Tetrahedron Letters No. 48, pp 4287 - 4290, 1975. Pergamon Press. Printed in Great Britain.

CARBON-13 NMR SPECTRA OF SOME POLYCYCLIC TRITERPENOIDS

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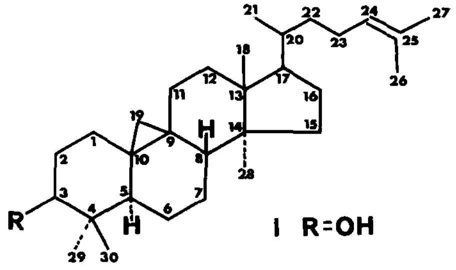
(Received in UK 1 October 1975; accepted for publication 20 October 1975)

Cimigoside (II) and actein (III) are highly oxygenated polycyclic glycosides isolated from Actea racemosa (1). Systematic studies carried out in one of these laboratories (2) have demonstrated their structural relationship with cycloartenol (1) and revealed their significant biological activity (3). Our current interest in the biogenesis of these complex cyclopropane triterpenoids prompted us to undertake a cmr spectral analysis permitting the use of ^{13}C-enriched precursors in the biosynthetic studies. We present here the results of the cmr analysis extended over the respective aglycons (IIa and IIIa), some derivatives (IIIb - IIId) and cycloartenol itself (4). Displaying a number of structural features - cyclopropane ring, cis B/C ring fusion, cyclic ethers - frequently encountered with steroidal and terpenoic natural products, the molecules studied here may also represent some general cmr interest (5).

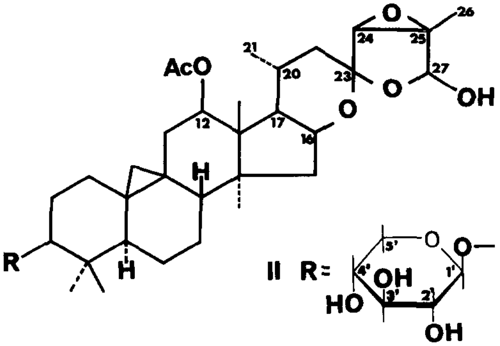
The analysis of the spectra was carried out by means of the well-known FT cmr assignment techniques (6). The complete assignment of the signals to the individual carbons in I to III was largely aided by spectral comparison permitting identification from already known substituent effects, empirical correlations and substituent parameters (7) and also, by taking advantage of correlations with the respective ^{1}H chemical shifts (4). The latter was based on series of single frequency off-resonance and single frequency selective $^{13}C - \{^1H\}$ decoupling experiments. In several instances use was made of the spectral informations provided by qualitative band shape analysis of the partially decoupled $^{13}C - \{^1H\}$ multiplets (8, 9). The assigned resonances are listed in the Table.

Comparison of the spectra of I to III, series of decoupling experiments and known chemical shifts of the isooctene side chain carbons (10) immediately gave the assignment for C-16, C-17, C-20, C-22, C-23, C-24, C-25, C-26, and C-27 in II and III. In a similar way, comparison of the spectra of parent glycosides with those of the respective aglycons and reference to literature

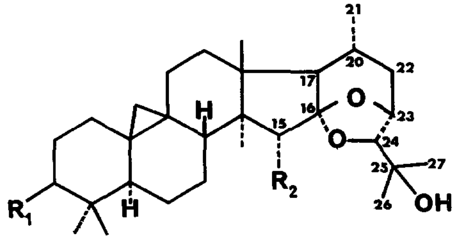


I R=OH

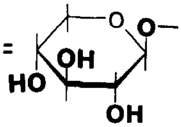
Ia R=OAc



IIa R=OH



III R_1=



; R_2= OH

IIIa R_1, R_2= OH

IIIb R_1, R_2= OAc

IIIc R_1= =O; R_2=OH

IIId R_1, R_2= =O

data on carbohydrates (11) led to the identification of signals due to the D-xylose carbons. Their chemical shift values corroborated earlier conclusions on a β-xylosidic bond (1).

Assignment of the A/B/C and D ring carbon resonances involved a simultaneous evaluation of the effects of the cyclopropane ring and associated with it stereochemical changes. In this process references was made to recent data on lanostan-3β-ol (12) and 5α-cholestan-3β-ol (13). Resonances due to C-9 and C-10 were singled out as the two high field quaternary carbon signals, while those due to C-13, C-14 and C-5, C-8 as the only quaternary and tertiary resonances with nontrivial assignments. An unambiguous distinction between these signals was provided by evaluating the effects of substituents at C-3, C-12 and C-15. A similar approach was used to differentiate between A/B/C/D ring methylene resonances. In view of its constancy upon substitution, the highest field methylene resonance was attributed to C-6, while the only unassigned methylene signal (at 28.18 ppm in I), by exclusion, to C-7. The cyclo propane methylene signal was readily spotted by its off-resonance line shape ("sharp" triplet) and selective decoupling experiments furnished additional evidence. Distinction between the geminal C-29 and C 30 methyl signals was based on their chemical shift difference and evaluation of C-3 substituent

Table. Carbon-13 Chemical Shifts[a]

	I[b]	Ia[b]	II[c]	IIa[c]	III[c]	IIIa[c]	IIIb[b]	IIIc[b]	IIId[b]
C- 1	32.08	31.74	31.66	31.81	31.91	32.04	31.88	33.67	33.65
C- 2	30.49	26.88	28.98	30.08	29.18	30.32	26.82	37.37	37.30
C- 3	78.89	80.74	88.04	77.50	88.12	77.40	79.97	216.30	215.79
C- 4	40.55	39.55	40.64	40.30	40.70	40.33	39.48	50.26	50.23
C- 5	47.25	47.30	46.76	46.57	47.16	46.97	47.08	48.40[d]	48.15
C- 6	21.19	21.02	20.19	20.38	20.64	20.82	20.76	21.35	21.47
C- 7	28.18	28.21	25.34	25.55	25.73	25.86	26.06	26.44	25.53
C- 8	48.03	47.90	45.65	45.71	48.13	48.15	47.47	48.08[d]	42.26
C- 9	20.11	20.27	19.77	19.72	19.62	19.56	19.86	20.97	21.19
C-10	26.23	26.13	26.39	26.64	26.20	26.43	26.52	26.44	26.36
C-11	26.07	25.89	36.69[d]	36.62[d]	25.97	25.92	25.83	25.89	25.67
C-12	33.03	33.00	76.67	76.77	33.58	33.60	33.36	33.55	31.77
C-13	45.39	45.41	47.59	47.60	41.36	41.39	42.22	41.84	40.53
C-14	48.89	48.93	48.24	48.25	46.58	46.60	46.37	46.98	53.27
C-15	35.66	35.66	43.35	43.37	79.47	79.49	80.51	79.74	211.52
C-16	26.60	26.65	72.51	72.55	110.96	110.99	110.78	111.46	103.43
C-17	52.41	52.42	55.99	56.00	58.99	58.97	59.45	59.19	56.92
C-18	19.36	19.36	12.97	12.97	18.98	18.98	19.37	19.16	20.33
C-19	29.93	29.81	29.79	29.91	30.67	30.75	30.84	30.53	29.95
C-20	35.97	35.97	25.34	25.33	23.47	23.45	23.39	23.68	23.05
C-21	18.04	17.99	20.76	20.73	19.33	19.32	19.86	19.33	19.74
C-22	36.45	36.47	36.29[d]	36.33[d]	37.75	37.74	37.44	37.67	37.23
C-23	25.04	25.05	105.16	105.19	71.23	71.28	71.37	71.74	72.58
C-24	125.36	125.39	62.22	62.17	89.46	89.48	88.92	89.06	89.62
C-25	130.81	130.77	64.59	64.60	70.42	70.40	70.88	71.31	71.15
C-26	17.61	17.64	12.47	12.44	25.04[d]	25.04[d]	25.73[d]	25.93	25.53[d]
C-27	25.70	25.70	97.23	97.29	25.30[d]	25.33[d]	25.83[d]	25.93	25.91[d]
C-28	18.32	18.33	19.49	19.53	11.22	11.23	12.45	11.11	14.24
C-29	25.49	25.49	25.34	25.55	25.30	25.59	25.43	22.21	22.24
C-30	14.03	15.20	14.91	14.07	14.95	14.20	15.14	20.76	20.69
C-1'	-	-	105.62	-	105.72	-	-	-	-
C-2'	-	-	73.54	-	73.67	-	-	-	-
C-3'	-	-	76.32	-	76.51	-	-	-	-
C-4'	-	-	69.74	-	69.74	-	-	-	-
C-5'	-	-	65.30	-	65.42	-	-	-	-
$\underline{\underline{C}}H_3CO$	-	21.23	21.49	21.51	-	-	21.25 21.34	-	-
$CH_3\underline{\underline{C}}O$	-	170.76	170.17	170.27	-	-	170.84 171.04		

[a] In parts per million relative to internal TMS. [b] In $CDCl_3$. [c] In the solvent mixture of $CDCl_3$-DMSO-d_6 (2:1). [d] Assignments may be reversed.

effects (12). Selective decoupling experiments were carried out to obtain an unambiguous assignment for the remaining C-18, C-21 and C-28 methyl resonances.

In an earlier study Piancatelli and Corsano have found (14) that in II the O-acetyl group at C-12 is equatorially oriented and is of β-configuration which requires a chair conformation for ring C. On the other hand, recent X-ray studies of pollinastanol acetate (15) have demonstrated that, as a consequence of the cyclopropane ring and *cis* B/C junction, in that molecule ring C assumes a boat conformation. The high field shift of the C-18 methyl resonance in II suggests *cis* relative orientation of C-12OAc and C-18 groups

(16) which, in view of the pmr data (14, 4), is only compatible with a ring C chair conformation. This apparent controversy may be rationalized in terms of differences between solid state and solute conformations and/or conformational effects of the C-12 substituent itself.

REFERENCES

1. G. Piancatelli, *Gazz. chim. ital.* **101**, 139 (1971) and references cited therein.
2. S. Corsano and G. Piancatelli, *Ricerca Sci.* **4**, 360 (1967).
3. E. Genazzani and L. Sorrentino, *Nature*, **194**, 544 (1962).
4. Natural abundance cmr spectra were recorded at 25.16MHz using a Varian XL-100-15 instrument equipped with Varian S124-XL FT accessory and 16 K 620L computer. For the selective decoupling experiments (see text) pmr spectra were rerun at 100.1 MHz using the same samples as for cmr.
5. While this paper was in preparation we learned about the Letter by F. Khuong-Huu *et al.* (17) describing the assignment of the spectrum of cycloartanol. Except for the saturated side chain in this molecule, the chemical shift values are in excellent agreement with those reported here; assignments of carbon C-12 and C-15 however appear reversed.
6. F.W. Wehrli, in *Nuclear Magnetic Resonance Spectroscopy of Nuclei Other than Protons*, T. Axenrod and G.A. Webb, Eds., Wiley Interscience, New York, 1974.
7. J.B. Stothers, *Carbon-13 NMR Spectroscopy*, Academic Press, New York, 1972.
8. J.B. Grutzner, *Chem. Commun.* 64 (1974).
9. H. Fritz and H. Sauter, *J. Magn. Res.* **18**, 527 (1975).
10. See *e.g.* G. Lukacs, F. Khuong-Huu, C.R. Bennett, B.L. Buckwalter, and E. Wenkert, *Tetrahedron Letters*, 3515 (1972).
11. J.B. Stothers, *loc. cit.* p. 462.
12. S.A. Knight, *Org. Magn. Res.* **6**, 603 (1974). Evaluation of the effects of cyclopropane ring suggests that in this reference assignments of C-12, C-15 and/or C-16 are interchanged.
13. H. Eggert and C. Djerassi, *J. Org. Chem.* **38**, 3788 (1973).
14. G. Piancatelli and S. Corsano, *Rend. Acc. Naz. Lincei*, **47**, 325 (1969).
15. A. Ducruix, C. Parcard-Billy, M. Devys, M. Barbier, and E. Lederer, *Chem. Commun.* 929 (1973).
16. J.D. Roberts, F.J. Weigert, J.L. Kroschwitz, and H.J. Reich, *J. Amer. Chem. Soc.* **92**, 1338 (1970).
17. F. Khuong-Huu, M. Sangare, V.M. Chari, A. Bekaert, M. Devys, M. Barbier, and G. Lukacs, *Tetrahedron Letters*, 1787 (1975).