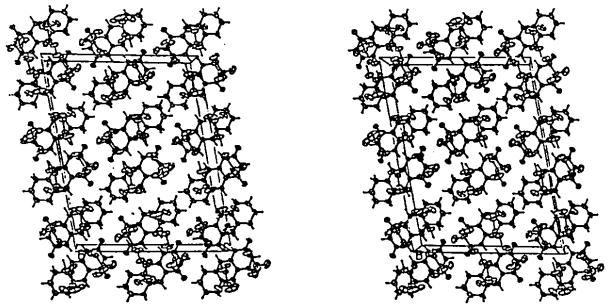

Fig. 2. An *ORTEP* (Johnson, 1970) stereodrawing showing the crystal packing. View is down the *b* axis.

References

ALCOCK, N. W. (1970). *Crystallographic Computing*, edited by F. R. AHMED, pp. 271–288. Copenhagen: Munksgaard.

BUSING, W. R., MARTIN, K. O. & LEVY, H. A. (1964). *ORFFE*. Report ORNL-TM-306. Oak Ridge National Laboratory, Tennessee.

FUREY, W. JR (1979). *SORAVE, FSFOUR*. Unpublished.

FUREY, W. JR (1984). *QWKREF. Methods and Applications in Crystallographic Computing*, edited by S. R. HALL & T. ASHIDA, pp. 353–371. Oxford: Clarendon Press.

GANGJEE, A., OHEMENG, K. O., TULACHKA, J. J., LIN, F. T. & KATOH, A. (1985). *J. Heterocycl. Chem.* **22**, 1149.

International Tables for X-ray Crystallography (1974). Vol. IV. Birmingham: Kynoch Press. (Present distributor D. Reidel, Dordrecht.)

IRWIN, W. J. & WIBBERLEY, D. G. (1969). *Adv. Heterocycl. Chem.* **10**, 149–198.

JOHNSON, C. K. (1970). *ORTEP*II. Report ORNL-3794, 2nd revision. Oak Ridge National Laboratory, Tennessee.

MAIN, P., HULL, S. E., LESSINGER, L., GERMAIN, G., DECLERCQ, J.-P. & WOOLFSON, M. M. (1978). *MULTAN*78. *A System of Computer Programs for the Automatic Solution of Crystal Structures from X-ray Diffraction Data*. Univs. of York, England, and Louvain, Belgium.

PATERSON, T. & WOOD, H.C.S. (1972). *J. Chem. Soc. Perkin Trans.* 1, pp. 1041–1050.

SHIONO, R. (1971). Tech. Rep. 49. Dept. of Crystallography, Univ. of Pittsburgh.

STARK, E. & BREITMAIER, E. (1973). *Tetrahedron*, **29**, 2209–2217.

TAYLOR, E. C. & FLETCHER, S. R. (1984). *J. Org. Chem.* **49**, 3226–3227.

WOOD, H. C. S., WRIGGLESWORTH, R., YEOWELL, D. A., GURNEY, F. W. & HURLBERT, B. (1974). *J. Chem. Soc. Perkin Trans.* 1, pp. 1225–1230.

Acta Cryst. (1987). C**43**, 1562–1564

Structure of Cryptosin* Monohydrate – a New Cardioactive Glycoside

BY N. NARENDRA AND M. A. VISWAMITRA

Department of Physics and ICMR Centre on Genetics and Cell Biology, Indian Institute of Science, Bangalore 560 012, *India*

AND R. VENKATESWARA, K. SANKARA RAO AND C. S. VAIDYANATHAN

Department of Biochemistry, Indian Institute of Science, Bangalore 560 012, *India*

(*Received* 14 *October* 1986; *accepted* 13 *February* 1987)

Abstract. $C_{29}H_{40}O_{11}.H_2O$, $M_r = 582{\cdot}7$, orthorhombic, $P2_12_12_1$, $a = 9{\cdot}663\ (5)$, $b = 11{\cdot}723\ (1)$, $c = 25{\cdot}626\ (3)$ Å, $Z = 4$, $V = 2902{\cdot}9$ Å^3, $D_x = 1{\cdot}33$ Mg m^{-3}, $\lambda(\text{Cu } K\alpha) = 1{\cdot}5418$ Å, $\mu = 0{\cdot}9$ mm^{-1}, $F(000) = 1248$, $T = 295$ K, final R for 2273 observed reflections is 0·077. Cryptosin contains deoxyglucose, a steroid group and a lactone ring. The glucopyranose ring assumes a chair conformation. The steroid group shows the presence of an epoxy group unlike in other cardioactive compounds such as strophanthidin and digitoxigenin. The *A*/*B* and *C*/*D* ring junctions are *cis* as in other cardioactive steroids. The molecules pack in a network which contains three distinct hydrogen bonds.

*IUPAC name: 3β-(D-deoxyglucopyranosyloxy)-11β,14β-dihydroxy-7,8-epoxy-12-oxo-5β-card-20(22)-enolide.

0108-2701/87/081562-03$01.50

Introduction. Cryptosin – a new glycoside – was isolated from the leaves and *in vitro* cultured cells of the milkweed, *Cryptolepis buchanani* Roem. & Schult. at the Department of Biochemistry in our Institute. The compound demonstrates cardioactive properties (Venkateswara, Sankara Rao & Vaidyanathan, 1985).

The X-ray analysis was undertaken in view of its medicinal importance and also because there was some uncertainty regarding its actual chemical structure, particularly in the number of oxygens present (Fig. 1).

Experimental. Needle-shaped crystals were grown by evaporation of acetone solutions. Unit-cell parameters and space group were obtained from rotation and Weissenberg photographs. The cell parameters were refined by least-squares calculations from 21 high-angle reflections collected on a CAD-4 diffractometer. Cu $K\alpha$

intensity data were collected up to a θ limit of 70° using a crystal 0·19 × 0·013 × 0·025 mm in the ω–2θ scan mode. 2273 independent reflections out of 3162 were considered observed [$|F_o| > 3\sigma(|F_o|)$]. Two strong reflections monitored periodically during data collection showed crystal stable to X-rays, with variations less than 6%. The minimum and maximum *h, k, l* values are 0,11; 0,14 and 0,31 respectively. Lorentz and polarization corrections were applied. Absorption correction was not applied ($\mu = 0{\cdot}9$ mm^{-1}). The structure was solved by direct methods (Main, Fiske, Hull, Lessinger, Germain, Declercq & Woolfson, 1980). Structure factors were normalized using least-squares straight line through Debye curve. Steroid group was located in the *E* map with highest CFOM of 2·83. The remaining non-H atoms were located from successive difference Fourier maps. The H atoms, except for those of the hydroxyl groups (O'3H, O'4H, O'6H and O11H), were either located from difference Fourier maps or fixed wherever possible from geometrical considerations. Block-diagonal least-squares refinement (Shiono, 1965) using the Cruickshank (1961) weighting scheme gave a final *R* of 0·077 and *wR* of 0·112. The function minimized was $\sum w(|F_o|K - |F_c|)^2$, where $w = (a + b|F_o| + c|F_o|^2)$ with $a = 2F_{min} = 6{\cdot}81$, $b = 1{\cdot}0$ and $c = 2|F_{max} = 0{\cdot}01$. $S = 4{\cdot}26$. Scattering factors for non-H atoms were taken from Cromer & Waber (1965), for H atoms from Stewart, Davidson & Simpson (1965). Maximum shift/e.s.d. for non-H atoms was 0·26, and 0·54 including H atoms. The minimum and maximum residual electron densities in the final difference Fourier map were −0·35 and 0·36 e Å^{-3}. The high value of *R* may be due to the rather poor quality of the crystal (which was, however, the best available).

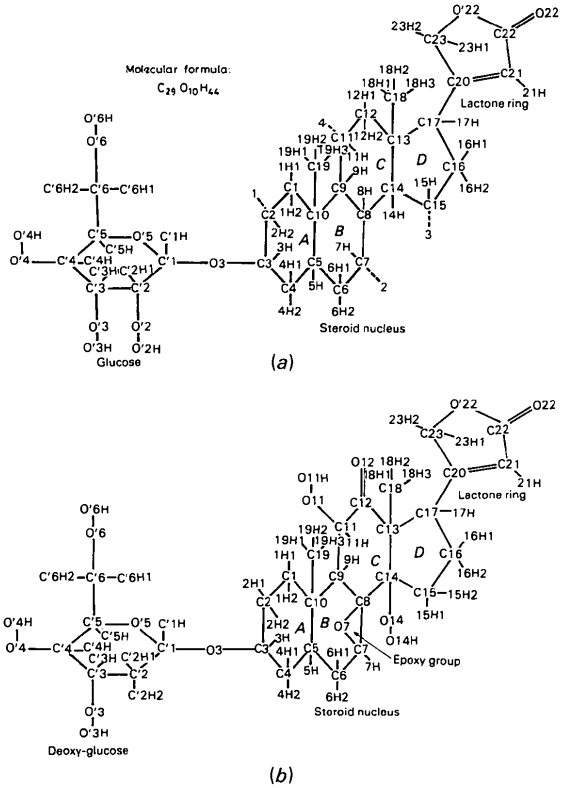

Fig. 1. (*a*) Chemical structure of cryptosin as known before X-ray analysis. Dotted lines indicate four possible positions for two hydroxyls. Molecular formula: $C_{29}H_{44}O_{10}$. (*b*) Chemical structure of cryptosin after X-ray analysis and atomic numbering. Molecular formula: $C_{29}H_{40}O_{11}$. The compound has 11 oxygens instead of the ten previously proposed. The presence of an epoxy group in the steroid nucleus was totally unexpected before the analysis.

Discussion. Atomic coordinates are in Table 1;* bond lengths are listed in Table 2. A schematic diagram of the molecule with atomic numbering is shown in Fig. 1(*b*). A stereoview of the cryptosin molecule is shown in Fig. 2.

Pyranose ring. Cryptosin contains hexose sugar (deoxyglucose) commonly found in cardioactive glycosides (Elderfield, 1945; Reichstein & Weiss, 1962; Overend & Stacey, 1953). The glycosidically bound sugar is believed to play a vital role in promoting cardiotonic activity (Schmid, Uehlinger, Tamn & Reichstein, 1959). The two endocyclic C–O bonds C'1–O'5 and C'5–O'5 are nearly equal [1·551(14), 1·543 (11) Å]. The anomeric C'1–O3 bond [1·418 (11) Å] is much shorter than the C'1–O'5 bond. The conformation about the exocyclic C'5–C'6 bond is *gauche–trans* with torsion angles O'6–C'6–C'5–O'5 = 86·5 (10)° and O'6–C'6–C'5–C'4 = −151·4 (9)°.

The glucopyranose ring assumes a chair conformation with C'4 and C'1 displaced from the C'2–C'3–C'5–O'5 plane by 0·676 (9) and −0·652 (9) Å respectively. Cremer & Pople (1975) puckering parameters are $Q = 0{\cdot}562$ (3) Å, $\theta = 6{\cdot}1$ (4)° and $\varphi = 169$ (3)°. The distortion from the perfect chair form is towards $B_{3,0}$ geometry (Stoddart, 1971).

Steroid group. The steroid group consists of four rings, labelled *A, B, C* and *D* (Fig. 1*b*). Interestingly the atoms C7, C8 and O7 form an epoxy group (Fig. 1*b*), unlike in other cardioactive compounds such as strophanthidin (Gilardi & Flippen, 1973) and digitoxigenin (Karle & Karle, 1969). Interior angles of the epoxy group have a mean value of 60·0°.

The presence of a hydroxyl group at C11 and C14 and a carbonyl oxygen at C12 are features which seem

* Lists of structure factors, anisotropic thermal parameters, H-atom parameters, bond and torsion angles, mean-plane calculations and hydrogen-bond distances have been deposited with the British Library Document Supply Centre as Supplementary Publication No. SUP 43789 (28 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

to be characteristic of cryptosin as they are not present in related compounds such as strophanthidin and digitoxigenin. The *A/B* and *C/D* ring junctions are *cis* as in other cardioactive compounds.

Table 1. *Fractional coordinates* ($\times 10^4$) *and equivalent isotropic temperature factors* ($\times 10$) *with e.s.d.'s in parentheses*

$B_{eq} = \frac{4}{3}\sum_i\sum_j \beta_{ij}\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	B_{eq}(Å^2)
C1	7250 (9)	1765 (7)	180 (3)	30 (2)
C2	8209 (10)	891 (7)	−51 (3)	33 (2)
C3	7914 (9)	−317 (7)	101 (3)	29 (2)
C4	7650 (9)	−414 (7)	686 (3)	30 (2)
C5	6600 (8)	452 (8)	892 (3)	29 (2)
C6	6335 (9)	236 (9)	1469 (3)	38 (2)
C7	7482 (9)	647 (7)	1813 (3)	30 (2)
C8	8507 (7)	1488 (6)	1610 (3)	20 (2)
C9	8398 (8)	1970 (6)	1063 (3)	24 (2)
C10	7024 (8)	1710 (7)	770 (3)	26 (2)
C11	8746 (9)	3238 (6)	1127 (3)	29 (2)
C12	10230 (8)	3318 (6)	1320 (3)	23 (2)
C13	10713 (7)	2663 (6)	1799 (3)	20 (1)
C14	9938 (8)	1480 (6)	1860 (3)	23 (2)
C15	10913 (8)	647 (6)	1635 (3)	27 (2)
C16	12340 (9)	1041 (7)	1831 (4)	36 (2)
C17	12288 (7)	2311 (7)	1723 (3)	27 (2)
C18	10416 (8)	3460 (7)	2263 (3)	28 (2)
C19	5834 (10)	2517 (9)	913 (3)	41 (2)
C20	13344 (9)	3025 (7)	1983 (3)	27 (2)
C21	14282 (9)	2713 (7)	2333 (3)	32 (2)
C22	15261 (10)	3654 (7)	2432 (3)	32 (2)
C23	13663 (9)	4217 (7)	1829 (4)	37 (2)
O3	6689 (6)	−666 (5)	−189 (2)	29 (1)
O7	7412 (6)	1868 (5)	1964 (2)	30 (1)
O11	8685 (8)	3894 (6)	658 (2)	45 (2)
O12	11045 (7)	3933 (5)	1087 (3)	43 (2)
O14	9841 (6)	1180 (4)	2398 (2)	28 (1)
O22	16266 (7)	3733 (6)	2718 (2)	44 (2)
O'22	14849 (6)	4555 (5)	2140 (2)	37 (2)
C'1	6582 (11)	−1867 (8)	−241 (3)	41 (2)
C'2	7747 (7)	−2377 (6)	−457 (2)	19 (1)
C'3	8029 (9)	−1998 (8)	−975 (3)	35 (2)
C'4	6853 (9)	−2360 (7)	−1335 (3)	30 (2)
C'5	5516 (9)	−1857 (7)	−1140 (3)	32 (2)
C'6	4427 (6)	−2316 (7)	−1452 (2)	20 (1)
O'3	9431 (13)	−2516 (17)	−1116 (5)	143 (6)
O'4	7108 (6)	−1977 (6)	−1848 (2)	34 (1)
O'5	5258 (11)	−2137 (10)	−560 (3)	81 (3)
O'6	3275 (13)	−1635 (15)	−1510 (5)	118 (5)
O*W*	7024 (21)	−4910 (17)	−204 (8)	182 (9)

Table 2. *Bond lengths* (Å)

C1–C2	1·503 (12)	C13–C17	1·589 (10)
C1–C10	1·528 (10)	C14–O14	1·426 (8)
C2–C3	1·496 (12)	C14–C15	1·475 (11)
C3–O3	1·456 (10)	C15–C16	1·538 (12)
C3–C4	1·526 (11)	C16–C17	1·516 (12)
C4–C5	1·529 (12)	C17–C20	1·478 (11)
C5–C6	1·520 (11)	C20–C21	1·328 (11)
C5–C10	1·563 (12)	C20–C23	1·484 (12)
C6–C7	1·496 (12)	C21–C22	1·476 (12)
C7–O7	1·484 (10)	C22–O22	1·220 (11)
C7–C8	1·491 (11)	C22–O'22	1·354 (10)
C8–C9	1·515 (10)	C23–O'22	1·451 (11)
C8–C14	1·524 (10)	O3–C'1	1·418 (11)
C8–O7	1·463 (9)	C'1–C'2	1·389 (12)
C9–C11	1·532 (10)	C'1–O'5	1·551 (14)
C9–C10	1·556 (11)	C'2–C'3	1·427 (10)
C10–C19	1·533 (12)	C'3–C'4	1·523 (12)
C11–O11	1·429 (10)	C'3–O'3	1·528 (17)
C11–C12	1·519 (12)	C'4–O'4	1·412 (9)
C12–O12	1·223 (10)	C'4–C'5	1·505 (12)
C12–C13	1·522 (10)	C'5–C'6	1·426 (10)
C13–C18	1·540 (10)	C'5–O'5	1·543 (11)
C13–C14	1·584 (10)	C'6–O'6	1·378 (16)

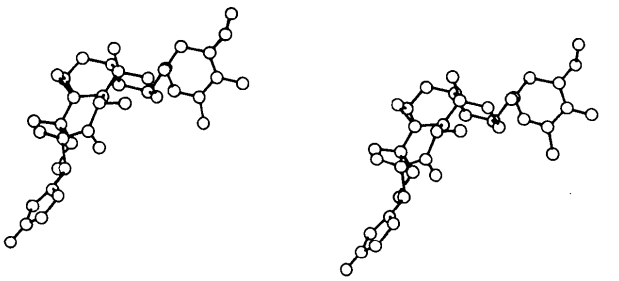

Fig. 2. Stereoview along **a** of cryptosin [drawn by the program *PLUTO* (Motherwell & Clegg, 1978)].

Lactone ring. Of the two endocyclic C–O bonds, C22–O'22 [1·354 (10) Å] is much shorter than C23–O'22 [1·451 (11) Å]. The torsion angle C13–C17–C20–C21 is 120·9 (9)° which may be compared with those found in strophanthidin (−110·9 and 84·9° for the two independent molecules in the unit cell) and digitoxigenin (76·2°).

Hydrogen bonding and molecular packing. There is a single water molecule per asymmetric unit, weakly hydrogen bonded to O11 [O*W*···O11, 3·07 (1) Å]. Cryptosin packs in a network which contains three distinct hydrogen bonds (see deposited Table of H-atom distances).

We acknowledge financial support from DST and NBTB (India).

References

CREMER, D. & POPLE, J. A. (1975). *J. Am. Chem. Soc.* **97**, 1354–1358.

CROMER, D. T. & WABER, J. T. (1965). *Acta Cryst.* **18**, 104–109.

CRUICKSHANK, D. W. J. (1961). *Computing Methods and the Phase Problem*. Oxford: Pergamon Press.

ELDERFIELD, R. C. (1945). *Adv. Carbohydr. Chem.* **1**, 147–173.

GILARDI, R. D. & FLIPPEN, J. L. (1973). *Acta Cryst.* B**29**, 1842–1848.

KARLE, I. L. & KARLE, J. (1969). *Acta Cryst.* B**25**, 434–442.

MAIN, P., FISKE, S. J., HULL, S. E., LESSINGER, L., GERMAIN, G., DECLERCQ, J.-P. & WOOLFSON, M. M. (1980). *MULTAN*80. *A System of Computer Programs for the Automatic Solution of Crystal Structures from X-ray Diffraction Data*. Univs. of York, England, and Louvain, Belgium.

MOTHERWELL, W. D. S. & CLEGG, W. (1978). *PLUTO*78. Program for plotting molecular and crystal structures. Univ. of Cambridge, England.

OVEREND, W. G. & STACEY, M. (1953). *Adv. Carbohydr. Chem.* **8**, 45–105.

REICHSTEIN, T. & WEISS, E. (1962). *Adv. Carbohydr. Chem.* **17**, 65–120.

SCHMID, W., UEHLINGER, H. P., TAMN, CH. & REICHSTEIN, T. (1959). *Helv. Chim. Acta*, **42**, 72–121.

SHIONO, R. (1965). *SFLS*. Block-diagonal least-squares refinement program. Private communication.

STEWART, R. F., DAVIDSON, E. R. & SIMPSON, W. T. (1965). *J. Chem. Phys.* **42**, 3175–3187.

STODDART, J. F. (1971). *Stereochemistry of Carbohydrates*, p. 58. New York: Wiley–Interscience.

VENKATESWARA, R., SANKARA RAO, K. & VAIDYANATHAN, C. S. (1985). *International Symposium on Biotechnology in Plant Science. Proceedings*. p. 26. Cornell Univ. Press.