CRYSTAL STRUCTURE ANALYSIS OF A 1,2,3,4-TETRA-*O*-ACETYL-5-DEOXY-5-PHENYLPHOSPHINYL-D-*ribo*-PYRANOSE DERIVATIVE

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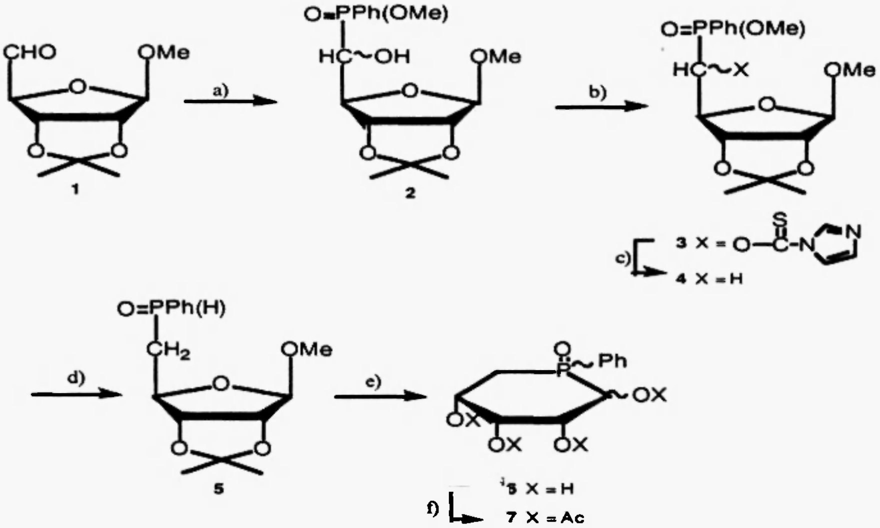
Abstract: X-Ray crystallographic analysis was performed on a single crystal of 1,2,3,4-tetra-*O*-acetyl-5-deoxy-5-phenylphosphinyl-D-*ribo*-pyranose derivative. The compounds have the (R_P) configuration at the phosphorus atom with the $^4C_1$ conformation for the pyranose ring.

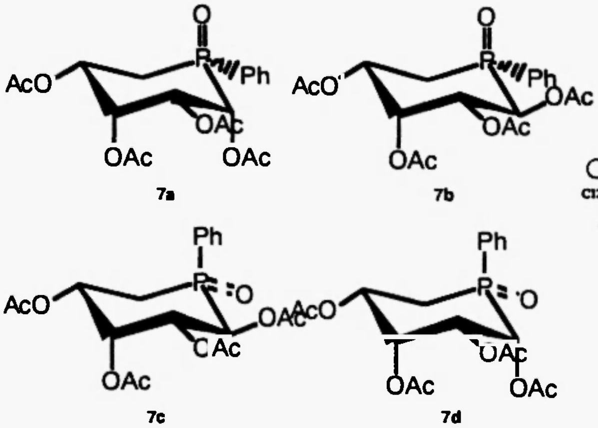
We previously reported [1] the transformation of methyl 2,3-*O*-isopropylidene-β-D-*ribo*-pentodialdo-1,4-furanoside **1** via several step functional group interconversions from methyl 2,3-*O*-isopropylidene-5-methoxy(phenyl)phosphinyl-β-D-*allo*- and α-L-*talo*-pentofuranosides (**2**) to 5-deoxy-5-phenylphosphinyl-D-*ribo*-pyranoses (**6**) as well as usual ring-transposition procedure to give 1,2,3,4-tetra-*O*-acetyl-5-deoxy-5-phenylphosphinyl-D-*ribo*-pyranoside derivatives [2]. We are interested in further investigation on the physico-chemical as well as biological properties of various phospha sugar analogues. In the preparative methodology (Scheme 1), four kinds of stereoisomeric phospha sugar derivatives might be preparated, and the stereoisomers were separated and isolated each other. To progress the study on the phospha sugar chemistry, here, we describe the X-ray crystallographic analysis of one of these 5-deoxy-5-phenylphosphinyl-D-*ribo*-pyranose derivatives to confirm the structural and conformational assignments previously made by NMR spectroscopy [1].

Determination of the absolute configuration at the phosphorus atom and conformational analysis of the pyranose ring were carried out for the previously prepared phospha sugars **7a-d**, and the precise structures of compounds 7a-d (Scheme 2) had been assigned on the basis of ^{1}H NMR spectral arguments [1]. From the isolated diastereomers 7a-d, single crystal of 7b was prepared. The tentative nature of these stereochemical conclusions prompted us to carry out an X-ray crystallographic analysis of compound 7b. Colorless rod-shaped crystals of 7b was grown from ethyl acetate-hexane. Precise lattice constants and three dimensional intensity data were obtained by a RIGAKU AFC7R four-circle X-ray diffractometer with Ni-filtered CuKα radiation. Summaries of the crystallographic data, bond distances, bond angles, and selected torsion angles are shown in Tables 1, 2, 3, and 4, respectively. Phase determination was made by a direct method (SHELXS) [4] and diffraction patterns were expanded using Fourier techniques [5]. The ORTEP plot for compound 7b is shown in Fig. 1.



Scheme 1 *Reagents and conditions*: a) PhP(O)(OMe)H, Et_3N, r.t.; b) 1,1'-(thiocarbonyl)diimidazole (TCDI), toluene, reflux; c) n-Bu_3SnH, toluene, reflux; d) SDMA, THF; e) conc.HCl, THF, reflux; f) Py, Ac_2O, r.t.

Stereoisomers 7a-d in Scheme 2 represent that the substituents at C2, C4, and P are linked equatorially to the $^4C_1$ conformation of the pyranose ring, and C1 acetoxy group orientates to axial or equatorial position depending on α- or β-anomer, while acetoxy group at C3 lines in axial fashion. Among these four kinds of stereoisomers, ORTEP drowing for the singl crystal shows that the structure analized by X-ray is 7b in which all substituents at C1-C4 and P atoms are equatorial with $^4C_1$ conformation, therefore, the structure must be most stable among these isomers. All the equatorial acetoxy groups on C1 to C4 have usual anti- or syn-parallel and almost planar arrangement where the C=O bonds and the C-H bonds of the same ring carbon atoms locate on the same side of the pyranose ring. The hydrogen atoms on the ring C atoms and the oxygen atoms of the carbonyl groups occupy closely related positions each other so as to form of the same ring carbon atoms weak C-H······O hydrogen bonds that may stabilize this conformation to a large extent [6]. The conformation about the anomeric OAc and P-Ph bonds around P-C1 is nearly *gauche*; C1-O2 has torsional angles to P1-O1 and P1-C15 of -55.6(4) and 67.5(4)°, respectively. As a result, the P1—C1—O2—C6 torsion angle is -120.5(5)°. The phenyl group is so oriented that P1—C15 is almost *trans* to C4—C5 with C4—C5—P1—C15 = 167.5(4)°. This X-ray structure determination confirmed the structure previously assigned to compound 7b. The D-*ribo*-pyranose ring of the compound **7b** in the solid state exists in a $^4C_1$ chair conformation, with Cremer-Pople [7] puckering parameters of Q = 0.683 Å, θ = 5.0°, Ψ = 174.4°. The deviation of C1 and C4 from the plane defined by C2, C3, C5 and P are 0.804 and -0.716 Å for **7b**, respectively.



Scheme 2

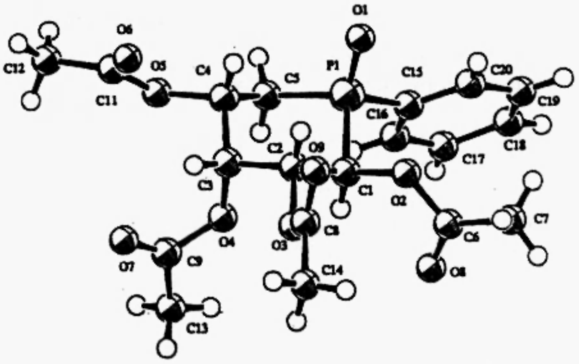


Fig. 1. ORTEP plot for compound **7b**.

Table 1. Crystallographic data for phospha sugar **7b**.

Formula	$C_{19}H_{23}O_{9}P$
Space group	$P2_12_12_1$ (#19)
Crystal system	orthorhombic
Lattice constants (Å)	a = 11.2049(9)
	b = 22.672(1)
	c = 8.5965(8)
Cell volume (Å^3)	V = 2183.9(2)
Crystal size (mm)	0.2×0.2×0.3
Dcalc (g/cm^3)	1.297
μ (CuKα, cm^{-1})	15.31
Z	4
$R = (\Sigma\, \|\,\|Fo\| - \|Fc\|\,\| / \Sigma\, \|Fo\|)$	0.043
$Rw = [\Sigma w (\|Fo\| - \|Fc\|)^2 / \Sigma w\, \|Fo\|^2]^{1/2}$	0.035
Function minimized	$\Sigma w(\|Fo\| - \|Fc\|)^2$
λ (Å)	1.542
F000	896.0
T (K)	293
Max. θ	120.1°
No. of unique reflections	1908
No. of refl. in refinement, No	1593 (I > 3σ)

Table 2. Selected bond distances (Å) for phospha sugar **7b**.

atom	atom	distance	atom	atom	distance
P(1)	O(1)	1.489(4)	C(6)	C(7)	1.50(1)
P(1)	C(1)	1.849(6)	P(1)	C(5)	1.814(6)
P(1)	C(15)	1.795(6)	O(2)	C(1)	1.424(6)
C(8)	C(14)	1.47(1)	O(2)	C(6)	1.360(7)

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(continued)

C(9)	C(13)	1.52(1)	O(3)	C(2)	1.450(7)
C(11)	C(12)	1.48(1)	O(3)	C(8)	1.343(8)
O(4)	C(3)	1.440(7)	C(2)	C(3)	1.512(8)
O(4)	C(9)	1.355(7)	O(5)	C(4)	1.441(7)
O(5)	C(11)	1.365(7)	O(6)	C(11)	1.191(7)
O(7)	C(9)	1.172(7)	O(8)	C(6)	1.179(7)
O(9)	C(8)	1.19(1)	C(1)	C(2)	1.509(8)
C(3)	C(4)	1.526(9)	C(4)	C(5)	1.512(8)

Table 3. Selected bond angles (°) for phospha sugar 7**b**.

atom	atom	atom	angle	atom	atom	atom	angle
O(1)	P(1)	C(1)	111.8(3)	O(1)	P(1)	C(5)	112.5(2)
C(1)	P(1)	C(5)	100.9(3)	C(3)	C(4)	C(5)	113.8(5)
C(1)	O(2)	C(6)	117.0(5)	C(3)	O(4)	C(9)	117.6(5)
P(1)	C(5)	C(4)	106.4(4)	P(1)	O(1)	O(2)	106.3(4)
P(1)	C(1)	C(2)	108.2(4)	O(2)	C(1)	C(2)	110.5(5)
C(1)	C(2)	C(3)	112.1(5)	C(2)	C(3)	C(4)	110.9(5)

Table 4. Selected torsion angles (°) for phospha sugar 7**b**.

P(1)	C(1)	C(2)	C(3)	62.8(6)	P(1)	C(5)	C(4)	O(5)	173.0(4)
P(1)	C(5)	C(4)	C(3)	-64.3(6)	O(1)	P(1)	C(1)	C(2)	63.1(4)
O(1)	P(1)	C(5)	C(4)	-63.2(5)	C(2)	C(1)	P(1)	O(15)	-173.8(4)
O(2)	C(1)	P(1)	C(5)	-175.4(4)	O(2)	C(1)	C(2)	O(3)	-60.6(6)
C(2)	C(3)	C(4)	C(5)	66.7(7)	C(1)	P(1)	C(5)	C(4)	56.1(5)
C(1)	C(2)	C(3)	C(4)	-64.9(7)	C(2)	C(1)	P(1)	C(5)	-56.7(4)
C(2)	C(1)	P(1)	C(15)	-173.8(4)	C(4)	C(5)	P(1)	C(15)	167.5(4)

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Received on July 4, 2000