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THREE BIFLAVONOIDS FROM *DAPHNE ODORA**

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Key Word Index—*Daphne odora*; Thymelaeaceae; biflavonoids; daphnodorins G–I; modified Mosher's method.

Abstract—Three new biflavonoids, daphnodorins G–I, were isolated from the roots of *Daphne odora* and their structures established from spectral and chemical means. These are two C-7/C-2″, C-8/C-3″ biflavonoids (upper half: apigenin, lower half: afzelechin), daphnodorins G and H and a spirobiflavonoid, daphnodorin I.

INTRODUCTION

In the course of our studies on constituents of thymelaeaceous plants, we have already reported the isolation of two new furanobiflavonoids, daphnodorins A and B, a new spirobiflavonoid, daphnodorin C, two C-8/C-3″ biflavonoids, atropisomers, daphnodorin D_1 and D_2 and two new C-7/C-2″, C-8/C-3″ biflavonoids, daphnodorins E and F, from the roots of *Daphne odora* [1–5]. We now report three new biflavonoids.

RESULTS AND DISCUSSION

Three new biflavonoids, daphnodorins G–I (**1–3**), were isolated from the polyphenol fraction by chromatographic purification. Compound **1**, $[\alpha]_D^{21}$ +43.6°, was isolated as a pale yellow amorphous powder and assigned the molecular formula $C_{30}H_{22}O_{11}$ by HR-SI mass spectrometry (*m/z* 559.1242 $[M+H]^+$). The UV spectrum showed absorption maxima at 330 sh, 297 sh, 284 and 228 nm. The IR spectrum showed absorption bands at 3300–2600, 1631, 1518 and 1466 cm^{-1}, suggesting the presence of hydroxyl and carbonyl groups and an aromatic ring. The ^1H NMR spectrum (Table 1) showed signals assignable to two pairs of 4-oxyphenyl groups [δ 7.04, 6.73 (each 2H, *d*, *J* = 8.8 Hz), 7.35 and 6.81 (each 2H, *d*, *J* = 8.8 Hz)], a 2,4,6-trioxyphenyl group [δ 6.04, 5.75 (each 1H, *d*, *J* = 2.2 Hz)], a 3-hydroxy-2,8 (or 2,6)-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran [δ 6.28 (1H, *s*), 4.71 (1H, *d*, *J* = 7.3 Hz), 4.26 (1H, *d*, *J* = 4.9 Hz), 3.88 (1H, *m*), 2.80 (1H, *dd*, *J* = 16.4 and 5.2 Hz) and 2.55 (1H, *dd*, *J* = 16.4 and 7.8 Hz)], an alcoholic hydroxyl group [δ 5.39 (1H, *s*)] and five phenolic hydroxyl groups [δ 11.56, 10.10, 9.14, 8.81 and 8.47 (each 1H, *s*)]. These signals were closely related to those of daphnodorin E (**5**), except for the presence of signals due to a 3-hydroxy-2,8 (or 2,6)-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran instead of the signals due to a 2,8-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran [δ 6.24 (1H, *s*), 4.95 (1H, *dd*, *J* = 10.1 and 1.9 Hz), 2.61 (2H, *m*), 2.13 (1H, *m*) and 1.73 (1H, *m*)]. The ^{13}C NMR spectrum of **1** (Table 2) was also related to that of **5** except for the presence of a methine carbon signal at (δ 68.1) and the lack of a methylene carbon signal at (δ 30.4). Methylation of **1** with diazomethane afforded a hexamethyl ether (**8**), whose methoxyl signals were observed at (δ 56.0 × 2, 55.9, 55.6, 55.5 and 54.0) in the ^{13}C NMR spectrum. Thus, **1** was deduced to be 3-hydroxydaphnodorin E.

Compound **2**, $[\alpha]_D^{21}$ −170.4°, was isolated as a pale yellow amorphous powder and assigned the molecular formula $C_{30}H_{22}O_{11}$, the same as **1**, by HR-SI mass spectrometry (*m/z* 559.1239 $[M+H]^+$). The UV spectrum of **2** showed absorption maxima at 327 sh, 293, 284 sh and 225 nm. The IR spectrum showed absorption bands at 3300–2600, 1641, 1519 and 1466 cm^{-1}, indicating the presence of hydroxyl and carbonyl groups and an aromatic ring. The ^1H NMR spectrum of **2** (Table 1) showed signals owing to two pairs of 4-oxyphenyl groups [δ 7.28 and 6.81 (each 2H, *d*, *J* = 8.8 Hz), 7.36 and 6.81 (each 2H, *d*, *J* = 8.8 Hz)], a 2,4,6-trioxyphenyl group [δ 5.95 and 5.92 (each 1H, *d*, *J* = 2.2 Hz)], a 3-hydroxy-2,8 (or 2,6)-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran [δ 6.28 (1H, *s*), 4.66 (1H, *d*, *J* = 7.3 Hz), 4.18 (1H, *d*, *J* = 5.0 Hz), 4.02 (1H, *m*), 2.88 (1H, *dd*, *J* = 16.2 and 5.2 Hz) and 2.55 (1H, *dd*, *J* = 16.2 and 7.9 Hz)], an alcoholic hydroxyl group [δ 5.29 (1H, *s*)] and five phenolic hydroxyl groups [δ 11.41, 9.81, 8.94, 8.64 and 8.34 (each 1H, *s*)]. These signals were closely related to those of daphnodorin F (**6**). On the other hand, the ^{13}C NMR spectrum of **2** (Table 2) was very similar to that of **1**. Furthermore, the NMR profile of the hexamethyl ether of **2** (**9**) was

*Part 13 in the series 'Chemical Studies on the Constituents of Thymelaeaceous Plants'. For part 12 see ref. [1].

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Table 1. ^{1}H NMR data for compounds **1**, **2**, **5** and **6** in acetone-d_6

H	1	2	5	6
2	4.71 *d* (7.3)	4.66 *d* (7.3)	4.95 *dd* (10.1, 1.9)	4.84 *br d* (8.4)
3	3.88 *m*	4.02 *m*	2.13 *m*	2.26 *m*
(OH or H)	4.26 *d* (4.9)	4.18 *d* (5.0)	1.73 *m*	1.86 *m*
4	2.80 *dd* (16.4, 5.2)	2.88 *dd* (16.2, 5.2)	2.61 *m*	2.65 *m*
	2.55 *dd* (16.4, 7.8)	2.55 *dd* (16.2, 7.9)		
6	6.28 *s*	6.28 *s*	6.24 *s*	6.27 *s*
2′,6′	7.04 *d* (8.8)	7.28 *d* (8.8)	7.13 *d* (8.8)	7.30 *d* (8.8)
3′,5′	6.73 *d* (8.8)	6.81 *d* (8.8)	6.78 *d* (8.8)	6.84 *d* (8.8)
3″-OH	5.39 *s*	5.29 *s*	5.29 *s*	5.35 *s*
6″	6.04 *d* (2.2)	5.95 *d* (2.2)	6.03 *d* (2.1)*	5.95 *d* (2.2)*
8″	5.75 *d* (2.2)	5.92 *d* (2.2)	5.93 *d* (2.1)*	5.92 *d* (2.2)*
2‴,6‴	7.35 *d* (8.8)	7.36 *d* (8.8)	7.34 *d* (8.8)	7.35 *d* (8.8)
3‴,5‴	6.81 *d* (8.8)	6.81 *d* (8.8)	6.90 *d* (8.8)	6.80 *d* (8.8)
-OH	11.56 *s*	11.41 *s*	11.61 *s*	11.51 *s*
	10.10 *s*	9.81 *s*	9.85 *s*	10.07 *s*
	9.14 *s*	8.94 *s*	8.87 *s*	9.06 *s*
	8.81 *s*	8.64 *s*	8.61 *s*	8.76 *s*
	8.47 *s*	8.34 *s*	8.29 *s*	8.47 *s*

*Assignments in each column may be interchanged.

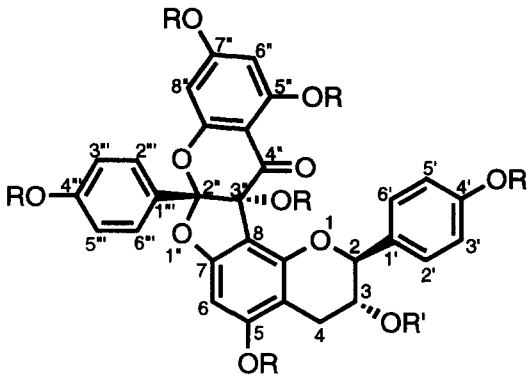
also similar to that of **8**. Thus, **2** was assumed to be 3-hydroxydaphnodorin F, i.e. a stereoisomer of **1**.

The relative configuration between C-2 and C-3 in **1** and **2** were concluded to be *trans*-catechin type from the characteristic feature of the 2-H signals [**1**: δ 4.71, *d*, $J = 7.3$ Hz; **2**: δ 4.66, *d*, $J = 7.3$ Hz] in the ^{1}H NMR spectrum. The determination of the absolute configuration of C-3 in **1** and **2** were carried out by the modified Mosher method [6] applied to those of genkwanol B and C [7, 8]. A comparison of the ^{1}H NMR data in chloroform-*d* for *R*-(+)-α-methoxy-α-trifluoromethylphenylacetic acid (MTPA) esters of **8** and **9** (**10** and **12**) and acetates of **8** and **9** (**11** and **13**) reveals a shielding of B-ring protons in **10** and **12** relative to the chemical shifts of those protons in **11** and **13** [**10**: $\Delta\delta$ −0.008, 2′,6′-H(B); −0.005, 3′,5′-H(B); **12**: $\Delta\delta$ −0.081, 2′,6′-H(B); −0.101, 3′,5′-H(B)] similar to those of (+)-catechin, respectively. Thus, the absolute

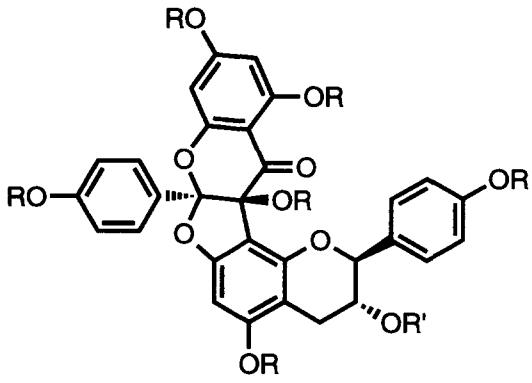
Table 2. ^{13}C NMR spectral data for compounds **1**, **2**, **5** and **6** in acetone-d_6

C	1	2	5	6
2	82.2	82.3	78.0	77.9
3	68.1	67.7	30.4	29.3
4	28.7	28.9	20.1	20.4
4a	103.9	104.3	105.2	105.6
5	159.9	159.9*	154.3*	154.4*
6	92.5	92.4	92.1	92.2
7	161.4	161.3	158.1*	158.1*
8	108.0	108.1	108.3	108.5
8a	153.4	153.7	159.7*	159.7*
1′	131.1	130.8	133.8	133.2
2′,6′	129.1	129.6	127.9	128.4
3′,5′	116.1	116.0†	116.2	116.1
4′	158.3	158.4	159.9*	159.9*
2″	118.9	118.8	118.7	118.9
3″	82.2	82.2	82.4	82.2
4″	194.5	194.1	194.4	194.4
4″a	100.0	100.1	100.1	100.1
5″	165.5	165.4	161.2*	161.1*
6″	97.6	97.5	95.8†	95.8†
7″	168.4	168.3	163.4*	163.3*
8″	95.7	95.8	97.5†	97.5†
8″a	163.4	163.3	165.5*	165.4*
1‴	126.4	126.4	124.4	126.4
2‴,6‴	129.8	129.9	129.8	129.8
3‴,5‴	115.9	115.9†	115.8	115.9
4‴	159.9	159.8*	168.4*	168.4*

*,†Assignments in each column may be interchanged.



Daphnodorin G (**1**): R=R'=H
8: R=Me, R'=H
10: R=Me, R'=(+)-MTPA
11: R=Me, R'=Ac



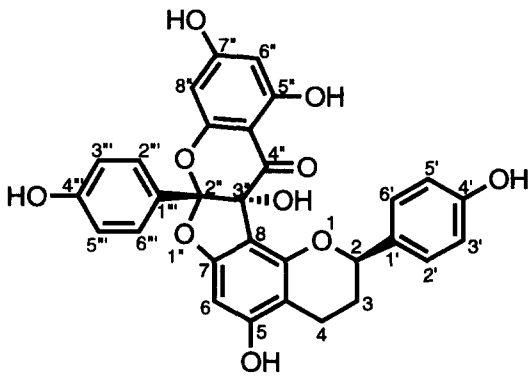
Daphnodorin H (**2**): R=R'=H
9: R=Me, R'=H
12: R=Me, R'=(+)-MTPA
13: R=Me, R'=Ac

configuration at the C-2 and C-3 positions in both **1** and **2** were assigned as *R* and *S*, respectively. The absolute configurations of C-2″ and C-3″ in **1** and **2** have been established by comparison of their circular dichroic (CD) spectra with those of **5** and **6** (Fig. 1).

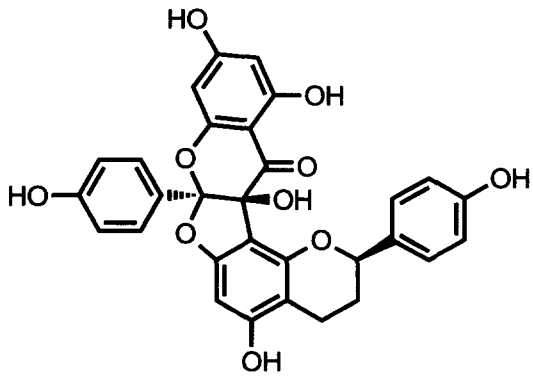
Compound **3**, $[\alpha]_D^{21}$ −250.0°, was isolated as a pale yellow amorphous powder and assigned the molecular formula $C_{30}H_{22}O_{10}$ by HR-SI mass spectrometry (*m/z* 543.1296 $[M+H]^+$). The UV spectrum of **3** showed absorption maxima at 321 sh, 278 and 227 nm. The IR spectrum showed absorption bands at 3300–2600, 1615, 1519 and 1470 cm^{-1}, indicating the presence of hydroxyl and carbonyl groups and an aromatic ring. The ^1H NMR spectrum of **3** (Table 3) showed signals assignable to two pairs of 4-oxyphenyl groups [δ 7.08 and 6.71 (each 2H, *d*, *J* = 8.8 Hz), 7.14 and 6.75 (each 2H, *d*, *J* = 8.8 Hz)], a 2,4,6-trioxyphenyl group [δ 5.75 and 5.59 (each 1H, *d*, *J* = 2.1 Hz)], a 3-hydroxy-2,8 (or 2,6)-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran [δ 6.17 (1H, *s*), 4.61 (1H, *d*, *J* = 7.5 Hz), 4.20 (1H, *d*, *J* = 4.9 Hz), 3.83 (1H, *m*), 2.87 (1H, *dd*, *J* = 16.0 and 5.2 Hz) and 2.55 (1H, *dd*, *J* = 16.0 and 8.1 Hz)], a benzylmethine [δ 5.60 (1H, *s*)] and five phenolic hydroxyl groups [δ 9.40, 8.93, 8.77, 8.47 and 8.24 (each 1H, *s*)]. These signals were closely related to those of daphnodorin C (**4**), except for the presence of signals due to a 3-hydroxy-2,8 (or 2,6)-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran instead of the signals due to a 2,8-disubstituted 5,7-dioxy-3,4-dihydrobenzopyran [δ 6.16 (1H, *s*), 4.85 (1H, *dd*, *J* = 8.6 and 1.2 Hz), 2.69 (2H, *m*), 2.29 (1H, *m*) and 1.68 (1H, *m*)]. The ^{13}C NMR spectrum of **3** (Table 4) was very similar to that of genkwanol A (**7**), indicating that **3** is a stereoisomer of **7**. The absolute configuration of the C-2 and C-3 positions in **3** was determined to be *R* and *S* because of the conversion of **3** into daphnodorin B upon heating in methanol with a small quantity of HCl similar to **7**. The absolute configuration of the C-2″ and C-3″ positions have been established to be *R* and *S*, respectively, by comparison of their CD spectra with those of **4** and **7** (Fig. 2).

EXPERIMENTAL

General. EIMS: 70 eV. SIMS: glycerol matrix. ^1H and ^{13}C NMR: 300 and 75.4 MHz with TMS as int. standard. CC: Merck silica gel 60 (70–230 mesh), Merck silica gel 60H and Sephadex LH-20. TLC and



Daphnodorin E (**5**)



Daphnodorin F (**6**)

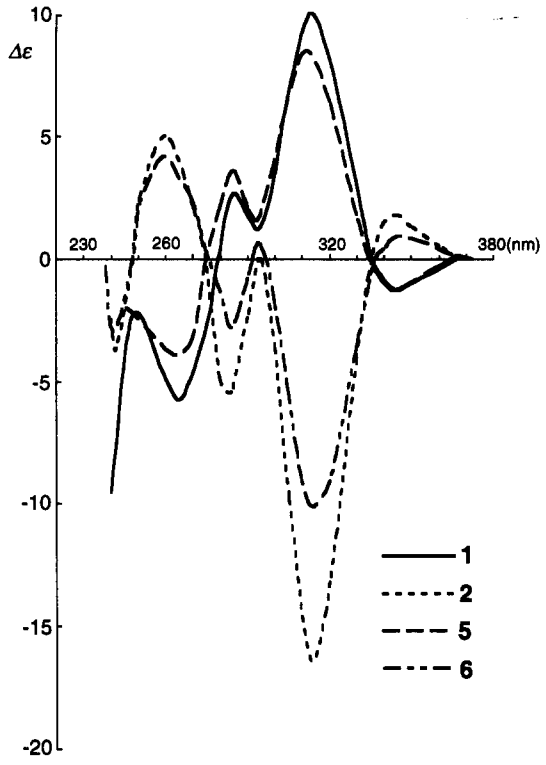


Fig. 1. The CD spectra of **1**, **2**, **5** and **6** in dioxane.

prep. TLC: Merck silica gel 60 F_{254} plate (0.25 mm) and Whatman silica gel 150A PLK5F (1 mm). Spots and bands were detected by UV irradiation (254 and 365 nm).

Plant material. Plants of *D. odora* Thumb. were cultivated and collected in the botanical garden of the Osaka University of Pharmaceutical Sciences in January 1992. A voucher specimen is deposited at this university.

Extraction and isolation. Air-dried roots (4.5 kg) were chopped into small pieces and extracted with EtOAc (20 l × 5) under reflux. The combined EtOAc

Table 3. ^{1}H NMR data for compounds **3**, **4** and **7** in acetone-d_6

H	3	4	7
2	4.61 *d* (7.5)	4.85 *dd* (8.6, 1.2)	4.62 *d* (7.7)
3	3.83 *m*	2.29 *m*	3.80 *m*
(OH or H)	4.20 *d* (4.9)	1.68 *m*	4.20 *d* (4.9)
4	2.87 *dd* (16.0, 5.2)	2.69 *m*	2.89 *dd* (16.1, 5.7)
	2.55 *dd* (16.0, 8.1)		2.54 *dd* (16.1, 8.4)
6	6.17 *s*	6.16 *s*	6.17 *s*
2′,6′	7.08 *d* (8.8)	6.98 *d* (8.7)	6.89 *d* (8.8)
3′,5′	6.71 *d* (8.8)	6.70 *d* (8.7)	6.60 *d* (8.8)
2″	5.60 *s*	*s*	5.63 *s*
6″	5.75 *d* (2.1)	5.85 *d* (1.8)	5.79 *d* (2.0)
8″	5.59 *d* (2.1)	5.66 *d* (1.8)	5.77 *d* (2.0)
10″,14″	7.14 *d* (8.8)	7.15 *d* (8.7)	7.15 *d* (8.8)
11″,13″	6.75 *d* (8.8)	6.77 *d* (8.7)	6.77 *d* (8.8)
-OH	9.40 *s*	9.43 *s*	9.55 *s*
	8.93 *s*	8.86 *s*	8.95 *s*
	8.77 *s*	8.82 *s*	8.60 *s*
	8.47 *s*	8.45 *s*	8.50 *s*
	8.24 *s*	8.21 *s*	8.25 *s*

Table 4. ^{13}C NMR spectral data for compounds **3** and **7** in acetone-d_6

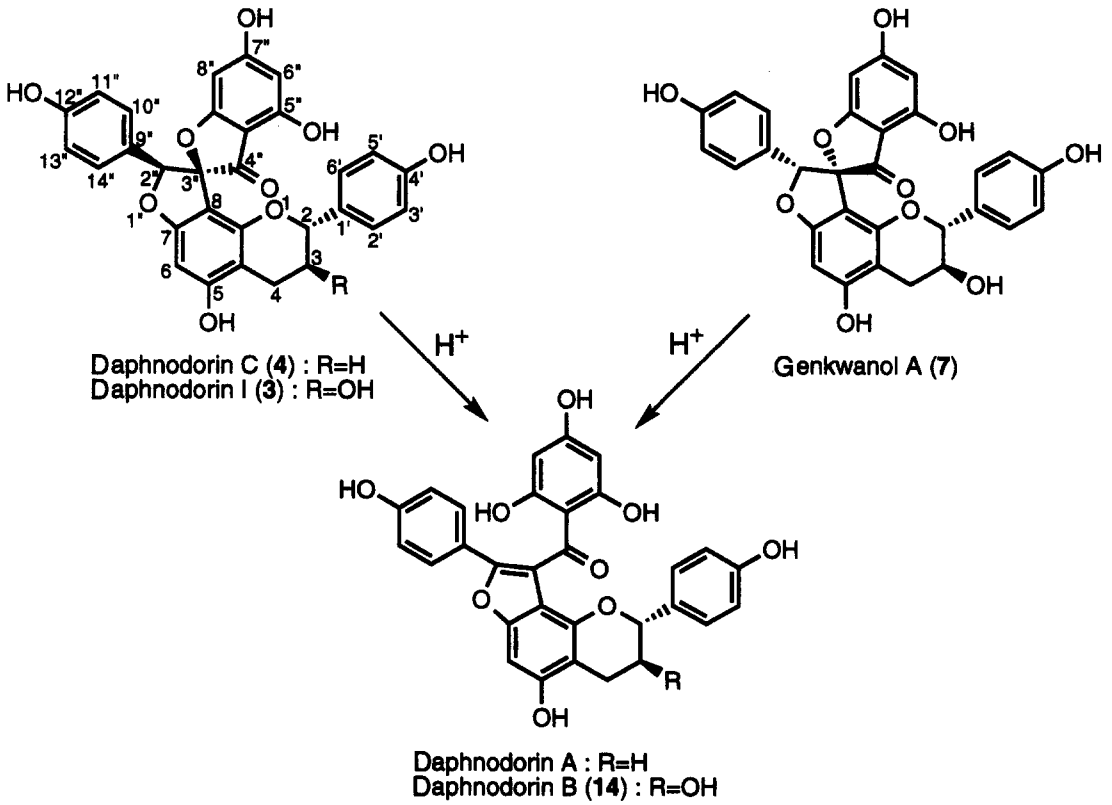
C	3	7
2	82.2	82.1
3	86.5	68.5
4	28.8	28.9
4a	102.7	102.9
5	163.2*	163.1*
6	91.1	91.1
7	160.7*	160.7*
8	103.8	104.1
8a	153.3	153.2
1′	130.9	130.8
2′,6′	129.0	128.7
3′,5′	116.0†	115.9
4′	158.1	158.0
2″	92.7	92.4
3″	95.9	96.2
4″	197.2	196.7
4″a	104.6	104.6
5″	158.6	158.6
6″	97.2	97.4
7″	169.9	170.1
8″	91.3	91.2
8″a	173.6	173.6
9″	125.4	125.5
10″,14″	130.2	130.1
11″,13″	116.0†	116.1
12″	159.1	159.1

*,†Assignments in each column may be interchanged.

extracts were concd to dryness *in vacuo*. The residue (825 g) was subjected to CC on silica gel eluted successively with hexane–EtOAc systems of increasing polarity. The 50% EtOAc eluates were rechromatographed on silica gel with $CHCl_3$–MeOH, then on Sephadex LH-20 with MeOH to give **1** (1.0 g), **2** (1.0 g) and **3** (0.3 g).

Daphnodorin G (**1**). Pale yellow amorphous powder. HR-SIMS *m/z* 559.1242 $[M+H]^+$ (calc. for $C_{30}H_{23}O_{11}$, 559.1239). UV $\lambda_{max}^{dioxane}$ nm (log ε): 330 (3.69), 297 sh (4.11), 284 (4.18), 228 (4.66). ORD (dioxane; *c* 0.76) $[\alpha]^{21}$ (nm): +43.6° (589), +54.5° (550), +76.4° (500), +101.8° (450), +203.6° (400), +349.1° (370), +43.6° (360). CD (dioxane; *c* 4.12×10^{-5}) $\Delta\varepsilon^{18}$ (nm): 0 (367), −1.32 (345), 0 (335.5), +10.10 (313), +1.18 (294), +2.65 (285), 0 (279.5), −5.73 (266), −2.35 (248), −9.56 (240). ^1H and ^{13}C NMR: see Tables 1 and 2.

Hexamethyl ether of **1** (**8**). Pale yellow viscous oil. HR-MS *m/z* 642.2107 $[M]^+$ (calc. for $C_{36}H_{34}O_{11}$, 642.2099). UV $\lambda_{max}^{dioxane}$ nm (log ε): 318 sh (3.66), 297 sh (3.91), 282 (4.01), 225 (4.53). CD (dioxane; *c* 3.43×10^{-5}) $\Delta\varepsilon^{18}$ (nm): 0 (356), +3.04 (319), 0 (308), −9.34 (294.5), 0 (287.5), +13.97 (278), 0 (259), −19.45 (237). ^1H NMR ($CDCl_3$): δ 7.49 (2H, *d*, *J* = 8.8 Hz), 6.94 (2H, *d*, *J* = 8.8 Hz), 6.86 (2H, *d*, *J* = 8.8 Hz), 6.65 (2H, *d*, *J* = 8.8 Hz), 6.33 (1H, *s*), 6.07 (1H, *d*, *J* = 2.2 Hz), 6.02 (1H, *d*, *J* = 2.2 Hz), 5.25 (1H, *d*, *J* = 3.8 Hz), 4.23 (1H, *m*), 3.80, 3.79, 3.78, 3.76, 3.55, 3.06 (each 3H, *s*), 2.71 (1H, *dd*, *J* = 16.5, 4.4 Hz),



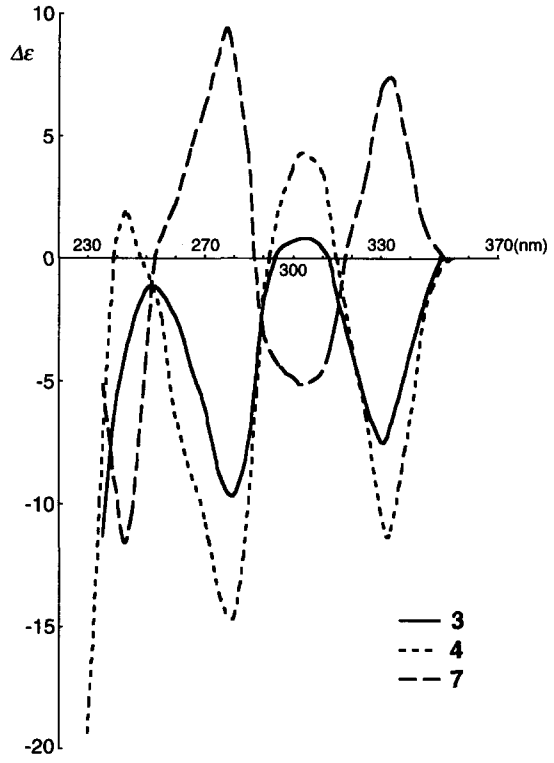


Fig. 2. The CD spectra of **3**, **4** and **7** in dioxane.

2.40 (1H, *dd*, $J = 16.5$, 4.4 Hz). ^{13}C NMR ($CDCl_3$): δ 187.8 (*s*), 165.9 (*s*), 162.9 (*s*), 161.8 (*s*), 161.7 (*s*), 161.4 (*s*), 160.9 (*s*), 159.3 (*s*), 153.0 (*s*), 131.8 (*s*), 128.6 (*d*) ×2, 127.8 (*s*), 127.2 (*d*) ×2, 117.7 (*s*), 113.9 (*d*) ×2, 113.8 (*d*) ×2, 104.6 (*s*), 103.6 (*s*), 102.5 (*s*), 94.0 (*d*), 93.5 (*d*), 88.2 (*s*), 88.1 (*d*), 80.8 (*d*), 67.3 (*d*), 56.0 (*q*) ×2, 55.9 (*q*), 55.6 (*q*), 55.5 (*q*), 54.0 (*q*), 23.8 (*t*).

(R)-(+)-*MTPA ester of* **8** (**10**). Compound **8** (6.0 mg) in pyridine (0.5 ml) and (+)-MPTA Cl (0.1 mmol) in CCl_4 (0.2 ml) were left to stand for 28 hr at room temp. *N,N*-Diethylethylenediamine (1 ml) was added with stirring, allowed to stand for 10 min and diluted with Et_2O (30 ml), washed with dil. HCl, satd Na_2CO_3 and H_2O, then dried. The filtered Et_2O soln was concd, and the residue was purified by prep. TLC with hexane–EtOAc (2:1) to afford **10** (5.1 mg).

Compound **10**. Viscous oil, HR-MS *m/z* 858.2488 $[M]^+$ (calc. for $C_{46}H_{41}F_3O_{13}$, 858.2497). ^1H NMR ($CDCl_3$): δ 7.46 (2H, *d*, $J = 8.8$ Hz), 7.45–7.25 (5H, *m*), 6.86 (2H, *d*, $J = 8.8$ Hz), 6.80 (2H, *d*, $J = 8.8$ Hz), 6.63 (2H, *d*, $J = 8.8$ Hz), 6.40 (1H, *s*), 6.04 (1H, *d*, $J = 2.2$ Hz), 5.92 (1H, *d*, $J = 2.2$ Hz), 5.49 (1H, *m*), 5.39 (1H, *br s*), 3.81, 3.79, 3.78, 3.76, 3.39, 3.36, 3.11 (each 3H, *s*), 2.93 (1H, *dd*, $J = 17.9$, 4.0 Hz), 2.39 (1H, *dd*, $J = 17.9$, 4.0 Hz).

Acetate of **8** (**11**). Viscous oil, HR-MS *m/z* 684.2209 $[M]^+$ (calc. for $C_{38}H_{36}O_{12}$, 684.2205). ^1H NMR ($CDCl_3$): δ 7.50 (2H, *d*, $J = 8.8$ Hz), 6.88 (2H, *d*, $J = 8.8$ Hz), 6.81 (2H, *d*, $J = 8.8$ Hz), 6.63 (2H, *d*, $J = 8.8$ Hz), 6.38 (1H, *s*), 6.05 (1H, *d*, $J = 2.2$ Hz), 5.92 (1H, *d*, $J = 2.2$ Hz), 5.37 (1H, *br s*), 5.27 (1H, *m*), 3.80, 3.79, 3.77, 3.76, 3.38, 3.37 (each 3H, *s*), 2.73 (1H, *dd*, $J = 17.2$, 4.0 Hz), 2.34 (1H, *dd*, $J = 17.2$, 4.2 Hz), 1.95 (3H, *s*).

Daphnodorin H (**2**). Pale yellow amorphous powder. HR-SIMS *m/z* 559.1239 $[M+H]^+$ (calc. for $C_{30}H_{23}O_{11}$, 559.1239). UV $\lambda_{max}^{dioxane}$ nm (log ε): 327 sh (3.81), 293 (4.19), 284 sh (4.16), 226 (4.72). ORD (dioxane; *c* 0.54) $[\alpha]^{21}$ (nm): −170.4° (589), −207.4° (550), −277.8° (500), −425.9° (450), −703.7° (400), −1000.0° (370). CD (dioxane; $c\ 4.12 \times 10^{-5}$) $\Delta\varepsilon^{18}$ (nm): 0 (367), +1.76 (345), 0 (335.5), −16.46 (313), 0 (295), −5.44 (284), 0 (274.5), +5.00 (260), 0 (248), −3.68 (242). ^1H and ^{13}C MMR: see Tables 1 and 2.

Hexamethyl ether of **2** (**9**). Pale yellow viscous oil. HR-MS *m/z* 642.2105 $[M]^+$ (calc. for $C_{36}H_{34}O_{11}$, 642.2099). UV $\lambda_{max}^{dioxane}$ nm (log ε): 314 sh (3.56), 293 sh (3.88), 281 (3.96), 225 (4.55). CD (dioxane; $c\ 3.12 \times 10^{-5}$) $\Delta\varepsilon^{18}$ (nm): 0 (358), −2.33 (315.5), 0 (307), +6.52 (294), 0 (287), −10.51 (278), −3.21 (258), −5.45 (245), 0 (236), +5.06 (232), 0 (229), −17.51 (225). ^1H NMR ($CDCl_3$): δ 7.50 (2H, *d*, $J = 8.7$ Hz), 7.26 (2H, *d*, $J = 8.7$ Hz), 6.91 (2H, *d*, $J = 8.7$ Hz), 6.88 (2H, *d*, $J = 8.7$ Hz), 6.36 (1H, *s*), 5.99 (1H, *d*, $J = 2.1$ Hz), 5.96 (1H, *d*, $J = 2.1$ Hz), 4.55 (1H, *d*, $J = 7.7$ Hz), 3.92 (1H, *m*), 3.84, 3.92, 3.80, 3.72, 3.46, 3.31 (each 3H, *s*), 2.96 (1H, *dd*, $J = 16.7$, 5.5 Hz), 2.54 (1H, *dd*, $J = 16.7$, 8.4 Hz). ^{13}C NMR ($CDCl_3$): δ 187.9 (*s*), 165.5 (*s*), 162.5 (*s*), 161.5 (*s*), 161.4 (*s*), 161.3 (*s*), 161.0 (*s*), 150.2 (*s*), 153.2 (*s*), 130.0 (*s*), 128.7 (*d*) ×2, 128.3 (*d*) ×2, 127.8 (*s*), 118.0 (*s*), 114.4 (*d*) ×2, 113.9 (*d*) ×2, 105.4 (*s*), 105.0 (*s*), 103.3 (*s*), 93.9

(*d*), 93.6 (*d*), 88.7 (*d*), 87.7 (*s*), 81.6 (*d*), 68.5 (*d*), 56.2 (*q*), 56.1 (*q*), 55.8 (*q*), 55.6 (*q*) ×2, 54.5 (*q*), 27.8 (*t*).

(R)-(+)-*MTPA ester of* **9** (**12**). Compound **9** (8.7 mg) in pyridine (0.5 ml) and (+)-MTPA Cl (0.1 mmol) in CCl_4 (0.2 ml) were left to stand for 28 hr at room temp. *N,N*-Diethylethylenediamine (1 ml) was added with stirring, allowed to stand for 10 min and diluted with Et_2O (30 ml), washed with dil. HCl, satd Na_2CO_3 and H_2O, then dried. The filtered Et_2O soln was concd, and the residue was purified by prep. TLC with hexane–EtOAc (2:1) to afford **12** (6.1 mg).

Compound **12**. Viscous oil, HR-MS *m/z* 858.2493 $[M]^+$ (calc. for $C_{46}H_{41}F_3O_{13}$, 858.2497). ^1H NMR ($CDCl_3$): δ 7.49 (2H, *d*, $J = 8.7$ Hz), 7.40–7.20 (5H, *m*), 7.14 (2H, *d*, $J = 8.7$ Hz), 6.87 (2H, *d*, $J = 8.7$ Hz), 6.76 (2H, *d*, $J = 8.7$ Hz), 6.38 (1H, *s*), 5.94 (1H, *d*, $J = 2.2$ Hz), 5.91 (1H, *d*, $J = 2.2$ Hz), 5.41 (1H, *m*), 4.92 (1H, *d*, $J = 6.5$ Hz), 3.83, 3.80, 3.79, 3.70, 3.47, 3.30, 3.21 (each 3H, *s*), 3.00 (1H, *dd*, $J = 17.0$, 5.0 Hz), 2.80 (1H, *dd*, $J = 17.0$, 6.6 Hz).

Acetate of **9** (**13**). Viscous oil, HR-MS *m/z* 684.2200 $[M]^+$ (calc. for $C_{38}H_{36}O_{12}$, 684.2205). ^1H NMR ($CDCl_3$): δ 7.50 (2H, *d*, $J = 8.8$ Hz), 7.22 (2H, *d*, $J = 8.8$ Hz), 6.88 (2H, *d*, $J = 8.8$ Hz), 6.86 (2H, *d*, $J = 8.8$ Hz), 6.36 (1H, *s*), 6.00 (1H, *d*, $J = 2.0$ Hz), 5.98 (1H, *d*, $J = 2.0$ Hz), 5.13 (1H, *m*), 4.86 (1H, *d*, $J =$ 6.6 Hz), 3.83, 3.81, 3.80, 3.73, 3.56, 3.30 (each 3H, *s*), 2.91 (1H, *dd*, $J = 16.8$, 5.1 Hz), 2.61 (1H, *dd*, $J = 16.8$, 7.1 Hz), 1.87 (3H, *s*).

Daphnodorin I (**3**). Pale yellow amorphous powder. HR-SIMS *m/z* 543.1296 $[M+H]^+$ (calc. for $C_{30}H_{23}O_{10}$, 543.1290). UV $\lambda_{max}^{dioxane}$ nm (log ε): 321 sh (3.62), 278 (4.29), 227 (4.65). ORD (dioxane; *c* 0.54) $[\alpha]^{21}$ (nm): −250.0° (589), −314.8° (550), −416.7° (500), −592.6° (450), −1000.0° (400), −2111.1° (360). CD (dioxane; *c* 3.69×10^{-5}) $\Delta\varepsilon^{18}$ (nm): 0 (355), −7.54 (331), 0 (310), +0.82 (303), 0 (294), −9.68 (280), −1.31 (250), −11.32 (235). ^1H and ^{13}C NMR: see Table 3.

Conversion of **3** *into* **14**. Compound **3** (51.0 mg) was dissolved in MeOH (5 ml), and 8% HCl–MeOH (5 ml) was added. The mixt. was heated at 100° for 1 min, diluted with ice–H_2O (100 ml) and extracted with EtOAc. The EtOAc soln was treated with 5% $NaHCO_3$, washed with H_2O, dried and concd *in vacuo*. The residue was purified by prep. TLC ($CHCl_3$–MeOH, 20:3) to afford **14** (29.5 mg).

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