Chem. Pharm. Bull.
36(10)3920—3927(1988)

Tannins of Hamamelidaceous Plants. III.[1] Isorugosins A, B and D, New Ellagitannins from *Liquidambar formosana*

TSUTOMU HATANO, REIKO KIRA, TAEKO YASUHARA and TAKUO OKUDA*

Faculty of Pharmaceutical Sciences, Okayama University, Tsushima, Okayama 700, Japan

(Received April 22, 1988)

A new dimeric hydrolyzable tannin named isorugosin D (**11**), and two new monomeric tannins of related structures, isorugosin A (**10**) and isorugosin B (**1**), were isolated from the leaf of *Liquidambar formosana* HANCE (Hamamelidaceae). The orientation of the valoneoyl group at O-4 and O-6 of the glucose core in isorugosins A, B and D was found to be different from that of rugosin A (**7**), rugosin B (**6**) and rugosin D (**18**), and the orientations of this group in the tannins of both type were confirmed on the basis of the two-dimensional nuclear magnetic resonance spectrum (long-range ^{1}H–^{13}C correlation spectrum) of rugosin A (**7**).

Keywords——isorugosin A; isorugosin B; isorugosin D; rugosin A; tannin; ellagitannin; dimeric hydrolyzable tannin; *Liquidambar formosana*; Hamamelidaceae; centrifugal partition chromatography

The isolation and the structure elucidation of liquidambin, which could be a precursor of a C-glucosidic tannin, casuarinin,[1] and the isolation of several co-existing hydrolyzable tannins,[2] from the leaf of *Liquidambar formosana* HANCE, were reported in our previous papers.[1,2] The remarkable seasonal change in the composition of the tannins, which is in accord with the biogenetic pathway from galloylglucoses to C-glucosidic tannins, was also reported.[2] Further investigation on the tannins of this plant has led to the isolation of three new tannins, which are described in this paper.

Results and Discussion

The *n*-butanol-soluble portion, obtained from the aqueous acetone homogenate of the autumn leaves of *Liquidambar formosana*, was chromatographed over Sephadex LH-20, and then on Toyopearl HW-40 to give a new compound, which was named isorugosin B on the basis of the following structural study. The ethyl acetate-soluble portion, obtained from the spring leaves of *L. formosana*, was subjected to centrifugal partition chromatography (CPC).[3] Subsequent column chromatography of a fraction from CPC over Toyopearl HW-40 and/or MCI-GEL CHP-20P, afforded another two new compounds, which were named isorugosin A and isorugosin D.

Isorugosin B (**1**), $[\alpha]_D$ +28° ($c=1$, methanol), was obtained as a light brown amorphous powder. The fast-atom bombardment mass spectrum (FAB-MS) shows the $[M+Na]^+$ ion at 977. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum of **1** (400 MHz, in acetone-d_6) indicates that this tannin forms an anomer mixture (α-anomer : β-anomer = 4 : 3), and that it possesses two galloyl groups [δ 7.04 (s) and 6.90 (s) (8/7H each, α-anomer); 7.05 (s) and 6.88 (s) (6/7H each, β-anomer)], a valoneoyl group [δ 7.27 (s), 6.65 (s) and 6.31 (s) (4/7H each, α-anomer); 7.28 (s), 6.66 (s) and 6.25 (s) (3/7H each, β-anomer)] and a glucopyranose core [δ 5.54 (d, $J=3.5$ Hz, H-1), 5.10 (dd, $J=3.5$, 10 Hz, H-2), 5.69 (t, $J=10$ Hz, H-3), 5.03 (t, $J=$

10 Hz, H-4), 4.57 (ddd, $J=1$, 7, 10 Hz, H-5), 5.28 (dd, $J=7$, 13 Hz, H_a-6) and 3.75 (dd, $J=1$, 13 Hz, H_b-6) (4/7 H each, α-anomer); 5.05 (d, $J=8$ Hz, H-1), 5.22 (dd, $J=8$, 10 Hz, H-2), 5.39 (t, $J=10$ Hz, H-3), 5.02 (t, $J=10$ Hz, H-4), 4.20 (ddd, $J=1$, 7, 10 Hz, H-5), 5.29 (dd, $J=7$, 13 Hz, H_a-6) and 3.82 (dd, $J=1$, 13 Hz, H_b-6) (3/7 H each, β-anomer)]. The presence of valoneoyl and galloyl groups in isorugosin B was confirmed by methanolysis after methylation of **1**, which yielded methyl tri-*O*-methylgallate (**2**) and trimethyl octa-*O*-methylvaloneate (**3**).

The coupling constants of glucose protons in the ^{1}H-NMR spectrum of **1** indicate that the glucose core adopts the $^4C_1$ conformation, and the chemical shifts of H-4, H_a-6 and H_b-6 of the $^4C_1$ glucopyranose core indicate that the hexahydroxydiphenoyl (HHDP) part of the valoneoyl group is located at O-4 and O-6 of the glucopyranose core.[4,5] As the anomeric center is not acylated, two galloyl groups should be at O-2 and O-3 of the glucose core. These locations of acyl groups on the glucose core were supported by treatment of isorugosin B with hot water, to afford 2,3-di-*O*-galloyl-D-glucose (**4**)[6] and valoneic acid dilactone (**5**)[7] (Chart 1). The circular dichroism (CD) spectrum of isorugosin B (**1**) (in methanol) shows a positive Cotton effect in the short wavelength region ($[\theta]_{222}$ $+9.0\times10^4$), indicating the *S*-configuration[8,9] of the HHDP part of the valoneoyl group. Therefore, isorugosin B is 2,3-di-*O*-galloyl-4,6-*O*-(*S*)-valoneoyl-D-glucose and is isomeric to rugosin B (**6**)[10] (Chart 2), as it is not identical with the latter. It is considered that the orientation of the valoneoyl group in isorugosin B (**1**) is different from that of rugosin B (**6**).

The evidence concerning the orientations of the valoneoyl group in rugosin B (**6**), and in the co-existing tannins, rugosin A (**7**)[10] and rugosin C (**8**),[10] is as follows. The orientation of the valoneoyl group in rugosin B (**6**) is identical with that of rugosin A (**7**), as indicated by the chemical correlation of these tannins.[10] The orientation of the valoneoyl group in rugosin C (**8**) should be as in structure **8** (Chart 3), which was correlated with praecoxin C (**9**)[11] by the selective hydrolysis of the depside linkage of **9**.[11] However, the identity of the orientation of

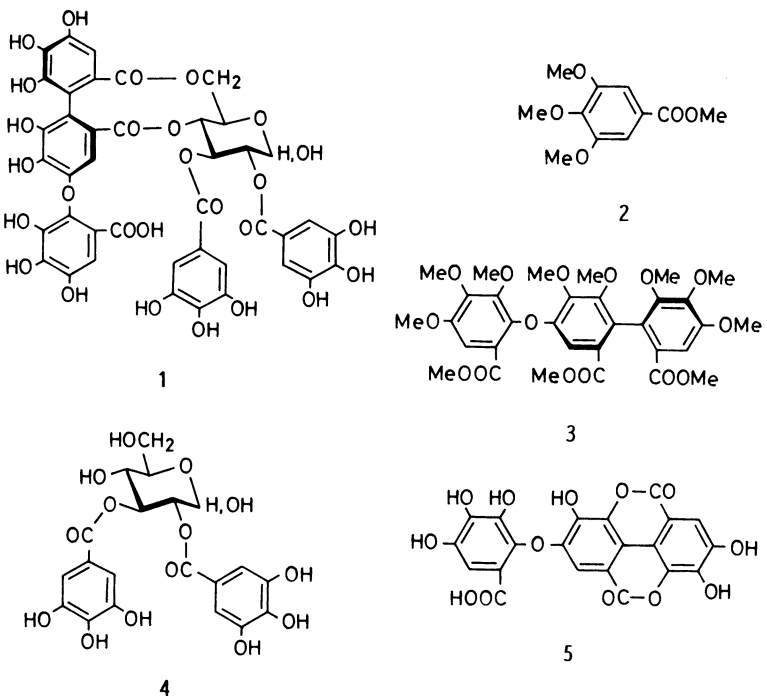
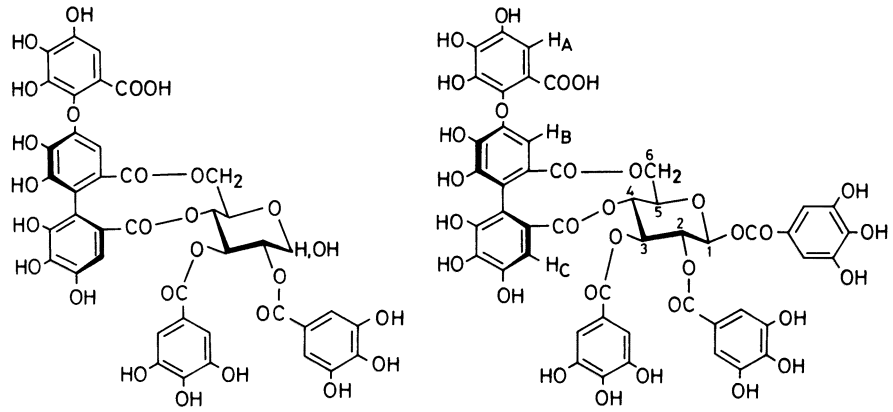
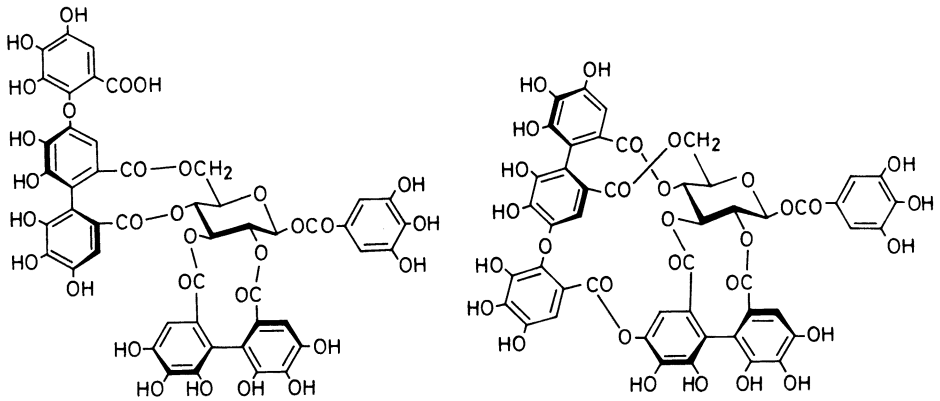


Chart 1



6 7

Chart 2



8 9

Chart 3

the valoneoyl group in **6** and in **7** with that of **8** was only based on the probable identity of their biogenetic routes. We have now confirmed the orientation of the valoneoyl group in **6** and in **7** as follows.

In the ^{1}H-NMR spectrum (90 MHz, in acetone-d_6 + D_2O) of rugosin A (**7**), the proton signals due to the valoneoyl group are at δ 7.14, 6.51 and 6.32. Obviously, the signal at δ 7.14 is assignable to the proton of the galloyl part of the valoneoyl group (H_A in formula **7**). Addition of pyridine-d_5 to a solution of rugosin A in acetone-d_6 + D_2O caused a large downfield shift of the proton at δ 6.32 to δ 6.58, while only small downfield shifts were observed for the other signals (δ 7.14→7.24, 6.51→6.61). The large downfield shift of the signal at δ 6.32 can be explained by association of a pyridine molecule with the carboxyl group of the valoneoyl group, which induced the large downfield shift of the neighboring proton (H_B in formula **7**). The remaining signal at δ 6.51 therefore should be H_C in formula **7**. In the long-range ^{1}H–^{13}C correlation spectrum (Fig. 1), rugosin A (in acetone-d_6) showed a cross peak for an ester carbonyl carbon at δ 167.8 and the H_B proton of the valoneoyl group, and another cross peak for the same ester carbonyl carbon and the H-6 proton (δ 3.79) of the glucose core. The spectrum also showed a cross peak for the carbonyl carbon at δ 167.6 and the H_C proton

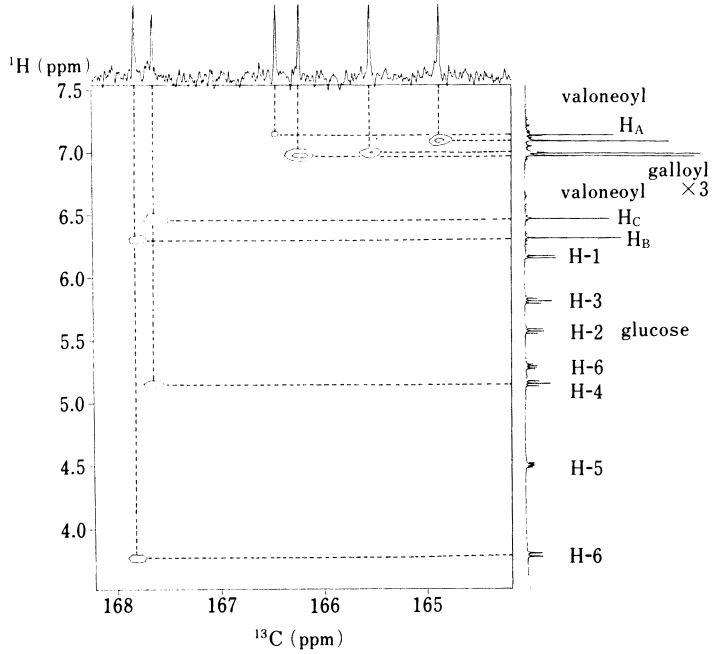


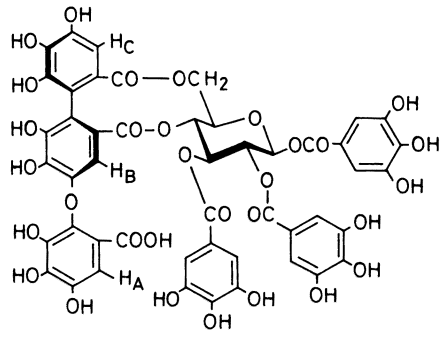
Fig. 1. The Long-Range ^{1}H–^{13}C Correlation Spectrum of Rugosin A (7)

The region of the ester carbonyl carbons in the ^{13}C-NMR spectrum is shown. The average J_{CH} value for two- or three-bond couplings was set at 10 Hz.

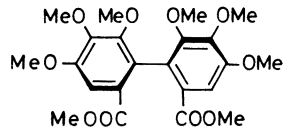
of the valoneoyl group, and another cross peak for this carbonyl carbon and the H-4 proton (δ 5.16) of the glucose core. These data indicate that the orientation of the valoneoyl group in rugosin A should be as in structure **7** (Chart 2). Therefore, rugosin B should also be formulated as **6**, and isorugosin B should have structure **1** as shown in Chart 1.

Isorugosin A (**10**), $[\alpha]_D$ +30° (c=0.63, acetone), was obtained as an off-white amorphous powder. The ^{1}H-NMR spectrum (500 MHz, in acetone-d_6) of **10** indicates the presence of three galloyl groups [δ 7.11 (2H, s), 6.99 (2H, s) and 6.90 (2H, s)], a valoneoyl group [δ 7.28 (1H, s, H_A), 6.65 (1H, s, H_C) and 6.29 (1H, s, H_B)] and a β-glucopyranose core adopting the $^4C_1$ conformation [δ 6.17 (d, J=8 Hz, H-1), 5.56 (dd, J=8, 10 Hz, H-2), 5.59 (t, J=10 Hz, H-3), 5.11 (t, J=10 Hz, H-4), 4.45 (dd, J=6.5, 10 Hz, H-5), 5.34 (dd, J=6.5, 13 Hz, H_a-6) and 3.84 (d, J=13 Hz, H_b-6) (1H each)]. The chemical shifts of the H-4, H_a-6 and H_b-6 protons on the $^4C_1$ glucopyranose core indicate that the HHDP part of the valoneoyl group in **10** is located at O-4 and O-6 of the glucose core. The three galloyl groups are therefore located at O-1, O-2 and O-3. Partial hydrolysis of isorugosin A (**10**) afforded isorugosin B (**1**). Therefore, the structure **10** (Chart 4), isomeric to rugosin A (**7**), was assigned for isorugosin A.

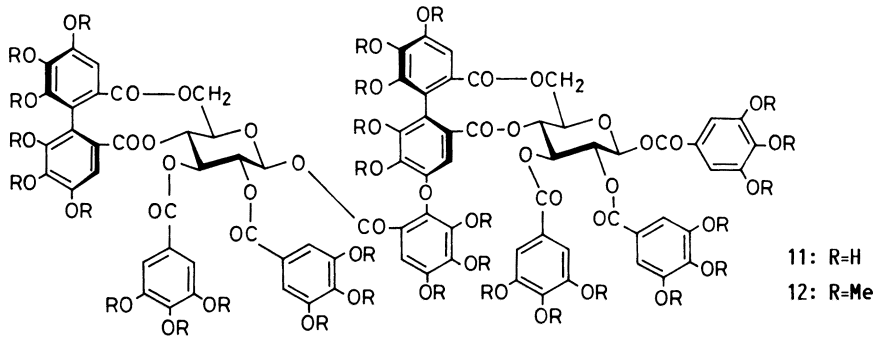
Isorugosin D (**11**), $[\alpha]_D$ +75° (c=0.5, methanol), was obtained as a light brown amorphous powder. The ^{1}H-NMR spectrum of **11** (500 MHz, in acetone-d_6) indicates the presence of five galloyl groups [δ 7.11 (2H, s), 7.04 (2H, s), 6.98 (2H, s), 6.96 (2H, s) and 6.91 (2H, s)], a valoneoyl group and an HHDP group [δ 7.23 (1H, s), 6.66 (1H, s), 6.65 (1H, s), 6.46 (1H, s) and 6.14 (1H, s)], and two β-glucopyranose cores both of which adopt the $^4C_1$ conformation [δ 6.11 (d, J=8.5 Hz, H-1), 5.58 (dd, J=8.5, 10 Hz, H-2), 5.80 (t, J=10 Hz, H-3), 5.19 (t, J=10 Hz, H-4), 4.49 (dd, J=6, 10 Hz, H-5), 5.29 (dd, J=6, 13.5 Hz, H_a-6) and 3.84 (d, J=13.5 Hz, H_b-6); 6.15 (d, J=8 Hz, H-1), 5.56—5.50 (2H, m, H-2 and H-3), 5.09 (t, J=10 Hz, H-4), 4.31 (dd, J=6, 10 Hz, H-5), 5.20 (dd, J=6, 13.5 Hz, H_a-6) and 3.84 (d, J=13.5 Hz, H_b-6)], in the molecule of **11**. The chemical shifts of the H-4, H_a-6 and H_b-6 protons



10



13



11: R=H
12: R=Me

Chart 4

of the two $^4C_1$ glucose cores indicate that the HHDP part of the valoneoyl group and the HHDP group are located at O-4 and O-6 in the glucose cores. The galloyl part of the valoneoyl group and the five galloyl groups therefore should be at O-1, O-2 and O-3 on the two glucose cores. The CD spectrum of **11** (in methanol) shows a positive Cotton effect in the short-wavelength region ($[\theta]_{228}$ $+2.5\times10^5$), with an amplitude about twice as large as that of isorugosin B. The configuration of the valoneoyl group and the HHDP group in **11** therefore should be *S*.

Methylation of isorugosin D (**11**) afforded nonacosamethylate (**12**), $[\alpha]_D$ $+3.5°$ ($c=0.23$, acetone). Methanolysis of **11** gave methyl tri-*O*-methylgallate (**2**), dimethyl hexamethoxybiphenylcarboxylate (**13**) and trimethyl octa-*O*-methylvaloneate (**3**) in a molar ratio of 5 : 1 : 1. Partial hydrolysis of isorugosin D (**11**) afforded isorugosin A (**10**) and tellimagrandin I (**14**), along with 1,2,3-tri-*O*-galloyl-β-D-glucose (**15**), **16** and tellimagrandin II (**17**)[12] (Chart 5). Therefore, the structure **11** (Chart 4), isomeric to rugosin D (**18**)[13] (Chart 6), was assigned for isorugosin D.

Rugosins A (**6**), B (**7**) and D (**18**) have not been found in the fractions obtained from *L. formosana*. It is biogenetically significant that the isomers of isorugosins A (**10**), B (**1**) and D (**11**) concerning the orientation of the valoneoyl group at O-4 and O-6 of the glucose cores, are absent in *L. formosana*, and that the latter type of tannins, **10**, **1** and **11**, have not been found in *Rosa rugosa* or in *Coriaria japonica*, which contain the former type of tannins, **6**, **7** and **18**.[8,10,13,14] As tellimagrandin I (**14**) and tellimagrandin II (**17**), which are presumed to be precursors of both types of tannins described above, are present in all of the three plants,[2,10,14] it is very probable that the C-O oxidative coupling[15] between the galloyl part and the HHDP part of the valoneoyl group in the biogenesis of isorugosins A, B and D (in *L.*

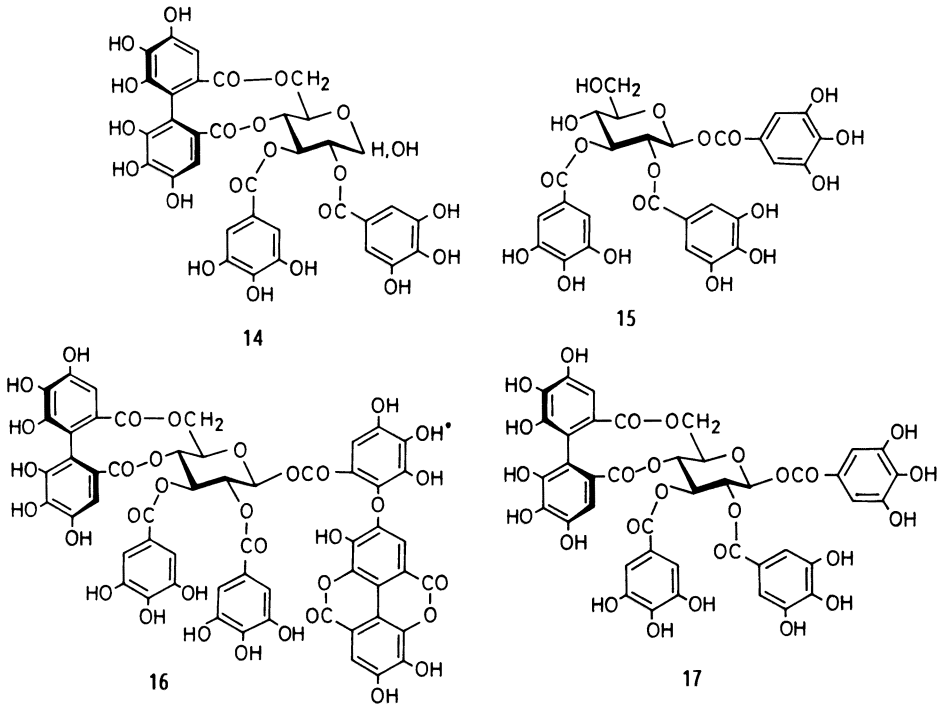


Chart 5

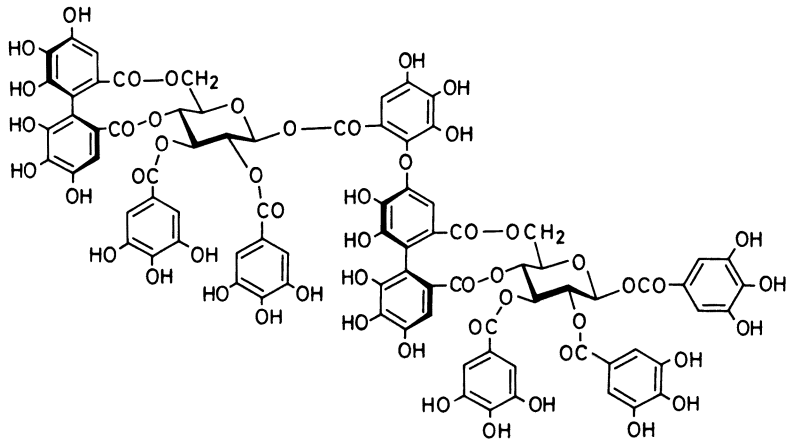


Chart 6

formosana) is effected by an enzyme different from that for rugosins A, B and D (in *R. rugosa* and *C. japonica*).

Experimental

Optical rotations were measured on a JASCO DIP-4 polarimeter. Ultraviolet (UV) and infrared (IR) spectra were recorded on a Hitachi 200-10 spectrophotometer and on a JASCO A-102 spectrometer, respectively. ^{1}H-NMR spectra were recorded on a Bruker AM-400 spectrometer (400 MHz) using tetramethylsilane as an internal standard;

chemical shifts are given in δ values (ppm). A Varian VXR-500 instrument (500 MHz) in the SC-NMR Laboratory of Okayama University, and a Hitachi R22-FTS spectrometer (90 MHz) were also used. FAB-MS spectra were measured on a JEOL JMS D-300 spectrometer and electron-impact mass spectra (EI-MS) on a Shimadzu LKB-9000 instrument. CD spectra were recorded on a JASCO J-500 machine equipped with a DP-501 data processor. CPC was performed on a Sanki L-90 machine equipped with twelve cartridges,[3] developing with *n*-butanol–*n*-propanol–water (4 : 1 : 5) at 1000 rpm. Reversed-phase high-performance liquid chromatography (HPLC) was conducted on a YMC A312 (ODS) (6 × 150 mm) column at 40 °C in a column oven. A YMC A324 (ODS) (10 × 300 mm) column was also used for preparative HPLC. The solvent systems used were (R1) 0.01 M H_3PO_4–0.01 M KH_2PO_4–methanol (3 : 3 : 2, by volume), (R2) 0.1 M H_3PO_4–0.1 M KH_2PO_4–ethanol–ethyl acetate (10 : 10 : 2 : 1) and (R3) 0.1 M H_3PO_4–0.1 M KH_2PO_4–ethanol (10 : 10 : 1). Normal-phase HPLC was run on a column (4 × 150 mm) packed with Develosil 60-5, developing with a solvent system (N1) consisting of hexane–methanol–tetrahydrofuran–formic acid (55 : 33 : 11 : 1) containing oxalic acid (450 mg/ml), or (N2) hexane–ethyl acetate (2 : 1). Thin layer chromatography (TLC) was performed on Kieselgel 60PF_{254} (Merck). Light petroleum refers to that fraction boiling in the range 75—125 C.

Isolation of Isorugosin B (1)——Fresh leaves of *Liquidambar formosana* (1 kg) collected in November, were homogenized in 70% acetone, and filtered. After concentration, the resulting aqueous solution was extracted with Et_2O, ethyl acetate and *n*-butanol, successively, and each solvent was evaporated. A portion (6.58 g) of the *n*-butanol extract (27 g) was subjected to column chromatography over Sephadex LH-20 (2.2 × 68 cm) using 70% EtOH as the developer; 10-g fractions were collected. Combined fractions 59—73 (192 mg) were purified by column chromatography on Toyopearl HW-40 (fine grade) eluted with 70% EtOH, and further purified by column chromatography on Toyopearl HW-40 eluted with 50% EtOH, to afford **1** (14 mg).

Isolation of Isorugosin A (10) and Isorugosin D (11)——Fresh leaves of *L. formosana* (3.6 kg) collected in May, were treated in an analogous way, and gave 50 g of ethyl acetate extract. A portion (2.8 g) of the ethyl acetate extract was subjected to CPC (reversed-phase development), and was separated into four fractions. The second fraction (432 mg) was submitted to column chromatography on MCI-GEL CHP-20P (1.1 × 10 cm) eluted with H_2O, 20% MeOH, 40% MeOH and 60% MeOH, successively. The 40% MeOH eluate (203 mg) was further chromatographed over Toyopearl HW-40 (superfine grade) with 70% EtOH as the eluant, to give casuarictin[2] and crude isorugosin A. Final purification was achieved by preparative HPLC [solvent system (R1)], to afford 2 mg of **10**. The 60% MeOH eluate (51 mg) from the column chromatography over MCI-GEL was submitted to column chromatography on Toyopearl HW-40 (superfine grade) eluted with 70% EtOH, 70% EtOH : 70% acetone (9 : 1) and 70% EtOH : 70% acetone (8 : 2), successively. The 70% EtOH : 70% acetone (8 : 2) eluate afforded 25 mg of **11**.

Isorugosin B (1)——A light brown amorphous powder, $[\alpha]_D$ +28° (*c* = 1, MeOH). *Anal.* Calcd for $C_{41}H_{30}O_{27}\cdot 6H_2O$: C, 46.34; H, 3.98. Found: C, 46.53; H, 3.83. FAB-MS: *m/z* 977 ($[M+Na]^+$). UV λ_{max}^{MeOH} nm (log ε): 219 (4.93), 271 (4.56). IR ν_{max}^{KBr} cm^{-1}: 1740—1710 (ester carbonyl), 1620. CD (MeOH) [θ] (nm): $+9.0\times10^4$ (222), $+3.4\times10^4$ (238), -3.6×10^4 (262), $+3.8\times10^4$ (288). ^{1}H-NMR: see text.

Methanolysis after Methylation of 1——A solution of **1** (5 mg) in ethanol (0.4 ml) was treated with ethereal diazomethane (0.4 ml) for 2 h at room temperature, and evaporated. The crude methyl ether was purified by preparative TLC using light petroleum–chloroform–acetone (4 : 6 : 3, *Rf* 0.30) as the developer, and then treated with 0.2% sodium methoxide in methanol (1 ml) overnight at room temperature. The mixture was acidified with acetic acid and then evaporated. The residue was subjected to preparative TLC with light petroleum–chloroform–acetone (6 : 3 : 1) as the developer, and gave methyl tri-*O*-methylgallate (**2**) (0.3 mg) [*Rf* 0.50. EI-MS: *m/z* 226 (M^+)] and trimethyl octa-*O*-methylvaloneate (**3**) (0.4 mg) [*Rf* 0.24. EI-MS: *m/z* 660 (M^+)].

Treatment of 1 with Hot Water——An aqueous solution (0.3 ml) of isorugosin B (1 mg) in a sealed tube was kept in a boiling water-bath for 18 h, and evaporated. 2,3-Di-*O*-galloyl-D-glucose (**4**) and valoneic acid dilactone (**5**) in the reaction mixture were identified by co-chromatography on HPLC [reversed-phase HPLC (R2) and normal-phase HPLC (N1)] with authentic samples. For the identification of **4**, reversed-phase HPLC using solvent system (R3) was also used.

Isorugosin A (10)——A light-brown amorphous powder. $[\alpha]_D$ +30° (*c* = 0.63, acetone). *Anal.* Calcd for $C_{48}H_{34}O_{31}\cdot 2H_2O$: C, 50.45; H, 3.35. Found: C, 50.97; H, 4.16. UV λ_{max}^{MeOH} nm (log ε): 227 (4.94), 274 (4.59). IR ν_{max}^{KBr} cm^{-1}: 1730—1710 (ester carbonyl), 1620. ^{1}H-NMR: see text.

Partial Hydrolysis of 10 with Tannase——An aqueous solution of **10** (1 mg), containing one drop of tannase solution, was kept at 37 °C for 3 h. The mixture was acidified with 1% HCl to pH 2, and subjected to chromatography on a SEP-PAK C_{18} cartridge (Waters Associates) eluted with water and then methanol. The methanol eluates afforded **1**, which was identified by ^{1}H-NMR, and co-chromatography on HPLC [reversed-phase HPLC (R1) and normal-phase HPLC (N1)] with an authentic sample.

Isorugosin D (11)——A light brown amorphous powder. $[\alpha]_D$ +75 (*c* = 0.5, MeOH). *Anal.* Calcd for $C_{82}H_{58}O_{52}\cdot 7H_2O$: C, 49.20; H, 3.62. Found: C, 49.49; H, 3.77. UV λ_{max}^{MeOH} nm (log ε): 218 (5.33), 277 (4.86). IR ν_{max}^{KBr} cm^{-1}: 1730—1710 (ester carbonyl), 1620. CD (MeOH) [θ] (nm): $+2.5\times10^5$ (228), -6.0×10^4 (255), $+3.1\times10^4$ (285). ^{1}H-NMR: see text.

Methylation of 11——An ethanol solution (0.5 ml) of **11** (5 mg) was treated with ethereal diazomethane (1 ml) and left to stand for 1 h. The solvent was evaporated off, and the residue was subjected to preparative TLC using

benzene–acetone (4 : 1, *Rf* 0.42), to give the nonacosamethylate (**12**) (1.5 mg), $[\alpha]_D$ +3.5° (c = 0.23, acetone). ^{1}H-NMR (400 MHz, in acetone-d_6): δ 7.32, 7.29, 7.22, 7.21, 7.07 (2H each, s, galloyl × 5), 7.41, 6.97, 6.96, 6.78, 6.46 (1H each, s, HHDP and valoneoyl), 6.34 [1H, d, J = 8 Hz, glucose (glu) H-1], 6.28 (1H, d, J = 8.5 Hz, glu H-1), 5.92 (1H, t, J = 10 Hz, glu H-3), 5.73—5.68 (3H, glu H-2 × 2, glu H-3), 5.34 (1H, t, J = 10 Hz, glu H-4), 5.32 (1H, dd, J = 6.5, 13.5 Hz, glu H_a-6), 5.31 (1H, dd, J = 6.5, 13.5 Hz, glu H_a-6), 5.21 (1H, t, J = 10 Hz, glu H-4), 4.62 (1H, dd, J = 6.5, 10 Hz, glu H-5), 4.60 (1H, dd, J = 6.5, 10 Hz, glu H-5), 3.98—3.64 (CH_3O– × 29). The signals of two H_b-6 protons were overlapped by the methoxyl signals.

Methanolysis of Nonacosa-*O*-methylisorugosin D (12)——Compound **12** (0.5 mg) was treated with 0.5% sodium methoxide in methanol (0.1 ml) overnight at room temperature. After neutralization with acetic acid, the solvent was distilled off. HPLC analysis [normal-phase, solvent system (N2)] of the residue showed the presence of methyl tri-*O*-methylgallate (**2**), dimethyl hexamethoxybiphenylcarboxylate (**13**) and trimethyl octa-*O*-methylvaloneate (**3**) in a molar ratio of 1 : 1 : 5.

Partial Hydrolysis of 11——Compound **11** (100 mg) was dissolved in 0.05 M acetate buffer (pH 6) and kept at 37 C for 22 h. The reaction mixture was acidified with 10% HCl to pH 2, and passed through a SEP PAK C_{18} cartridge with water and then methanol, as eluants. The methanol eluate was chromatographed over Toyopearl HW-40 (superfine grade) with 70% ethanol, and then with a mixture of 70% ethanol and 70% acetone (9 : 1), as eluants. The 70% ethanol eluate afforded 1,2,3-tri-*O*-galloyl-β-D-glucose (**15**) (5 mg) and tellimagrandin I (**14**) (23 mg). The 70% ethanol–70% acetone (9 : 1) eluate gave **10** (6 mg) and tellimagrandin II (**17**) (3 mg). An additional product (**16**) (3 mg) was also obtained from isorugosin D (120 mg), by preparative HPLC on a YMC A324 column [solvent system (R1)] after column chromatography of a mixture of hydrolyzates on Toyopearl HW-40. ^{1}H-NMR of **16** (400 MHz, in acetone-d_6): δ 7.62, 7.22, 7.15 (1H each, s, lactonized valoneoyl), 6.95, 6.93 (2H each, s, galloyl × 2), 6.66, 6.46 (1H each, s, HHDP), 6.11 (1H, d, J = 8 Hz, glu H-1), 5.75 (1H, t, J = 10 Hz, glu H-3), 5.54 (1H, dd, J = 8, 10 Hz, glu H-2), 5.26 (1H, dd, J = 6, 13 Hz, glu H_a-6), 5.17 (1H, dd, J = 10 Hz, glu H-4), 4.46 (1H, dd, J = 6, 10 Hz, glu H-5), 3.76 (1H, d, J = 13 Hz, glu H_b-6).

Acknowledgements We thank Prof. T. Shingu, Faculty of Pharmaceutical Sciences, Kobe Gakuin University, for the 400 MHz ^{1}H-NMR spectra, and Prof. T. Fujita, Faculty of Pharmaceutical Sciences, Kyoto University, Assoc. Prof. Y. Takeda and Mrs. Y. Yoshioka, Faculty of Pharmaceutical Sciences, Tokushima University, for measuring FAB-MS. We are also indebted Miss T. Kaneda and Miss T. Morimoto for their technical assistance.

References and Notes

1) For Part II[2] in the series of "Tannins of Hamamelidaceous Plants," see T. Okuda, T. Hatano, T. Kaneda, M. Yoshizaki and T. Shingu, *Phytochemistry*, **26**, 2053 (1987).
2) For Part I in the series of "Tannins of Hamamelidaceous Plants," see T. Hatano, R. Kira, M. Yoshizaki and T. Okuda, *Phytochemistry*, **25**, 2787 (1986).
3) T. Okuda, T. Yoshida, T. Hatano, K. Yazaki, R. Kira and Y. Ikeda, *J. Chromatogr.*, **362**, 375 (1986).
4) R. K. Gupta, S. M. K. Al-Shafi, K. Layden and E. Haslam, *J. Chem. Soc., Perkin Trans. 1*, **1983**, 2525.
5) Participation of the galloyl moiety of valoneoyl group in the diester bridge formation at O-4 and O-6 of the glucose core of **1** can be excluded by the presence of the optically active valoneoyl group in **1**, as observed in the CD spectrum. See ref. 10, and T. Okuda and K. Seno, *Nippon Kagaku Kaishi*, **1981**, 671.
6) T. Okuda, T. Hatano, N. Ogawa, R. Kira and M. Matsuda, *Chem. Pharm. Bull.*, **32**, 4662 (1984).
7) O. T. Schmidt and E. Komarek, *Justus Liebigs Ann. Chem.*, **591**, 156 (1955).
8) T. Hatano, S. Hattori and T. Okuda, *Chem. Pharm. Bull.*, **34**, 4533 (1986).
9) T. Okuda, T. Yoshida, T. Hatano, T. Koga, N. Toh and K. Kuriyama, *Tetrahedron Lett.*, **23**, 3937 (1982).
10) T. Okuda, T. Hatano, K. Yazaki and N. Ogawa, *Chem. Pharm. Bull.*, **30**, 4230 (1982).
11) T. Okuda, T. Hatano and K. Yazaki, *Chem. Pharm. Bull.*, **31**, 333 (1983).
12) The production of tellimagrandin II (**17**) is regarded as due to cleavage of the ether linkage of the valoneoyl group. See ref. 7, and T. Yoshida, L. Chen, T. Shingu and T. Okuda, *Chem. Pharm. Bull.*, **36**, 2940 (1988).
13) T. Okuda, T. Hatano and N. Ogawa, *Chem. Pharm. Bull.*, **30**, 4234 (1982).
14) T. Hatano, S. Hattori and T. Okuda, *Chem. Pharm. Bull.*, **34**, 4092 (1986).
15) T. Yoshida, T. Hatano, T. Okuda, M. U. Memon, T. Shingu and K. Inoue, *Chem. Pharm. Bull.*, **32**, 1790 (1984).