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Key indicators

Single-crystal X-ray study
T = 296 K
Mean $\sigma(C-C)$ = 0.003 Å
R factor = 0.038
wR factor = 0.096
Data-to-parameter ratio = 8.8

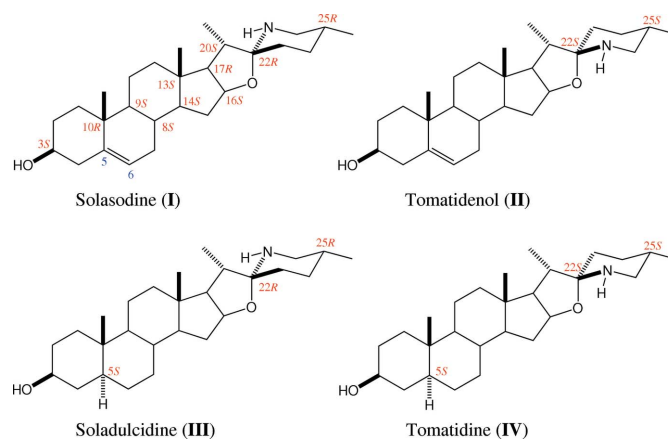
For details of how these key indicators were automatically derived from the article, see <http://journals.iucr.org/e>.

Solasodine monohydrate: an authentic structural characterization and a reinterpretation of a previous report

The title compound, $C_{27}H_{43}NO_2 \cdot H_2O$, is the monohydrate of a common naturally occurring steroidal alkaloid, for which an X-ray crystal structure has previously been published [Turdybekov, Lindeman, Struchkov, Gazaliev, Balitskii & Zhurinov (1989). *Chem. Nat. Compd.* **25**, 75–76]. This paper reports the correct structure of the title compound and proposes an alternative interpretation of the structure reported in the 1989 paper.

Comment

Many plants of the Solanaceae family accumulate steroidal alkaloids based on C_{27} cholestane skeletons, *e.g.* solasodine, (I), tomatidenol, (II), and tomatidine, (IV) (Friedman & McDonald, 1997). Solasodine was used for a long time in the partial synthesis of pregnane derivatives (Sato *et al.*, 1951, 1957), nitrogenous brassinosteroids (Quyen *et al.*, 1994) and 22,26-epiminocholestanes (Bird *et al.*, 1979), among other alkaloids of interest.



The chemical structure of solasodine [(22*R*,25*R*)-spiro[5-en-3 β -ol] was first established by Briggs *et al.* (1950) and the correct assignment confirmed by syntheses from known precursors (*e.g.* Schreiber *et al.*, 1964; Kessar *et al.*, 1971). An X-ray crystal structure proposed as solasodine monohydrate, (I)· H_2O , was published by Turdybekov *et al.* [(1989*a,b*); refcode TAFXON in the Cambridge Structural Database (CSD), Version 5.27; Allen, 2002], using high-resolution single-crystal data ($2\theta_{\max}$ = 60°, Mo $K\alpha$ radiation; R = 0.035 and R_w = 0.042). Unfortunately, there are a number of inconsistencies in that report that do not support that conclusion. Firstly, the formula is reported as $C_{27}H_{45}NO_2 \cdot H_2O$, with a single C5–C6 bond, found for example in soladulcidine, (III), while (I) is a Δ^5 steroid. Secondly, the methyl group at C25 has the axial orientation, giving an absolute config-

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uration of 25*S*, while (I) actually belongs to the 25*R* series. Thirdly, some bond lengths in TAFXON are unrealistic, for example, C25–C26 = 1.735 Å and C10–C19 = 1.067 Å (both are σ C–C bonds). Finally, the H-atom positions, determined from difference maps, were not deposited with the CSD. In conclusion, we feel that the deposited structure of solasodine monohydrate (TAFXON) is more likely to be tomatidine monohydrate, (IV)·H₂O.

We have now collected diffraction data for (I)·H₂O and refined its structure (Fig. 1). Cell parameters compare well with those reported for TAFXON, deviations between the two cells being at the 6–8 σ level. Atoms C5 and C6 are clearly sp^2 -hybridized, and the C5=C6 bond length is as expected for a formal double bond (Table 1). Methyl group C26 is equatorial to the ring and chiral atom C25 presents, as expected, an *R* absolute configuration. Finally, the hydrogen-bond network involving the water molecule, and the 3-OH functionality and the amine group (N26) in solasodine (Table 2), are very close to that described by Turdybekov *et al.* (1989*a,b*). It is not surprising that the hydrogen bonding is similar to that observed by Turdybekov *et al.*, since the differences between solasodine and tomatidine would not have been expected to influence hydrogen-bonding patterns.

Experimental

A crude batch of (I)·H₂O was donated to one of us in the 1980s by Syntex (now Grupo Roche Syntex de México). The Solanaceae used as the raw material for the extraction is unknown and does not necessarily correspond to the plant depicted in Fig. 1. The crude batch was purified by column chromatography, with petroleum ether–ethyl acetate (87:13) as the eluent and basic alumina as the stationary phase. The resulting solid was dissolved in hot ethyl acetate and the resulting solution filtered. By slowly cooling to 298 K, crystals of (I)·H₂O were formed, and these were washed with cool ethyl acetate.

Crystal data

C ₂₇ H ₄₃ NO ₂ ·H ₂ O	Z = 4
<i>M_r</i> = 431.64	<i>D_x</i> = 1.166 Mg m ⁻³
Orthorhombic, <i>P</i> 2 ₁ 2 ₁ 2 ₁	Mo <i>K</i> α radiation
<i>a</i> = 7.6497 (8) Å	μ = 0.07 mm ⁻¹
<i>b</i> = 9.6076 (17) Å	<i>T</i> = 296 (2) K
<i>c</i> = 33.445 (5) Å	Plate, colourless
<i>V</i> = 2458.0 (6) Å ³	0.60 × 0.50 × 0.18 mm

Data collection

Bruker <i>P4</i> diffractometer	<i>R</i> _{int} = 0.019
ω scans	θ_{\max} = 25.0°
Absorption correction: none	3 standard reflections
3574 measured reflections	every 97 reflections
2517 independent reflections	intensity decay: 1%
2112 reflections with <i>I</i> > 2 σ (<i>I</i>)	

Refinement

Refinement on <i>F</i> ²	$w = 1/[\sigma^2(F_o^2) + (0.0474P)^2 + 0.2778P]$
$R[F^2 > 2\sigma(F^2)] = 0.038$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.096$	$(\Delta/\sigma)_{\max} < 0.001$
<i>S</i> = 1.05	$\Delta\rho_{\max} = 0.15 \text{ e } \text{Å}^{-3}$
2517 reflections	$\Delta\rho_{\min} = -0.15 \text{ e } \text{Å}^{-3}$
285 parameters	Extinction correction: <i>SHELXTL-Plus</i> (Sheldrick, 1998)
H-atom parameters constrained	Extinction coefficient: 0.0025 (5)

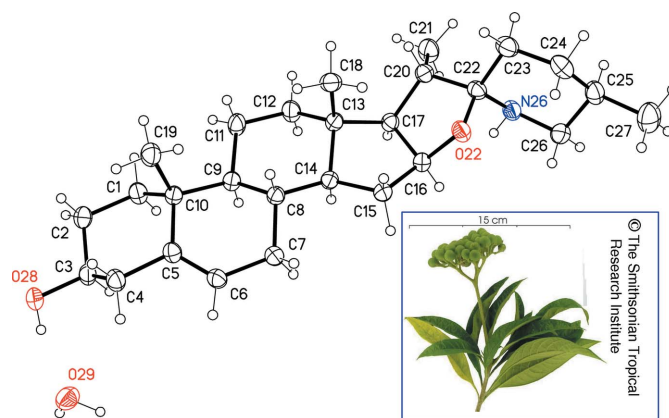


Figure 1

The molecular structure of (I)·H₂O, with displacement ellipsoids drawn at the 30% probability level. The inset is a photograph of *Solanum asperum*, a natural source of (I), which is extracted from fruit clusters (Bhattacharyya, 1984).

Table 1

Selected geometric parameters (Å, °).

C3–O28	1.432 (3)	C22–O22	1.451 (3)
C5–C6	1.315 (3)	C22–N26	1.465 (3)
C10–C19	1.552 (3)	C25–C27	1.529 (4)
C13–C18	1.535 (4)	C26–N26	1.475 (3)
C16–O22	1.423 (3)		
C6–C5–C4	120.6 (2)	C5–C6–C7	125.9 (2)
C6–C5–C10	122.8 (2)	C16–O22–C22	106.38 (18)
C4–C5–C10	116.6 (2)	C22–N26–C26	112.7 (2)

Table 2

Hydrogen-bond geometry (Å, °).

<i>D</i> –H··· <i>A</i>	<i>D</i> –H	H··· <i>A</i>	<i>D</i> ··· <i>A</i>	<i>D</i> –H··· <i>A</i>
O28–H28···O29	0.81	1.99	2.791 (3)	169
O29–H29 <i>B</i> ···O28 ⁱ	0.86	2.03	2.861 (3)	161
O29–H29 <i>A</i> ···N26 ⁱⁱ	0.92	2.05	2.953 (3)	170

Symmetry codes: (i) $-x + 1, y - \frac{1}{2}, -z + \frac{3}{2}$; (ii) $x + \frac{1}{2}, -y + \frac{1}{2}, -z + 1$.

All H atoms bonded to C atoms were easily found in a difference map, but they were positioned geometrically and refined using a riding model in order to optimize the data-to-parameter ratio. Bond lengths were constrained to 0.96 (methyl CH₃), 0.97 (methylene CH₂), 0.98 (methine CH) or 0.93 Å (Csp²–H). Methyl groups were allowed to rotate about their C–C bonds, in order to obtain accurate torsion angles. H atoms bonded to heteroatoms were found in a difference map and refined as riding on their carrier O or N atom, with bond lengths constrained as found in the difference map; O–H = 0.81–0.92 Å and N–H = 0.91 Å. Isotropic displacement parameters were fixed for all H atoms: *U*_{iso}(H) = 1.2*U*_{eq}(C) for methylene CH₂ and methine CH groups, and *U*_{iso}(H) = 1.5*U*_{eq}(C,N) for all others. In the absence of significant anomalous scattering effects, 688 Friedel pairs were merged.

Data collection: *XSCANS* (Siemens, 1996); cell refinement: *XSCANS*; data reduction: *XSCANS*; program(s) used to solve structure: *SHELXTL-Plus* (Sheldrick, 1998); program(s) used to refine structure: *SHELXTL-Plus*; molecular graphics: *SHELXTL-*

Plus; software used to prepare material for publication: *SHELXTL-Plus*.

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