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^{13}C NMR Spectra of 4,6-*O*-Benzylidenehexopyranosides and Their 2,3-Di-*O*-sulfonate Derivatives

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Synopsis. ^{13}C NMR spectra of the title compounds were measured. The relationship between their chemical shifts and reactivity is discussed.

In the course of studies on the 2,3-unsaturation of 4,6-*O*-benzylidene-2,3-di-*O*-sulfonylhexopyranosides[1] and of 4′,6′-*O*-benzylidene-2,2′-anhydro-3′-*O*-sulfonylhexopyranosyl nucleosides,[2] it was found that the configuration and conformation of a sugar ring mainly control unsaturation. This led us to study the C-13 NMR spectra of these compounds, since the C-13 chemical shift is highly susceptible to configurational and conformational changes.[3] The C-13 NMR spectra of some compounds in the present study were studied by Conway *et al.*,[4] and we have compared our results with theirs.

All methyl 4,6-*O*-benzylidenehexopyranosides (**1**—**10**) and 4′,6′-*O*-benzylidenehexopyranosyl nucleosides (**11**—**18**) showed almost the same phenyl carbon signals of benzylidene moiety, 126, 127.8, 128.6 (para), and 137.8 ppm (quarternary). Signals at 100.7±0.6 ppm in these spectra should be assigned to C-7 of benzylidene moiety because of the same environment throughout the series of compounds. The shift values of methyl 4,6-*O*-benzylidene-α-D-glucopyranoside (**1**), its β-anomer (**2**), and methyl 4,6-*O*-benzylidene-α-D-mannopyranoside (**3**) are the results of the study of Conway *et al.*[4]

The anomeric signal of methyl 4,6-*O*-benzylidene-β-D-mannopyranoside (**4**) can be assigned to 101.9 ppm, since the anomeric signal of methyl β-mannoside shows a slightly lower chemical shift than that of the α-anomer;[5] those of 2,3-di-*O*-tolylsulfonyl derivatives (**9** and **10**) show the same tendency (Table 1). The signals at 78.4, 66.6, and 67.8 ppm of **4** can be assigned to C-4, -5, and -6, respectively, by comparison with those of **1**, **2**, and **3**. The signals at 70.8 and 69.8 ppm should be attributed to C-2 and -3, respectively, since 4,6-*O*-benzylidenation makes 3.0—4.2 ppm upfield shift on C-3 and 0.1—1.1 ppm upfield shift on C-2 of **1**, **2**, and **3**.[4,5]

The assignment of methyl 4,6-*O*-benzylidene-2,3-di-*O*-*p*-tolylsulfonyl-α-D-glucopyranoside (**5**) and its 2,3-di-*O*-methylsulfonyl substituent (**7**) is the same as the assignment by Conway *et al.*[4] However, there are slight differences due to the difference in solvent. In the cases of methyl 4,6-*O*-benzylidene-2,3-di-*O*-*p*-tolylsulfonyl-β-D-glucopyranoside (**6**) and its 2,3-di-*O*-methylsulfonyl substituent (**8**), the chemical shifts of *O*-methyl, C-5 and -6 can be assigned by a comparison with those of **2**, since sulfonation causes no noticeable effect on these carbons. Disulfonation makes 4.0—4.8 ppm downfield shift on C-2 and 5.2—5.5 ppm downfield shift on C-3 of **5** and **7**. The signals at 79.0 and 79.5 ppm of **6** can thus be assigned to C-2 and -3, respectively. Sulfonation effect on C-1 and -4 of **5** and **7** shows 0.6—3.7 ppm upfield shift, C-1 and -4 chemical shifts

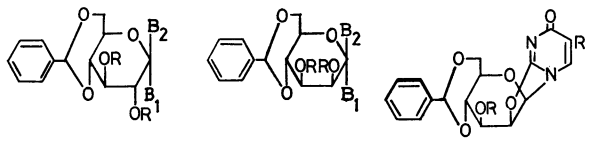
Table 1. ^{13}C chemical shifts of 4,6-*O*-benzylidene derivatives of hexopyranosides

	C-1′	C-2′	C-3′	C-4′	C-5′	C-6′	C-7′	C-2	C-4	C-5	C-6	Me
1[a]	99.9	72.4	70.5	80.8	62.0	68.5	101.5					54.9
2[a]	104.2	74.2	72.9	80.3	65.9	68.3	101.5					56.8
3[a]	101.7	70.6	68.0	78.5	62.9	68.4	101.7					54.4
4	101.9	70.8	69.8	78.4	66.6	67.8	100.8					56.1
5	97.4	76.4	75.7	77.1	62.3	67.3	100.5					55.1
6	100.5	79.5	79.0	77.3	64.7	67.4	100.9					56.4
7	98.5	77.2	76.0	78.1	62.8	68.1	101.1					55.7
8	100.2	78.6	78.5	77.4	64.8	67.3	100.8					56.7
9	98.5	74.0	74.0	67.9	63.6	66.9	100.4					54.8
10	98.6	75.5	74.4	78.6	65.9	67.0	100.2					56.2
11	83.1	73.2	71.5	80.1	68.6	67.7	100.8	150.8	163.5	109.7	137.8	11.8
12	80.5	76.9	75.7	79.5	67.2	67.2	100.7	150.2	162.7	102.7	140.8	
13	80.0	76.9	75.6	78.9	67.1	67.0	100.5	150.2	163.3	110.5	136.6	11.8
14	81.2	68.5	74.4	78.3	68.3	67.2	100.7	149.7	162.8	100.4	141.8	
15	80.3	75.0	74.3	77.0	68.7	66.9	100.6	149.6	162.7	101.6	139.8	
16	80.7	75.8	75.0	78.1	69.5	67.7	101.3	150.3	163.3	109.9	137.7	12.6
17	83.4	73.8	74.4	78.8	65.0	66.7	100.2	159.9	170.4	108.9	136.8	
18	83.7	73.8	74.5	78.4	64.9	66.7	100.1	159.7	171.1	117.1	132.4	13.1

a) Data from Conway *et al.*[4]

being assigned as in Table 1. A similar procedure was used for the assignment of methyl 4,6-*O*-benzylidene-2,3-di-*O*-*p*-tolylsulfonyl-α-D-mannopyranoside (**9**) and its β-anomer (**10**).

In the cases of nucleosides 1-(4′,6′-*O*-benzylidene-β-D-glucopyranosyl)thymine (**11**), its 2′,3′-di-*O*-methylsulfonyl derivative (**13**), 1-(4′,6′-*O*-benzylidene-2′,3′-di-*O*-methylsulfonyl-β-D-glucopyranosyl)uracil (**12**), 1-(4′,6′-*O*-benzylidene-3′-*O*-methylsulfonyl-β-D-mannopyranosyl)uracil (**14**), its 2′,3′-di-*O*-methanesulfonate (**15**), 1-(4′,6′-*O*-benzylidene-2′,3′-di-*O*-methylsulfonyl-β-D-mannopyranosyl)thymine (**16**), 2,2′-anhydro-1-(4′,6′-*O*-benzylidene-3′-*O*-methylsulfonyl-β-D-mannopyranosyl)uracil (**17**), and 2,2′-anhydro-1-(4′,6′-*O*-benzylidene-3′-*O*-methylsulfonyl-β-D-mannopyranosyl)thymine (**18**), it is easy to assign the chemical shift of a sugar moiety, since the displacement of methyl by nucleoside base on C-1′ gives no serious effect on the chemical shifts of a sugar moiety except that of C-1′. It is easy to assign those of a sugar moiety of cyclic nucleosides **17** and **18**. The assignment of a base moiety is as the same as in previous reports.[6]



I, II, V, VI, VII, VIII, XI, XII, XIII III, IV, IX, X, XIV, XV, XVI XVII, XVIII

Table 2. Chemical shift differences due to sulfonylation

Δ	C-1	C-2	C-3	C-4	C-5	Sum of $\lvert\Delta-\Delta'\rvert$
5—**1**	−2.5	4.0	5.2	−3.7	0.3	
$\lvert\Delta-\Delta'\rvert$	0.4	5.2	4.0	1.6	1.1	12.3
6—**2**	−3.7	5.3	6.1	−3.0	−1.2	
$\lvert\Delta-\Delta'\rvert$	1.6	3.9	3.1	0.9	0.4	9.9
7—**1**	−1.4	4.8	5.5	−2.7	0.8	
$\lvert\Delta-\Delta'\rvert$	0.7	4.4	3.7	0.6	1.6	11.0
8—**2**	−4.0	4.4	5.6	−2.9	−1.1	
$\lvert\Delta-\Delta'\rvert$	1.9	4.8	3.6	0.8	0.3	11.4
Predicted Δ' [a] (glucoside)	−2.1	9.2	9.2	−2.1	−0.8	
9—**3**	−3.2	3.4	6.0	−1.6	0.7	
$\lvert\Delta-\Delta'\rvert$	1.1	5.8	3.2	0.4	2.0	12.3
10—**4**	−3.3	4.7	4.6	0.2	−0.7	
$\lvert\Delta-\Delta'\rvert$	1.2	4.5	4.6	2.0	0.6	12.9
Predicted Δ' [a] (mannoside)	−2.1	9.2	9.2	−1.8	−1.3	

a) Predicted from Duddeck's results.[7] Negative sign represents upfield difference.

Duddeck has shown with adamantane derivatives that the effect of substitution hydroxyl group for sulfonyloxyl one is 10.9 ppm downfield shift on α-carbon, 1.7 ppm upfield shift on β-carbon, and less than 1 ppm upfield shift on γ- and δ-carbons.[7] Usually the substitution effect on carbon chemical shift is additive and predictable.[8] However, our results can hardly be predicted by Duddeck's results. This discrepancy can be attributed mainly to steric effect.[8,9] The sum of absolute values of these differences ($\Delta-\Delta'$) (Table 2) suggests the dgree of the steric compression due to sulfonylation. The order of reactivity of unsaturation of 2,3-disulfonates is **6**>**10**>**5**>**9**.[1] As seen in Table 2, there is no relationship between the sum of $\lvert\Delta-\Delta'\rvert$ and reactivity. Thus, the steric interaction of the starting static state is not important and the steric and electrostatic effects of the dynamic intermediates are important as regards unsaturation.[1]

Experimental

NMR Spectra. The spectra were obtained at 25.15 MHz on a JEOL JNM-MH-100 instrument with JNM-MFT-100 Fourier transform accessory and a JEC-6 computer. Saturated solution was used as a sample in $(CD_3)_2SO$. The deuterium signal provided a field frequency lock, the carbon signal being used as an internal standard (39.5 ppm downfield from Me_4Si). Measurement conditions were as follow: pulse width, 27.5 μs (*ca.* 45°); repetition time, 4 s; spectral width, 6.25 KHz; data points, 8192; acquisition time 0.655 s; noise modulated proton decoupling power, 20 W. All the chemical shifts are expressed in ppm downfield from Me_4Si.

Materials. Compounds **3**—**10**,[1] thymine nucleosides (**11**), (**13**), (**16**), and (**18**)[2] and uracil nucleosides (**12**), (**14**), (**15**), and (**17**)[10] were prepared according to the methods reported.

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