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^{13}C-NMR SPECTRUM AND ABSOLUTE STEREOCHEMISTRY OF FUROSCALAROL+

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In 1972, an uncommon tetracarbocyclic sesterterpene, scalarin[1] (1), was isolated from the marine sponge Cacospongia scalaris. Latter, the presence in Porifera of a number of sesterterpenes having the same skeleton was reported[2]. Their biosynthesis could take place from geranylfarnesol by a standard triterpene-type cyclization initiated at the isopropylidene group[3]. More recently a further C_{25} terpene, furoscalarol[4] (2), has been isolated from the sponge C. mollior. This compound is closely related to the scalarin-like compounds, and could derive biogenetically from a cyclization similar to that proposed for scalarin, the only difference being the closure of the ring D.

We wish now to report the determination of the stereochemistry of this compound on the basis of its ^{13}C-NMR spectrum. Table I contains ^{13}C-NMR data and relative assignments for furoscalarol (2), its deacetyl derivative (3) and those previously[5] determined for scalarin.

Three types of ^{13}C-NMR spectra were run for furoscalarol (1) and for its deacetyl derivative (2): proton resonance decoupled spectra for the determination of the ^{13}C chemical shift values, noise off-resonance decoupled spectra (nord)[6] for the detection of non protonated carbon sites, and single-frequency off-resonance decoupled spectra (sford)[7] for the differentiation of carbon species. Further as-

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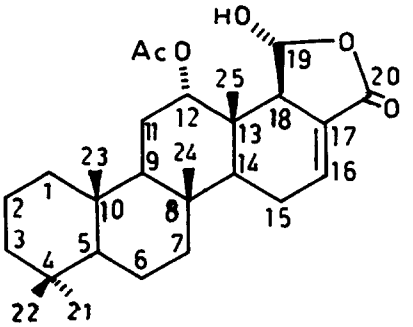

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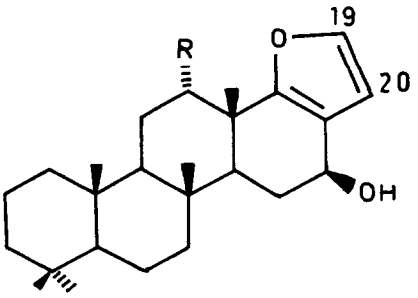

2 R = -OAc
3 R = -OH

sistance was obtained by comparison with published data for structurally related compounds, especially diterpenes[8] and scalarin-like sesterterpenes[5,9] of known stereochemistry. The assignment of the signals of the furan carbons was based on published data[10].

Comparison of the ^{13}C-NMR spectra of 2 and 3[11] with that of 1 allowed ready recognition of the signals corresponding to the carbon atoms of the rings A and B. Similarly, the four methyl groups on these two rings were identified. Assignments for C-23 and C-24 were tentative and were based on the fact that the chemical shift value of C-23 in 1 should be very similar to that assigned to C-23 of scalarin[12]. The signals corresponding to the functionalized C-12 and to the two adjacent carbons were readily recognized by comparison of ^{13}C-NMR spectrum of 2 with that of its deacetyl derivative (3). In the spectrum of 3 the signal due to C-12 showed an expected upfield shift[13], while the signals due to C-11 and C-13 shifted downfield as a consequence of deacetylation[13]. The two off-resonance doublets at δ 49.8 and δ 66.5 in the spectrum of 2 were ascribed to C-14 and C-16, respectively. This chemical shift difference can be well explained on the basis that the hydroxy-substituted carbon atom (C-16) must be more deshielded. The resonance due to C-9 and C-14 were in agreement with the axial orientation of the acetoxy substituent at C-12[5,8] and the quasi-equatorial orientation of the hydroxy substituent at C-16[5,8], both assigned on the basis of the ^{1}H-NMR of 2 (C_6D_6; H_{12} at δ 5.40, W 1/2 ca. 6 Hz; H_{16} at δ 4.64, dd, J 9 and 5 Hz). The remaining two signals at δ 29.3 and δ 22.1 were ascribed to C-15 and C-25, respectively, on the basis of their multiplicity. The signal due to the C-25 angular methyl group, compared with that of scalarin(1),

showed an expected downfield shift. In fact, in 1 the C-25 methyl group is shielded by its γ-gauche interaction with the C-19 methyne group. On the basis of the above spectral data, in agreement with the previous findings for scalarin-like sesterterpenes[5,9], a trans-anti-trans configuration must be suggested for the A/B and B/C ring junctions of 2. The remaining C/D trans fusion has been assigned considering that the chemical shifts of C-14 and C-11 require quasi-axial orientations for H-14 and Me-25, respectively.

All these data led us to assign the relative stereochemistry of furoscalarol. The Horeau method[14] applied to 2 allowed to determine the chirality at C-16 as S, and this determines the absolute stereochemistry of 2.

TABLE I

Carbon-13 chemical shifts+ for compounds 1[5], 2 and 3

	1	2	3
C-1	39.8	39.6	38.4
C-2	18.1 (a)	18.1 (a)	17.3 (a)
C-3	41.6 (b)	41.3 (b)	40.5 (b)
C-4	33.3	33.2	32.1
C-5	56.5	56.5	55.4
C-6	18.5 (a)	18.5 (a)	17.7 (a)
C-7	42.1 (b)	41.9 (b)	41.0 (b)
C-8	37.9 (d)	36.9 (c)	36.0 (c)
C-9	52.5	53.0	50.7
C-10	37.4	37.1 (c)	36.4 (c)
C-11	22.4	21.7	23.9
C-12	74.6	73.5	69.6
C-13	36.9 (d)	40.7	42.0
C-14	49.9	49.8	47.4
C-15	24.2	29.3	29.0
C-16	135.3	66.5	65.4
C-17	128.1	120.0	121.1
C-18	50.8	156.6	157.2
C-19	98.9	140.9	139.6
C-20	167.8	108.1	108.3
C-21	33.3	33.2	32.1
C-22	21.4	21.3 (d)	20.2
C-23	16.1 (c)	15.9	15.2
C-24	16.1 (c)	17.2	16.4
C-25	15.1	22.1	21.6
$CH_3\underline{C}O$	171.0	170.0	--
$\underline{C}H_3CO$	21.4	21.0 (d)	--

+Solutions in $CDCl_3$ for 1 and 2 and C_5D_5N for 3; 25.20 MHz; Varian XL-100 Fourier Transform spectrometer; chemical shifts in p.p.m. from internal Me_4Si.

(a-d) Assignments may be reversed.

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11. It is to be noted that the ^{13}C-NMR spectrum has been run in C_5D_5N, which causes an upfield shift of all sp^3 carbon signals.
12. Our assignments agree with those recently published by Kashman and Rudi[9] for heteronemin, except for the chemical shifts of C-1 (41.7 p.p.m.) and C-8 or C-10 (39.9 p.p.m.). In our opinion, besides all arguments reported throughout the text, the close similarity of the CMR spectra for a series of several scalarin-like compounds[5] supportes our assignments.
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