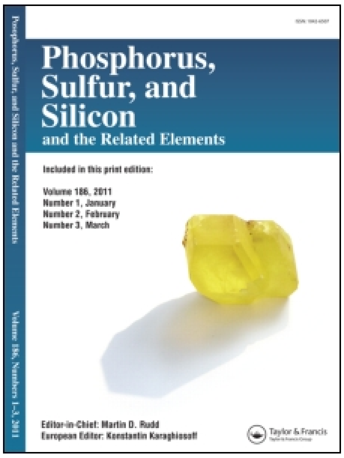

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K. Michał Pietrusiewicz[a]; Wanda Wieczorek[b]; Andrea Goti[c]; Alberto Brandi[c]
[a] The Polish Academy of Sciences, Centre of Molecular and Macromolecular Studies, Łódź, Poland [b] Institute of General Chemistry, Technical University of Łódź, łódź, Poland [c] Centro dei Composti Eterociclici-C.N.R., Dipartimento di Chimica Organica "Ugo Schiff", Universita di Firenze, Firenze, Italy

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K. MICHAŁ PIETRUSIEWICZ*
The Polish Academy of Sciences, Centre of Molecular and Macromolecular Studies, Sienkiewicza 112, 90-363 Łódź, Poland

and

WANDA WIECZOREK
Institute of General Chemistry, Technical University of Łódź, Żwirki 36, 90-924 Łódź, Poland

and

ANDREA GOTI and ALBERTO BRANDI*
Centro dei Composti Eterociclici-C.N.R., Dipartimento di Chimica Organica "Ugo Schiff", Universita di Firenze, via G. Capponi 9, 50121 Firenze, Italy

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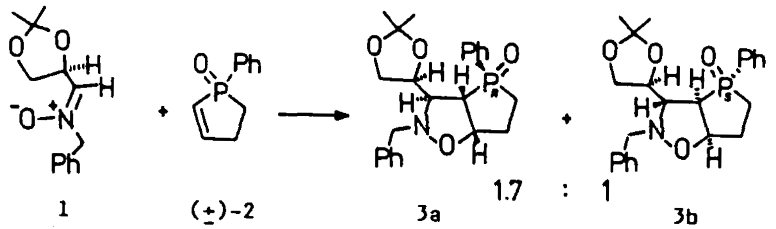
The structure and absolute configuration of homochiral 2-benzyl-3-(2,2-dimethyl-1,3-dioxolan-4-yl)-4-phenylhexahydro-4*H*-phospholo-[2,3-*d*]isoxazole 4-oxide obtained in predominance from racemic 2,3-dihydro-1-phenyl-1*H*-phosphole 1-oxide and *D*-glyceraldehyde derived nitrone in the process of kinetic resolution was analyzed by a single-crystal X-ray diffraction technique. $C_{23}H_{28}NO_4P$, monoclinic, space group $P2_1$, $a = 5.7646(4)$ Å, $b = 8.7280(4)$ Å, $c = 21.3417(9)$ Å, $\beta = 92.828(5)°$, $V = 1072.464(5)$ $Å^3$, $Z = 2$. The structure was solved by direct methods and was refined by full matrix least-squares calculations to $R = 0.034$ and $R_w = 0.041$ using 2282 unique reflections with $I > 3\sigma(I)$. The absolute configuration was determined by Hamilton method and was found to be 3*S*, 3a*S*, 4*R*, 6a*S*, 4'*S*. All the three five-membered rings in the studied molecule assumed a deformed envelope conformation and the planes of the two fused rings are found to form a dihedral angle of 59.3(1)°. One intramolecular and one intermolecular short contacts of the C—H···O nature were revealed.

Key words: Phospholene oxide; 1,3-dipolar cycloaddition; enantiomeric C—P heterocycle; absolute configuration; X-ray analysis; C—H···O short contacts.

INTRODUCTION

In our recent studies we have demonstrated that cycloadditions of nitrones to P-chiral and P-prochiral vinylphosphine derivatives can lead to the formation of the stereoisomeric 5-phosphinyl isoxazolidines in a highly stereoselective and predictable manner.[2] As we have subsequently found, making such cycloadditions doubly asymmetric by using the two reactants in the "matched" enantiomeric forms leads to a further increase of selectivity which has eventually been shown to reach a practical 46:1 level securing convenient access to the homochiral 5-phosphinyl isoxazolidines.[3]

In an attempt to similarly assess the level of asymmetric induction to analogous cycloadditions leading to 4-phosphinyl isoxazolidines we choose to study[1] the reaction of (*S*)-Z-*N*-(2,2-dimethyl-1,3-dioxolan-4-yl)methylenebenzylamine *N*-oxide (**1**) with racemic 2,3-dihydro-1-phenyl-1*H*-phosphole 1-oxide (**2**), expected to yield the desired 4-regioisomer exclusively[4] and in the form of the fused C—P heterocycles containing five contiguous stereogenic centers. As depicted in the Equation below, the studied cycloaddition afforded a 1.7:1 mixture of only two stereoisomeric cycloadducts **3a** and **3b**, originating from the *R* and *S* enantiomer of **2**, respectively, and thus made an interesting case of kinetic resolution.[5] These stereochemical conclusions based originally on spectal data[1] were subsequently corroborated by the isolation of small amounts of the unreacted phospholene oxide in the optically active form,[1] and were also supported by a single-crystal X-ray diffraction experiment on **3a**. The details of this experiment including the pertinent configurational assessment will be presented in the following report. To the best of our knowledge the report will provide the first collection of the crystallographic data for the perhydrophospholo[2,3-*d*]-isoxazole ring system.



1 (±)-2 3a 3b

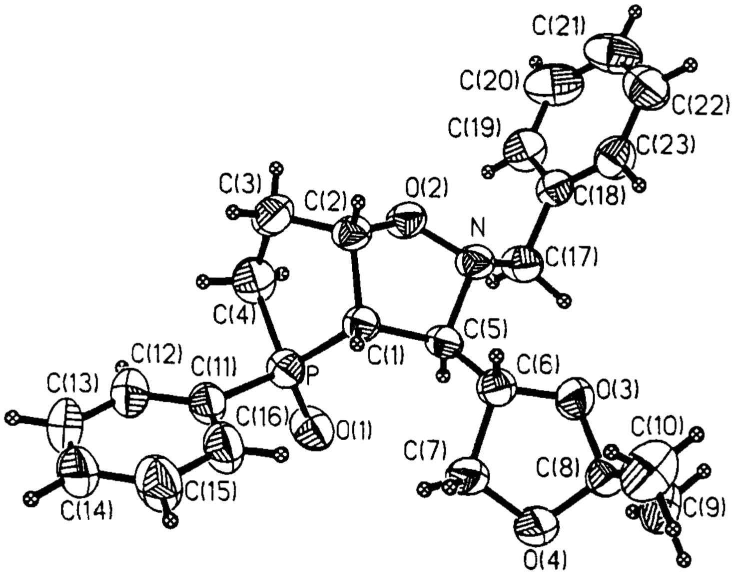


FIGURE 1 ORTEP drawing of **3a** showing 50% probability elipsoids with arbitrary atom numbering.

RESULTS AND DISCUSSION

The molecular structure of **3a** is displayed in Figure 1 which shows also its absolute configuration. According to the Cahn-Ingold-Prelog rules[6] the found configuration is 1*S*, 2*S*, 5*S*, 6*S* and P*R*, expectedly corresponding at C6 with the chirality of the starting nitrone.

Inspection of the bond angles which are collected in Table I reveals that the phosphorus tetrahedron in **3a** is deformed showing increased O—P—C angles and decreased C—P—C angles with the corresponding values ranging from 113.0(1) to 116.3(1)°, and from 96.4(1) to 107.6(1)°, respectively. The most distorted is the endocyclic C1—P—C4 angle. The found bond lengths which are listed in Table II represent rather typical values and require no comments.

The analysis of conformational features of **3a** revealed in turn that all three

TABLE I

Bond angles (°) in **3a** with estimated standard deviations

C1	-P	-O1	116.3(1)	C4	-P	-O1	115.8(1)
C4	-P	-C1	96.4(1)	C11	-P	-O1	113.0(1)
C11	-P	-C1	106.1(1)	C11	-P	-C4	107.6(1)
C2	-O2	-N	102.7(2)	C8	-O3	-C6	107.2(2)
C8	-O4	-C7	108.3(2)	C5	-N	-O2	102.2(2)
C17	-N	-O2	104.3(2)	C17	-N	-C5	111.8(2)
C2	-C1	-P	105.0(1)	C5	-C1	-P	113.3(1)
C5	-C1	-C2	103.9(2)	C1	-C2	-O2	102.8(2)
C3	-C2	-O2	107.9(2)	C3	-C2	-C1	111.0(2)
C4	-C3	-C2	107.8(2)	C3	-C4	-P	103.8(2)
C1	-C5	-N	103.2(1)	C6	-C5	-N	111.4(2)
C6	-C5	-C1	111.1(2)	C5	-C6	-O3	110.8(2)
C7	-C6	-O3	102.8(2)	C7	-C6	-C5	112.6(2)
C6	-C7	-O4	105.5(2)	O4	-C8	-O3	103.6(2)
C9	-C8	-O3	109.3(2)	C9	-C8	-O4	108.8(2)
C10	-C8	-O3	111.0(2)	C10	-C8	-O4	111.3(2)
C10	-C8	-C9	112.5(2)	C12	-C11	-P	121.2(2)
C16	-C11	-P	120.3(2)	C16	-C11	-C12	118.3(2)
C13	-C12	-C11	120.5(3)	C14	-C13	-C12	120.3(2)
C15	-C14	-C13	120.0(2)	C16	-C15	-C14	120.0(3)
C15	-C16	-C11	120.8(2)	C18	-C17	-N	111.9(2)
C19	-C18	-C17	119.8(2)	C23	-C18	-C17	120.8(2)
C23	-C18	-C19	119.4(2)	C20	-C19	-C18	120.7(3)
C21	-C20	-C19	119.9(3)	C22	-C21	-C20	120.3(3)
C23	-C22	-C21	119.3(3)	C22	-C23	-C18	120.4(2)

TABLE II

Bond lengths (Å) in **3a** with estimated standard deviations

O1	---P	1.485(2)	C1	---P	1.844(2)
C4	---P	1.811(3)	C11	---P	1.813(2)
N	---O2	1.468(2)	C2	---O2	1.420(3)
C6	---O3	1.429(3)	C8	---O3	1.424(3)
C7	---O4	1.407(3)	C8	---O4	1.421(3)
C5	---N	1.489(3)	C17	---N	1.467(3)
C2	---C1	1.544(3)	C5	---C1	1.536(3)
C3	---C2	1.518(3)	C4	---C3	1.540(4)
C6	---C5	1.512(3)	C7	---C6	1.538(3)
C9	---C8	1.500(4)	C10	---C8	1.517(3)
C12	---C11	1.387(3)	C16	---C11	1.387(3)
C13	---C12	1.400(4)	C14	---C13	1.362(5)
C15	---C14	1.380(4)	C16	---C15	1.391(3)
C18	---C17	1.508(3)	C19	---C18	1.386(4)
C23	---C18	1.364(3)	C20	---C19	1.384(5)
C21	---C20	1.372(5)	C22	---C21	1.382(5)
C23	---C22	1.408(4)			

TABLE III

Crystal data and experimental parameters

Molecular formula	$C_{23}H_{28}NO_4P$
M_r	413.45
Space group	$P2_1$
a(Å)	5.7646(4)
b(Å)	8.7280(4)
c(Å)	21.3417(9)
β(°)	92.828(5)
V(Å^3)	1072.464(5)
Z	2
F(000)	440
D_x(Mg m^{-3})	1.280(3)
D_m(Mg m^{-3})	1.27(2)
μ(CuKα) (cm^{-1})	13.55

TABLE III (*Continued*)

Radiation	CuKα
Scan mode	ω–2θ
2θ range	1–55°
Reflections measured	2582
Reflections with $I > 2\sigma(I)$	2282
R	0.034
R_w	0.041
R^-	0.045
R_w^-	0.058

heterocyclic five-membered rings (P—C1—C2—C3—C4, N—O2—C2—C1—C5 and O3—C6—C7—O4—O8) assume a deformed envelope conformation with the C3, O2 and C8 atoms out of the corresponding ring planes. The found deviations of the C3, O2 and C8 atoms from the corresponding four-atom planes of their rings are −0.574(2), −0.687(2) and 0.497(2) Å, respectively, and the average puckering of the rings $|\Phi|$ av. is 26.1, 32.2 and 23.3°, respectively. The asymmetry parameters[7] of these rings in relation to their planes of symmetry are ΔC_s(P—C1) = 5.9, ΔC_s(C1—C5) = 10.1 and ΔC_s(C6—C7) = 8.8°. The planes P—C1—C2—C4 and C2—C1—C5—N of the two condensed five-membered rings form the dihedral angle of 59.3(1)°. In turn, the C2—C1—C5—N and O3—C6—C7—O4 planes of the isoxazolidine and dioxolane ring are almost ideally coplanar as indicated by the dihedral angle between them equal to 0.5(1)°. The coplanar arrangement of the two rings is probably imposed by the revealed C—H···O type[8] intramolecular interaction between C17—H172 and O3. The found H172···O3 distance is 2.48 Å, the C17···O3 distance is 3.130(3) Å and the C17—H172···O3 angle is 123°.

Inspection of the molecular packing revealed also that the molecules operated by translation along the *x* axis are connected by similar C—H···O hydrogen bonding involving C7—H71 and phosphoryl oxygen (O1). The corresponding H71···O1 and C7···O1 distances are equal to 2.48 and 3.314(3) Å, respectively, and the C7—H71···O1 angle is equal to 145°.

EXPERIMENTAL

The crystal of **3a** suitable for X-ray investigation was obtained by crystallization from petroleum ether. The cell parameters and intensities were measured on an Enraf-Nonius CAD 4 diffractometer. The accurate cell parameters were determined from a least-squares refinement of the $(\sin \theta/\lambda)^2$ values for 25 reflections. The measured intensities were corrected for Lorentz, polarization and absorption effects. The crystal data and experimental details are listed in Table III.

The structure was solved by direct methods using the SHELXS-86 program.[9] Positional and thermal parameters were refined by full-matrix least-squares by minimizing the function $\Sigma_w(F_o - F_c)^2$ with $w = 1/\sigma^2(F)$ for the observed reflections and $w = 0$ for the unobserved. All nonhydrogen atoms were refined with anisotropic thermal parameters. The hydrogen atoms were placed in geometrically cal-

TABLE IV

Positional parameters ($\times 10^5$) for the P atom and ($\times 10^4$) for the O, N and C atoms with estimated standard deviations

	x	y	z
P	43642(8)	30413(0)	86225(2)
O1	5894(3)	4384(3)	8533(1)
O2	3226(3)	1345(2)	7242(1)
O3	234(3)	5776(2)	6812(1)
O4	109(4)	7587(2)	7551(1)
N	2022(3)	2657(2)	6944(1)
C1	1883(3)	2824(2)	8050(1)
C2	2053(4)	1164(3)	7807(1)
C3	3574(5)	193(3)	8251(1)
C4	5649(5)	1185(4)	8486(1)
C5	2096(3)	3809(2)	7459(1)
C6	105(4)	4932(3)	7383(1)
C7	221(5)	6197(3)	7885(1)
C8	-662(3)	7266(3)	6922(1)
C9	440(5)	8390(4)	6496(1)
C10	-3293(4)	7279(5)	6847(2)
C11	3161(3)	2993(3)	9391(1)
C12	4278(6)	2220(4)	9887(1)
C13	3394(7)	2263(5)	10486(1)
C14	1459(6)	3100(4)	10592(1)
C15	328(6)	3882(5)	10105(1)
C16	1171(5)	3820(4)	9506(1)
C17	3504(4)	3103(3)	6435(1)
C18	3364(4)	1967(3)	5902(1)
C19	5217(4)	995(4)	5809(1)
C20	5140(6)	-36(5)	5316(2)
C21	3227(6)	-86(4)	4908(2)
C22	1365(5)	875(5)	4992(1)
C23	1450(4)	1903(3)	5501(1)

culated positions and refined in the riding mode. An empirical isotropic extinction correction was introduced and the parameter x was refined to the value of 0.028(4). Refinement was terminated when the maximum shift in any parameter was less than 0.1σ. The final difference Fourier map did not show any peaks higher than 0.27 eÅ^{-3}. Computations were performed with SHELX-76 crystal structure determination program[10] on an AMSTRAD 1512 minicomputer. The final positional parameters for all nonhydrogen atoms of **3a** are listed in Table IV.

The absolute configuration of the studied molecule was determined by Hamilton method.[11] The model of the structure with reversed signs of all the positional atom parameters were refined as described above. The resulting R_w^- values of 0.045 and 0.058 showed that the model with inverse configuration had to be rejected with very high probability. The $R(R_w)$ ratio $= R^-/R^+ (R_w^-/R_w^+) = 1.323(1.415)$ for $N = 1992$. According to the Pearson and Hartley tables of R-ratio values[12] as the function of the significance level α and number of independent parameters N, for a one-dimensional hypothesis, the significance level was $\alpha < 10^{-6}$.

Atomic coordinates for the structure have been deposited with the Cambridge Crystallographic Data Centre. The coordinates can be obtained from the Cambridge Crystallographic Data Centre, University Chemical Laboratory, Lensfield Road, Cambridge, CB2 1EW, UK.

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REFERENCES

1. Part 14: A. Goti, S. Cicchi, A. Brandi and K. M. Pietrusiewicz, *Tetrahedron: Asymmetry,* **2**, 1371 (1991).
2. A. Brandi, S. Cicchi, A. Goti, K. M. Pietrusiewicz, M. Zabłocka and W. Wiśniewski, *J. Org. Chem.*, **56**, 4383 (1991); A. Brandi, P. Cannavo, K. M. Pietrusiewicz, M. Zabłocka and W. Wieczorek, *J. Org. Chem.*, **54**, 3073 (1989).
3. A. Brandi, S. Cicchi, A. Goti and K. M. Pietrusiewicz, *Tetrahedron: Asymmetry,* **2**, 1063 (1991).
4. A. Brandi, S. Cicchi, A. Goti, K. M. Pietrusiewicz and W. Wiśniewski, *Tetrahedron*, **46**, 7093 (1990).
5. For a recent review on theoretical and practical aspects of kinetic resolution, see: H. B. Kagan and J. C. Fiaud in *Topics in Stereochemistry,* E. L. Eliel and S. H. Wilen, Eds.; Interscience, New York, 1988, Vol. 18, pp. 249–330.
6. R. S. Cahn, C. K. Ingold and V. Prelog, *Angew. Chem.*, **78**, 413 (1966); V. Prelog and G. Helmchen, *Angew. Chem., Int. Ed. Engl.*, **21**, 567 (1982).
7. W. L. Duax and D. A. Norton, *Atlas of Steroid Structure,* Plenum Press, New York, 1975.
8. R. Taylor and O. Kennard, *J. Am. Chem. Soc.*, **104**, 5063 (1982).
9. SHELXS-86: G. M. Sheldrick, C. Krüger and R. Goddard, *Crystallographic Computing 3,* Oxford University Press, 1985, pp. 175–189.
10. G. M. Sheldrick, *SHELX 76. Program for Crystal Structure Determination,* University of Cambridge, England, 1976.
11. W. C. Hamilton, *Acta Cryst.*, **18**, 502 (1965).
12. E. S. Pearson and H. O. Hartley, *Biometrica Tables for Statistitians,* 3rd ed., Cambridge University Press, 1966, Vol. 1, Table 18.