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(1a*S*,1b*S*,4a*R*,4b*R*,7a*S*,10*R*)-Methyl 1a,1b,4a,4b,-7a,8,10,11-octahydro-8-oxo-bis(2-methyl-1,3-oxazino)[6,5,4-*cd*][4,5,6-*de*]thiazolo[3,2-*a*]-azepine-10-carboxylate

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Key indicators

Single-crystal X-ray study
T = 193 K
Mean σ(C–C) = 0.002 Å
R factor = 0.022
wR factor = 0.052
Data-to-parameter ratio = 10.7

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

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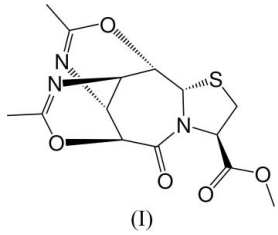
The absolute configuration of the title tetracyclic bis-oxazine, $C_{14}H_{17}N_3O_5S$, has been determined. It is an unexpected product from the attempt to synthesize a new class of bis-oxazolines. The seven-membered lactam ring exhibits four axial (O and N) and one equatorial (S) substituents. The *ortho*-condensed and *cis*-configurated oxazine rings are positioned on opposite sides of the lactam ring.

Comment

In recent years, bis-oxazoline–ligand–metal complexes have received attention through their use in various catalytic processes (Ghosh *et al.*, 1998). Therefore, the synthesis of new classes of bis-oxazolines poses a challenge to create new chiral auxilliaries (Gant & Meyers, 1994). An attempt to synthesize the bis-oxazoline based on the thiazolo[3,2-*a*]azepine scaffold failed. Instead of the desired bis-oxazoline, we obtained an analogous tetracyclic bis-oxazine (I). The entangled seven-membered-ring system is stable under aqueous conditions at room temperature.



(I)

The title compound, (I), was prepared from the starting material (3*R*,6*S*,7*S*,8*S*,9*S*,9a*S*)-methyl perhydro-6,7,8,9-tetrahydroxy-5-oxothiazolo[3,2-*a*]azepine-3-carboxylate, which is obtained by condensation of D-mannurono-3,6-lactone with the methyl ester of L-cysteine (Tremmel & Geyer, 2002). Regioselective activation and subsequent substitution with NaN_3 yielded the 7,8-bisazide. The acetylation of the remaining hydroxyl groups was performed with acetic anhydride in dry pyridine (Hörger *et al.*, 2005). The azide was reduced with H_2 and Pd/C, followed by an *O*,*N*-acyl shift. Finally the bisamide was treated with Appel reagents to form the tetracyclic bisoxazine (I) (Vorbrüggen & Krolikiewicz, 1993). The bond lengths and angles (Table 1) are within normal ranges.

Experimental

Compound (I) was prepared from (3*R*,6*S*,7*R*,8*R*,9*S*,9a*S*)-methyl-7,8-diacetamidoperhydro-6,9-dihydroxy-5-oxothiazolo[3,2-*a*]azepine-3-carboxylate (70 mg, 0.186 mmol) by treatment with triphenyl-

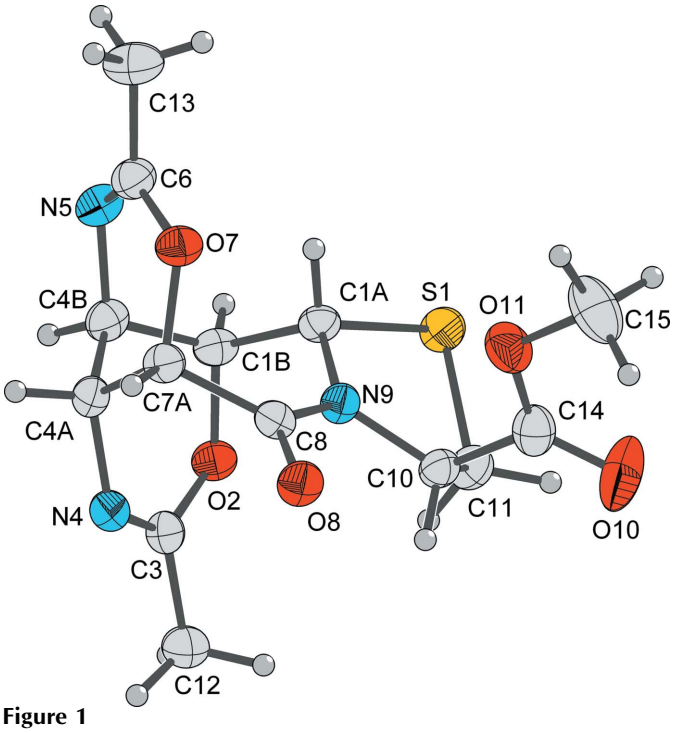


Figure 1
The molecular structure of (I), showing the atomic numbering scheme. Displacement ellipsoids are drawn at the 50% probability level.

phosphine (293 mg, 1.119 mmol), tetrachloromethane (0.54 ml, 5.580 mmol) and triethylamine (0.54 ml) in dry dichloromethane for 20 h at 273 K. After removal of the solvent, the crude product was purified by flash chromatography (dichloromethane–methanol, 10:1 *v*/*v*). Colorless crystals were obtained by recrystallization from ethyl acetate (yield: 41 mg, 0.121 mmol; 65%). ^{1}H NMR: (500 MHz, $CDCl_3$); δ 5.29 (*d*, $^3J_{10\text{-}H,11'\text{-}H}$ = 6.29 Hz, 1H, 3-H), 5.14 (*s*, 1H, 1a-H), 5.12 (*dd*, $^3J_{7a\text{-}H,4aH}$ = 7.69 Hz, ^4J = 2.28 Hz, 1 H, 7a-H), 4.55 (*dd*, $^3J_{1b\text{-}H,4b\text{-}H}$ = 5.87 Hz, ^4J = 2.36 Hz, 1H, 1b-H), 3.97 (*dt*, $^3J_{44;b\text{-}H,4a\text{-}H/1a\text{-}H}$ = 5.58 Hz, ^4J = 2.40 Hz, 1H, 4b-H), 3.89 (*ddd*, $^3J_{4a\text{-}H,7a\text{-}H}$ = 7.69 Hz, $^3J_{4a\text{-}H,4b\text{-}H}$ = 5.17 Hz, ^{4}J = 2.61 Hz, 1H, 4a-H), 3.76 (*s*, 3 H, OCH_3), 3.35 (*dd*, $^2J_{11'\text{-}H,11\text{-}H}$ = 11.41 Hz, $^3J_{11'\text{-}H,10\text{-}H}$ = 6.27 Hz, 1H, 11'-H), 3.15 (*d*, $^2J_{11\text{-}H,11'\text{-}H}$ = 11.41 Hz, 1H, 2-H), 2.11 (*s*, 3H, CH_3), 1.99 (*s*, 3H, CH_3). ^{13}C NMR: (125 MHz, $CDCl_3$); δ169.33 (**C**OCH_3), 165.78 (8), 159.48 (O–**C**CH_3–N), 159.46 (O–**C**CH_3–N), 79.13 (7a-C), 75.98 (1 b-C), 65.89 (10-C), 59.35 (1a-C), 53.13 (OCH_3), 47.02 (4b-C), 43.49 (4a-C), 31.15 (11-C), 21.68 (O–C**C**H_3–N), 21.36 (O–C**C**H_3–N).

Crystal data

$C_{14}H_{17}N_3O_5S$
M_r = 339.37
Orthorhombic, $P2_12_12_1$
a = 6.3486 (5) Å
b = 8.9324 (5) Å
c = 26.1484 (19) Å
V = 1482.83 (18) Å^3
Z = 4
D_x = 1.52 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 13957 reflections
θ = 1.5–26°
μ = 0.25 mm^{-1}
T = 193 (2) K
Prism, colorless
0.39 × 0.18 × 0.12 mm

Data collection

Stoe IPDS-2 diffractometer
ω scans
Absorption correction: none
14439 measured reflections
2965 independent reflections
2697 reflections with $I > 2\sigma(I)$
R_{int} = 0.029
θ_{max} = 26.2°
$h = -7 \rightarrow 7$
$k = -10 \rightarrow 11$
$l = -32 \rightarrow 32$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.022
$wR(F^2)$ = 0.052
S = 1.03
2965 reflections
277 parameters
All H-atom parameters refined
$w = 1/[\sigma^2(F_o^2) + (0.0325P)^2 + 0.0185P]$
where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 0.14 e Å^{-3}
$\Delta\rho_{min}$ = −0.15 e Å^{-3}
Extinction correction: *SHELXL97*
Extinction coefficient: 0.0075 (11)
Absolute structure: Flack (1983), 1219 Friedel Pairs
Flack parameter: 0.03 (6)

Table 1
Selected geometric parameters (Å, °).

C1*A*—N9	1.4825 (17)	C4*A*—C7*A*	1.5318 (19)
C1*A*—C1*B*	1.5357 (19)	C4*B*—N5	1.4563 (18)
C1*A*—S1	1.8211 (14)	C6—N5	1.2686 (18)
C1*B*—O2	1.4443 (16)	C6—O7	1.3665 (17)
C1*B*—C4*B*	1.528 (2)	C7*A*—O7	1.4480 (17)
C3—N4	1.2672 (18)	C7*A*—C8	1.5256 (19)
C3—O2	1.3759 (17)	C8—N9	1.3560 (18)
C4*A*—N4	1.4575 (18)	C10—C11	1.521 (2)
C4*A*—C4*B*	1.516 (2)	C11—S1	1.8050 (16)
N9—C1*A*—C1*B*	113.90 (11)	C4*B*—C4*A*—C7*A*	110.47 (11)
N9—C1*A*—S1	104.22 (9)	N5—C4*B*—C4*A*	113.36 (11)
C1*B*—C1*A*—S1	112.26 (9)	N5—C4*B*—C1*B*	112.00 (12)
O2—C1*B*—C4*B*	108.50 (11)	C4*A*—C4*B*—C1*B*	109.13 (12)
O2—C1*B*—C1*A*	109.64 (11)	N5—C6—O7	127.00 (12)
C4*B*—C1*B*—C1*A*	116.38 (11)	O7—C7*A*—C8	109.99 (11)
N4—C3—O2	128.07 (13)	O7—C7*A*—C4*A*	113.07 (11)
N4—C4*A*—C4*B*	112.75 (12)	C8—C7*A*—C4*A*	112.09 (11)
N4—C4*A*—C7*A*	110.08 (11)	N9—C8—C7*A*	118.72 (12)
N9—C1*A*—C1*B*—O2	−48.87 (16)	C7*A*—C4*A*—C4*B*—C1*B*	75.09 (14)
S1—C1*A*—C1*B*—O2	69.28 (12)	O2—C1*B*—C4*B*—N5	−176.49 (10)
N9—C1*A*—C1*B*—C4*B*	74.71 (15)	C1*A*—C1*B*—C4*B*—N5	59.34 (16)
S1—C1*A*—C1*B*—C4*B*	−167.14 (10)	O2—C1*B*—C4*B*—C4*A*	57.16 (14)
N4—C4*A*—C4*B*—N5	−174.12 (11)	C1*A*—C1*B*—C4*B*—C4*A*	−67.01 (15)
C7*A*—C4*A*—C4*B*—N5	−50.49 (16)	N4—C4*A*—C7*A*—O7	159.77 (11)
N4—C4*A*—C4*B*—C1*B*	−48.54 (15)	C4*B*—C4*A*—C7*A*—O7	34.60 (15)

The U_{eq} value for H1a is low, probably due to H1a being involved in two short contacts. All H atoms were located in a difference map and refined isotropically [C—H = 0.89 (2)–1.03 (2) Å].

Data collection: *X-AREA* (Stoe & Cie, 2005); cell refinement: *X-AREA*; data reduction: *X-AREA*; program(s) used to solve structure: *SIR92* (Altomare *et al.*, 1993); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *DIAMOND* (Brandenburg, 2004); software used to prepare material for publication: *WinGX* publication routines (Farrugia, 1999).

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