

Communications to the Editor

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ABSOLUTE STEREOSTRUCTURES OF CLAVIRIDENONE-A, -B, -C, AND -D
FOUR PROSTANOIDS FROM THE OKINAWAN SOFT CORAL CLAVULARIA VIRIDIS

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By means of the circular dichroic exciton chirality method applied to various benzoyl derivatives, the absolute stereostructures of claviridenone-a (1), -b (2), -c (3), and -d (4), which were isolated from the Okinawan soft coral *Clavularia viridis*, have been elucidated.

KEYWORDS — claviridenone; prostanoid; soft coral; *Clavularia viridis*; Clavulariidae; CD; exciton chirality method; ¹³C NMR

As a continuing study on marine natural products,¹⁾ we reported the plane structures of four new prostanoids named claviridenone-a (1), -b (2), -c (3), and -d (4), which were isolated from the Okinawan soft coral *Clavularia viridis* Quoy and Gaimard (Stolonifera, Clavulariidae).²⁾ We have now elucidated the absolute stereostructures of these prostanoids by means of an extension of the CD exciton chirality method,³⁾ which is the subject of this communication.

As reported previously,²⁾ claviridenone-a (1), -b (2), -c (3), and -d (4) are geometric isomers in regard to the 5,7-diene chromophores in their α -chains and possess the same but unknown C-4 and C-12 absolute configurations. In order to investigate this matter, we prepared some benzoylated analogs from claviridenone-c (3) and -d (4) and have examined them by use of the CD exciton chirality method.³⁾

NaBH₄ reduction of claviridenone-c (3) yielded two tetrahydro isomers, 5^{2,4)} and 8, C₂₅H₃₈O₇,⁵⁾ $\lambda_{\text{max}}^{\text{MeOH}}$ 251 nm (ϵ 22000), in 10:1 ratio. Benzoylation of 5 and 8 furnished respective monobenzoates, 6 and 9, both C₃₂H₄₂O₈. The CD spectra of both monobenzoates demonstrated occurrence of the coupling between CD excitons of the 5,7-diene and the C-9 benzoyloxy chromophores, respectively (Table I). From signs of the first Cotton effect, the C-9 configurations in 6 and 9 have been assigned R and S, respectively, as depicted in Fig. 1. In the case of the anisoyl derivative (7) of 5, C₃₃H₄₄O₉, an enhanced Cotton effect was observed in the CD spectrum (Table I), which is attributable to an overlap of the UV absorption maxima of the anisoyl and the 5,7-diene chromophores.³⁾

Since a Cotton effect, resulting from the coupling between the conjugated diene and the allylic benzoate excitons, has been observed, we next prepared the C-4 and the C-12 benzoates in order to elucidate the absolute configurations at C-4 and C-12. LiAlH₄ reduction followed by *t*-butyldimethylsilylation of 5 furnished a

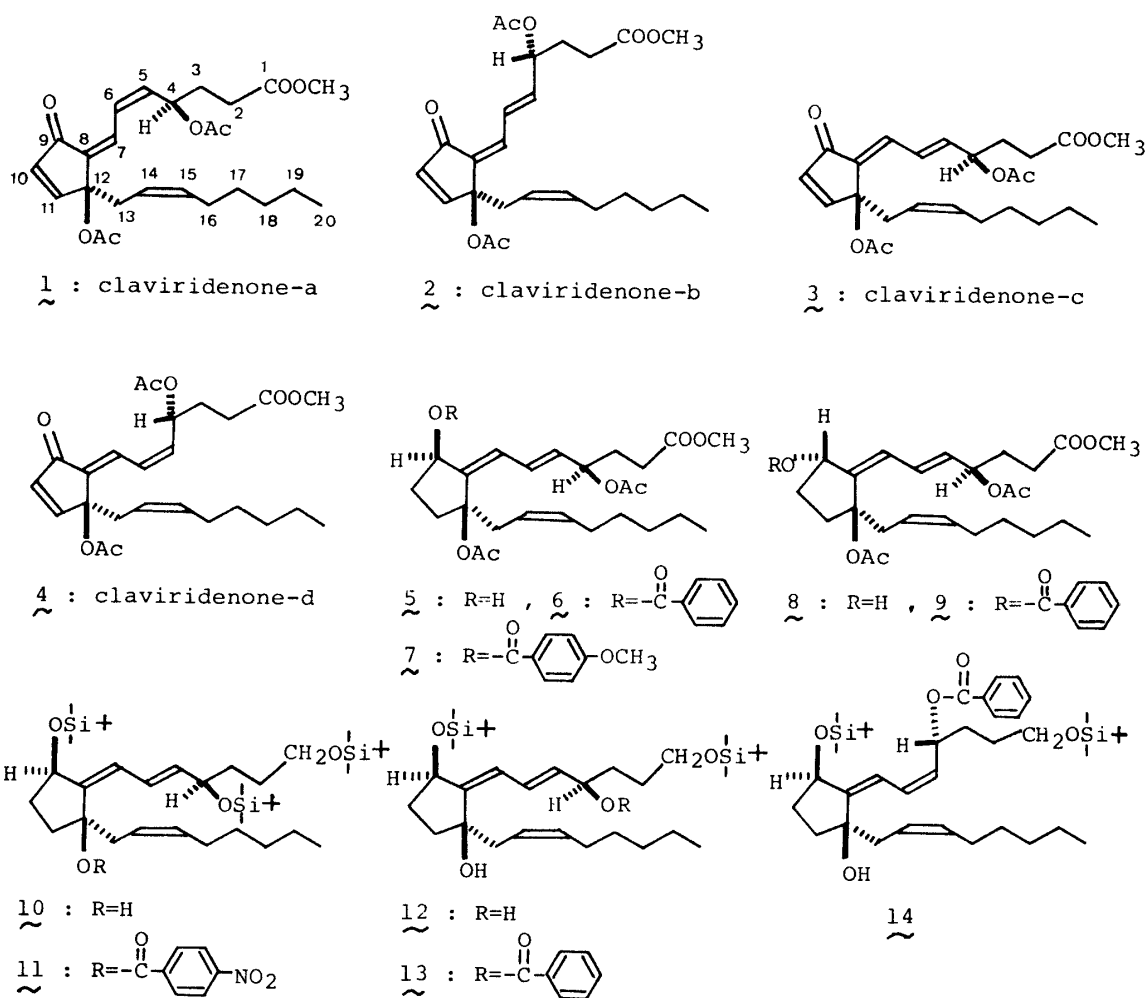


Chart 1

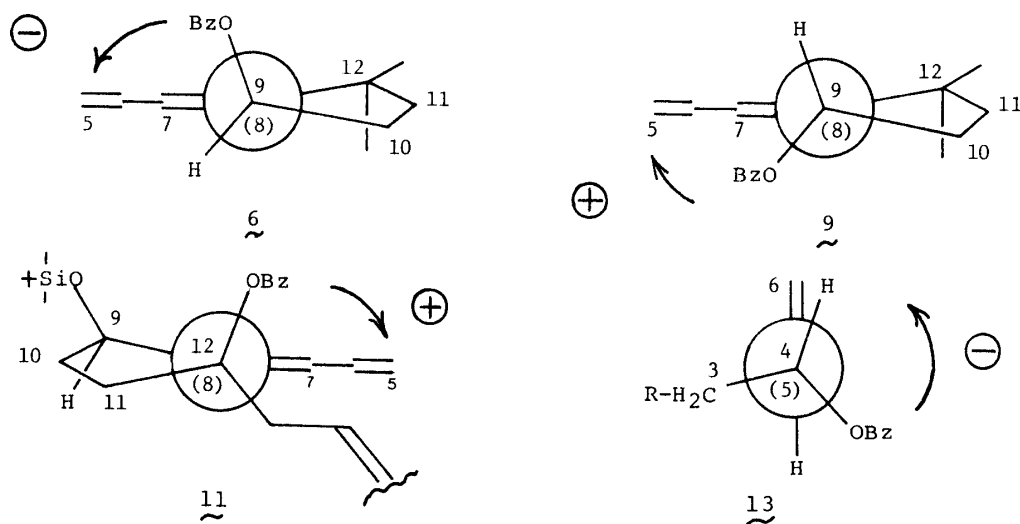


Fig. 1

Table I. UV and CD Data for 6, 7, 9, 11, 13, and 14

	UV $\lambda_{\max}$ (MeOH)	CD (MeOH)
<u>6</u>	229 nm ($\epsilon=25000$)	$[\theta]_{295} 0$, $[\theta]_{246} -95000$ (neg.max.), $[\theta]_{232} 0$,
	245 nm (sh. $\epsilon=20000$)	$[\theta]_{225} +37000$ (pos.max.), $[\theta]_{211} +13000$ (pos.min.), $[\theta]_{200} +76000!$
<u>7</u>	249 nm ($\epsilon=36000$)	$[\theta]_{290} 0$, $[\theta]_{262} -159000$ (neg.max.), $[\theta]_{249} 0$,
		$[\theta]_{241} +69000$ (pos.max.), $[\theta]_{224} +6000$ (pos.min.), $[\theta]_{200} +58000!$
<u>9</u>	242 nm ($\epsilon=25000$)	$[\theta]_{286} 0$, $[\theta]_{245} +64000$ (pos.max.), $[\theta]_{237} 0$,
		$[\theta]_{228} -79000$ (neg.max.), $[\theta]_{214} 0$, $[\theta]_{207} +22000$ (pos.max.)
<u>11</u>	247 nm ($\epsilon=37000$)	$[\theta]_{310} 0$, $[\theta]_{265} +30000$ (pos.max.), $[\theta]_{257} 0$,
		$[\theta]_{240} -85000$ (neg.max.), $[\theta]_{216} 0$, $[\theta]_{200} +30000!$
<u>13</u>	238 nm ($\epsilon=29000$)	$[\theta]_{295} 0$, $[\theta]_{246} -149000$ (neg.max.), $[\theta]_{231} 0$,
	244 nm (sh. $\epsilon=28500$)	$[\theta]_{223} +45000$ (pos.max.), $[\theta]_{214} +25000$ (pos.min.), $[\theta]_{200} +83000!$
<u>14</u>	239 nm ($\epsilon=28000$)	$[\theta]_{295} 0$, $[\theta]_{247} -114000$ (neg.max.), $[\theta]_{232} 0$,
	247 nm (sh. $\epsilon=27500$)	$[\theta]_{224} +51000$ (pos.max.), $[\theta]_{211} +23000$ (pos.min.), $[\theta]_{200} +61000!$

! end absorption

Table II. ^{13}C NMR Data for 5, 6, 9, 11, 13, and 14^{a)}

Carbon	<u>5</u>	<u>6</u>	<u>9</u>	<u>11</u>	<u>13</u>	<u>14</u>
1	173.1(s)	173.2(s)	172.9(s)	63.2(t)	62.8(t)	63.0(t)
2	29.2(t) ^{b)}	29.5(t) ^{b)}	29.3(t) ^{b)}	28.0(t) ^{b)}	28.6(t)	28.7(t)
3	29.8(t) ^{b)}	29.8(t) ^{b)}	29.7(t) ^{b)}	34.7(t)	31.1(t)	31.6(t)
4	73.4(d)	73.3(d)	73.2(d)	72.2(d)	74.9(d)	70.6(d)
5	133.1(d)	133.2(d)	133.5(d) ^{c)}	139.4(d)	132.4(d)	129.8(d)
6	126.6(d)	125.8(d)	127.4(d)	124.1(d)	124.0(d) ^{b)}	126.3(d)
7	128.3(d)	128.4(d)	128.1(d)	128.3(d)	128.0(d)	119.7(d)
8	148.9(s)	144.2(s)	144.5(s)	144.5(s)	151.6(s)	152.9(s)
9	75.5(d)	76.2(d)	78.7(d)	75.1(d)	75.5(d)	75.7(d)
10	32.0(t)	29.8(t) ^{b)}	30.0(t)	32.3(t)	32.6(t)	32.6(t)
11	37.1(t)	37.8(t)	38.6(t)	37.5(t)	39.1(t)	39.0(t)
12	88.0(s)	87.6(s)	87.3(s)	89.4(s)	79.3(s)	79.4(s)
13	32.6(t)	33.7(t)	34.5(t)	32.9(t)	36.0(t)	36.2(t)
14	123.1(d)	123.0(d)	123.3(d)	123.6(d)	124.2(d) ^{b)}	124.1(d)
15	134.2(d)	134.5(d)	133.8(d) ^{c)}	134.4(d)	133.5(d)	133.8(d)
16	27.5(t)	27.6(t)	27.6(t)	27.7(t) ^{b)}	27.5(t)	27.6(t)
17	29.4(t) ^{b)}	29.3(t) ^{b)}	29.3(t) ^{b)}	29.3(t)	29.3(t)	29.3(t)
18	31.5(t)	31.6(t)	31.5(t)	31.6(t)	31.6(t)	31.6(t)
19	22.5(t)	22.6(t)	22.5(t)	22.6(t)	22.6(t)	22.6(t)
20	14.0(q)	14.1(q)	14.0(q)	14.1(q)	14.1(q)	14.1(q)
COOCH ₃	51.7(q)	51.7(q)	51.6(q)			
CH ₃ C=	170.8(s)	170.0(s)	169.7(s)			
x 2	170.0(s)	169.5(s)	169.4(s)			
	21.6(q)	21.7(q)	21.4(q)			
O	21.1(q)	21.2(q)	21.0(q)			

a) Abbreviations given in parentheses denote the signal patterns observed in off-resonance experiments: d=doublet, q=quartet, s=singlet, t=triplet.

b), c) The assignments for these signals within the same vertical column may be interchanged.

trisilyl ether (10), $\text{C}_{38}\text{H}_{76}\text{O}_4\text{Si}_3$ and a disilyl ether (12), $\text{C}_{32}\text{H}_{62}\text{O}_4\text{Si}_2$. Subsequent esterification of 10 with *p*-nitrobenzoyl chloride and pyridine in the presence of $\text{AgCN}^{6)}$ furnished the *p*-nitrobenzoate (11), $\text{C}_{45}\text{H}_{79}\text{NO}_7\text{Si}_3$, IR (CCl_4): 1718 cm^{-1} . The ^1H NMR spectrum (200 MHz, CDCl_3) of 11 showed signals due to its skeletal protons⁷⁾: δ 3.53 (2H, br s, 1-H₂), 4.16 (1H, m, 4-H), 5.69 (1H, dd, J=15,

5 Hz, 5-H), 6.70 (1H, dd, $J=15, 12$, 6-H), 6.17 (1H, dd, $J=12, 2$, 7-H), 4.38 (1H, br t, $J=8$, 9-H), 3.11, 2.73 (2H, AB in ABX, $J_{AB}=14$, $J_{AX}=8$, $J_{BX}=7$, 13-H₂), 5.35 (1H, m, 14-H), 5.55 (1H, m, 15-H), together with signals due to three *t*-butyldimethylsilyl (TBDMS) residues and a *p*-nitrobenzoyl group. In addition, among the ^{13}C NMR signals assigned as given in Table II, a signal due to C-12 was observed at δ 89.4; thus *p*-nitrobenzoylation of 12-OH in 11 has been proved. The CD spectrum of 11 showed a positive first Cotton effect (Table I); thus the absolute C-12 configuration in 10 has been corroborated as R (*cf.* Fig. 1).⁷⁾

On the other hand, benzoylation of 12 furnished a monobenzoate (13), $\text{C}_{39}\text{H}_{66}\text{O}_5\text{Si}_2$, IR (CCl_4): 3590 (OH), 1712 (CO), ^1H NMR⁸⁾: δ 3.65 (2H, t, $J=6$ Hz, 1-H₂), 5.60 (1H, dt, $J=7, 6$, 4-H), 5.74 (1H, dd, $J=15, 7$, 5-H), 7.07 (1H, dd, $J=15, 11.5$, 6-H), 6.11 (1H, d, $J=11.5$, 7-H), 4.29 (1H, br t, $J=7$, 9-H), 2.58, 2.40 (2H, AB in ABX, $J_{AB}=14$, $J_{AX}=8$, $J_{BX}=7$, 13-H₂), 5.30 (1H, m, 14-H), 5.50 (1H, m, 15-H), together with signals due to two TBDMS residues and one benzoyl group. The signal at δ 5.60 showed that the 4-OH group in 12 was benzoylated to give 13. We then applied to 13 the exciton chirality rule, which was recently extended to acyclic allylic benzoates by Nakanishi et al.⁹⁾ Since the $J_{4,5}$ value of 13 was 7 Hz (in CD_3OD) and the CD spectrum of 13 (in MeOH) showed a negative first Cotton effect, 13 has been considered to take a conformation in MeOH as depicted in Fig. 1. Thus, the C-4 absolute configuration has been assigned R. The assignment has been further supported by a similar CD curve observed for 14, $\text{C}_{39}\text{H}_{66}\text{O}_5\text{Si}_2$, which was prepared from claviridenone-d (4) through the same procedure as that for 13 from 3.

Based on the above-mentioned evidence, the absolute stereostructures of claviridenone-a (1), -b (2), -c (3), and -d (4) have been determined.

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- 4) The structures of compounds (5 - 14) have been substantiated by the ^{13}C NMR analysis in detail as partly shown in Table II.
- 5) The molecular compositions of compounds with the chemical formulae were determined by high resolution mass spectrometry.
- 6) S. Takimoto, J. Inanaga, T. Katsuki, and M. Yamaguchi, Bull. Chem. Soc. Jpn., 49, 2335 (1976).
- 7) The 12-benzoate of 10 showed a rather complicated CD spectrum, which was presumably due to a CD Cotton effect of opposite sign of the inherent 5,7-diene chirality in this benzoate. The similar tendencies were observed more or less throughout all compounds having the 5,7-diene chromophore, which will be discussed in detail in our full paper.
- 8) The assignments for skeletal protons have been made on the basis of spin-decoupling experiments in detail.
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