Shinjulactones G and H, New Bitter Principles of *Ailanthus altissima* SWINGLE

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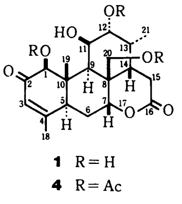
Synopsis. Two bitter quassinoids, shinjulactones G and H were isolated from *Ailanthus altissima* SWINGLE and their structures were determined to be 1*β*,11*β*,12*α*,20-tetrahydroxypicras-3-ene-2,16-dione and 2*α*,12*β*-dihydroxypicrasane-1,11,16-trione, respectively, by spectral and chemical means.

In the continuation of our studies on the bitter principles of Simaroubaceous plants, the structure determination of six quassinoids isolated from *Ailanthus altissima* SWINGLE (Japanese name: Shinju or Niwaurushi) has been reported.[1] Two new bitter principles named shinjulactones G and H (**1** and **2**), have been isolated from the same plant. This paper describes the structure determination of **1** and **2**.

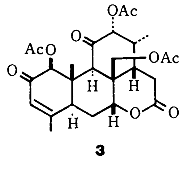
Aqueous extract of the root bark of *A. altissima* was continuously extracted with dichloromethane. The organic layer was subjected to separation by a silica-gel column chromatography and then further purified by a partition column chromatography on silicic acid to afford two minor bitter quassinoids, shinjulactone G (**1**, *ca.* 0.0003% yield) and shinjulactone H (**2**, *ca.* 0.001% yield) together with other quassinoids.

Shinjulactone G (**1**), mp 274—277 °C, gave a weak molecular ion peak in high resolution mass spectrum, leading to the molecular formula, $C_{20}H_{28}O_7$, for **1**. IR and ^{1}H NMR spectra of **1** revealed the presence of a vinyl methyl, a tertiary methyl, a secondary methyl, a hydroxymethyl, and an *α*,*β*-unsaturated carbonyl, and a lactone grouping. ^{1}H NMR decoupling experiment suggested that the structure of shinjulactone G (**1**) might be formulated as 20-hydroxyklaineanone. Configuration of the hydroxyl groups at C-11 and C-12 was determined by coupling constants ($J_{11,12}$=3 and $J_{12,13}$=2.5 Hz). The structure of shinjulactone G (**1**) was further confirmed by chemical conversion of **1** into chaparrinone triacetate (**3**).[2] According to the procedure described for klaineanone[2] and 15-hydroxyklaineanone,[3] shinjulactone G (**1**) was acetylated to give a triacetate (**4**), which showed an IR absorption band at 3450 cm^{-1} and a doublet signal at *δ* 7.84 (J=5 Hz) due to a hydroxyl group in the ^{1}H NMR of **4**. Since the doublet signal coupled with a broad singlet signal due to $C_{(11)}$–H at *δ* 5.05 with the coupling constant J=5 Hz, the hydroxyl group was concluded to exist at C-11. Jones oxidation of **4** afforded chaparrinone triacetate (**3**), which was completely identical with an authentic sample. Thus, the structure of shinjulactone G (**1**) was determined to be 1*β*,11*β*,12*α*,20-tetrahydroxypicras-3-ene-2,16-dione.

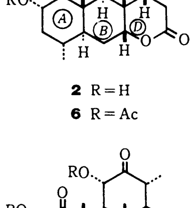
Shinjulactone H (**2**), mp 135—139 °C, was shown to have a molecular formula, $C_{20}H_{28}O_6$, by high resolution mass spectrum. ^{1}H (Table 1) and ^{13}C NMR spectra indicated the presence of two tertiary methyls, two secondary methyls, two isolated carbonyls, and a lactone grouping. The IR absorption band at 3450 cm^{-1} and two doublet signals at *δ* 81.9 and 69.9 in the ^{13}C NMR spectrum of **2** indicated that the remaining two oxygen atoms are ascribed to hydroxyl groups. These spectral features are very similar to those of amarolide (**5**).[4,5] Acetylation of shinjulactone H (**2**) gave a diacetate (**6**) which was not identical with amarolide diacetate (**7**).[5] The ^{1}H NMR spectral comparison between shinjulactone H (**2**) and amarolide (**5**) could reveal a difference in the relative position of hydroxyl and carbonyl groups in ring C. Shinjulactone H (**2**) showed a double doublet at *δ* 4.01 with coupling constants J=11 and 3 Hz and a multiplet at *δ* 2.16, assignable to $C_{(12)}$–H and $C_{(13)}$–H, respectively. On irradiation at *δ* 4.01, the multiplet signal resulted in a change of its shape. When D_2O was added, the double doublet was changed into a doublet with a coupling constant J=11 Hz, which implies the protons at C-12 and C-13 are in trans-diaxial relationship and the former was coupled with the hydroxyl proton at C-12. From these observations together with a singlet signal at *δ* 2.94 due to $C_{(9)}$–H, the structure (**2**) was proposed for shinjulactone H. The proposed structure (**2**) was firmly established by a preparation of shinjulactone H diacetate (**6**) from known chaparrolide (**8**).[6] Acetylation of chaparrolide (**8**) afforded two diacetates (**9** and **10**) and a known triacetate, 1,2,12-tri-*O*-acetylchaparrolide (**11**).[6] From the ^{1}H NMR spectra, the diacetates (**9** and **10**) were assigned to be 2,12- and 1,2-di-*O*-acetyl derivatives, respectively. 2,12-Di-*O*-acetylchaparrolide (**9**) was oxidized with Jones reagent to give a keto acetate (**6**), which was completely identical with the diacetate (**6**) derived from shinjulactone H (**2**). The structure of shinjulactone H (**2**) was, therfore, concluded to be 2*α*,12*β*-dihydroxypicrasane-1,11,16-trione.[7]



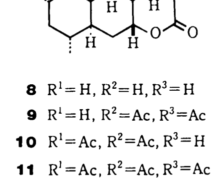
1 R=H
4 R=Ac



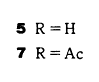
3



2 R=H
6 R=Ac



8 R¹=H, R²=H, R³=H
9 R¹=H, R²=Ac, R³=Ac
10 R¹=Ac, R²=Ac, R³=H
11 R¹=Ac, R²=Ac, R³=Ac



5 R=H
7 R=Ac

TABLE 1. ^{1}H NMR SPECTRA AT 400 MHz OF SHINJULACTONES G AND H (**1** AND **2**)$^{a,b)}$

	1		**2**	
	δ	*J*	δ	*J*
1-H	4.18 s			
2-H			4.77 ddd	12, 7.5, 4.5
3-H	6.15 br s		1.92—2.05$^{c)}$	
3-H′			2.45 ddd	13, 7.5, 3.5
4-H			1.92—2.05$^{c)}$	
5-H	3.15—3.18$^{c)}$		1.39 ddd	12.5, 12.5, 3
6-H	2.22 ddd	15, 3.5, 3.5	2.04 ddd	15, 3, 3
6-H′	2.27 ddd	15, 12.5, 2.5	1.87 ddd	15, 12.5, 2.5
7-H	5.34 dd	3.5, 2.5	4.31 dd	3, 2.5
9-H	2.85 d	2.5	2.94 s	
11-H	5.87 br s$^{d)}$			
12-H	4.14 br s$^{d)}$		4.01 dd	11, 3
13-H	2.93 m$^{d)}$		2.16 m	
14-H	3.15—3.18$^{c,d)}$		1.92—2.05$^{c)}$	
15-H	4.33 dd	19, 11.5	2.70 dd	19, 13
15-H′	2.97 dd	19, 7	2.84 dd	19, 7
4-CH_3	1.76 br s		0.95 d	6.5
8-CH_3			1.13 s$^{e)}$	
10-CH_3	1.53 s		1.58 s$^{e)}$	
13-CH_3	1.23 d	7	1.20 d	7
20-H	5.55 d	12		
20-H′	4.38 d	12		
2-OH			3.43 d	4.5
12-OH			3.53 d	3

a) δ and *J* are expressed in ppm and Hz, respectively. b) Measured in C_5D_5N for **1** and in $CDCl_3$ for **2**. c) Signals were overlapped. d) Coupling constants were determined by decoupling experiment; $J_{9,11}=2.5$, $J_{11,12}=3$, $J_{12,13}=2.5$, and $J_{13,14}=4.5$ Hz. e) Signals may be reversed.

Experimental[8)]

Shinjulactone G (1). Mp 274—277 °C; $[\alpha]^{26}_{D}$ +6.5° (*c* 1.2, pyridine); IR (KBr) 3470, 1730, 1700, 1675, and 1280 cm^{-1}; UV (ethanol) 237 nm (ε 5300); ^{1}H NMR (Table 1); ^{13}C NMR (pyridine-*d*$_5$) δ 12.4q, 15.5q, 22.4q, 26.4t, 27.9d, 29.4t, 36.2d, 41.7d, 42.4s, 43.3d, 48.8s, 61.8t, 74.2d, 77.7d, 79.7d, 85.0d, 124.8d, 165.1s, 172.2s, and 199.6s; MS *m*/*z* (%) 380 (M$^+$), 362 (100), 347 (27), and 151 (50); Found: *m*/*z* 380.1824. Calcd for $C_{20}H_{28}O_7$: M, 380.1834.

1,12,20-Tri-O-acetylshinjulactone G (4). Shinjulactone G (**1**; 7 mg) was acetylated in the usual manner to afford **4** (8 mg), mp 130—134 °C, IR (film) 3450, 1735, 1680, and 1235 cm^{-1}; ^{1}H NMR (pyridine-*d*$_5$) δ 0.94 (3H, d, *J*=7 Hz), 1.65 (3H, s), 1.80 (3H, br s), 1.90, 2.07, and 2.18 (each 3H, s), 5.05 (1H, br s), 5.73 (1H, s), 5.96 (1H, d, *J*=13 Hz), 6.10 (1H, br s), and 7.84 (1H, d, *J*=5 Hz); MS *m*/*z* (%) 506 (M$^+$; 7), 488 (9), 446 (70), and 404 (100); Found: *m*/*z* 506.2104. Calcd for $C_{26}H_{34}O_{10}$: M, 506.2150.

Oxidation of 4 with Jones Reagent. 1,12,20-Tri-*O*-acetylshinjulactone G (**4**; 7.5 mg) was treated with Jones reagent (in excess) in acetone (6 mL) at room temperature for 8 h. The usual work-up afforded chaparrionone triacetate (**3**; 5 mg), which was identified with an authentic sample by TLC, ^{1}H NMR, IR, and mass spectra.

Shinjulactone H (2). Mp 135—139 °C; $[\alpha]^{21}_{D}$ −14° (*c* 3.9, ethanol); IR (KBr) 3450, 1720, and 1230 cm^{-1}; ^{1}H NMR (Table 1); ^{13}C NMR ($CDCl_3$) δ 15.2q, 15.2q, 18.2q, 23.8q, 26.7t, 27.6t, 27.9d, 39.2s, 39.4d, 45.3d, 46.6t, 46.8d, 47.0d, 48.8s, 69.9d, 76.2d, 81.9d, 169.3s, 208.2s, and 213.0s; MS *m*/*z* (%) 364 (M$^+$; 23), 346 (43), 321 (46), and 57 (100); Found: *m*/*z* 364.1877. Calcd for $C_{20}H_{28}O_6$: M, 364.1884.

2,12-Di-O-acetylshinjulactone H (6). Acetylation of shinjulactone H (**2**; 10 mg) gave **6** (12 mg), mp 146—150 °C; IR (KBr) 1745, 1730, and 1230 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.96 (3H, d, *J*=6.5 Hz), 1.04 (3H, d, *J*=6 Hz), 1.17 (3H, s), 1.60 (3H, s), 2.11 and 2.17 (each 3H, s), 4.26 (1H, t, *J*=3 Hz), 5.12 (1H, d, *J*=12.5 Hz), and 5.77 (1H, dd, *J*=13 and 7 Hz); MS *m*/*z* (%) 448 (M$^+$; 9), 406 (10), 388 (100), and 328 (21); Found: *m*/*z* 448.2089. Calcd for $C_{24}H_{32}O_8$: M, 448.2096.

Acetylation of Chaparrolide (8). Chaparrolide (**8**; 61 mg) was acetylated with acetic anhydride (1 mL) in pyridine (2 mL) at room temperature for 6 h. After the usual work-up, the reaction mixture was separated by a column chromatography (silica gel; 30 g). Elution with benzene-acetone (9:1) afforded **11** (*ca.* 30 mg), **10** (*ca.* 25 mg), and **9** (16 mg) in succession. **9**: mp 152—154 °C; IR (KBr) 3450, 1735, and 1250 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.88 (3H, d, *J*=6.5 Hz), 1.06 (3H, d, *J*=6 Hz), 1.15 (3H, s), 1.36 (3H, s), 2.03 and 2.16 (each 3H, s), 3.17 (1H, dd, *J*=9 and 5 Hz), 4.31 (1H, t, *J*=3 Hz), 4.87 (1H, m), and 4.89 (1H, d, *J*=11.5 Hz); MS *m*/*z* (%) 450 (M$^+$; 7), 390 (100), 348 (43), and 330 (54); Found *m*/*z* 450.2226. Calcd for $C_{24}H_{34}O_8$: M, 450.2253. **10**: mp 167—168 °C; IR (KBr) 3450, 1735, and 1235 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.90 (3H, d, *J*=6 Hz), 1.06 (3H, s), 1.12 (3H, d, *J*=6.5 Hz), 1.46 (3H, s), 1.86 and 1.97 (each 3H, s), 3.27 (1H, d, *J*=5 Hz), 3.80 (1H, dd, *J*=10.5 and 5 Hz), 4.28 (1H, t, *J*=2.5 Hz), 4.62 (1H, d, *J*=10 Hz), and 5.06 (1H, m); MS *m*/*z* (%) 450 (M$^+$; 24), 390 (84), 348 (57), and 330 (100); Found: *m*/*z* 450.2238. Calcd for $C_{24}H_{34}O_8$: M, 450.2253.

Oxidation of 9 with Jones Reagent. 2,12-Di-*O*-acetylchaparrolide (**9**; 16 mg) was treated with Jones reagent (in excess) at 0 °C for 1.5 h. After the usual work-up, a keto acetate (**6**; 12.5 mg) was obtained and was identified with 2,12-di-*O*-acetylshinjulactone H (**6**) by TLC, ^{1}H NMR, IR, and mass spectra.

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7) This structure had been previously proposed for amarolide by Casinovi *et al.*[4)] but the structure of amarolide was later revised to **5**.[5)]

8) General Procedures are the same as described in the previous papers.[1)] Root bark of *A. altissima* was collected at the Botanical Gardens, Faculty of Science, the University of Tokyo in August 1982.