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^{13}C -NMR ASSIGNMENTS FOR *CYSTOSEIRA* MERODITERPENOIDS

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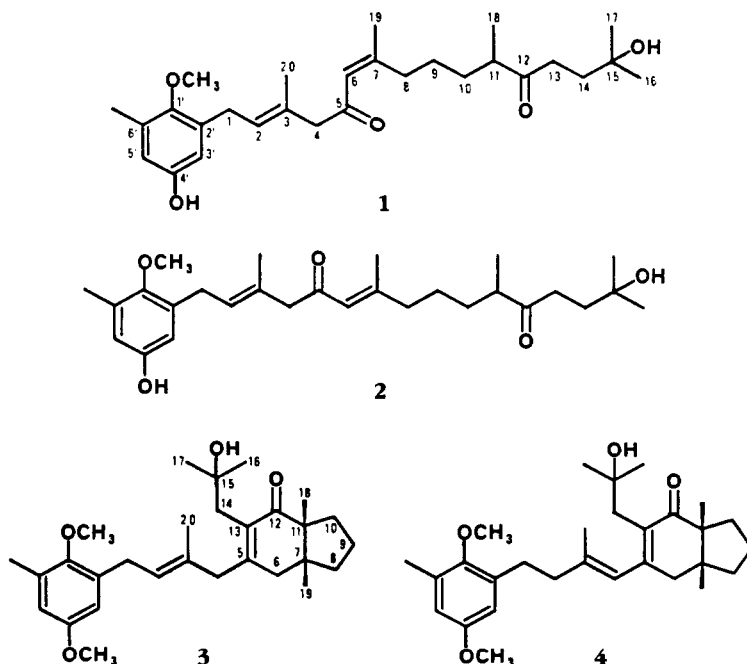
ABSTRACT.—The ^{13}C -nmr chemical shifts of six meroditerpenoids from *Cystoseira* species were completely assigned by the application of homonuclear and heteronuclear 2D nmr experiments.

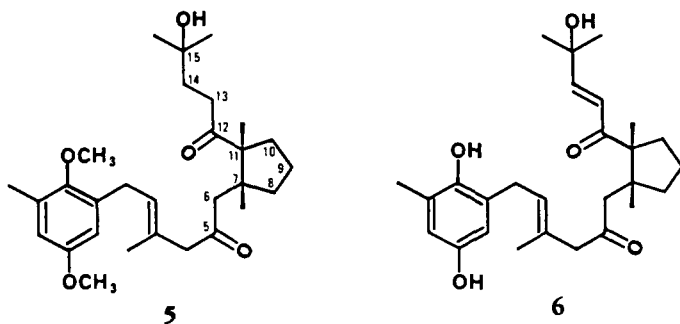
In the past 10 years or so a host of meroditerpenoids have been isolated from brown algae of the genera *Cystoseira*, *Cystophora*, *Halidrys*, and *Bifurcaria* (1–5). In many cases the original ^{13}C -nmr assignments of these compounds were made before the introduction of 2D nmr techniques, and we have now used these new methods to obtain the complete ^{13}C -nmr assignments for some of these algal metabolites 1–6 that were available from previous work.

The ^{13}C -nmr assignments (Table 1) for compounds 1 and 2, previously isolated from *Cystoseira sauvageauana* (6),

followed from a combination of the ^1H assignments (Table 2), and were definitely confirmed by COSY experiments and data from ^1H - ^{13}C correlations. The protonated carbons were straightforwardly identified by one-bond ^1H - ^{13}C correlation, while long-range HETCOR spectra permitted the assignment of the quaternary carbons.

Spectral reexamination of cystalgerone [3], a metabolite from *Cystoseira algeriensis* (7,8) and *Cystoseira platyramosa* (9), revealed that, while the ^1H spectrum was identical to that previously reported, the same did not hold





true for the ^{13}C spectrum, which showed slight but clear differences. Presumably the original metabolite had undergone some structural change during or prior to determination of the spectrum, possibly due to the acidity of the solvent

(CHCl_3). To test this conjecture, **3** was treated with acid, and in a few hours compound **4** was obtained in almost quantitative yield. Its ^{13}C -nmr spectrum was identical to that reported (7). A thorough examination of the spectral

TABLE 1. ^{13}C -nmr Assignments for Compounds 1-6.^a

Carbon	Compound					
	1	2	3	4	5	6
C-1	27.9 t	28.2 t	28.3 t	28.6 t	28.7 t	28.6 t
C-2	127.7 d	128.2 d	126.2 d	40.1 t	128.3 d	127.8 d
C-3	130.7 s	131.0 s	132.5 s	138.3 s	130.4 s	131.1 s
C-4	55.1 t	55.7 t	45.1 t	125.2 d	55.9 t	56.6 t
C-5	199.4 s	200.3 s	154.6 s	154.0 s	209.7 s	209.6 s
C-6	123.6 d	122.6 d	41.3 t	42.5 t	48.3 t	46.4 t
C-7	159.8 s	159.2 s	44.4 s	44.6 s	46.1 s	46.9 s
C-8	33.6 t	41.2 t	34.8 t	34.8 t	36.6 t	36.6 t
C-9	25.6 t	25.1 t	18.7 t	18.8 t	19.5 t	20.0 t
C-10	33.0 t	32.5 t	29.2 t	29.2 t	33.6 t	34.2 t
C-11	46.2 d	46.2 d	54.8 s	54.9 s	60.8 s	60.2 s
C-12	216.1 s	216.4 s	208.1 s	208.5 s	216.7 s	205.9 s
C-13	35.7 t	36.2 t	131.8 s	131.5 s	36.0 t	122.6 d
C-14	36.7 t	36.6 t	38.9 t	40.2 t	36.7 t	153.6 d
C-15	70.5 s	70.7 s	71.0 s	70.9 s	70.1 s	71.2 s
C-16	29.3 q	29.5 q	29.4 q	28.9 q	29.6 q	29.3 q
C-17	29.0 q	29.3 q	30.2 q	30.8 q	29.6 q	29.3 q
C-18	16.6 q	16.5 q	20.9 q	21.0 q	21.4 q	20.2 q
C-19	25.4 q	19.4 q	22.4 q	22.5 q	22.0 q	21.1 q
C-20	16.6 q	16.5 q	16.2 q	18.0 q	16.7 q	16.2 q
C-1'	149.9 s	150.2 s	150.2 s	150.5 s	150.9 s	145.4 s
C-2'	134.3 s	134.8 s	134.5 s	135.0 s	134.0 s	127.9 s
C-3'	113.8 d	114.7 d	112.5 d	112.8 d	113.0 d	113.1 d
C-4'	152.4 s	152.2 s	155.4 s	155.4 s	156.0 s	149.8 s
C-5'	115.5 d	115.8 d	113.7 d	113.7 d	114.4 d	115.4 d
C-6'	131.7 s	132.1 s	131.7 s	131.8 s	132.4 s	125.8 d
6'-Me	16.1 q	16.3 q	16.3 q	16.4 q	16.4 q	16.3 q
1'-OMe	60.4 q	60.6 q	60.3 q	60.5 q	60.6 q	—
6'-OMe	—	—	55.2 q	55.3 q	55.6 q	—

^a ^{13}C -nmr spectra were recorded in CDCl_3 at 62.9 MHz and referenced to TMS; multiplicities were obtained by DEPT experiments; for each compound a ^1J HETCOR experiment and two long-range HETCOR spectra were performed with polarization transfer optimized for $J = 5.0$ and 10.0 Hz.

TABLE 2. ¹H nmr of Compounds 1-6 (250 MHz, CDCl₃, TMS as internal standard).^a

Proton	Compound					
	1	2	3	4	5	6
H-3'	6.50	6.49 bs	6.52	6.55	6.56	6.40
H-5'	6.55		6.57	6.58	6.59	6.50
H-1	3.36 d(7)	3.36 d(7.2)	3.37 d(7.3)	2.76 bt(7.8)	3.39 d(7.5)	3.29 d(7)
H-2	5.34 t(7.5)	5.42 t(7.5)	5.37 t(7.5)	2.38 bt(7)	5.40 t(7.5)	5.35 t(7)
H-4	3.12 s	3.08 s	{H _a 3.06 d(14.5) H _b 2.97 d(14.5)}	5.77 s	3.11	3.00 bs
H-6	6.08 s	6.11 s	{H _a 2.45 d(18.5) H _b 2.22 d(18.5)}	{H _a 2.53 d(12.5) H _b 2.26 d(12.5)}	{H _a 3.04 d(15.5) H _b 2.45 d(15.5)}	2.44 2.30
H-8	2.49 ^b	2.06 ^b		1.75 ^b	1.60 ^b	2.23 ^b
H-9	1.37 ^b 1.73 ^b	1.39 ^b 1.60 ^b			1.70 ^b 2.40 ^b	1.45 ^b 1.70 ^b
H-10	1.43 ^b	1.30 ^b		1.16 ^b	1.50 ^b	1.80 ^b 1.68 ^b
H-11	2.60 m	2.57 m				
H-13	2.66 t(7.4)	2.59 t(7.4)	{H _a 2.74 d(14.5) H _b 2.47 d(14.5)}	{H _a 2.47 d(10.4) H _b 2.41 d(10.4)}	2.59 t(7.5)	6.59
H-14	1.75 t(7.2)	1.76 t(7.2)			1.65 ^b	6.85
Me-16	1.21 s	1.23 s	1.13 s	1.09 s	1.26 s	1.28 s
Me-17	1.21 s	1.21 s	1.22 s	1.15 s	1.26 s	1.30 s
Me-18	1.06 s	1.07 s	1.04 s	1.01 s	1.06 s	1.14 s
Me-19	1.84 s	2.09 s	0.81 s	0.91 s	0.94 s	1.15 s
Me-20	1.69 s	1.71 s	1.67 s	1.66 s	1.74 s	1.68 s
6'-Me	2.22 s	2.22 s	2.27 s	2.28 s	2.27 s	2.17 s
1'-OMe	3.65 s	3.66 s	3.68 s	3.70 s	3.68 s	3.68 s
4'-OMe	—	—	3.74 s	3.75 s	3.74 s	—

^aCoupling constants (*J* in parentheses) are given in Hz.^bOverlapped signals; assignments and chemical shifts have been obtained by one-bond ¹H-¹³C correlation spectroscopy.

properties of **4** with the use of 1D and 2D nmr techniques (for the ^1H -nmr spectrum see Table 2) revealed that cystalgerone had undergone an acid-catalyzed migration of the double bond from position 2 to position 3. The stereochemistry at the C-3 double bond in **4** was inferred as *E* on the basis of the chemical shift of the pertinent methyl in the ^{13}C -nmr spectrum (18.0 ppm) (10).

The ^{13}C -nmr spectrum of diketone **5**, a metabolite from *C. algeriensis* (8), had been assigned on the basis of signal multiplicities and chemical shifts with reference to model compounds. A reexamination based on heteronuclear correlations, both one-bond and long-range, allowed us to assign all the resonances unambiguously (Table 1), rectifying some minor misassignments.

Bifurcarenone was originally isolated as a levorotatory oil from the brown alga *Bifurcaria galapagensis* (Cystoseiraceae) (11, 12) and assigned structure **6** (apart from absolute stereochemistry). Work from our group on the Mediterranean species *Cystoseira stricta* (13) lead to the isolation of the enantiomer of (–)-bifurcarenone. Because none of the previous papers on this algal metabolite contains full details on the ^{13}C -nmr spectrum, we have now made a complete assignment (Tables 1 and 2) with the help of DEPT and 2D nmr techniques.

EXPERIMENTAL

GENERAL METHODS.—Nmr spectra were recorded at room temperature (23°) on a Bruker AC-250 PFT nmr spectrometer, operating at 250.13 MHz for ^1H and 62.9 MHz for ^{13}C and equipped with a 5 mm $^1\text{H}/^{13}\text{C}$ dual probe head. The spectra were obtained in CDCl_3 and referenced to TMS. DEPT experiments were performed setting variable pulse θ to 90° and 135°. COSY and 1J HETCOR 2D spectra were obtained using the standard Bruker microprograms COSY.AU and XHCORRD.AU. The 2D long-range heterocorrelations were obtained using the Freeman-Morris pulse sequence modified with the insertion of a one-step low-pass *J*-filter and a BIRD pulse (14, 15). For each compound two separate experiments were performed with the same τ (3.3 ms), and the polarization transfer

delay was optimized to observe $J = 5.0$ and 10.0 Hz long-range couplings.

ACID TREATMENT OF CYSTALGERONE [3] TO GIVE 4.—A solution of **3** (20 mg) in CHCl_3 (3 ml) was added to 0.3 ml of 1 M HCl, and the mixture was stirred for 4 h at room temperature. The organic layer was separated and evaporated to give a residue which was subjected to preparative layer chromatography [Kieselgel-60, $i\text{PrOH}-\text{C}_6\text{H}_{12}$ (1:16)] to give pure **4** (18 mg).

COMPOUND 4.—Hreims $[M]^+$ 454.3088, calcd for $\text{C}_{29}\text{H}_{42}\text{O}_4$, 454.3082; $[\alpha]^{20}(\lambda)$ +77.3° (589), +81.9° (578), +93.7° (546), +146.1° (436); $\text{ir } \nu$ max (film) 3430, 1660, 1600 cm^{-1} ; $\text{uv } \lambda$ max (EtOH) 280 nm ($\epsilon = 7800$), 222 ($\epsilon = 10300$); ^{13}C nmr see Table 1; ^1H nmr see Table 2.

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