

# Crystal structure of (–)-(5*R*,7*R*,8*S*,9*R*,10*S*)-8-methyl-7-[(5*R*)-3-methyl-2-oxoxolan-3-en-5-yl]-1-aza-6-oxatricyclo[8.3.0.0<sup>5,9</sup>]tridecan-13-one monohydrate

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**Keywords:** crystal structure; isosaxorumamide; tetracyclic compound; fused tricyclic core; oxolane; azepane; pyrrolidine; hydrogen bond.

**CCDC reference:** 1830268

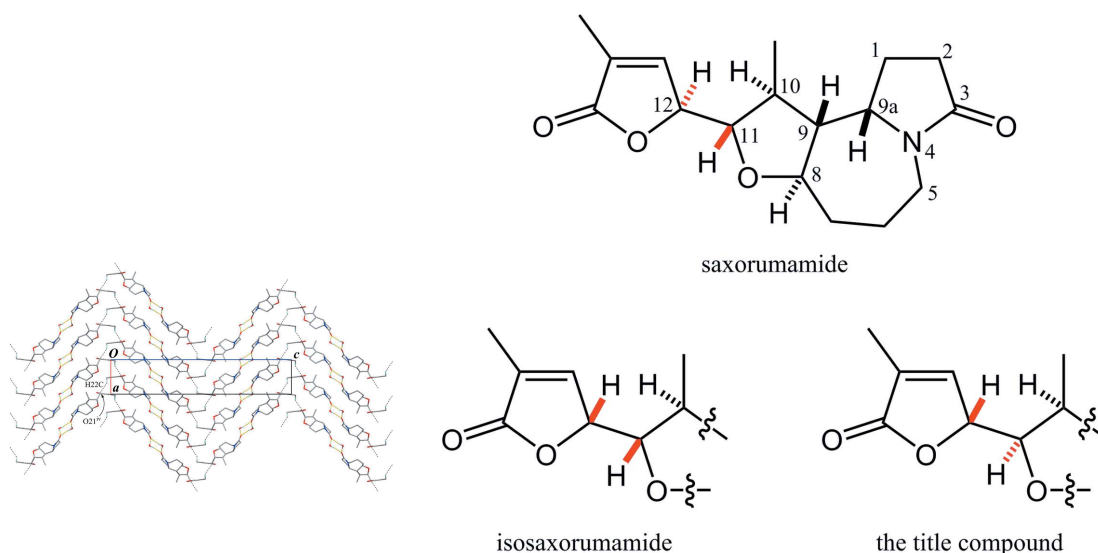
**Supporting information:** this article has supporting information at journals.iucr.org/e

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The title compound, C<sub>17</sub>H<sub>23</sub>NO<sub>4</sub>·H<sub>2</sub>O, is an epimer of the natural tetracyclic alkaloid isosaxorumamide which consists of a fused 5–7–5 tricyclic core and a dihydrofuranone substituent. The terminal dihydrofuranone ring is essentially planar with a maximum deviation of 0.0273 (14) Å from the mean plane and oxolane, azepane and pyrrolidine rings in the tricyclic ring system adopt twist, twist-chair and envelope forms, respectively. In the crystal, the amide and water molecules are linked by O–H···O hydrogen bonds, forming a tape structure running along the *b*-axis direction. The tapes are further connected by C–H···O interactions into a three-dimensional architecture.

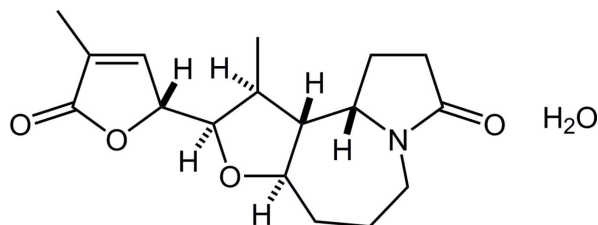
## 1. Chemical context

Saxorumamide and isosaxorumamide are natural *Stemona* alkaloids isolated from the root of *Stemona Saxorum* (Wang *et al.*, 2007). They are a pair of diastereomer (12-epimer of each other) which consist of a fused octahydrofuro[3,2-*c*]pyrrolo[1,2-*a*]azepane nucleus with a dihydrofuranone substituent (Fig. 1). The *Stemona* alkaloids have been isolated from various *Stemonaceae* species, and over 150 metabolites have

**Figure 1**

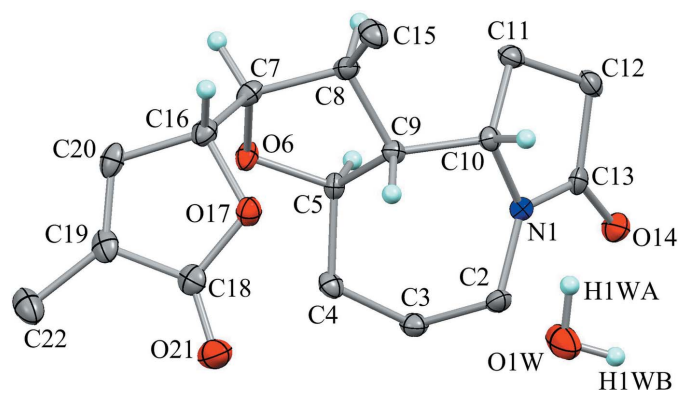
Structures of two natural products, saxorumamide and isosaxorumamide, and the title compound. Differences in the relative stereochemistries of these three diastereomers are shown in red.

been elucidated (Pilli *et al.*, 2000, 2010). Extracts of *Stemonaceae* plants have been traditionally used for folk medicines as antitussive and anthelmintic agents in the wide regions of East Asia and Southeast Asia (Greger, 2006). *Stemona Saxorum* has also been utilized for endemic disease in Vietnam. The title compound is an 11-epimer of isosaxorumamide afforded in a synthetic study of stemoamide-type alkaloids (Yoritata *et al.*, 2017).



## 2. Structural commentary

The asymmetric unit of the title compound is shown in Fig. 2. The terminal 3-methyloxolan-3-en-2-one unit (C16/O17/C18–C20/O21/C22) is essentially planar with a maximum deviation of 0.0383 (16) Å at atom O17. The oxolane ring (C5/O6/C7–C9) in the fused tricyclic ring system adopts a twist form with puckering parameters of  $Q(2) = 0.350(3)$  Å and  $\varphi(2) = 271.0(4)^\circ$ . Atoms C8 and C9 deviate from the plane through the other three atoms by 0.309 (6) and  $-0.271(6)$  Å, respectively. The central seven-membered azepane ring (N1/C2–C5/C9/C10), which is *trans*-fused to the oxolane ring, adopts a twist-chair form with puckering parameters of  $Q = 0.796(2)$ ,  $Q(2) = 0.472(2)$  Å,  $\varphi(2) = 195.0(3)^\circ$ ,  $Q(3) = 0.641(2)$  Å and  $\varphi(3) = 246.7(2)^\circ$ . The pyrrolidine ring (N1/C10–C13) fused to the azepane ring adopts an envelope form with puckering parameters of  $Q(2) = 0.300(3)$  Å and  $\varphi(2) = 251.1(5)^\circ$ . The flap atom C11 deviates from the mean plane through the other four atoms by 0.473 (4) Å. The amide moiety (N1/C2/C10/C13/O14) is planar, and atoms N1 and O14 deviate from the mean plane through the other three atoms by 0.028 (2) and  $-0.035(4)$  Å, respectively.



**Figure 2**  
The asymmetric unit of the title compound, showing the atom labelling. Displacement ellipsoids are drawn at the 50% probability level. Only H atoms connected to O and chiral C atoms are shown for clarity.

**Table 1**  
Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
$O1W-H1WA\cdots O14^i$	0.86 (2)	2.02 (2)	2.874 (3)	173 (3)
$O1W-H1WB\cdots O14^{ii}$	0.86 (2)	1.99 (2)	2.835 (3)	167 (3)
$C7-H7\cdots O21^{iii}$	1.00	2.47	3.254 (3)	135
$C22-H22C\cdots O21^{iv}$	0.98	2.58	3.407 (3)	142

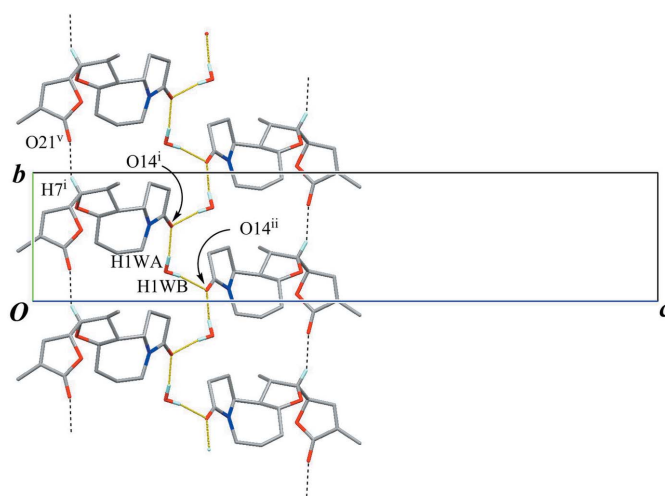
Symmetry codes: (i)  $x-1, y, z$ ; (ii)  $-x+2, y-\frac{1}{2}, -z+\frac{1}{2}$ ; (iii)  $x, y+1, z$ ; (iv)  $x+\frac{1}{2}, -y+\frac{1}{2}, -z$ .

## 3. Supramolecular features

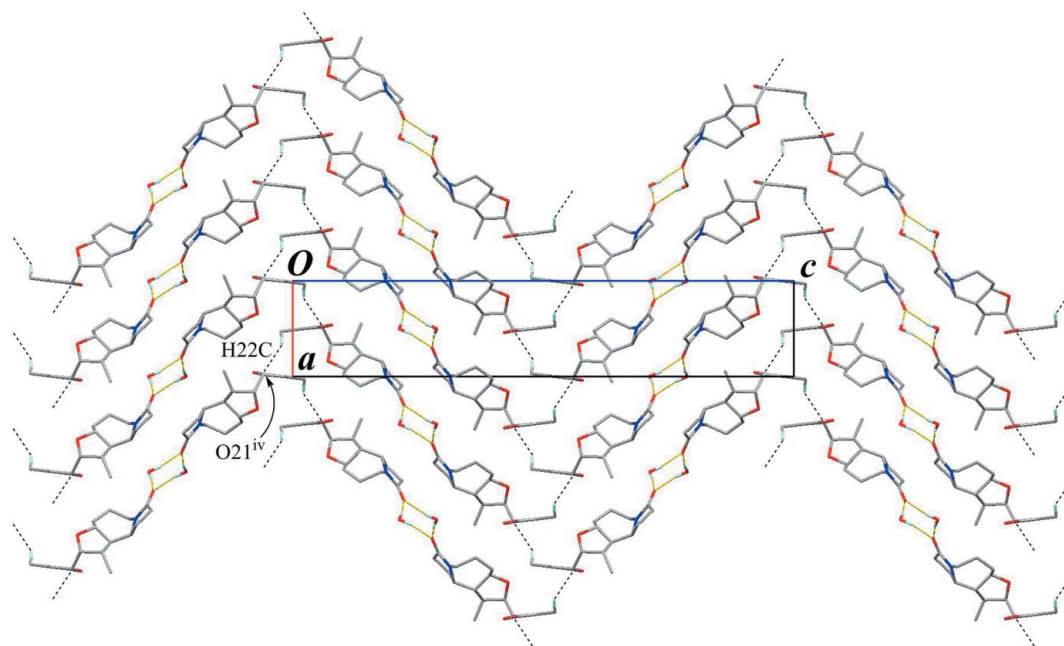
The crystal packing is stabilized by  $O-H\cdots O$  hydrogen bonds ( $O1W-H1WA\cdots O14^i$  and  $O1W-H1WB\cdots O14^{ii}$ ; symmetry codes as in Table 1) between the water molecule and the amide O atom (Fig. 3). The amide and water molecules are linked alternately into a tape with a  $C_2^1(4)$  graph-set motif running along the  $b$ -axis direction. A  $C-H\cdots O$  interaction ( $C7-H7\cdots O21^{iii}$ ; Table 1) supports the tape structure, generating a  $C(6)$  graph-set motif. Furthermore, a weak  $C-H\cdots O$  interaction ( $C22-H22C\cdots O21^{iv}$ ; Table 1) links the tape structures, extending them into a three-dimensional network (Fig. 4).

## 4. Database survey

In the Cambridge Structural Database (CSD, Version 5.39, Nov. 2017; Groom *et al.*, 2016), 19 structures are registered which contain an 8-methyl-1-aza-6-oxatricyclo[8.3.0.0<sup>5,9</sup>]-tridecane skeleton, (a), *i.e.* the fused tricyclic core related to the title compound (Fig. 5). These include four structures of its -13-one derivatives, (b), with CSD refcodes VATJAC (Kakuta *et al.*, 2003), KEGYIF (Olivo *et al.*, 2006), XATFOP (Bates &



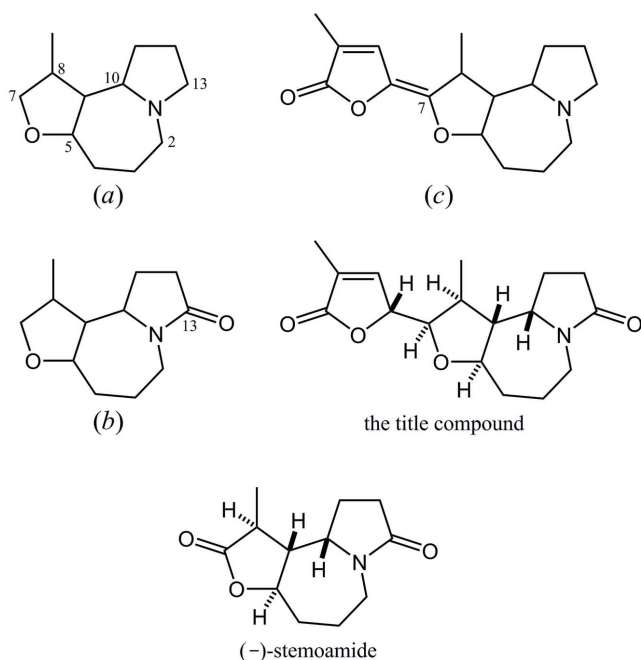
**Figure 3**  
A partial packing diagram viewed down the  $a$  axis, showing the tape structure running along the  $b$ -axis direction. Yellow lines indicate the  $O-H\cdots O$  hydrogen bonds. Black dashed lines indicate  $C-H\cdots O$  interactions. Only H atoms involved in the hydrogen bonds are shown for clarity. [Symmetry codes: (i)  $x-1, y, z$ ; (ii)  $-x+2, y-\frac{1}{2}, -z+\frac{1}{2}$ ; (v)  $x-1, y+1, z$ .]


**Figure 4**

The crystal packing of the title compound, viewed down the *b* axis, showing wavy architectures which consist of the tape structures running along the *b*-axis direction. Yellow lines indicate the O–H···O hydrogen bonds. Black dashed lines indicate C–H···O interactions. Only H atoms involved in the hydrogen bonds are shown for clarity. [Symmetry code: (iv)  $x + \frac{1}{2}, -y + \frac{1}{2}, -z$ .]

Sridhar, 2011) and YAHMIF (Zhang *et al.*, 2011), and three structures of its 7-(3-methyl-2-oxoxolan-3-en-5-ylidene) derivatives, (*c*), with refcodes PROTMI (Ishizuka *et al.*, 1972), PROTOS10 (Irie *et al.*, 1973) and OJIRII (Kaltenegger *et al.*, 2003). For the former four structures, the stereochemical and conformational properties, as *trans*-fused furoazepane, rela-

tive stereochemistry and conformation of nitrogen-containing rings, are almost coincident with those of the title compound. On the other hand, the oxolane ring shows an envelope form in these four structures rather than a twist form as in the title compound. KEGYIF (space group  $P2_1$ ) is the natural alkaloid (–)-stemoamide, which is a -7,13-dione derivative of (*a*), and XATFOP (space group  $P2_1/n$ ) is its racemate.


**Figure 5**

The core structures for database survey; (*a*) 8-methyl-1-aza-6-oxatricyclo[8.3.0.0<sup>5,9</sup>]tridecane, and its (*b*) –13-one and (*c*) 7-(3-methyl-2-oxoxolan-3-en-5-ylidene) derivatives. Structures of the title compound and (–)-stemoamide are also shown for comparison.

## 5. Synthesis and crystallization

The title compound was afforded in a synthetic study of saxorumamide and isosaxorumamide, from ethyl 4-bromobutanoate and a siloxypyrrole analogue (Yoritake *et al.*, 2017). The stereochemistry was controlled at the first step of the synthesis by enantioselective alkylation according to the reported conditions (Trost *et al.*, 2006, 2012), and confirmed with HPLC analysis (>98% ee). The (–)-stemoamide was provided as a tricyclic core intermediate, and its structure and relative and absolute configurations were identical with those reported (Lin *et al.*, 1992). Purification was carried out by silica gel column chromatography, and pale-yellow crystals were obtained from an EtOAc/hexane mixed solvent (9:1) under a hexane-saturated atmosphere by slow evaporation at ambient temperature, m.p. 466–467 K.  $[\alpha]_D^{23} - 37.9$  (*c* 0.100, CHCl<sub>3</sub>). HRMS (ESI) *m/z* calculated for C<sub>17</sub>H<sub>24</sub>NO<sub>4</sub><sup>+</sup> [*M* + H]<sup>+</sup>: 306.1705; found: 306.1703.

## 6. Refinement

Crystal data, data collection and structure refinement details are summarized in Table 2. C-bound H atoms were positioned geometrically with C–H = 0.95–1.00 Å, and constrained to

**Table 2**  
Experimental details.

Crystal data	
Chemical formula	C <sub>17</sub> H <sub>23</sub> NO <sub>4</sub> ·H <sub>2</sub> O
<i>M</i> <sub>r</sub>	323.38
Crystal system, space group	Orthorhombic, <i>P</i> 2 <sub>1</sub> 2 <sub>1</sub> 2 <sub>1</sub>
Temperature (K)	90
<i>a</i> , <i>b</i> , <i>c</i> (Å)	6.6180 (3), 7.1197 (3), 34.7351 (15)
<i>V</i> (Å <sup>3</sup> )	1636.65 (12)
<i>Z</i>	4
Radiation type	Mo <i>K</i> α
μ (mm <sup>-1</sup> )	0.10
Crystal size (mm)	0.23 × 0.20 × 0.18
Data collection	
Diffractionmeter	Bruker D8 Venture
Absorption correction	Multi-scan ( <i>SADABS</i> ; Bruker, 2016)
<i>T</i> <sub>min</sub> , <i>T</i> <sub>max</sub>	0.98, 0.98
No. of measured, independent and observed [ <i>I</i> > 2σ( <i>I</i> )] reflections	29644, 2879, 2759
<i>R</i> <sub>int</sub>	0.047
(sin θ/λ) <sub>max</sub> (Å <sup>-1</sup> )	0.595
Refinement	
<i>R</i> [ <i>F</i> <sup>2</sup> > 2σ( <i>F</i> <sup>2</sup> )], <i>wR</i> [ <i>F</i> <sup>2</sup> ], <i>S</i>	0.033, 0.069, 1.00
No. of reflections	2879
No. of parameters	216
No. of restraints	3
H-atom treatment	H atoms treated by a mixture of independent and constrained refinement
Δρ <sub>max</sub> , Δρ <sub>min</sub> (e Å <sup>-3</sup> )	0.21, -0.19

Computer programs: *APEX3* (Bruker, 2016), *SAINT* (Bruker, 2016), *SHELXT2014/5* (Sheldrick, 2015a), *SHELXL2014/7* (Sheldrick, 2015b), *Mercury* (Macrae *et al.*, 2008), *publCIF* (Westrip, 2010) and *PLATON* (Spek, 2009).

ride on their parent atoms with  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$  or  $1.5U_{\text{eq}}(\text{methyl C})$ . Water H atoms were located in a difference-Fourier map, and then refined freely with  $U_{\text{iso}}(\text{H}) = 1.5U_{\text{eq}}(\text{O})$ , and with distance restraints of O–H = 0.84 (2) Å and H⋯H = 1.33 (4) Å.

## Acknowledgements

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## supporting information

*Acta Cryst.* (2018). E74, 555-558 [https://doi.org/10.1107/S2056989018004425]

## Crystal structure of (–)-(5*R*,7*R*,8*S*,9*R*,10*S*)-8-methyl-7-[(5*R*)-3-methyl-2-oxooxolan-3-en-5-yl]-1-aza-6-oxatricyclo[8.3.0.0<sup>5,9</sup>]tridecan-13-one monohydrate

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### Computing details

Data collection: *APEX3* (Bruker, 2016); cell refinement: *SAINTE* (Bruker, 2016); data reduction: *SAINTE* (Bruker, 2016); program(s) used to solve structure: *SHELXT2014/5* (Sheldrick, 2015a); program(s) used to refine structure: *SHELXL2014/7* (Sheldrick, 2015b); molecular graphics: *Mercury* (Macrae *et al.*, 2008); software used to prepare material for publication: *publCIF* (Westrip, 2010) and *PLATON* (Spek, 2009).

(–)-(5*R*,7*R*,8*S*,9*R*,10*S*)-8-Methyl-7-[(5*R*)-3-methyl-2-oxooxolan-3-en-5-yl]-1-aza-6-oxatricyclo[8.3.0.0<sup>5,9</sup>]tridecan-13-one monohydrate

### Crystal data

C<sub>17</sub>H<sub>23</sub>NO<sub>4</sub>·H<sub>2</sub>O

*M<sub>r</sub>* = 323.38

Orthorhombic, *P*2<sub>1</sub>2<sub>1</sub>2<sub>1</sub>

*a* = 6.6180 (3) Å

*b* = 7.1197 (3) Å

*c* = 34.7351 (15) Å

*V* = 1636.65 (12) Å<sup>3</sup>

*Z* = 4

*F*(000) = 696

*D<sub>x</sub>* = 1.312 Mg m<sup>-3</sup>

Melting point = 466–467 K

Mo *K*α radiation, λ = 0.71073 Å

Cell parameters from 9946 reflections

θ = 2.4–25.1°

μ = 0.10 mm<sup>-1</sup>

*T* = 90 K

Prism, pale yellow

0.23 × 0.20 × 0.18 mm

### Data collection

Bruker D8 Venture

diffractometer

Radiation source: fine-focus sealed tube

Multilayered confocal mirror monochromator

Detector resolution: 7.4074 pixels mm<sup>-1</sup>

φ and ω scans

Absorption correction: multi-scan

(*SADABS*; Bruker, 2016)

*T<sub>min</sub>* = 0.98, *T<sub>max</sub>* = 0.98

29644 measured reflections

2879 independent reflections

2759 reflections with *I* > 2σ(*I*)

*R<sub>int</sub>* = 0.047

θ<sub>max</sub> = 25.0°, θ<sub>min</sub> = 2.4°

*h* = –7→7

*k* = –8→8

*l* = –41→41

### Refinement

Refinement on *F*<sup>2</sup>

Least-squares matrix: full

*R*[*F*<sup>2</sup> > 2σ(*F*<sup>2</sup>)] = 0.033

*wR*(*F*<sup>2</sup>) = 0.069

*S* = 1.00

2879 reflections

216 parameters

3 restraints

Primary atom site location: structure-invariant direct methods

Secondary atom site location: difference Fourier map



Hydrogen site location: mixed  
H atoms treated by a mixture of independent  
and constrained refinement

$$w = 1/[\sigma^2(F_o^2) + 1.385P]$$

where  $P = (F_o^2 + 2F_c^2)/3$

$$(\Delta/\sigma)_{\max} < 0.001$$

$$\Delta\rho_{\max} = 0.21 \text{ e } \text{\AA}^{-3}$$

$$\Delta\rho_{\min} = -0.19 \text{ e } \text{\AA}^{-3}$$

### Special details

**Experimental.** IR (film): 2925, 2855, 1756, 1667, 1455, 1261, 1083, 802  $\text{cm}^{-1}$ ;  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ):  $\delta$  (p.p.m.) 6.97 (dq,  $J = 1.7, 1.4$  Hz, 1H; H20), 4.89–4.86 (m, 1H; H16), 4.22 (dd,  $J = 8.3, 0.9$  Hz, 1H; H7), 4.07–4.01 (m, 1H; H2B), 3.92 (ddd,  $J = 10.9, 6.9, 6.3$  Hz, 1H; H10), 3.73 (ddd,  $J = 10.2, 9.7, 2.9$  Hz, 1H; H5), 2.72–2.65 (m, 1H; H2A), 2.59–2.51 (m, 1H; H8), 2.47 (ddd,  $J = 12.0, 9.7, 6.9$  Hz, 1H; H9), 2.42–2.31 (m, 2H; H12AB), 2.00–1.92 (m, 2H; H4A & H11A), 1.95 (dd,  $J = 1.7, 1.4$  Hz, 3H; H22ABC), 1.74–1.59 (m, 2H; H3B & H11B), 1.45–1.28 (m, 2H; H3A & H4B), 1.24 (d,  $J = 6.6$  Hz, 3H; H15ABC)  $^{13}\text{C}$  NMR (125 MHz,  $\text{CDCl}_3$ ):  $\delta$  (p.p.m.) 174.7 (C; C18), 174.1 (C; C13), 146.7 (CH; C19), 131.1 (C; C20), 80.6, 80.3, 80.0 (CH x3; C16, C7 & C5), 56.3 (CH; C10), 51.3 (CH; C9), 40.5 (CH<sub>2</sub>; C2), 38.5 (CH; C8), 35.1 (CH<sub>2</sub>; C12), 31.0 (CH<sub>2</sub>; C11), 25.9 (CH<sub>2</sub>; C4), 22.1 (CH<sub>2</sub>; C3), 13.1 (CH<sub>3</sub>; C22), 10.9 (CH<sub>3</sub>; C15)

**Geometry.** All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.

**Refinement.** Refinement of  $F^2$  against ALL reflections. The weighted  $R$ -factor  $wR$  and goodness of fit  $S$  are based on  $F^2$ , conventional  $R$ -factors  $R$  are based on  $F$ , with  $F$  set to zero for negative  $F^2$ . The threshold expression of  $F^2 > 2\sigma(F^2)$  is used only for calculating  $R$ -factors(gt) *etc.* and is not relevant to the choice of reflections for refinement.  $R$ -factors based on  $F^2$  are statistically about twice as large as those based on  $F$ , and  $R$ -factors based on ALL data will be even larger.

### Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters ( $\text{\AA}^2$ )

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
N1	1.0068 (3)	0.5967 (3)	0.18662 (5)	0.0148 (4)
C2	1.0057 (4)	0.4003 (3)	0.17441 (6)	0.0163 (5)
H2A	0.8647	0.3539	0.1739	0.02*
H2B	1.0817	0.3241	0.1933	0.02*
C3	1.0999 (4)	0.3752 (4)	0.13469 (7)	0.0174 (5)
H3A	1.2346	0.4357	0.1346	0.021*
H3B	1.1204	0.2393	0.13	0.021*
C4	0.9764 (4)	0.4558 (3)	0.10156 (7)	0.0160 (5)
H4A	1.0537	0.4403	0.0774	0.019*
H4B	0.8499	0.3825	0.099	0.019*
C5	0.9231 (4)	0.6613 (3)	0.10638 (6)	0.0138 (5)
H5	1.0485	0.7338	0.1126	0.017*
O6	0.8410 (3)	0.7277 (2)	0.07027 (4)	0.0169 (4)
C7	0.6625 (4)	0.8368 (3)	0.07655 (7)	0.0165 (5)
H7	0.678	0.9594	0.0628	0.02*
C8	0.6556 (4)	0.8755 (3)	0.11996 (7)	0.0156 (5)
H8	0.7432	0.9872	0.1251	0.019*
C9	0.7626 (4)	0.7031 (3)	0.13668 (6)	0.0129 (5)
H9	0.6641	0.5966	0.1368	0.015*
C10	0.8418 (4)	0.7289 (3)	0.17783 (6)	0.0144 (5)
H10	0.7283	0.7068	0.1963	0.017*
C11	0.9401 (4)	0.9177 (3)	0.18706 (7)	0.0171 (5)
H11A	0.8389	1.0086	0.1967	0.021*

H11B	1.0069	0.9711	0.164	0.021*
C12	1.0951 (4)	0.8701 (4)	0.21821 (7)	0.0186 (6)
H12A	1.2148	0.9531	0.2164	0.022*
H12B	1.0354	0.8817	0.2442	0.022*
C13	1.1500 (4)	0.6692 (3)	0.20942 (7)	0.0165 (5)
O14	1.2991 (3)	0.5844 (3)	0.22177 (5)	0.0233 (4)
C15	0.4482 (4)	0.9164 (4)	0.13680 (7)	0.0218 (6)
H15A	0.382	1.0147	0.1216	0.033*
H15B	0.4629	0.9589	0.1635	0.033*
H15C	0.366	0.802	0.1362	0.033*
C16	0.4817 (4)	0.7338 (3)	0.05958 (6)	0.0180 (5)
H16	0.3564	0.8095	0.0639	0.022*
O17	0.4601 (3)	0.5530 (2)	0.07769 (5)	0.0184 (4)
C18	0.4827 (4)	0.4170 (4)	0.05060 (7)	0.0196 (5)
C19	0.5050 (4)	0.5060 (4)	0.01261 (7)	0.0207 (6)
C20	0.5018 (4)	0.6892 (4)	0.01778 (7)	0.0203 (6)
H20	0.5109	0.7799	-0.0022	0.024*
O21	0.4813 (3)	0.2530 (3)	0.05902 (5)	0.0289 (5)
C22	0.5281 (4)	0.3907 (4)	-0.02303 (7)	0.0292 (7)
H22A	0.5321	0.4736	-0.0455	0.044*
H22B	0.4134	0.3044	-0.0253	0.044*
H22C	0.654	0.3185	-0.0216	0.044*
O1W	0.5010 (4)	0.2300 (3)	0.21248 (6)	0.0424 (6)
H1WA	0.440 (5)	0.334 (4)	0.2174 (10)	0.064*
H1WB	0.549 (6)	0.198 (5)	0.2345 (7)	0.064*

Atomic displacement parameters ( $\text{\AA}^2$ )

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
N1	0.0184 (10)	0.0129 (10)	0.0131 (9)	0.0011 (10)	-0.0012 (9)	0.0001 (8)
C2	0.0202 (12)	0.0116 (11)	0.0170 (11)	-0.0013 (12)	-0.0012 (11)	0.0025 (9)
C3	0.0188 (13)	0.0137 (12)	0.0197 (13)	0.0027 (11)	-0.0005 (11)	-0.0013 (10)
C4	0.0149 (13)	0.0179 (13)	0.0152 (11)	0.0027 (11)	0.0027 (11)	-0.0030 (10)
C5	0.0147 (12)	0.0168 (12)	0.0098 (11)	-0.0005 (10)	-0.0003 (10)	0.0009 (9)
O6	0.0151 (9)	0.0225 (9)	0.0133 (8)	0.0052 (8)	0.0010 (7)	0.0030 (7)
C7	0.0147 (12)	0.0161 (12)	0.0186 (12)	0.0030 (11)	0.0018 (10)	0.0049 (10)
C8	0.0164 (12)	0.0120 (12)	0.0184 (12)	0.0001 (11)	-0.0021 (10)	0.0000 (10)
C9	0.0123 (11)	0.0130 (12)	0.0134 (11)	0.0000 (10)	0.0018 (10)	-0.0001 (10)
C10	0.0157 (12)	0.0146 (12)	0.0130 (11)	0.0009 (11)	0.0038 (10)	0.0002 (10)
C11	0.0204 (13)	0.0133 (12)	0.0177 (12)	0.0015 (11)	0.0027 (10)	-0.0031 (10)
C12	0.0230 (13)	0.0186 (13)	0.0141 (12)	-0.0010 (11)	0.0010 (11)	-0.0045 (10)
C13	0.0220 (14)	0.0183 (13)	0.0092 (11)	-0.0005 (12)	0.0011 (10)	0.0023 (10)
O14	0.0257 (10)	0.0215 (9)	0.0227 (9)	0.0035 (9)	-0.0099 (8)	-0.0002 (8)
C15	0.0203 (13)	0.0235 (13)	0.0217 (13)	0.0057 (12)	-0.0004 (11)	-0.0050 (11)
C16	0.0171 (13)	0.0193 (12)	0.0177 (11)	0.0038 (11)	0.0002 (11)	0.0030 (10)
O17	0.0194 (9)	0.0202 (9)	0.0157 (8)	-0.0035 (8)	-0.0002 (7)	0.0015 (7)
C18	0.0139 (12)	0.0230 (14)	0.0220 (13)	0.0017 (12)	-0.0053 (11)	-0.0009 (11)
C19	0.0133 (12)	0.0297 (14)	0.0190 (12)	0.0060 (13)	-0.0038 (11)	-0.0020 (11)

C20	0.0143 (13)	0.0297 (14)	0.0169 (12)	0.0007 (13)	-0.0022 (11)	0.0058 (10)
O21	0.0334 (11)	0.0210 (10)	0.0324 (10)	0.0006 (10)	-0.0099 (10)	0.0010 (8)
C22	0.0267 (15)	0.0374 (16)	0.0234 (14)	0.0100 (15)	-0.0053 (12)	-0.0085 (12)
O1W	0.0562 (15)	0.0365 (12)	0.0345 (11)	0.0201 (13)	-0.0228 (12)	-0.0136 (10)

*Geometric parameters (Å, °)*

N1—C13	1.338 (3)	C10—H10	1.0
N1—C2	1.461 (3)	C11—C12	1.529 (3)
N1—C10	1.474 (3)	C11—H11A	0.99
C2—C3	1.525 (3)	C11—H11B	0.99
C2—H2A	0.99	C12—C13	1.507 (3)
C2—H2B	0.99	C12—H12A	0.99
C3—C4	1.524 (3)	C12—H12B	0.99
C3—H3A	0.99	C13—O14	1.234 (3)
C3—H3B	0.99	C15—H15A	0.98
C4—C5	1.515 (3)	C15—H15B	0.98
C4—H4A	0.99	C15—H15C	0.98
C4—H4B	0.99	C16—O17	1.440 (3)
C5—O6	1.446 (3)	C16—C20	1.492 (3)
C5—C9	1.525 (3)	C16—H16	1.0
C5—H5	1.0	O17—C18	1.359 (3)
O6—C7	1.431 (3)	C18—O21	1.204 (3)
C7—C16	1.522 (4)	C18—C19	1.471 (3)
C7—C8	1.534 (3)	C19—C20	1.317 (4)
C7—H7	1.0	C19—C22	1.493 (3)
C8—C15	1.521 (3)	C20—H20	0.95
C8—C9	1.531 (3)	C22—H22A	0.98
C8—H8	1.0	C22—H22B	0.98
C9—C10	1.533 (3)	C22—H22C	0.98
C9—H9	1.0	O1W—H1WA	0.86 (2)
C10—C11	1.528 (3)	O1W—H1WB	0.86 (2)
C13—N1—C2	123.0 (2)	C11—C10—C9	116.5 (2)
C13—N1—C10	113.62 (19)	N1—C10—H10	108.9
C2—N1—C10	123.2 (2)	C11—C10—H10	108.9
N1—C2—C3	111.90 (19)	C9—C10—H10	108.9
N1—C2—H2A	109.2	C10—C11—C12	103.9 (2)
C3—C2—H2A	109.2	C10—C11—H11A	111.0
N1—C2—H2B	109.2	C12—C11—H11A	111.0
C3—C2—H2B	109.2	C10—C11—H11B	111.0
H2A—C2—H2B	107.9	C12—C11—H11B	111.0
C4—C3—C2	114.8 (2)	H11A—C11—H11B	109.0
C4—C3—H3A	108.6	C13—C12—C11	103.2 (2)
C2—C3—H3A	108.6	C13—C12—H12A	111.1
C4—C3—H3B	108.6	C11—C12—H12A	111.1
C2—C3—H3B	108.6	C13—C12—H12B	111.1
H3A—C3—H3B	107.5	C11—C12—H12B	111.1



C5—C4—C3	113.9 (2)	H12A—C12—H12B	109.1
C5—C4—H4A	108.8	O14—C13—N1	125.7 (2)
C3—C4—H4A	108.8	O14—C13—C12	125.9 (2)
C5—C4—H4B	108.8	N1—C13—C12	108.4 (2)
C3—C4—H4B	108.8	C8—C15—H15A	109.5
H4A—C4—H4B	107.7	C8—C15—H15B	109.5
O6—C5—C4	107.90 (18)	H15A—C15—H15B	109.5
O6—C5—C9	105.84 (19)	C8—C15—H15C	109.5
C4—C5—C9	115.3 (2)	H15A—C15—H15C	109.5
O6—C5—H5	109.2	H15B—C15—H15C	109.5
C4—C5—H5	109.2	O17—C16—C20	104.1 (2)
C9—C5—H5	109.2	O17—C16—C7	109.86 (19)
C7—O6—C5	110.83 (17)	C20—C16—C7	114.2 (2)
O6—C7—C16	109.18 (19)	O17—C16—H16	109.5
O6—C7—C8	105.77 (19)	C20—C16—H16	109.5
C16—C7—C8	116.4 (2)	C7—C16—H16	109.5
O6—C7—H7	108.4	C18—O17—C16	108.90 (17)
C16—C7—H7	108.4	O21—C18—O17	121.5 (2)
C8—C7—H7	108.4	O21—C18—C19	129.5 (2)
C15—C8—C9	115.1 (2)	O17—C18—C19	109.0 (2)
C15—C8—C7	116.1 (2)	C20—C19—C18	107.6 (2)
C9—C8—C7	102.43 (19)	C20—C19—C22	131.2 (2)
C15—C8—H8	107.6	C18—C19—C22	121.2 (2)
C9—C8—H8	107.6	C19—C20—C16	110.2 (2)
C7—C8—H8	107.6	C19—C20—H20	124.9
C5—C9—C8	102.52 (19)	C16—C20—H20	124.9
C5—C9—C10	115.4 (2)	C19—C22—H22A	109.5
C8—C9—C10	114.6 (2)	C19—C22—H22B	109.5
C5—C9—H9	108.0	H22A—C22—H22B	109.5
C8—C9—H9	108.0	C19—C22—H22C	109.5
C10—C9—H9	108.0	H22A—C22—H22C	109.5
N1—C10—C11	101.69 (19)	H22B—C22—H22C	109.5
N1—C10—C9	111.73 (18)	H1WA—O1W—H1WB	103 (3)
C13—N1—C2—C3	-96.5 (3)	C5—C9—C10—C11	77.7 (3)
C10—N1—C2—C3	89.0 (3)	C8—C9—C10—C11	-41.0 (3)
N1—C2—C3—C4	-69.5 (3)	N1—C10—C11—C12	-28.7 (2)
C2—C3—C4—C5	54.7 (3)	C9—C10—C11—C12	-150.4 (2)
C3—C4—C5—O6	169.37 (19)	C10—C11—C12—C13	28.6 (2)
C3—C4—C5—C9	-72.6 (3)	C2—N1—C13—O14	2.5 (4)
C4—C5—O6—C7	134.6 (2)	C10—N1—C13—O14	177.4 (2)
C9—C5—O6—C7	10.7 (3)	C2—N1—C13—C12	-176.1 (2)
C5—O6—C7—C16	-113.8 (2)	C10—N1—C13—C12	-1.1 (3)
C5—O6—C7—C8	12.1 (3)	C11—C12—C13—O14	163.8 (2)
O6—C7—C8—C15	-155.9 (2)	C11—C12—C13—N1	-17.7 (2)
C16—C7—C8—C15	-34.4 (3)	O6—C7—C16—O17	59.7 (2)
O6—C7—C8—C9	-29.6 (2)	C8—C7—C16—O17	-59.9 (3)
C16—C7—C8—C9	91.8 (2)	O6—C7—C16—C20	-56.8 (3)

O6—C5—C9—C8	-28.7 (2)	C8—C7—C16—C20	-176.4 (2)
C4—C5—C9—C8	-147.9 (2)	C20—C16—O17—C18	4.8 (3)
O6—C5—C9—C10	-153.92 (19)	C7—C16—O17—C18	-117.8 (2)
C4—C5—C9—C10	86.9 (3)	C16—O17—C18—O21	176.1 (3)
C15—C8—C9—C5	161.9 (2)	C16—O17—C18—C19	-4.3 (3)
C7—C8—C9—C5	35.0 (2)	O21—C18—C19—C20	-178.6 (3)
C15—C8—C9—C10	-72.4 (3)	O17—C18—C19—C20	1.9 (3)
C7—C8—C9—C10	160.7 (2)	O21—C18—C19—C22	0.8 (4)
C13—N1—C10—C11	19.3 (2)	O17—C18—C19—C22	-178.7 (2)
C2—N1—C10—C11	-165.7 (2)	C18—C19—C20—C16	1.2 (3)
C13—N1—C10—C9	144.3 (2)	C22—C19—C20—C16	-178.1 (3)
C2—N1—C10—C9	-40.7 (3)	O17—C16—C20—C19	-3.7 (3)
C5—C9—C10—N1	-38.5 (3)	C7—C16—C20—C19	116.1 (3)
C8—C9—C10—N1	-157.2 (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>
O1 <i>W</i> —H1 <i>WA</i> ...O14 <sup>i</sup>	0.86 (2)	2.02 (2)	2.874 (3)	173 (3)
O1 <i>W</i> —H1 <i>WB</i> ...O14 <sup>ii</sup>	0.86 (2)	1.99 (2)	2.835 (3)	167 (3)
C7—H7...O21 <sup>iii</sup>	1.00	2.47	3.254 (3)	135
C22—H22 <i>C</i> ...O21 <sup>iv</sup>	0.98	2.58	3.407 (3)	142

Symmetry codes: (i)  $x-1, y, z$ ; (ii)  $-x+2, y-1/2, -z+1/2$ ; (iii)  $x, y+1, z$ ; (iv)  $x+1/2, -y+1/2, -z$ .