Carbon-13 NMR spectra of some pentacyclic triterpenoids with the olean-28,13-olide skeleton

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ABSTRACT: ^{13}C Nuclear magnetic resonance spectral analysis of several pentacyclic triterpenoids with the olean-28,13-olide skeleton was undertaken. The assignment of all the carbons has been achieved by means of single frequency off-resonance, selective decoupling methods (APT and DEPT) and by comparison of the signals with those of related substances.

INTRODUCTION

The most important method for structural elucidation of pentacyclic triterpenoids, particularly for stereochemical problems,[1-3] is NMR spectroscopy. The NMR of some triterpenoid derivatives of the ursane[4-7] and oleanane[3,6,8,9] series have been reported previously. However, additional data is needed regarding the systematic ^{13}C NMR evaluations of this type of secondary metabolites.

In this paper, we report a ^{13}C NMR study of some γ-lactone of the oleanane-type triterpenes. A comparison of the effects induced in the oleanane skeleton by the bromolactonization of the Δ^{12}-17β-COOH precursor is discussed.

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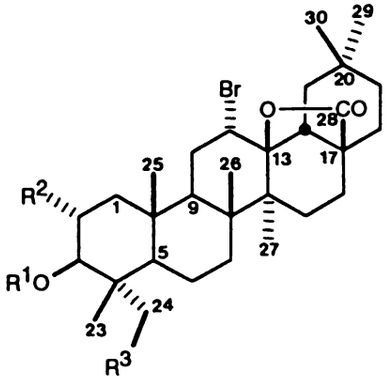
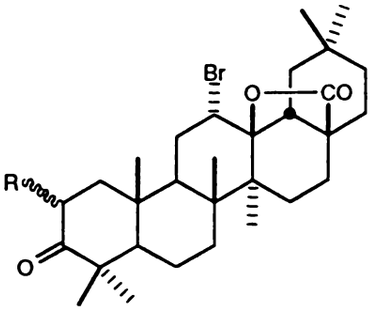
RESULTS AND DISCUSSION

The chemical shifts data for **1-18** are given in table I. The ^{13}C NMR spectra were assigned on the basis of their multiplicities in the APT and DEPT modes, chemical shift theory and by comparison with data reported in the literature.[1,3,7]

The ^{13}C NMR data of **1-11,** when compared with those of **15** showed the predictable α paramagnetic effect attributable to the bromination on C-12 ($\Delta\delta$ +28.1). This comparison also indicated a considerable β-deshielding of C-11 ($\Delta\delta \simeq +9.5$). However, C-13 is not sensitive to this effect, since the σ-bond polarization induced by the halogen was reduced by the hyperconjugative interaction of the lone pairs of the oxygen at C-13 with the $C_{12\text{-}13}$ bond.[15]



1 $R^1=R^2=R^3=H$
2 $R^1=Ac$; $R^2=R^3=H$
6 $R^1=R^3=H$; $R^2=OH$
7 $R^1=R^3=H$; $R^2=OAc$
8 $R^1=Ac$; $R^2=OH$; $R^3=H$
9 $R^1=Ac$; $R^2=OAc$; $R^3=H$
11 $R^1=Ac$; $R^2=H$; $R^3=OAc$



3 R=H
4 R=2β-Br
5 R=2α-Br

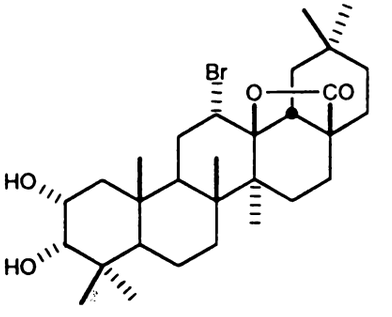


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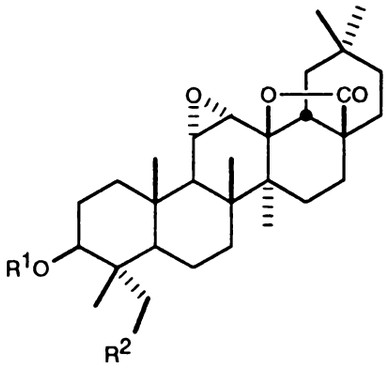
TABLE I. ^{13}C-nmr spectra of compounds 1-18 ($CDCl_3$, TMS as internal standard)

Carbon atom	Compound									
	1	2	3	4	5	6	7	8	9	10
1	38.31	37.94	39.07	51.83	53.23	45.94	43.36	47.54	43.60	41.57
2	27.16	23.48	33.82	55.40	50.90	68.44	73.08	67.55	69.83	66.01
3	78.68	80.51	217.56	206.61	208.60	83.18	80.61	84.63	80.32	78.61
4	38.90	37.72	47.18	39.22	49.18	39.04	39.31	39.83	39.38	39.28
5	55.16	55.23	54.42	51.52	51.98	55.08	55.85	56.15	54.91	51.33
6	17.69	17.47	19.08	18.68	19.31	17.51	17.66	17.66	17.59	17.88
7	33.85	33.77	33.84	33.82	33.82	33.65	33.85	33.85	33.84	33.84
8	39.92	39.92	39.97	39.85	40.03	39.70	39.90	39.90	39.89	39.90
9	45.54	45.44	44.80	44.90	44.67	45.26	45.50	45.50	45.50	45.68
10	36.53	36.36	36.22	31.07	38.65	37.60	37.74	37.88	37.72	38.02
11	29.18	29.08	29.16	29.17	29.71	28.94	29.17	29.17	28.93	28.46
12	56.46	56.15	56.15	56.27	55.84	55.92	55.12	55.12	55.89	55.88
13	91.64	91.56	91.59	91.32	91.43	91.42	91.50	91.44	91.45	91.50
14	42.41	42.35	42.23	42.52	42.09	42.29	42.49	42.49	42.49	42.40
15	27.51	27.45	27.47	27.47	27.33	27.50	27.50	27.50	27.50	27.48
16	21.32	21.22	21.30	21.26	21.25	21.13	21.30	21.30	21.28	21.30
17	43.37	43.31	43.46	43.52	42.52	43.22	43.43	43.43	43.43	43.35
18	52.31	52.23	52.36	52.25	52.42	52.09	52.28	52.28	52.26	52.29
19	45.54	45.44	45.51	45.47	45.47	45.32	45.50	45.50	45.48	45.50
20	30.43	30.36	30.82	30.71	30.70	30.34	30.53	30.54	30.53	30.55
21	34.61	34.48	33.94	34.11	34.11	34.30	34.43	34.43	34.38	34.30
22	31.88	31.76	31.90	31.89	31.90	31.69	31.89	31.89	31.92	31.68
23	27.97	27.79	26.98	29.28	26.45	28.37	28.37	28.37	28.24	28.46
24	15.42	16.38	20.91	21.81	20.81	16.55	17.44	16.48	17.43	21.78
25	16.96	16.93	17.05	21.07	16.69	18.01	18.14	18.00	18.09	16.70
26	19.07	19.00	18.69	19.17	18.16	18.92	19.08	19.12	19.08	19.08
27	21.12	21.03	20.93	20.05	20.05	20.96	21.15	21.15	20.94	20.94
28	178.85	178.92	178.69	178.62	178.56	178.67	178.69	178.69	178.69	178.68
29	33.27	33.17	33.26	33.25	33.26	33.08	33.27	33.27	33.26	33.27
30	23.57	23.34	23.54	23.57	23.53	23.40	23.58	23.58	23.58	23.40

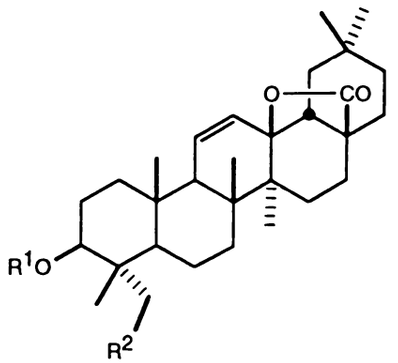
The α-orientation for the C-12 bromide group gave rise to a *γ-gauche* effect[16] on C-9 ($\Delta\delta \simeq -5.1$). In addition, the synaxial interaction between the C_{12} -Br and $C_{18\text{-}19}$ bonds caused a strong shift of ca. +6.9 ppm to lower field of C-19. On the other hand, this steric δ effect on C-27 is smaller ($\Delta\delta \simeq +2.7$).

Dehydrohalogenation of **1, 2,** and **11** afforded olefins **12-14**, respectively. The most important variations are due to the presence of a double bond at C-11 (δ 135) and C-12 (δ 127). A part from causing a paramagnetic contribution at C-9 (Δδ +8.0), the absence of halogen at C-12 affects by a strong negative value the chemical shifts of C-27 (Δδ -3.0) and C-19 (Δδ -8.5) due to the elimination of the induced steric compression shifts through interaction with the 1,3-*syndiaxial* substituent (δ effect).[15]



16 $R^1=R^2=H$
17 $R^1=Ac$; $R^2=H$
18 $R^1=Ac$; $R^2=OAc$

Epoxidation of Δ^{11} double bond in compounds **12-14** gave the 11α,12α-epoxiderivatives **16-18**, where the hybridation changes at C-11 and C-12 is confirmed by their upfield shift [$\delta_{(C\text{-}11)12} - \delta_{(C\text{-}11)16} = -83.2$; $\delta_{(C\text{-}12)10} - \delta_{(C\text{-}12)14} = -70$]. The steric effects, as a consequence of the α-orientation of the **11, 12**-epoxide, are evident by the *γ-gauche* diamagnetic shift of C-9 [$\delta_{(C\text{-}9)15} - \delta_{(C\text{-}9)16} = -1$; $\delta_{(C\text{-}9)12} - \delta_{(C\text{-}9)14} = -3.5$] and the downfield shift for *synaxial* δ effect of C-27 [$\delta_{(C\text{-}27)15} - \delta_{(C\text{-}27)16} = +1.7$; $\delta_{(C\text{-}27)12} - \delta_{(C\text{-}27)16} = +2.1$].



12 $R^1=R^2=H$
13 $R^1=Ac$; $R^2=H$
14 $R^1=Ac$; $R^2=OAc$
15 $R^1=R^2=H$; 11,12-dihydro

EXPERIMENTAL

MATERIALS. Compounds **1, 2, 6, 10** and **11** were prepared by bromination of the corresponding Δ^{12} – 17β-carboxilic acid precursor.[10-12] Jones oxidation of **1** afforded **3.** Treatment of oleanolic acid with Br_2/AcOH[13] gave bromolactone **1** and the mixture of **4** and **5.** The acetates of **6** (**7-9**) were obtained by the usual acetylation procedures while **13** and **14** resulted from dehydrobromination[11] with DBU of the bromolactones **2** and **11,** respectively. Compounds **12, 15** and **16** are natural products and details on their identification have already been described by us.[11,14] Acetylation of **16** afforded derivative **17.** Compound **18** was prepared from hederagenin according to procedures described previously.[11]

METHODS. Natural abundance ^{13}C NMR spectra were recorded on a Varian VXR-300 instrument operating at 75.4 MHz. The ^{13}C NMR spectra were measured at room temperature using a deuterium lock. The concentrations of the solutions were 0.2-0.4 mmol ml^{-1}. $CDCl_3$ was used as solvent in all cases. Chemical shifts are relative to TMS, and estimated to be accurate to $\pm$ 0.1 ppm. The ^{13}C NMR spectra were first recorded in the proton noise decoupling mode with a WALTZ-16 modulated sequence, and then the degree of substitution of each carbon atom was deduced by obtaining the spectra in the J-modulated spin-echo (APT) mode and by the DEPT sequence.

RESUMEN

La presente investigación describe el análisis de la resonancia magnética nuclear de ^{13}C de dieciocho triterpenos pentacíclicos con esqueleto de olean-28,13-ólida. Las asignaciones de los núcleos de carbono se realizaron mediante métodos de desacoplamiento selectivo (APT y DEPT), así como por comparación de las señales con modelos estructurales relacionados descritos en la literatura. Se discuten los efectos sobre el desplazamiento químico inducido en el esqueleto de oleanano por la bromolactonización del precursor triterpénico con una sustitución Δ^{12} – 17β-COOH.

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ADDENDA

Carbon-13 NMR spectra of some Pentacyclic triterpenoids with the olean-28,13-olide skeleton. E. Gonzalez-Chimeo, R. Pereda-Miranda, M. I. Chavez and G. Delgado. An. Esc. nac. Cienc. biol., Méx. 39: 103-108.

Continuación de la Tabla 1 (Continuation of Table 1)

Table 1. ^{13}C-nmr Spectra of Compounds 1-18 ($CDCl_3$, TMS as Internal Standard)

Carbon atom	Compound							
	11	12	13	14	15	16	17	18
1	37.66	39.00	37.84	37.51	37.82	38.09	37.80	37.68
2	22.84	27.26	23.23	22.71	23.80	26.65	23.60	22.52
3	74.13	78.89	80.53	74.10	80.73	78.68	80.43	74.02
4	40.60	38.39	37.77	40.60	37.48	38.81	37.72	40.78
5	47.98	54.59	54.76	47.62	55.01	54.51	54.63	47.43
6	17.30	17.75	17.42	17.26	18.22	17.55	17.47	17.19
7	33.82	31.07	31.00	31.40	33.27	31.41	31.04	31.40
8	39.88	41.54	41.30	41.30	38.63	41.23	41.30	41.21
9	45.66	53.34	53.03	53.10	50.54	49.53	49.58	49.53
10	36.31	36.47	36.18	36.11	36.76	36.40	36.37	36.21
11	29.21	135.85	135.69	135.32	19.68	52.71	52.62	52.46
12	56.07	127.03	127.02	127.06	27.81	57.03	57.01	56.94
13	91.46	89.82	89.73	89.59	91.72	87.49	87.50	87.35
14	42.36	41.74	41.52	41.49	42.29	40.45	40.50	40.57
15	27.48	25.48	25.29	25.31	26.54	26.72	26.99	26.61
16	21.26	21.41	21.22	21.20	21.82	21.22	21.26	21.16
17	43.29	44.10	43.94	43.96	44.08	43.81	43.85	43.78
18	52.25	50.66	50.46	50.46	50.34	50.62	50.58	50.70
19	45.48	37.46	37.22	37.26	38.65	37.69	37.80	37.39
20	30.47	31.46	31.36	30.80	31.36	31.03	31.45	30.76
21	34.23	34.49	34.27	34.29	34.13	34.23	34.28	34.22
22	31.84	27.08	27.06	27.08	31.53	26.94	26.69	26.94
23	65.28	27.81	27.63	65.29	27.3	27.74	27.73	65.16
24	12.89	17.65	15.95	12.49	16.42	15.09	16.23	12.59
25	17.38	18.31	18.17	18.37	16.10	17.17	17.27	17.20
26	19.06	19.00	18.90	18.90	17.11	18.82	18.82	18.84
27	21.20	17.95	17.93	18.31	18.31	20.02	20.07	19.96
28	178.67	179.6	180.05	179.89	180.28	179.31	179.29	179.22
29	33.22	33.30	33.20	33.23	33.41	33.16	33.19	33.14
30	23.54	23.59	23.47	23.51	23.63	23.57	23.60	23.52