''')$; $\delta(\text{C})$ 17.0 ($\text{C}(5''''')$)), one CH_2 group ($\delta(\text{H})$ 1.54 (*dquint.*, $J = 14.6, 7.1$ Hz, $\text{H}_a-\text{C}(3''''')$) and 1.74 (*dquint.*, $J = 14.6, 7.1$ Hz, $\text{H}_b-\text{C}(3''''')$; $\delta(\text{C})$ 28.1

Table 2. ^1H - and ^{13}C -NMR Data (400 and 100 MHz, resp.; in CD_3OD) of **3**¹. δ in ppm, J in Hz.

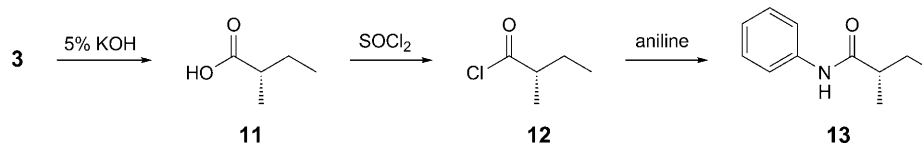
	$\delta(\text{H})$	$\delta(\text{C})$		$\delta(\text{H})$	$\delta(\text{C})$
C(1)	–	110.7	H–C(3'')	7.21 (<i>dd</i> , $J = 8.3, 1.0$)	116.6
C(2)	–	158.1	H–C(4'')	7.32 (<i>ddd</i> , $J = 8.3, 7.6, 1.5$)	130.8
H–C(3)	6.74 (<i>dd</i> , $J = 8.3, 1.0$)	107.7	H–C(5'')	7.06 (<i>dt</i> , $J = 7.6, 1.0$)	123.6
H–C(4)	7.28 (<i>dd</i> , $J = 8.5, 8.3$)	134.2	H–C(6'')	7.54 (<i>dd</i> , $J = 7.6, 1.5$)	130.7
H–C(5)	6.60 (<i>dd</i> , $J = 8.5, 1.0$)	111.8	$\text{CH}_2(7'')$	5.48, 5.53 (<i>d</i> , $J = 13.0$, each)	63.7
C(6)	–	160.1	H–C(1''')	4.94 (<i>d</i> , $J = 7.8$)	102.9
C(7)	–	170.0	H–C(2''')	3.16–3.54 (overlapped)	74.9
H–C(1')	5.03 (<i>d</i> , $J = 7.8$)	102.4	H–C(3''')	3.16–3.54 (overlapped)	78.3
H–C(2')	3.16–3.54 (overlapped)	73.1	H–C(4''')	3.16–3.54 (overlapped)	71.3
H–C(3')	4.99 (<i>t</i> , $J = 9.3$)	78.2	H–C(5''')	3.16–3.54 (overlapped)	78.0
H–C(4')	3.16–3.54 (overlapped)	69.4	$\text{CH}_2(6''')$	3.70 (<i>dd</i> , $J = 12.2, 4.8$), 3.88 (<i>dd</i> , $J = 12.2, 1.7$)	62.2
H–C(5')	3.16–3.54 (overlapped)	78.1	C(1''')	–	178.1
$\text{CH}_2(6')$	3.67 (<i>dd</i> , $J = 12.0, 4.6$), 3.83 (<i>dd</i> , $J = 12.0, 1.2$)	62.5	H–C(2''')	2.48 (<i>sext.</i> , $J = 7.1$)	42.6
C(1'')	–	126.7	$\text{CH}_2(3''')$	1.54 (<i>dquint.</i> , $J = 14.6, 7.1$), 1.74 (<i>dquint.</i> , $J = 14.6, 7.1$)	28.1
C(2'')	–	156.9	Me(4''')	0.98 (<i>t</i> , $J = 7.1$)	12.0
			Me(5''')	1.19 (<i>d</i> , $J = 7.1$)	17.0

Fig. 3. ^1H , ^1H -COSY correlations (bold line) and key HMBCs (full-line arrows) of **3**

(C(3''')), and one CH group ($\delta(\text{H})$ 2.48 (*sext.*, $J = 7.1$ Hz, H–C(2''')); $\delta(\text{C})$ 42.6 (C(2''')). Detailed analysis of the ^1H - and ^{13}C -NMR spectra of the additional signals were undertaken with the aid of ^1H , ^1H -COSY, HMQC, and HMBC experiments (Fig. 3), suggesting the additional moiety to be a 2-methylbutanoyl moiety. From the findings presented above, compound **3** was deduced to be a 2-methylbutanoic acid ester of henryoside. The additional 2-methylbutanoyl moiety of **3** is attached to OH–C(3') of henryoside as established by the HMBC between H–C(3') ($\delta(\text{H})$ 4.99) and C(1'''). Other HMBCs (Fig. 3) confirmed the planar structure of **3**. To determine the absolute configuration at C(2''') of the 2-methylbutanoyl moiety of **3**, we referred to a reported HPLC method by means of a chiral column [16]. Briefly, alkaline hydrolysis of **3** was carried out to afford 2-methylbutanoic acid (**11**), which was converted into the

corresponding acyl chloride **12** with SOCl_2 . Treatment of **12** with aniline (= benzenamine) afforded amide **13** (Scheme). The (2*S*)-2-methyl-*N*-phenylbutanamide and racemic (2*RS*)-2-methyl-*N*-phenylbutanamide were synthesized from commercial (2*S*)-2-methylbutanoic acid and (2*RS*)-2-methylbutanoic acid as described for **13** above. The (2*RS*)-methyl-*N*-phenylbutanamide was separated into its enantiomers by HPLC with a chiral column. Comparison of the retention time of **13** with the synthetic (2*S*)-2-methyl-*N*-phenylbutanamide and racemic (2*RS*)-2-methyl-*N*-phenylbutanamide revealed the absolute configuration at C(2'') of the 2-methylbutanoyl moiety of **3** to be (*S*). From the above data, the structure of **3** was established as 2''-(β-D-glucopyranosyloxy)benzyl 2-hydroxy-6-[[3-*O*-[(2*S*)-2-methylbutanoyl]-β-D-glucopyranosyl]oxy]benzoate, and named 3'-*O*-[(2*S*)-2-methylbutanoyl]henryoside.

Scheme. Synthesis of (2*S*)-2-Methyl-*N*-phenylbutanamide (**13**) from **3**



We thank Mrs. S. Sato and T. Matsuki of Tohoku Pharmaceutical University for NMR and MS measurements.

Experimental Part

General. Column chromatography (CC): silica gel (SiO_2 ; 70–230 mesh; Merck) and Sephadex LH-20 (Pharmacia Fine Chemicals). HPLC: Tosoh-8020 apparatus; TSKgel-ODS-80TM column (5 μm , 6.0 mm i.d. $\times$ 15 cm; Tosoh), TSKgel-ODS-120T column (10 μm , 7.8 mm i.d. $\times$ 30 cm; Tosoh), and Cosmosil-5SL column (5 μm , 10 mm i.d. $\times$ 25 cm; Nacalai tesque); t_R in min. Optical rotation: Jasco-DIP-360 digital polarimeter. UV Spectra: Beckman-DU-64 spectrometer; λ_{max} (log ϵ) in nm. NMR Spectra: Jeol-JNM-GSX-400 spectrometer; δ in ppm rel. to Me_4Si ; J in Hz. EI-, HR-EI-, FAB-, and HR-FAB-MS: Jeol-JMS-303 mass spectrometer; in m/z (rel. %), with glycerol as matrix for FAB.

Plant Material. Leaves of *Viburnum plicatum* THUNB. var. *tomentosum* MiQ. were collected in June 2007 in Sendai, Miyagi prefecture, Japan, and identified by M. K. A voucher specimen is deposited in the laboratory of M. K. (No. 2007-6-KM2).

Extraction and Isolation. Fresh leaves of *V. plicatum* THUNB. var. *tomentosum* MiQ. (450 g) were extracted two times consecutively (10 d each time) with MeOH (2 $\times$ 8 l) at r.t. The MeOH extract was concentrated and the residue (41.7 g) suspended in H_2O (500 ml). This suspension was successively extracted with CHCl_3 (3 $\times$ 500 ml), AcOEt (3 $\times$ 500 ml), and BuOH (3 $\times$ 500 ml). The AcOEt-soluble fraction (3.1 g) was subjected to CC (Sephadex LH-20, 50% MeOH), and the eluate was separated into Fractions 1–13. Fr. 3 was subjected to prep. HPLC (TSKgel-ODS-80TM, MeOH/ H_2O 1:2, flow rate 1.0 ml/min, column temp. 40°, detection at 205 nm) to give five Peaks 1–5. Peak 3 (t_R 48) was purified by prep. HPLC (Cosmosil-5SL, $\text{CH}_2\text{Cl}_2/\text{MeOH}/\text{H}_2\text{O}$ 80:10:1, flow rate 1.5 ml/min, r.t., detection at 225 nm): **2** (10.5 mg; t_R 35.4). Peak 4 (t_R 65) was purified by prep. HPLC (Cosmosil-5SL, $\text{CH}_2\text{Cl}_2/\text{MeOH}/\text{H}_2\text{O}$ 70:10:1, flow rate 1.5 ml/min, r.t., detection at 225 nm): **3** (25.0 mg; t_R 31.2). Peak 5 (t_R 100) was purified by prep. HPLC (Cosmosil-5SL, $\text{CH}_2\text{Cl}_2/\text{MeOH}/\text{H}_2\text{O}$ 80:10:1, flow rate 1.5 ml/min, r.t., detection at 225 nm): **1** (8.5 mg; t_R 31.2) and **4** (30.5 mg; t_R 34.0). The BuOH-soluble fraction (9.7 g) was subjected to CC (SiO_2 , $\text{CHCl}_3/\text{MeOH}/\text{H}_2\text{O}$ 30:10:1), and the eluate was separated into Frs. 1–3. Fr. 1 was further subjected to CC (Sephadex LH-20, 50% MeOH), and the eluate was separated into Frs. 1.1–1.5. Fr. 1.2 was subjected to prep. HPLC (TSKgel-ODS-80TM, MeOH/ H_2O 1:3, flow rate 0.8 ml/min,

column temp. 40°, detection at 205 nm): **5** (3.0 mg; t_R 38.7) and **6** (6.5 mg; t_R 41.0). *Fr. 1.4* was subjected to prep. HPLC (TSKgel-ODS-120T, MeOH/H₂O 2:5, flow rate 1.5 ml/min, column temp. 40°, detection at 205 nm): **7** (4.8 mg; t_R 28.0), **8** (6.5 mg; t_R 31.0), **9** (7.0 mg; t_R 42.0), and **10** (12.5 mg; t_R 48.6).

7-O-Tigloylsecologanol (= rel-(2R,3S,4R)-3-Ethenyl-2-(β-D-glucopyranosyloxy)-3,4-dihydro-4-[2-[(2-methyl-1-oxobut-2-en-1-yl)oxy]ethyl]-2H-pyran-5-carboxylic Acid Methyl Ester; **1**): Amorphous powder. $[\alpha]_D^{27} = -70.0$ ($c = 0.20$, MeOH). UV (MeOH): 221 (4.07). ¹H- and ¹³C-NMR (CD₃OD): Table 1. FAB-MS: 495 ($[M + Na]^+$). HR-FAB-MS: 495.1855 ($[M + Na]^+$, C₂₂H₃₂NaO₁₁; calc. 495.1829).

7-O-Tigloylsecologanolic Acid (= rel-(2R,3S,4R)-3-Ethenyl-2-(β-D-glucopyranosyloxy)-3,4-dihydro-4-[2-[(2-methyl-1-oxobut-2-en-1-yl)oxy]ethyl]-2H-pyran-5-carboxylic Acid; **2**): Amorphous powder. $[\alpha]_D^{27} = -116.2$ ($c = 0.37$, MeOH). UV (MeOH): 219 (4.18). ¹H- and ¹³C-NMR (CD₃OD): Table 1. FAB-MS: 481 ($[M + Na]^+$). HR-FAB-MS: 481.1671 ($[M + Na]^+$, C₂₁H₃₀NaO₁₁; calc. 481.1686).

3'-O-[(2S)-2-Methylbutanoyl]henryoside (= 2''-(β-D-Glucopyranosyloxy)benzyl 2-Hydroxy-6-[[3-O-[(2S)-2-methylbutanoyl]-β-D-glucopyranosyl]oxy]benzoate = 2-[[[2-[(β-D-Glucopyranosyl)oxy]phenyl]methoxy]carbonyl]-3-hydroxyphenyl β-D-Glucopyranoside 3-[(2S)-2-Methylbutanoate; **3**): Amorphous powder. $[\alpha]_D^{27} = -43.5$ ($c = 0.23$, MeOH). UV (MeOH): 306 (3.24), 273 (3.39), 246 (3.67), 205 (4.38). ¹H- and ¹³C-NMR (CD₃OD): Table 2. FAB-MS: 691 ($[M + Na]^+$). HR-FAB-MS: 691.2207 ($[M + Na]^+$, C₃₁H₄₀NaO₁₆; calc. 691.2214).

Alkaline Hydrolysis and Determination of the Absolute Configuration of the 2-Methylbutanoyl Moiety in 3. Compound **3** (5.0 mg) was treated with 5% KOH soln. (1.5 ml) for 1.5 h at 40°. The soln. was neutralized with 1M HCl and partitioned with CHCl₃. The CHCl₃ layer was dried (Na₂SO₄) and concentrated. The residue containing 2-methylbutanoic acid (**11**) was refluxed for 1 h with SOCl₂ (600 μl). The excess SOCl₂ was removed under reduced pressure to afford 2-methylbutanoyl chloride (**12**). Chloride **12** was dissolved in CHCl₃ (5 ml), and aniline (500 μl) was added dropwise. After stirring for 1.5 h at r.t., the CHCl₃ layer was washed three times with 4M HCl, dried (Na₂SO₄), and concentrated: amide **13**.

(2S)-2-Methyl-N-phenylbutanamide and racemic (2RS)-2-methyl-N-phenylbutanamide were synthesized from commercial (2S)-2-methylbutanoic acid and (2RS)-2-methylbutanoic acid by the method described above. The (2R)- and (2S)-enantiomers of 2-methyl-N-phenylbutanamide were separated by HPLC (Daicel Chiral OD (10 μm, 4.6 mm i.d. × 25 cm; Daicel Chemical Co.), column temp. r.t., hexane/i-PrOH 10:1, flow rate 0.5 ml/min, detection at 254 nm): **13**, t_R 24.0; (2S)-2-methyl-N-phenylbutanamide, t_R 24.0; (2R)-2-methyl-N-phenylbutanamide, t_R 26.4.

(2S)-2-Methyl-N-phenylbutanamide: Colorless crystals. $[\alpha]_D^{27} = +26.7$ ($c = 1.80$, CHCl₃). ¹H-NMR (400 MHz, CDCl₃): 7.54 (br. d, $J = 7.8$); 7.32 (t, $J = 7.8$); 7.10 (br. t, $J = 7.8$); 2.25 (sext., $J = 7.3$); 1.78 (dq, $J = 15.1, 7.3$); 1.51 (dq, $J = 15.1, 7.3$); 1.24 (d, $J = 7.3$); 0.97 (t, $J = 7.3$). EI-MS: 177 (M^+). HR-EI-MS: 177.1154 (M^+ , C₁₁H₁₅NO⁺; calc. 177.1154).

Determination of the Absolute Configuration of the Sugar Residues in Compounds 1–3. Each compound (ca. 1 mg) was refluxed with 1M HCl (1 ml) for 5 h. The mixture was neutralized with Ag₂CO₃ and filtered. The soln. was concentrated and dried to give a sugar fraction. The sugar fraction was analyzed by HPLC TSKgel Amide-80 (10 μm, 7.8 mm i.d. × 30 cm; Tosoh), column temp. 45°, MeCN/H₂O 4:1, flow rate 1.0 ml/min, chiral detection (Jasco OR-2090). Identification of the D-glucose present in the sugar fraction was established by comparison of the t_R and $[\alpha]_D$ with that of an authentic sample; t_R 39.0 (D-glucose, pos. $[\alpha]_D$).

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