Tetrahedron Vol 39 No 2, pp 313 to 316, 1983
Printed in Great Britain

0040-4020/83/020313-04$03 00/0
Pergamon Press Ltd

CONFIRMATION OF THE STRUCTURE OF ALDONOLACTONES BY ^{13}C-NMR

ALICIA FERNÁNDEZ CIRELLI, MARCOS SZNAIDMAN, OSCAR J. VARELA and ROSA M. DE LEDERKREMER*
Departamento de Química Orgánica, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, 1428 Buenos Aires, Argentina

(*Received in UK* 29 *April* 1982)

Abstract—^{13}C-NMR spectra of deoxyaldonolactones, derived from L-rhamnose, are interpreted and discussed in terms of ring-size and substituents. It is shown that this spectroscopic method constitutes a useful tool in the structural determination of isomeric 1,4- and 1,5-lactones.

In our work on the synthesis of deoxy sugars of biological significance *via* β-elimination reactions, we have described dideoxy and trideoxyaldonolactones.[1-5] The assignment of a five- or six-membered ring structure was made in all cases on the basis of the IR absorption of the carbonyl group and the chemical shifts of the ring protons. Recently, Chmielewski[6] in his report on the total synthesis of 3-deoxy and 3,6-dideoxy-DL-hexoses, has objected the δ-lactone structure assigned by us to 2,4 - di - O - benzoyl - 3,6 - dideoxy - L - *arabino* - hexono - 1,5 - lactone (1), based on the $J_{2,3}$ and $J_{2,3'}$ values of 9 Hz observed in the ^{1}H-NMR spectrum of 1. He has found $J_{2,3}$ and $J_{2,3'}$ values between 7.5 and 10.5 for the 1,4-lactones described in his paper. The coupling constants as an isolated parameter are not indicative of the lactone configuration. In fact, in the course of our synthetic work, we have found that these values are close for both types of rings. In Table 1, we can see that 2,5 - di - O - benzoyl - 3,6 - dideoxy - L - *arabino* - hexono - 1,4 - lactone[3] (2; isomer of 1) shows $J_{2,3} = 8.4$ Hz and $J_{2,3'} = 10.2$ Hz. Nevertheless, while we cannot differentiate the methylene protons (H-3 and H-3′) in compound 1 because of their similar environments in the distorted-boat conformation adopted by the δ-lactone, they appear as two well-separated multiplets in compound 2. The isomeric trideoxylactones: 2 - O - benzoyl - 3,4,6 - trideoxy - DL - *threo* - hexono - 1,5 - lactone[5] (3) and 2 - O - benzoyl - 3,5,6 - trideoxy - DL - *threo* - hexono - 1,4 - lactone[4] (4), also show analogous values for $J_{2,3}$ and $J_{2,3'}$.

As a new structural evidence, we now report the ^{13}C-NMR of related aldonolactones (Table 2). It can be observed that C-1 in γ-lactones (2, 4 and 8) resonates at lower fields than C-1 in the corresponding δ-lactones (1, 3 and 9, respectively). This result is in accordance with the findings of Bui *et al.*,[7] who have studied a series of lactones in various solvents through ^{13}C-NMR spectroscopy and have found that the chemical shifts of the carbonyl carbon is characteristic of the type of lactone. A similar behaviour was observed for the α,β-unsaturated lactones 5 and 6. In the enono - 1,5 - lactone 5, C-1 appears at 157.68 ppm, shifted upfield (-9.19 ppm) with respect to the enono - 1,4 - lactone 6. A similar value was observed for the chemical shift of C-2 in 3 - benzoyloxy - 6 - methyl - pyran - 2 - one (7).

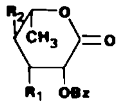
If we compare the C-1 in compounds 1 and 5, there is a marked shielding (-9.47 ppm) due to the sp^2 centre α to the lactone carbonyl. In the five membered rings (4 and 6), this upfield shift was also observed (-5.09 ppm).

If we compare the 1,4 - lactones (2 and 8) with the isomeric 1,5 - lactones (1 and 9), the greatest differences are observed, as expected, in C-4 (5–7 ppm downfield in 1,4 - lactones) and C-5 (6–7 ppm upfield in 1,4 - lactones). This result can be explained in terms of structural changes and the greater electron-withdrawing power of the lactone group compared with an ester group,[8] and could be used in the determination of ring size in isomeric 1,4- and 1,5-lactones.

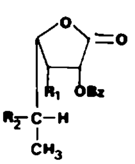
Another difference observed between both types of lactones is that C-6 in 1,5 - lactones appears at lower field than C-6 in 1,4 - lactones. This effect can be explained taking into account that C-6 in the former is attached to a more deshielded atom.

On the basis of the ^{13}C-NMR data (Fig. 1), we can affirm that the δ-structure assigned by us to 1 is correct.

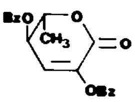
Considering the 1,4 - lactones, C-5 in 8 is shifted upfield (-3.29 ppm) in comparison with C-5 in 2. This



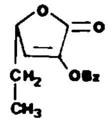
1 - R1 = H, R2 = OBz
3 - R1 = R2 = H
9 - R1 = R2 = OBz



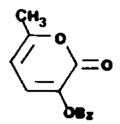
2 - R1 = H, R2 = OBz
4 - R1 = R2 = H
8 - R1 = R2 = OBz



5



6



7

Table 1. ^{1}H-NMR chemical shifts and coupling constants of lactones 1–4

	H-2	H-3	H-3'	H-4	H-5	H-6	$J_{2,3}$	$J_{2,3'}$
1	5.85(t)	2.6(m)	2.6(m)	5.25(m)	4.80(m)	1.50(d)	9.0	9.0
2	5.68(q)	2.96(m)	2.34(m)	4.63(m)	5.37(m)	1.49(d)	8.4	10.2
3	5.75(q)	1.6-2.7(m)	1.6-2.7(m)	1.6-2.7(m)	4.60(m)	1.40(d)	8.0	10.0
4	5.66(q)	2.87(m)	2.05(m)	4.41(m)	1.80(m)	1.08(t)	8.5	10.4

Fig. 1. ^{13}C-NMR spectrum of 2,4 - di - O - benzoyl - 3,6 - dideoxy - L - *arabino* - hexono - 1,5 - lactone (**1**). Single frequency decoupled at the center of the ^{1}H resonance assigned independently to: (A) H-5; (B) H-4; (C) H-2; (D) Fully decoupled.

fact can be explained in terms of steric crowding produced by the benzoyloxy group on C-3 in **8**. This influence can also be observed in the chemical shifts of C-3 in compounds **2** and **4**. A similar behaviour was observed for L - rhamnono - 1,4 - lactone (C-5: 65 ppm) and 3,6 - dideoxy - L - *arabino* - hexono - 1,4 - lactone (C-5; 67.9 ppm).[9]

In Table 2, the ^{13}C-NMR data of 2,5 - di - O - acetyl - 3,6 - dideoxy - DL - *arabino* - hexono - 1,4 - lactone[6] (**10**) are shown for comparison with the benzoylated lactone **2**. The greatest differences were observed in the chemical shifts of C-2 and C-5. As our values were confirmed by SFD (Fig. 2) it is probable that the chemical shifts assigned for C-2 and C-5 in **10** are interchanged.

In **1**, **3** and **9**, the differences in chemical shifts observed for the ring atoms can be explained in terms of electrical effects, which is in accord with the fact that the three lactones are in the same conformation (distorted boat) as was established by ^{1}H-NMR.[1,5]

On the basis of the chemical shifts of C-1, C-4, C-5 and C-6, we can conclude that ^{13}C-NMR spectroscopy is a useful tool in the structural determination of isomeric 1,4- and 1,5 - aldonolactones.

EXPERIMENTAL

^{1}H-NMR spectra were determined with a Varian XL-100 spectrometer with solutions in chloroform-d, and tetramethyl-silane as internal reference; the apparent coupling constants (in Hz) reported are the directly observed line-spacings. Assignments were substantiated by double-irradiation experiments.

^{13}C-NMR spectra were recorded in chloroform-d at 25.2 MHz on a Varian XL-100 spectrometer using tetramethyl-silane as internal standard. Signal assignments have been achieved from selective decoupling experiments (except for **3**, where ^{1}H-signals overlap) and from non-decoupled spectra.

Compounds **1**, **2**, **3**, **5**, **7** and **9** were synthesized from L - rhamnono - 1,5 - lactone as previously described.[1-3,5]

Compounds **4**, **6** and **8** were synthesized from L - rhamnono - 1,4 - lactone according to Ref 4.

Acknowledgements—We are indebted to UMYMFOR (CONICET-FCEN), particularly to Dr Gerardo Burton, for the spectra and to the Subsecretaría de Estado de Ciencia y Tecnología (SUBCYT) for financial support.

Table 2. ^{13}C-NMR data for 1,4- and 1,5-lactones

	C-1	C-2	C-3	C-4	C-5	C-6
9	165.53	67.53	71.75	74.75	74.21	19.14
8	169.53	69.58	68.79	79.89	67.33	17.51
1	167.58	64.79	30.09	70.27	76.62	19.14
2	171.50	68.57	30.81	77.62	70.62	15.33
3[a]	169.05	66.47	27.81*	23.34*	74.15	21.05
4	171.96	69.02	34.35	77.99	28.07	9.02
5	157.68	140.61	125.29	68.47	77.25	18.32
6	166.87	137.92	127.97	80.21	26.81	8.78
7[b]	158.10	134.98	131.66	102.12	159.74	19.55
10[c]	172.19	70.53	29.09	78.50	67.61	15.48

[a] The assignments marked with an asterisk may be interchanged.
[b] The carbon atoms were numbered as for a lactone for comparison.
[c] The data for compound **10** are taken from Ref 6.

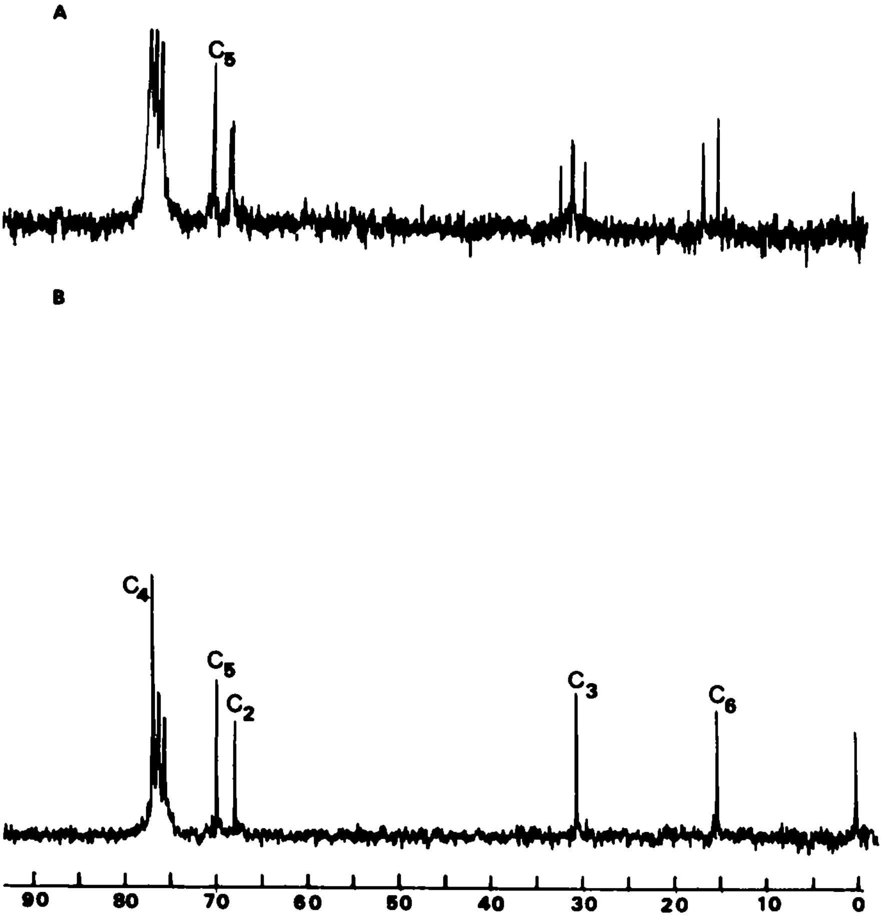


Fig. 2. ^{13}C-NMR spectrum of 2,5 - di - O - benzoyl - 3,6 - dideoxy - L - *arabino* - hexono - 1,4 - lactone (**2**). (A) Single frequency decoupled at the center of the ^{1}H resonance assigned independently to H-5. (B) Fully decoupled.

REFERENCES

[1] O. J. Varela, A. Fernández Cirelli and R. M. de Lederkremer, *Carbohydr. Res.* **70**, 27 (1979).

[2] O. J. Varela, A. Fernández Cirelli and R. M. de Lederkremer, *Ibid.* **79**, 219 (1980).

[3] O. J. Varela, A. Fernández Cirelli and R. M. de Lederkremer, *Ibid.* **85**, 130 (1980).

[4] O. J. Varela, A. Fernández Cirelli and R. M. de Lederkremer, *Ibid.* **100**, 000 (1982).

[5] M. Sznaidman, A. Fernández Cirelli and R. M. de Lederkremer, *Anales Asoc. Quim. Argentina* **70**, 341 (1982).

[6] M. Chmielewski, *Tetrahedron* **36**, 2345 (1980).

[7] A.-M. Bui, A. Cavé, M.-M. Janot, J. Parello and P. Potier, *Ibid.* **30**, 1327 (1974).

[8] R. Riguera, *Tetrahedron* **34**, 2039 (1978).

[9] V. N. Shivaev, V. A. Petrenko, L. L. Danilov, N. S. Utkina, M. I. Struchkova and N. K. Kochetkov, *Izv. Akad. Nauk SSSR, Ser. Khim.* 158 (1980).