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Furanoeremophilane-Type Sesquiterpenes from *Cacalia adenostyloides*

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Four new furanoeremophilane-type sesquiterpenes, adenostylol (**1a**), adenostin A (**2a**), adenostin B (**3a**) and adenostylide (**4a**), were isolated from *Cacalia adenostyloides* MATSUM., along with eight known sesquiterpenes, cacalol (**5**), cacalolide (**6**), cacalone (**7**), epicacalone (**8**), adenostylone (**9**), neoadenostylone (**10**), 6β-propionyloxy-1,10-dehydrofuranoeremophil-9-one (**11**) and tetrahydromaturinone (**12**). Of these compounds, **2a** and **3a** are novel-type dimers.

Keywords——*Cacalia adenostyloides*; Compositae, furanoeremophilane; adenostylol; adenostin A; adenostin B; adenostylide; cacalol; sesquiterpene dimer

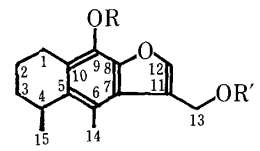
A large number of furanoeremophilane-type sesquiterpenes have been isolated as common constituents of *Cacalia* sp.,[1] *Senecio* sp.,[2] *Liguralia* sp.,[3] *Fargium* sp.[4] and *Adenostyles* sp.[5] (Compositae). *Cacalia adenostyloides* MATSUM. (Japanese name "Kanikomori") grows under conifers on high land in Japan. There has been no previous work on the constituents of the plant. The rhizomes of the plant yielded four new sesquiterpenes along with eight known sesquiterpenes. Two of these new compounds are novel-type dimers. These structures were elucidated based on physicochemical and spectral evidence as follows.

The ethyl acetate (AcOEt)-soluble fraction of the hot methanol (MeOH) extract of the rhizomes was extensively separated by silica gel column chromatography and preparative layer chromatography (PLC) to give the four new compounds, adenostylol (**1a**), adenostin A (**2a**), B (**3a**) and adenostylide (**4a**), along with cacalol (**5**),[6] cacalolide (**6**),[7] cacalone (**7**),[8] epicacalone (**8**),[8] adenostylone (**9**),[9] neoadenostylone (**10**),[10] 6β-propionyloxy-1,10-dehydrofuranoeremophil-9-one (**11**)[11] and tetrahydromaturinone (**12**).[7]

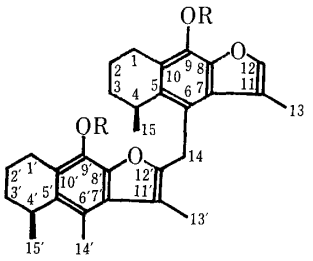
Adenostylol (**1a**) was obtained as a colorless oil. The mass spectrum (MS) of **1a** showed peaks at *m/z* 288 (M^+) ($C_{17}H_{20}O_4$) and 246 ($M^+ - C_2H_2O$, base peak). The infrared (IR) spectrum of **1a** showed the presence of hydroxy (3460 cm^{-1}) and ester (1740 cm^{-1}) groups. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum [δ 2.05 (3H, s)] and carbon-13 nuclear magnetic resonance (^{13}C-NMR) spectrum (Table I) [δ 21.1(q) and 171.1(s)] of **1a** showed the presence of an acetyl group. Compound **1a** gave a diacetate (**1b**), MS *m/z*: 330 (M^+, $C_{19}H_{22}O_5$), on acetylation and a diol (**1c**), MS *m/z*: 246(M^+, $C_{15}H_{18}O_3$), on alkaline hydrolysis. The ^{1}H-NMR spectra of **1a** and **1b** indicated the absence of a methyl group on the furan ring but the presence of an oxymethyl group at the β-position of the furan ring (δ 5.21 in **1a** and 5.18 in **1b**). In the ^{1}H-NMR spectrum of **1c** the oxymethyl signal appeared at higher field (δ 4.82) than in the cases of **1a** and **1b**, so the position of the acetyl group of **1a** was at C-13. All other signals were almost the same as those of cacalol (**5**) (*vide infra*). The ^{13}C-NMR spectra of these compounds showed almost the same signal patterns as in the case of **5**, except for the methyl group on the furan ring, and showed the presence of a methylene carbon bearing an oxygen (δ 58.1 in **1a**, 57.7 in **1b** and 56.0 in **1c**). These results indicated that the structure of adenostylol is **1a**. The ^{1}H- and ^{13}C-NMR spectra of **1b** and **1c** also supported this structure.

Adenostin A (**2a**) was obtained as colorless needles, mp 186—188 °C, which were somewhat unstable and turned pale orange on exposure to the air. The MS of **2a** showed the molecular ion at *m/z* 458 ($C_{30}H_{34}O_4$) and a fragment ion at *m/z* 228 ($C_{15}H_{16}O_2$), suggesting that **2a** is a dimer. This was supported by the ^{13}C-NMR spectrum (Table I) of **2a**, which showed thirty signals. On acetylation, **2a** gave a diacetate (**2b**), MS *m/z*: 542 (M^+, $C_{34}H_{38}O_6$). The ^{13}C-NMR spectrum of **2b** showed the presence of thirty-four carbons in the molecule. The ^{1}H-NMR spectrum of **2a** indicated the presence of two secondary methyl groups at δ 1.16 (d, J=7.0 Hz) and 1.17 (d, J=7.0 Hz), two methyl groups on the furan rings at δ 2.29 (d, J=1.3 Hz) and 2.25 (s), an aromatic methyl group at δ 2.52 (s) and a methylene group at δ 4.38 (s), existing between aromatic rings. One of the methyl groups on the furan rings appeared as a singlet having no long-range coupling with a proton at the α-position of the furan ring, and only one α-proton of the furan ring was observed. The ultraviolet (UV) spectrum of **2a** showed almost the same absorption curve as in the case of **5a**. These results indicated that adenostin A is a dimer between C-12 and C-14 of **5a**, so the structure was concluded to be **2a**. The ^{1}H- and ^{13}C-NMR spectra of **2b** also supported this structure.

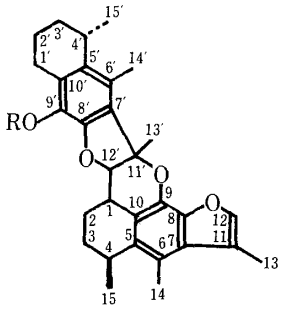
Adenostin B (**3a**) was obtained as colorless needles, mp 202—205 °C. The MS and elemental analysis of **3a** showed that the molecular formula was $C_{30}H_{34}O_4$, which was supported by the ^{13}C-NMR spectrum (Table I). These data indicated that **3a** is a dimer of furanoeremophilanes. Compound **3a** gave a monoacetate (**3b**), MS *m/z*: 500 (M^+, $C_{32}H_{36}O_5$). The ^{1}H-NMR spectrum of **3a** showed the presence of two secondary methyl groups at δ 0.93 (d, J=7.0 Hz) and 1.16 (d, J=7.0 Hz), two methyl groups on benzene rings at δ 2.41 (s) and 2.46 (s), a methyl group at the β-position of a furan ring at δ 2.24 (d, J=1.3 Hz), a tertiary



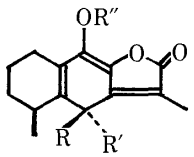
1a : R=H, R′=Ac
1b : R=Ac, R′=Ac
1c : R=H, R′=H



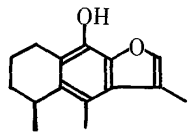
2a : R=H
2b : R=Ac



3a : R=H
3b : R=Ac



4a { R=Me, R′=OH, R″=H
R=OH, R′=Me, R″=H
4b { R=Me, R′=OAc, R″=Ac
R=OAc, R′=Me, R″=Ac



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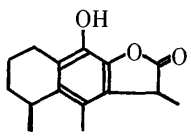

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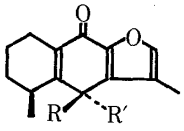
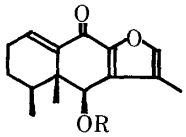


7 : R=Me, R′=OH
8 : R=OH, R′=Me



9 : R= -C(=O)-CH$_3$
10 : R= -C(=O)-CH=CH$_2$
11 : R= -C(=O)-C$_2$H$_5$

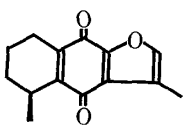


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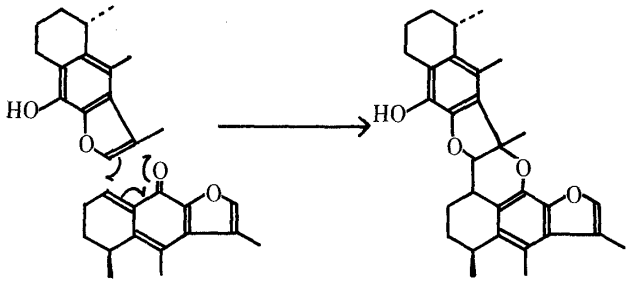
Chart 1



3a

Chart 2

TABLE I. ^{13}C-NMR Data for Compounds, **1a**, **2a**, **3a**, **4a** and **5**

	1a[a]	**2a**[b]	**3a**[a]	**4a**[a]	**5**[a]
C-1	23.1	23.0 or	30.6	23.0, 23.2	23.3
C-1′		23.4	22.9		
C-2	16.7	16.7 or	19.9	16.3, 16.4	16.9
C-2′		17.2	16.4		
C-3	30.1	30.1 or	28.8	29.5, 29.6	30.2
C-3′		30.6	29.8		
C-4	29.2	29.0 or	28.5[d]	28.6	29.0
C-4′		29.3	28.8[d]		
C-5	124.5	127.2 or	127.1	135.3, 135.6	126.1
C-5′		127.8	124.9		
C-6	136.5	138.0 or	137.7	74.3, 74.6	135.5
C-6′		135.7	135.5		
C-7	119.9[c]	120.1	121.5	138.4[e]	120.1[f]
C-7′		120.1	124.3		
C-8	136.6	136.1 or	144.7	137.2, 137.1	136.4
C-8′		136.6	144.1		
C-9	142.7	140.5 or	144.7	138.3[e]	142.4
C-9′		142.8	144.1		
C-10	119.5[c]	119.0 or	119.1	126.8, 126.9	119.1[f]
C-10′		118.4	124.5		
C-11	116.8	116.9 or	116.3	124.7, 124.8	117.1
C-11′		110.6	88.2		
C-12	144.1	141.7	141.1	178.4	140.7
C-12′		151.1	96.4		
C-13	58.1	10.6 or	11.2	12.5	11.2
C-13′		11.2	26.4		
C-14	14.0	25.5	13.7	24.0, 24.3	13.7
C-14′		13.9	12.5		
C-15	21.4	21.6 or	20.9	20.8	21.4
C-15′		22.0	19.5		
Ac	21.1				
	171.1				

a) Measured in $CDCl_3$. *b*) Measured in $CDCl_3+CD_3OD$. *c*—*f*) Assignments may be interchangeable within the same column.

methyl group at δ 2.00 (s), an α-proton of the furan ring at δ 7.04 (q, $J=1.3$ Hz) and a methine proton at δ 4.85 (d, $J=3.0$ Hz), and other methylene and methine protons appeared at the same positions as in the case of **5a**. The doublet methine proton (δ 4.85) became a singlet on irradiation of the benzylic methine region (δ 3.05). The ^{13}C-NMR spectrum of **3a** showed the presence of fourteen sp^2 carbons and sixteen sp^3 carbons. Of the sp^3 carbons, one methine

carbon and one methylene carbon were substituted by oxygen atoms [δ 96.4 (d) and 88.2 (s)]. These results indicated that **3a** is a dimer arising from a Diels–Alder reaction as shown in Chart 2. The ^{1}H- and ^{13}C-NMR spectra of **3b** also supported the proposed structure. The stereochemistry of **3a** has not been elucidated, but the configurations of C-4 and C-4′ are presumed to be *R* by analogy with **5a**, and the ring junction at C-11′ and C-12′ must be *cis*.

Adenostylide (**4a**) was obtained as an amorphous powder, MS *m/z*: 262 (M^+, $C_{15}H_{18}O_4$). The IR spectrum of **4a** showed the presence of hydroxyl (3380 cm^{-1}) and α,β-unsaturated-γ-lactone (1820 cm^{-1}) groups. The ^{1}H-NMR spectrum of **4a** showed the presence of a secondary methyl group at δ 1.08 (d, J=6.8 Hz), a tertiary methyl group at δ 1.64 (s) and a vinyl methyl group at δ 2.27 (s), and methine and methylene groups appeared at the same positions as in **5a**. The ^{13}C-NMR spectrum of **4a** showed twenty-four peaks, six of which might overlap, so thirty carbons might be expected. Sixteen sp^3 carbons were identified, six of which were assigned as methyl groups (δ 12.5 × 2, 20.8 × 2, 24.0 and 24.3). The presence of an α,β-unsaturated-γ-lactone group was also identified from the spectrum (δ 178.4, 124.7 and 138.3). Compound **4a** gave a diacetate (**4b**), $C_{19}H_{22}O_6$. The ^{1}H- and ^{13}C-NMR spectra of **4b** appeared as a duplicated pattern of cacalol-type sesquiterpenes. These results indicated that **4a** exists as a 1 : 1 mixture of epimers at C-6, *i.e.* (4*R*, 6*R*) and (4*R*, 6*S*). This mixture could not be separated by thin layer chromatography or high-performance liquid chromatography, but gave a single spot or peak.

Compounds **5**, **6**, **7**, **8**, **9**, **10**, **11** and **12** were identified as cacalol,[6] cacalolide,[7] cacalone,[8] epicacalone,[8] adenostylone,[9] neoadenostylone,[10] 6β-propionyloxy-1,10-dehydrofuranoeremophil-9-one[11] and tetrahydromatrinone,[7] respectively, by physical and spectral methods. Cacalolide was obtained as a 1 : 1 mixture of epimers at C-11 and cacalone was isolated as a 1 : 1 mixture with epicacalone, but epicacalone was obtained as a pure compound.

Furanoeremophilane sesquiterpenes exist in some species of Compositae as characteristic constituents. Only a few examples of furanoeremophilane dimers have been isolated from natural sources,[12] so **2a** and **3a** are interesting additions to the list.

Experimental

All melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. IR spectra were recorded on a JASCO A-202 grating infrared spectrometer. UV spectra were recorded on a Hitachi model 200-10 or Shimadzu UV-210 spectrometer. Optical rotations were determined on a JASCO DIP-140 digital polarimeter. ^{1}H-NMR spectra were recorded on a JEOL JNM-FX 90Q FT (90 MHz) NMR spectrometer with tetramethylsilane (TMS) as an internal standard (δ value). ^{13}C-NMR spectra were recorded on a JEOL JNM-FX 90Q FT (22.5 MHz) NMR spectrometer (δ value). MS were recorded on JEOL JMS D-100 and JEOL JMS 01SG-2 mass spectrometers. Thin-layer chromatography (TLC) was carried out on precoated Silica gel $60F_{254}$ plates (Merck). Column chromatography was carried out on Silica gel, Type 60 (Merck).

Extraction and Isolation of Constituents——The powdered root (2.5 kg) of *Cacalia adenostyloides*, collected in Shizuoka prefecture, was extracted with hot MeOH. The extract was fractionated between AcOEt and water to give the AcOEt-soluble fraction, which showed many spots having UV absorption on TLC. The AcOEt fraction (100 g) was chromatographed on a silica gel column using an *n*-hexane–AcOEt gradient as the developing solvent, to give seven fractions, Frs. I—VII. Fr. II gave adenostine B (**3a**) (120 mg), cacalol (**5**), mp 93—95 °C (*n*-hexane) (5.5 g), tetrahydromatrinone (**12**), mp 83—85 °C (*n*-hexane) (72 mg), cacalolide (**6**), mp 174—179 °C (MeOH) (280 mg), cacalone (**7**), mp 120—122 °C (*n*-hexane–benzene) (150 mg) and epicacalone (**8**), mp 121—123 °C (*n*-hexane) (120 mg) upon column chromatography and preparative layer chromatography (PLC). Fr. III gave adenostylone (**9**), oil (43 mg), neoadenostylone (**10**), mp 96—98 °C (MeOH) (200 mg) and 6β-propionyloxy-1,10-dehydrofuranoeremophil-9-one (**11**), mp 93—95 °C (MeOH) (150 mg) upon column chromatography and PLC. Fr. V gave adenostylol (**1a**) (57 mg), adenostin B (**2a**) (40 mg) and adenostylide (**4a**) (120 mg).

Adenostylol (1a)——Viscous oil. IR ν_{max}^{film} cm^{-1}: 3450, 1740, 1720, 1240. UV λ_{max}^{MeOH} nm (log ε): 208 (4.12), 251 (4.04), 261 sh (4.02), 311 (3.89). $[\alpha]_D^{20°}$ +33.3° (c=0.12, $CHCl_3$). MS *m/z*: 288.1330 (M^+) (Calcd for $C_{17}H_{20}O_4$, 288.1362), 273.1154 ($M^+ - CH_3$) (Calcd for $C_{16}H_{17}O_4$, 273.1128), 246.1253 ($M^+ - C_2H_2O$) (Calcd for $C_{15}H_{18}O_3$, 246.1257). ^{1}H-NMR ($CDCl_3$): 1.17 (3H, d, J=7.0 Hz, 15-CH_3), 1.78 (4H, br, 2-H, 3-H), 2.05 (3H, s, Ac), 2.41 (3H, s, 14-CH_3), 2.5—3.5 (3H, m, 1-H, 4-H), 5.21 (2H, d, J=0.7 Hz, 13-H), 5.82 (H, br, OH), 7.27 (H, t, J=0.7 Hz, 12-H).

^{13}C-NMR as given in Table I.

Adenostin A (2a)——mp 186—188 °C (*n*-hexane–$CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3400, 1440, 1410, 1230, 1108. UV λ_{max}^{MeOH} nm (log ε): 220 (4.72), 261 (4.28), 268 (4.37), 286 sh (3.66), 295 (3.47). $[\alpha]_D^{20°}$ −2.4 ° (*c*=0.5, $CHCl_3$). MS *m/z*: 458.2553 (M^+) (Calcd for $C_{30}H_{34}O_4$, 458.2544). ^{1}H-NMR ($CDCl_3$): 1.16 (3H, d, *J*=7.0 Hz, 15-CH_3 or 15′-CH_3), 1.17 (3H, d, *J*=7.0 Hz, 15′-CH_3 or 15-CH_3), 1.75 (8H, br, 2-H, 3-H, 2′-H, 3′-H), 2.23 (3H, d, *J*=1.3 Hz, 13-CH_3), 2.34 (3H, s, 13′-CH_3), 2.51 (3H, s, 14-CH_3), 2.7—3.0 (2H, br, 4-H, 4′-H), 3.0—3.4 (4H, br, 1-H, 1′-H), 4.38 (2H, s, 14-H), 7.27 (H, q, *J*=1.3 Hz, 12-H). ^{13}C-NMR as given in Table I.

Adenostin B (3a)——mp 202—205 °C (*n*-hexane). IR ν_{max}^{KBr} cm^{-1}: 3500, 1628, 1450, 1225, 1106, 1088. UV λ_{max}^{MeOH} nm (log ε): 209 (4.74), 220 sh (4.56), 255 (3.93), 262 (3.94), 283 (3.44), 293 (3.45). $[\alpha]_D^{20°}$ −158.3 ° (*c*=1.0, $CHCl_3$). MS *m/z*: 458 (M^+) ($C_{30}H_{34}O_4$), 230, 229 (base peak). ^{1}H-NMR ($CDCl_3$): 0.93 (3H, d, *J*=7.0 Hz, 15′-CH_3), 1.16 (3H, d, *J*=7.0 Hz, 15-CH_3), 1.66 (8H, br, 2-H, 3-H, 2′-H, 3′-H), 2.00 (3H, s, 13′-CH_3), 2.24 (3H, d, *J*=1.3 Hz, 13-CH_3), 2.41 (3H, s, 14′-CH_3), 2.46 (3H, s, 14-CH_3), 2.8—3.3 (5H, br, 1-H, 4-H, 1′-H, 4′-H), 4.85 (H, d, *J*=4.0 Hz, 12′-H), 7.04 (H, q, *J*=1.3 Hz, 12-H). ^{13}C-NMR as given in Table I. *Anal.* Calcd for $C_{30}H_{34}O_4$: C, 78.57; H, 7.47. Found: C, 78.35; H, 7.51.

Adenostylide (4a)——mp 140—141 °C (MeOH). IR ν_{max}^{KBr} cm^{-1}: 3380, 1802, 1630, 1445, 1100, 1070. MS *m/z*: 262.1181 (M^+) (Calcd for $C_{15}H_{18}O_4$, 262.1206). UV λ_{max}^{MeOH} nm (log ε): 204 (4.29), 294 (3.42). ^{1}H-NMR ($CDCl_3$): 1.08 (3H, d, *J*=6.8 Hz, 15-CH_3), 1.64 (3H, s,14-CH_3), 1.65 (4H, br, 2-H, 3-H), 2.27 (3H, s, 13-CH_3), 2.2—2.6 (3H, m, 1-H, 4-H). ^{13}C-NMR as given in Table I.

Acetyladenostylol (1b)——Viscous oil. IR ν_{max}^{film} cm^{-1}: 1770, 1740, 1230, 1195. $[\alpha]_D^{20°}$ +7.6 ° (*c*=0.8, $CHCl_3$). MS *m/z*: 330 (M^+) ($C_{19}H_{22}O_5$). ^{1}H-NMR ($CDCl_3$): 1.19 (3H, d, *J*=7.0 Hz, 15-CH_3), 1.80 (4H, br, 2-H, 3-H), 2.09 (3H, s, 13-Ac), 2.38 (3H, s, 9-Ac), 2.52 (3H, s, 14-CH_3), 2.6—3.5 (3H, m, 1-H, 4-H), 5.18 (2H, s, 13-H), 7.32 (H, s, 12-H). ^{13}C-NMR ($CDCl_3$): 14.4 (14-C), 16.6 (2-C), 20.4 (13-Ac), 21.0 (9-Ac), 21.4 (15-C), 23.5 (3-C), 29.2 (4-C), 30.0 (1-C), 57.7 (13-C), 116.5 (11-C), 125.4 (7-C), 125.8 (10-C), 126.3 (5-C), 131.7 (6-C), 136.4 (9-C), 144.7 (12-C), 145.3 (8-C), 168.3 (13-Ac), 170.6 (9-Ac).

Diol (1c)——mp 186—190 °C (*n*-hexane–$CHCl_3$). IR ν_{max}^{KBr} cm^{-1}: 3430, 3180, 1470, 1215, 1117. $[\alpha]_D^{20°}$ −9.6 ° (*c*=0.5, $CHCl_3$). MS *m/z*: 246.1217 (M^+) (Calcd for $C_{15}H_{18}O_3$, 246.1257). UV λ_{max}^{MeOH} nm (log ε): 218 (4.48), 255 (3.98), 261 (3.95), 284 (3.27), 294 sh (3.19). ^{1}H-NMR ($CDCl_3$ + CD_3OD): 1.16 (3H, d, *J*=7.0 Hz, 15-CH_3), 1.78 (4H, br, 2-H, 3-H), 2.50 (3H, s, 14-CH_3), 3.0—3.5 (3H, m, 1-H, 4-H), 4.82 (2H, d, *J*=0.7 Hz, 13-H), 7.46 (H, t, *J*=0.7 Hz, 12-H). ^{13}C-NMR ($CDCl_3$ + CD_3OD): 13.7 (14-C), 16.6 (2-C), 21.0 (15-C), 22.9 (1-C, 4-C), 29.9 (3-C), 56.1 (13-C), 119.0 (11-C), 119.7 (10-C), 121.5 (7-C), 125.4 (5-C), 135.7 (6-C), 136.6 (8-C), 141.8 (12-C), 142.1 (9-C).

Acetyladenostin A (2b)——Amorphous powder. IR ν_{max}^{KBr} cm^{-1}: 1770, 1450, 1200. MS *m/z*: 542 (M^+) ($C_{34}H_{38}O_6$), 228 (base peak) ($C_{15}H_{16}O_2$). ^{1}H-NMR ($CDCl_3$): 1.15 (3H, d, *J*=6.8 Hz, 15-CH_3), 1.20 (3H, d, *J*=7.0 Hz, 15′-CH_3), 1.76 (8H, br, 2-H, 3-H, 2′-H, 3′-H), 2.20 (3H, s, Ac), 2.25 (3H, s, 13′-CH_3), 2.29 (3H, d, *J*=1.3 Hz, 13-CH_3), 2.6—3.0 (4H, br, 1-H, 1′-H), 3.0—3.4 (2H, br, 4-H, 4′-H), 4.37 (2H, br, 14-H), 7.26 (H, q, *J*=1.3 Hz, 12-H). ^{13}C-NMR ($CDCl_3$): 10.4, 11.1 (13-C or 13′-C), 14.3 (14′-C), 16.4, 16.7 (2-C or 2′-C), 20.2, 20.4 (15-C or 15′-C), 21.5, 21.9 (Ac), 23.0, 23.4 (1-C or 1′-C), 25.7 (14-C), 28.7, 29.0 (4-C or 4′-C), 29.6, 30.2 (3-C or 3′-C), 110.8 (11′-C), 117.0 (11-C), 124.1, 125.1 (7-C or 7′-C), 125.2, 126.0 (10-C or 10′-C), 128.2, 128.4 (5-C or 5′-C), 131.2 (6′-C), 132.6 (6-C), 135.3 (9-C), 136.5 (9′-C), 141.7 (12-C), 151.1 (12′-C).

Acetyladenostin B (3b)——mp 228—230 °C (*n*-hexane). IR ν_{max}^{KBr} cm^{-1}: 1768, 1612, 1455, 1210, 1110. $[\alpha]_D^{20°}$ −131.5 ° (*c*=1.5, $CHCl_3$). MS *m/z*: 500 (M^+), 230 (base peak). ^{1}H-NMR ($CDCl_3$): 0.92 (3H, d, *J*=7.0 Hz, 15′-CH_3), 1.16 (3H, d, *J*=7.0 Hz, 15-CH_3), 1.62 (8H, 2H, 3-H, 2′-H, 3′-H), 2.01 (3H, s, 13′-CH_3), 2.12 (3H, s, Ac), 2.23 (3H, d, *J*=1.3 Hz, 12-CH_3), 2.40 (3H, s, 13′-CH_3), 2.51 (3H, s, 14-CH_3), 2.8—3.6 (5H, m, 1-H, 4-H, 1′-H, 4′-H), 4.82 (H, d, *J*=4.0 Hz, 12′-H), 7.01 (H, q, *J*=1.3 Hz, 12-H). ^{13}C-NMR ($CDCl_3$): 11.3 (13-C), 13.0 (14′-C), 13.7 (14-C), 16.4 (2′-C), 19.6 (15-C), 19.8 (2-C), 20.2 (Ac), 21.0 (15-C), 23.4 (1′-C), 26.3 (13′-C), 28.3, 28.5 (4-C or 4′-C), 28.9 (3-C), 29.6 (3′-C), 30.7 (1-C), 87.9 (11′-C), 96.5 (12′-C), 116.4 (11-C), 119.4 (7-C), 121.7 (10-C), 126.0 (4-C), 127.2 (5-C), 129.9 (10′-C), 130.2 (5′-C), 131.9 (6′-C), 133.8 (9′-C), 135.7 (6-C), 137.7 (8-C), 141.1 (12-C), 144.2 (9-C), 149.2 (8′-C), 168.3 (Ac).

Acetyladenostylide (4b)——**4a** (a 1 : 1 mixture of the epimers) was acetylated to give a diacetate (**4b**) (a 1 : 1 mixture of the epimers), mp 155—156 °C (MeOH). IR ν_{max}^{KBr} cm^{-1}: 1820, 1770, 1755, 1640, 1435, 1240, 1190, 1050. UV λ_{max}^{MeOH} nm (log ε): 210 (4.40), 284 (3.11). $[\alpha]_D^{20°}$ +19.2 ° (*c*=1.3, MeOH). MS *m/z*: 304 (M^+), 234 (base peak). ^{1}H-NMR ($CDCl_3$): 1.12, 1.16 (each 3/2H, d, *J*=7.0 Hz, 15-CH_3), 1.75 (4H, br, 2-H, 3-H), 1.77, 1.79 (each 3/2H, 14-CH_3), 2.06, 2.08 (3/2H, s, 6-Ac), 2.29 (3H, s, 13-CH_3), 2.32 (3H, s, 9-Ac), 2.3—3.2 (3H, m, 1-H, 4-H). ^{13}C-NMR ($CDCl_3$): 12.8 (13-C), 16.0, 16.1 (2-C), 19.8 (19-Ac), 20.1 (6-Ac), 20.7 (15-C), 22.2 (1-C), 23.4, 23.6 (14-C), 28.7 (4-C), 29.3 (3-C), 76.4, 77.2 (6-C), 123.5 (11-C), 129.8 (10-C), 130.6 (5-C), 131.7 (9-C), 138.2 (7-C), 142.3 (8-C), 167.7 (Ac), 168.8 (Ac), 173.3 (12-C). *Anal.* Calcd for $C_{19}H_{22}O_6$: C, 65.88; H, 6.40. Found: C, 65.55; H, 6.30.

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References

1) K. Takai, M. Nakanishi, and K. Omura, *Chem. Lett.*, **1977**, 1179; N. A. El-Emary, T. Takemoto, and G.

Kusano, *Planta Medica*, **38**, 161 (1980).
2) F. Bohlmann and C. Zdero, *Phytochemistry*, **17**, 1161 (1978); F. Bohlmann, C. Zdero, D. Berger, A. Suwita, P. Mahanta, and C. Jeffrey, *ibid.*, **18**, 79 (1979); F. Bohlmann and J. Ziesche, *ibid.*, **19**, 1851 (1980).
3) Y. Moriyama and T. Takahashi, *Bull. Chem. Soc. Jpn.*, **49**, 3196 (1976); F. Bohlmann and K-H. Knoll, *Phytochemistry*, **18**, 877 (1979).
4) H. Nagano and T. Takahashi, *Bull. Chem. Soc. Jpn.*, **51**, 3335 (1978).
5) J. Harmatha, Z. Samek, L. Novotny, V. Herout, and F. Sorm, *Collect. Czech. Chem. Commun.*, **34**, 2792 (1969).
6) M. Terada, M. Tada, and T. Takahashi, *Bull. Chem. Soc. Jpn.*, **51**, 661 (1978); Y. Inoue, Y. Uchida, and H. Kakisawa, *ibid.*, **50**, 961 (1977).
7) K. Naya, Y. Miyoshi, H. Mori, K. Takai, and M. Nakanishi, *Chem. Lett.*, **1976**, 73.
8) F. Yuste, E. Diaz, F. Walls, and K. Jankowski, *J. Org. Chem.*, **41**, 4103 (1976); K. Omura, M. Nakanishi, K. Takai, and K. Naya, *Chem. Lett.*, **1978**, 1257.
9) J. Harmatha, *Tetrahedron Lett.*, **1968**, 1409.
10) F. Bohlmann, A. Suwita, and P. Mahanta, *Chem. Ber.*, **109**, 3570 (1976).
11) F. Bohlmann, C. Zdero, and M. Grenz, *Chem. Ber.*, **110**, 474 (1977).
12) F. Bohlmann and C. Zdero, *Chem. Ber.*, **111**, 3140 (1978).