

# Crystal and Molecular Structure of 14-Hydroxy-strychnobrasiline

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The crystal and molecular structure of 14-hydroxy-strychnobrasiline has been determined at 121 K by X-ray crystallographic methods using 1133 reflections observed by counter methods. The crystals are orthorhombic, space group  $P2_12_12_1$  with unit cell dimensions  $a=6.891(3)\text{Å}$ ,  $b=9.021(3)\text{Å}$ ,  $c=29.782(12)\text{Å}$ . The structure was refined to a conventional  $R$ -factor of 6.5. Estimated standard deviations are  $0.01\text{ Å}$  and  $0.9^\circ$  in interatomic distances and angles when hydrogen atoms are not involved. The structure displays a transanular N...C=O distance of  $2.24\text{ Å}$ .

The crystallographic investigation of the present compound was initiated by the wish to identify the position of 14-OH group.<sup>1</sup> However, a transanular interaction between the N4 nitrogen and the C3 carbon atom has been indicated by spectrographic methods in strychno-brasiline itself<sup>2</sup> and in view of the description of such

interactions given by Dunitz<sup>3</sup> a closer study of the geometrical structure of the molecule was considered to be of interest.

## EXPERIMENTAL AND STRUCTURE SOLUTION

About 3 mg, representing the total sample, was recrystallized from acetone by evaporation. The compound separated from the acetonic solution as elongated, plateformed, colourless crystals. The largest piece of a single crystal in the recrystallized sample was measured to be about  $0.3\times 0.3\times 0.1\text{ mm}$  and used for the collection of the X-ray data. The general data of the experimental procedure is given in the table below.

Cell parameters were determined by least squares fit to the diffractometer settings for 15 general reflections. The intensity data were corrected for Lorentz and polarization effects and

## EXPERIMENTAL CONDITIONS

Instrument  
Radiation

Crystal dimensions/mm

Scanning mode

Scan speed/ $^\circ\text{ min}^{-1}$

Scan range/ $^\circ$

Background counts

Temperature/K

$2\theta$  range/ $^\circ$

Number of reflections measured

Number of reflections  $I>3\sigma(I)$

Number of standard reflections

Number of reflections between standard reflections

SYNTEX P1

Graphite crystal

monochromated  $\text{MoK}\alpha$

$\lambda=0.71069\text{ Å}$

$0.3\times 0.3\times 0.1$

$\theta/2\theta$

3.0

$2\theta_{\alpha_1}-0.8$  to  $2\theta_{\alpha_1}+1.0$

For 0.35 of scan time at scan limits

121

2.0–50.0

1930

1133

3

57

Table 1. Fractional atomic coordinates. Estimated standard deviations in parentheses.

Atom	x	y	z
O1	0.2019(9)	0.0190(6)	0.8975(1)
O2	0.6812(10)	0.4465(6)	0.8025(1)
O3	0.7601(9)	0.1583(7)	0.7913(2)
O4	0.1729(10)	0.4502(7)	1.0007(2)
N1	0.3393(12)	0.3780(8)	0.9386(2)
N4	0.3426(13)	0.2859(8)	0.7881(2)
C2	0.3665(14)	0.2983(10)	0.8951(2)
C3	0.5997(13)	0.3602(11)	0.8284(3)
C5	0.1970(14)	0.4023(10)	0.8043(3)
C6	0.3061(15)	0.5064(9)	0.8387(2)
C7	0.4618(13)	0.4181(10)	0.8641(2)
C8	0.5637(13)	0.5134(9)	0.8991(3)
C9	0.7082(16)	0.6168(10)	0.8932(3)
C10	0.7807(15)	0.6970(10)	0.9308(3)
C11	0.6969(18)	0.6682(10)	0.9726(3)
C12	0.5531(16)	0.5660(11)	0.9792(2)
C13	0.4832(14)	0.4864(9)	0.9414(2)
C14	0.6833(15)	0.2063(10)	0.8335(2)
C15	0.5407(14)	0.0959(10)	0.8544(2)
C16	0.4764(13)	0.1558(10)	0.9012(3)
C17	0.3673(14)	0.0294(10)	0.9241(2)
C18	0.2580(15)	0.0715(10)	0.8530(2)
C19	0.0763(13)	0.1299(10)	0.8304(3)
C20	0.3632(13)	0.0576(10)	0.8299(2)
C21	0.2621(15)	0.1419(10)	0.8001(2)
C22	0.3933(14)	0.3023(10)	0.7400(3)
C23	0.1780(17)	0.3799(10)	0.9659(3)
C24	0.0026(15)	0.2935(11)	0.9500(2)

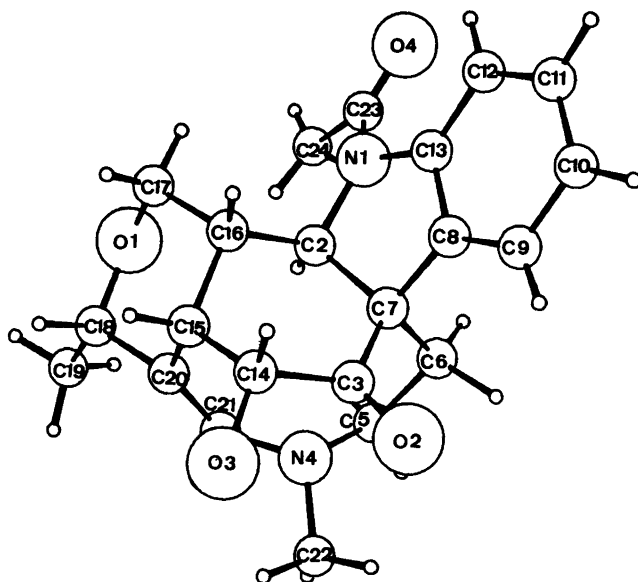


Fig. 1. 14-hydroxy-strychnobrasiline. Mirror image of the absolute configuration of the natural compound.

scattering factors used were those of Doyle and Turner<sup>4</sup> for O, N and C and of Steward, Davidson and Simpson<sup>5</sup> for H.

The structure was solved by direct methods using the program assembly MULTAN-80<sup>6</sup> and refined to a conventional *R*-factor of 0.065 and a goodness of fit  $S=(\sum w\Delta^2/m-n)^{1/2}=1.8$ . The hydrogen atoms were introduced from stereochemical considerations, except for the hydrogen atom at O3. The position of this hydrogen atom could not be determined from the data, nor guessed from the structure. The atomic coordinates for the non-hydrogen atoms are given in Table 1. Temperature factors as well as tables of observed and calculated structure factors are available from the author.

#### CRYSTAL DATA

14-hydroxy-strychnobrasiline.  $C_{22}N_2O_4H_{26}$ , orthorhombic,  $a=6.891(3)$  Å,  $b=9.021(3)$  Å,  $c=29.782(12)$  Å,  $V=1851.2$  Å<sup>3</sup>;  $M=382$ ;  $Z=4$ ;  $F(000)=816$ . Space group No. 19:  $P2_12_12_1$ .

#### DESCRIPTION AND DISCUSSION

Bond lengths and angles are given in Table 2 and some torsional angles are listed in Table 3. A drawing of the molecule as it appears in the crystal when seen down the *a*-axis is given in Fig. 1 where the numbering of the atoms is also indicated.

The packing of the molecules in the investigated crystals is illustrated in Fig. 2 as seen down the *a*-axis.

Even if the limited data have not allowed the position of the O3-hydrogen atom to be defined, there seem to be no intermolecular hydrogen bonds in the present crystal structure as the shortest distance from O3 to a non-hydrogen atom in a neighbour molecule is 3.506 Å (O3...C22). Thus the molecular packing appears to be governed by van der Waals' forces only, the shortest intermolecular contacts, except for the one mentioned above, are O4...C24:3.49 Å O4...C16:3.36 Å.

The most interesting part of the present study is the molecular conformation. The benzene ring

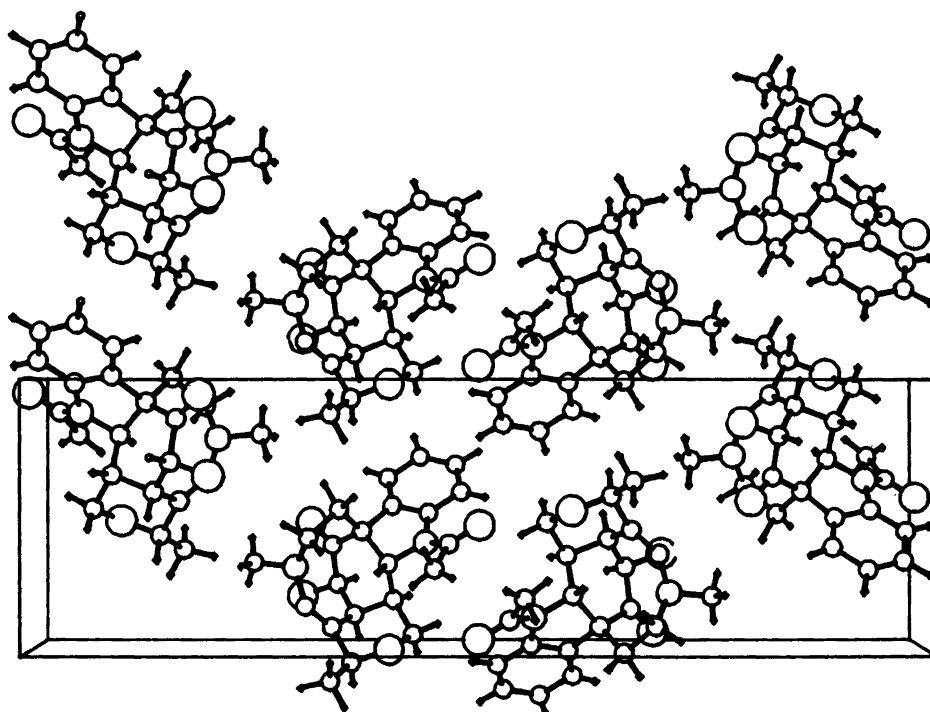


Fig. 2. Molecular packing of 14-OH-strychnobrasiline molecules in the crystal as seen down the *a*-axis.

Table 2. Bond lengths and angles in 14-OH-strychnobrasiline.

Distance	(Å)	Distance	(Å)
O1-C17	1.46(1)	O1-C18	1.46(1)
C18-C19	1.52(1)	C18-C20	1.53(1)
C20-C15	1.46(1)	C15-C16	1.56(1)
C16-C17	1.53(1)	C16-C2	1.50(1)
C2-C7	1.57(1)	C7-C3	1.52(1)
C3-O2	1.23(1)	C3-C14	1.51(1)
C14-O3	1.43(1)	C14-C15	1.53(1)
C20-C21	1.36(1)	C21-N4	1.46(1)
N4-C22	1.48(1)	N4-C5	1.53(1)
C5-C6	1.58(1)	C6-C7	1.54(1)
C7-C8	1.52(1)	C8-C9	1.38(1)
C9-C10	1.42(1)	C10-C11	1.40(1)
C11-C12	1.37(1)	C12-C13	1.42(1)
C13-C8	1.40(1)	C13-N1	1.40(1)
N1-C2	1.49(1)	N1-C23	1.38(1)
C23-O4	1.22(1)	C23-C24	1.51(1)

Angle	(°)	Angle	(°)
C17-O1-C18	112.6(7)	O1-C18-C19	107.3(8)
O1-C18-C20	106.6(7)	C18-C20-C15	110.5(8)
C18-C20-C21	118.3(9)	C19-C18-C20	117.1(8)
C20-C15-C16	106.8(8)	C20-C15-C14	119.2(7)
C20-C21-N4	117.6(9)	C15-C16-C17	106.3(8)
C15-C16-C2	109.3(7)	C16-C17-O1	111.4(7)
C15-C14-O3	113.4(8)	C15-C14-C3	113.2(8)
C16-C2-N1	111.7(7)	C16-C2-C7	116.8(8)
C21-C4-C22	114.6(7)	C21-N4-C5	106.5(7)
C22-N4-C5	113.1(7)	N4-C5-C6	107.5(8)
C5-C6-C7	110.1(8)	C6-C7-C8	111.5(8)
C6-C7-C2	110.8(8)	C6-C7-C3	105.7(7)
C14-C3-C7	119.0(9)	C14-C3-O2	118.0(9)
O3-C14-C3	109.3(8)	O2-C3-C7	120.5(9)
C3-C7-C2	116.0(8)	C3-C7-C8	112.6(8)
C7-C8-C9	129.0(9)	C7-C8-C13	109.6(8)
C7-C2-N1	103.4(7)	C2-N1-C13	107.5(7)
C2-N1-C23	128.2(9)	N1-C23-O4	122.2(10)
N1-C23-C24	117.0(9)	O4-C23-C24	120.7(10)
N1-C13-C8	110.5(8)	N1-C13-C12	130.1(9)
C8-C9-C10	119.9(9)	C9-C10-C11	117.5(9)
C10-C11-C12	123.6(9)	C11-C12-C13	118.3(9)
C12-C13-C8	119.4(9)	C13-C8-C9	121.3(9)
C13-N1-C23	122.0(8)	C22-N4...C3	107.6(6)
C5-N4-C3	98.2(6)	C21-N4...C3	115.8(7)

and its two substituents C7 and N1 is planar within the accuracy of the structure determination, but the five-membered ring exhibits an envelope conformation, the N1,C2,C7 plane having an angle of about 28° with the benzene

ring plane. The C2 atom is thus 0.43 Å out of the aromatic plane, and the torsion angles about the N1-C13 bond (C12-C13-N1-C2) and the C7-C8 bond (C9-C8-C7-C2) are -162 and 164° respectively. The N1 atom is found to be

Table 3. Some torsional angles in 14-OH-strychnobrasiline in the crystal state.

Dihedral angle	(°)
C12–C13–N1–C23	33.6
C12–C13–N1–C2	-162.3
C13–N1–C23–O4	-19.1
C13–N1–C2–C7	-28.4
C2–N1–C23–C24	-1.4
C2–N1–C23–O4	-179.6
C10–C9–C8–C7	178.5
C9–C8–C7–C2	163.7
N1–C2–C7–C8	27.4
C5–N4–C21–C20	-116.6
C21–N4–C5–C6	120.7
C22–N4–C5–C6	-112.6
C22–N4–C21–C20	117.6
O2–C3–C7–C2	179.9
O2–C3–C7–C6	56.7
O2–C3–C7–C8	-65.2
O2–C3–C14–O3	-34.9
O2–C3–C14–C15	-162.3
C7–C3–C14–O3	163.2
C7–C3–C14–C15	35.7
C14–C3–C7–C2	-18.6
C14–C3–C7–C6	-141.8
C14–C3–C7–C8	96.3
N4–C5–C6–C7	-31.8
C5–C6–C7–C3	59.9
O3–C14–C15–C16	176.8
O3–C14–C15–C20	-60.6
C3–C14–C15–C20	60.6
C14–C15–C20–C21	-28.5
C15–C20–C21–N4	4.2

situated 0.13 Å out of the plane through atoms C2, C13 and C23 and for this reason as well as because of the twist about the N1–C13 bond, C23 is 0.66 Å out of the aromatic plane (C12–C13–N1–C23: 33.6°). However, whereas the torsion angle C13–N1–C23–O4 is -19° it may be seen from Table 3 that the atom group C2, N1, C23, C24 and O4 is close to planarity, the deviations from a least squares plane through this atoms being less than 0.01 Å (C23).

The pyranose ring is in a normal chair conformation with C17 and C20 about 0.7 Å on each side of the plane through C15, C16, C18 and O1. The angle between the planes O1, C17, C16 and C15, C18, C20 is 6.2°.

The conformation of the cyclohexane ring and the interconnected nine-membered ring (N4, C5, C6, C7, C3, C14, C15, C20, C21) seem to be influenced by the transannular interaction between N4 and C3=O. The distance between N4 and C3 is found to be 2.24 Å indicating a strong interaction between these two atoms. A number of similar interactions has been reviewed by Dunitz<sup>2</sup> and interpreted as examples of nucleophilic attacks by the nitrogen atom on the C=O group.

In this context the present study is of some interest as it presents an example of the interaction in question involving a nine-membered ring whereas the other examples referred to by Dunitz include eight- and ten-membered rings.

In the present structure the N4 atom is 0.44 Å

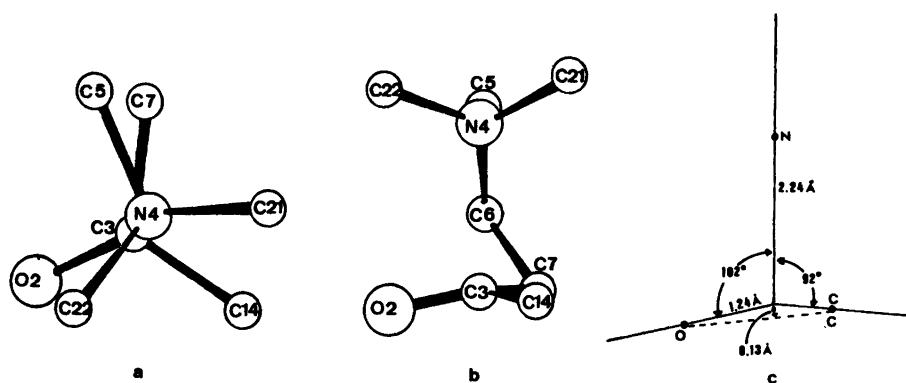


Fig. 3. Geometry of the N4...C=O interaction. a: View along the N4–C3 direction. The relative rotation of the two groups about this direction is 30°. b: The position of the atoms in a projection in the O2–C3–N4 plane. c: The geometry of the N–C=O interaction.

out of the plane through atoms C5, C21, C22 in the direction towards the C3 carbon atom, and the sum of angles about N4 is  $334^\circ$  indicating  $sp^3$  conditions at this atom. Similarly the C3 atom is  $0.13 \text{ \AA}$  out of the O2, C7, C14-plane and in the direction of the N4-atom. The lone pair of the N4 atom points in the general direction of the C3 atom, the angle between the direction of the lone pair and the N4-C3 direction being about  $13^\circ$ . The rotation of the C3, C7, C14, O2 group about the C3-N4 direction relative to the N4, C5, C22, C21 group is close to  $30^\circ$  and the angle between the C5, C21, C22 plane and the plane through atoms O2, C7, C14 is  $12^\circ$ . The geometry of the two interacting groups is also depicted in Fig. 3. From the equations suggested by Dunitz the N...C distance of  $2.24 \text{ \AA}$  should correlate with an "out of the plane" distance for C3 of  $0.16 \text{ \AA}$  whereas the value found in the present work is  $0.13 \text{ \AA}$ .

It may be noticed that an "out of plane" situation is also found in the C20, C18, C21, C15 group where C20 is  $0.14 \text{ \AA}$  out of the plane through C18, C21, C15.

The conformation of the cyclohexane ring (C2, C7, C3, C14, C15, C16) is that of a twisted chair, the angles between the planes (C15, C16, C7) and (C7, C3, C15) being about  $26^\circ$ .

If one assume a "bond" between N4 and C3 the nine-membered ring may be considered to consist of a fused five-membered ring (N4, C3, C7, C6, C5) and a six-membered ring (N4, C3, C14, C15, C20, C21). The five-membered "ring" is in a normal envelope conformation, the C3, N4, C5, C6 group being planar within  $0.047 \text{ \AA}$  and C7  $0.75 \text{ \AA}$  out of this plane. The six-membered "ring" is found to be in a flattened chair conformation, the atoms C15, C20, N4, C3 being planar within  $0.04 \text{ \AA}$  and C14 and C21 being out of the plane by  $-0.71$  and  $0.10 \text{ \AA}$  respectively.

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