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Ethyl 2-hydroxy-5,11-dioxopyrrolo-[2,1-*c*][1,4]benzodiazepine-10-acetate

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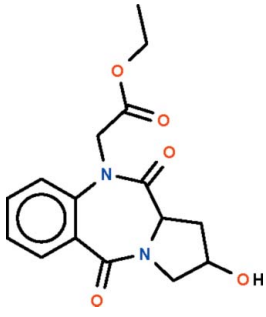
Key indicators: single-crystal X-ray study; T = 293 K; mean σ(C–C) = 0.003 Å; R factor = 0.032; wR factor = 0.098; data-to-parameter ratio = 9.0.

The title compound, $C_{16}H_{18}N_2O_5$, consists of a benzodiazepinedione system fused to a pyrrole system. The seven-membered ring adopts a boat-shaped conformation (with the methine C atom as the prow); the five-membered ring adopts an enveloped-shaped conformation (with the hydroxy-bearing C atom as the flap). The hydroxy group is hydrogen bonded to the carbonyl O atom of an adjacent molecule generating a zigzag chain in the crystal structure.

Related literature

Pyrrolo[2,1-*c*][1,4]benzodiazepines are potent antibiotics produced by *Streptomyces* species; see: Cargill *et al.* (1974). For the design of DNA inter-strand cross-linking as well as of conjugate agents to enhance the sequence selectivity and selectivity for tumor cells, see: Gregson *et al.* (2004).



Experimental

Crystal data

$C_{16}H_{18}N_2O_5$
M_r = 318.32
Orthorhombic, $P2_12_12_1$
a = 8.5503 (2) Å
b = 9.6580 (2) Å
c = 18.2734 (4) Å
V = 1509.00 (6) Å^3
Z = 4
Mo $K\alpha$ radiation
μ = 0.11 mm^{-1}
T = 293 K
0.3 × 0.3 × 0.3 mm

Data collection

Bruker APEXII diffractometer
11809 measured reflections
1907 independent reflections
1765 reflections with $I > 2\sigma(I)$
R_{int} = 0.024

Refinement

$R[F^2 > 2\sigma(F^2)]$ = 0.032
$wR(F^2)$ = 0.098
S = 1.04
1907 reflections
213 parameters
1 restraint
H atoms treated by a mixture of independent and constrained refinement
$\Delta\rho_{max}$ = 0.21 e Å^{-3}
$\Delta\rho_{min}$ = −0.17 e Å^{-3}

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

D—H···A	D—H	H···A	D···A	D—H···A
O3—H3···O1^{i}	0.84 (1)	2.02 (2)	2.810 (2)	157 (4)

Symmetry code: (i) $-x, y+\frac{1}{2}, -z+\frac{1}{2}$.

Data collection: *APEX2* (Bruker, 2005); cell refinement: *SAINT* (Bruker, 2005); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *X-SEED* (Barbour, 2001); software used to prepare material for publication: *publCIF* (Westrip, 2010).

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Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: BT5201).

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supporting information

Acta Cryst. (2010). E**66**, o733 [doi:10.1107/S1600536810006914]

Ethyl 2-hydroxy-5,11-dioxopyrrolo[2,1-*c*][1,4]benzodiazepine-10-acetate

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S1. Experimental

2-Hydroxy- pyrrolo[2,1-*c*][1,4]benzodiazepine-5,11-dione (0.5 g, 2.15 mmol), ethyl bromoacetate (0.45 ml, 4.3 mmol), potassium carbonate (0.6 g, 4.3 mmol) along with a catalytic amount of tetra-*n*-butyl ammonium bromide were stirred in *N*,*N*-dimethylformamide (20 ml) for 24 h. After the completion of the reaction (monitored by TLC), the solid material was removed by filtration and the solvent evaporated under vacuum. Dichloromethane (20 ml) was added and the solution filtered. The solvent was removed and the product purified by recrystallization from ethanol to afford colorless crystals in 80% yield.

S2. Refinement

Carbon-bound H-atoms were placed in calculated positions (C—H 0.93-0.98 Å) and were included in the refinement in the riding model approximation, with *U*(H) set to 1.2–1.5*U*(C). The oxygen-bound H-atom was located in a difference Fourier map, and was refined isotropically with a distance restraint of O–H = 0.84±0.01 Å. Due to the absence of anomalous scatterers Friedel pairs were merged and the absolute configuration was arbitrarily set.

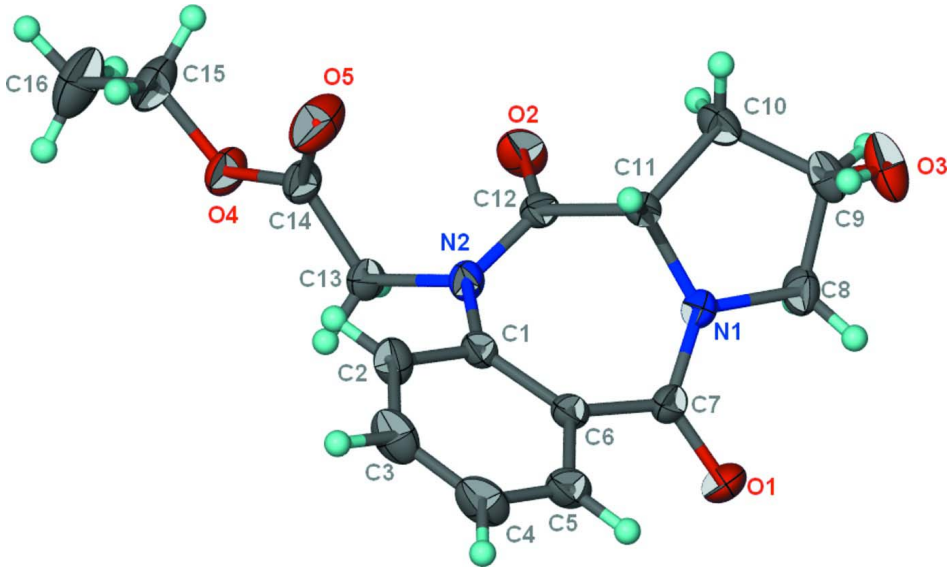

Figure 1

Anisotropic displacement ellipsoid plot (Barbour, 2001) of $C_{16}H_{18}N_2O_5$ at the 50% probability level; hydrogen atoms are drawn as arbitrary radius.

Ethyl 2-hydroxy-5,11-dioxopyrrolo[2,1-*c*][1,4]benzodiazepine-10-acetate

Crystal data

$C_{16}H_{18}N_2O_5$
$M_r = 318.32$
Orthorhombic, $P2_12_12_1$
Hall symbol: P 2ac 2ab
$a = 8.5503$ (2) Å
$b = 9.6580$ (2) Å
$c = 18.2734$ (4) Å
$V = 1509.00$ (6) Å^3
$Z = 4$
$F(000) = 672$
$D_x = 1.401$ Mg m^{-3}
Mo $K\alpha$ radiation, $\lambda = 0.71073$ Å
Cell parameters from 6127 reflections
$\theta = 2.2$–$32.7°$
$\mu = 0.11$ mm^{-1}
$T = 293$ K
Block, colorless
0.3 × 0.3 × 0.3 mm

Data collection

Bruker APEXII diffractometer
Radiation source: fine-focus sealed tube
Graphite monochromator
φ and ω scans
11809 measured reflections
1907 independent reflections
1765 reflections with $I > 2\sigma(I)$
$R_{int} = 0.024$
$\theta_{max} = 27.5°$, $\theta_{min} = 3.1°$
$h = -10 \rightarrow 9$
$k = -12 \rightarrow 12$
$l = -23 \rightarrow 23$

Refinement

Refinement on F^2
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)] = 0.032$
$wR(F^2) = 0.098$
$S = 1.04$
1907 reflections
213 parameters
1 restraint
Primary atom site location: structure-invariant direct methods
Secondary atom site location: difference Fourier map
Hydrogen site location: inferred from neighbouring sites
H atoms treated by a mixture of independent and constrained refinement
$w = 1/[\sigma^2(F_o^2) + (0.0709P)^2 + 0.1392P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} = 0.001$
$\Delta\rho_{max} = 0.21$ e Å^{-3}
$\Delta\rho_{min} = -0.17$ e Å^{-3}

Special details

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.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å²)

	x	*y*	*z*	U_{iso}*/U_{eq}
O1	−0.0674 (2)	1.16444 (16)	−0.01855 (9)	0.0502 (4)
O2	0.1577 (2)	1.04456 (15)	0.23744 (7)	0.0480 (4)
O3	0.2180 (2)	1.50177 (16)	0.09188 (10)	0.0577 (5)
H3	0.277 (3)	1.452 (3)	0.0664 (16)	0.077 (10)*
O4	0.25606 (19)	0.66847 (14)	0.26892 (8)	0.0426 (4)
O5	0.4250 (2)	0.8107 (2)	0.21372 (11)	0.0677 (6)
N1	0.0805 (2)	1.20584 (14)	0.08027 (8)	0.0306 (4)
N2	0.1825 (2)	0.92800 (14)	0.13177 (7)	0.0299 (3)

C1	0.2136 (2)	0.92042 (17)	0.05498 (9)	0.0275 (4)
C2	0.3094 (3)	0.81259 (19)	0.03067 (10)	0.0386 (4)
H2	0.3605	0.7567	0.0645	0.046*
C3	0.3287 (3)	0.7885 (2)	−0.04302 (12)	0.0478 (6)
H3A	0.3932	0.7168	−0.0586	0.057*
C4	0.2530 (3)	0.8699 (2)	−0.09410 (11)	0.0495 (6)
H4	0.2638	0.8517	−0.1438	0.059*
C5	0.1614 (3)	0.9784 (2)	−0.07053 (9)	0.0395 (5)
H5	0.1116	1.0338	−0.1050	0.047*
C6	0.1411 (2)	1.00772 (17)	0.00397 (8)	0.0289 (4)
C7	0.0428 (2)	1.13048 (18)	0.02157 (9)	0.0325 (4)
C8	0.0024 (3)	1.33736 (19)	0.09788 (12)	0.0403 (4)
H8A	−0.0890	1.3219	0.1282	0.048*
H8B	−0.0292	1.3855	0.0537	0.048*
C9	0.1259 (3)	1.41889 (18)	0.13900 (11)	0.0385 (5)
H9	0.0747	1.4784	0.1752	0.046*
C10	0.2186 (3)	1.30721 (18)	0.17856 (11)	0.0383 (4)
H10A	0.1717	1.2869	0.2257	0.046*
H10B	0.3256	1.3371	0.1863	0.046*
C11	0.2141 (2)	1.17906 (16)	0.12901 (9)	0.0270 (3)
H11	0.3111	1.1711	0.1008	0.032*
C12	0.1830 (2)	1.04664 (17)	0.17179 (8)	0.0292 (4)
C13	0.1586 (3)	0.79979 (17)	0.17246 (10)	0.0333 (4)
H13A	0.1398	0.7249	0.1382	0.040*
H13B	0.0663	0.8092	0.2029	0.040*
C14	0.2970 (3)	0.76303 (19)	0.22022 (10)	0.0353 (4)
C15	0.3801 (3)	0.6167 (3)	0.31610 (14)	0.0548 (6)
H15A	0.4280	0.6929	0.3425	0.066*
H15B	0.4602	0.5718	0.2869	0.066*
C16	0.3116 (4)	0.5171 (3)	0.36799 (15)	0.0711 (9)
H16A	0.3933	0.4765	0.3970	0.107*
H16B	0.2580	0.4457	0.3414	0.107*
H16C	0.2390	0.5641	0.3994	0.107*

Atomic displacement parameters (Å²)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
O1	0.0530 (10)	0.0443 (7)	0.0533 (8)	0.0063 (8)	−0.0280 (8)	0.0017 (7)
O2	0.0756 (12)	0.0458 (7)	0.0226 (6)	−0.0069 (8)	0.0034 (6)	0.0001 (5)
O3	0.0718 (13)	0.0293 (6)	0.0720 (11)	−0.0031 (8)	0.0311 (10)	0.0004 (7)
O4	0.0435 (9)	0.0418 (7)	0.0425 (7)	−0.0019 (7)	−0.0044 (6)	0.0179 (6)
O5	0.0443 (10)	0.0727 (12)	0.0861 (13)	−0.0162 (10)	−0.0148 (9)	0.0430 (10)
N1	0.0319 (9)	0.0271 (7)	0.0328 (7)	0.0039 (6)	−0.0047 (6)	0.0007 (5)
N2	0.0402 (10)	0.0256 (6)	0.0240 (6)	−0.0003 (6)	0.0007 (6)	0.0043 (5)
C1	0.0333 (10)	0.0243 (7)	0.0250 (7)	−0.0037 (7)	0.0014 (6)	−0.0006 (6)
C2	0.0468 (13)	0.0303 (8)	0.0387 (9)	0.0031 (9)	0.0036 (9)	−0.0004 (7)
C3	0.0591 (16)	0.0382 (9)	0.0462 (11)	0.0012 (10)	0.0159 (11)	−0.0116 (8)
C4	0.0744 (17)	0.0461 (10)	0.0279 (8)	−0.0115 (11)	0.0115 (10)	−0.0091 (8)

C5	0.0553 (14)	0.0376 (9)	0.0255 (8)	−0.0098 (9)	−0.0031 (8)	0.0026 (7)
C6	0.0348 (10)	0.0267 (7)	0.0250 (7)	−0.0057 (7)	−0.0024 (7)	0.0008 (6)
C7	0.0371 (11)	0.0287 (8)	0.0316 (8)	−0.0007 (7)	−0.0070 (7)	0.0061 (6)
C8	0.0391 (12)	0.0301 (8)	0.0516 (10)	0.0083 (8)	0.0007 (9)	0.0006 (8)
C9	0.0464 (13)	0.0264 (8)	0.0428 (10)	0.0008 (8)	0.0135 (9)	−0.0059 (7)
C10	0.0432 (12)	0.0319 (8)	0.0398 (9)	−0.0016 (8)	0.0003 (9)	−0.0115 (7)
C11	0.0292 (10)	0.0258 (7)	0.0259 (7)	−0.0001 (7)	−0.0024 (6)	−0.0019 (6)
C12	0.0322 (10)	0.0314 (7)	0.0239 (7)	−0.0010 (7)	−0.0028 (7)	0.0007 (6)
C13	0.0387 (11)	0.0300 (8)	0.0311 (8)	−0.0042 (7)	−0.0018 (7)	0.0077 (6)
C14	0.0365 (12)	0.0328 (8)	0.0366 (9)	−0.0016 (8)	−0.0015 (8)	0.0095 (7)
C15	0.0501 (15)	0.0564 (12)	0.0579 (13)	0.0070 (12)	−0.0091 (11)	0.0248 (11)
C16	0.080 (2)	0.0770 (17)	0.0566 (14)	0.0242 (17)	0.0073 (14)	0.0332 (13)

Geometric parameters (Å, º)

O1—C7	1.238 (2)	C5—H5	0.9300
O2—C12	1.219 (2)	C6—C7	1.489 (3)
O3—C9	1.415 (2)	C8—C9	1.517 (3)
O3—H3	0.841 (10)	C8—H8A	0.9700
O4—C14	1.322 (2)	C8—H8B	0.9700
O4—C15	1.455 (3)	C9—C10	1.521 (3)
O5—C14	1.193 (3)	C9—H9	0.9800
N1—C7	1.336 (2)	C10—C11	1.534 (2)
N1—C11	1.471 (2)	C10—H10A	0.9700
N1—C8	1.471 (2)	C10—H10B	0.9700
N2—C12	1.359 (2)	C11—C12	1.522 (2)
N2—C1	1.430 (2)	C11—H11	0.9800
N2—C13	1.459 (2)	C13—C14	1.513 (3)
C1—C2	1.397 (3)	C13—H13A	0.9700
C1—C6	1.402 (2)	C13—H13B	0.9700
C2—C3	1.376 (3)	C15—C16	1.472 (3)
C2—H2	0.9300	C15—H15A	0.9700
C3—C4	1.381 (3)	C15—H15B	0.9700
C3—H3A	0.9300	C16—H16A	0.9600
C4—C5	1.377 (3)	C16—H16B	0.9600
C4—H4	0.9300	C16—H16C	0.9600
C5—C6	1.401 (2)		

C9—O3—H3	110 (2)	C8—C9—H9	109.1
C14—O4—C15	116.28 (18)	C10—C9—H9	109.1
C7—N1—C11	125.27 (15)	C9—C10—C11	106.17 (15)
C7—N1—C8	122.48 (16)	C9—C10—H10A	110.5
C11—N1—C8	111.83 (14)	C11—C10—H10A	110.5
C12—N2—C1	124.78 (13)	C9—C10—H10B	110.5
C12—N2—C13	116.22 (13)	C11—C10—H10B	110.5
C1—N2—C13	118.86 (13)	H10A—C10—H10B	108.7
C2—C1—C6	119.74 (15)	N1—C11—C12	108.85 (15)
C2—C1—N2	117.34 (16)	N1—C11—C10	103.58 (14)

C6—C1—N2	122.65 (16)	C12—C11—C10	112.28 (13)
C3—C2—C1	120.47 (19)	N1—C11—H11	110.6
C3—C2—H2	119.8	C12—C11—H11	110.6
C1—C2—H2	119.8	C10—C11—H11	110.6
C4—C3—C2	120.6 (2)	O2—C12—N2	120.99 (15)
C4—C3—H3A	119.7	O2—C12—C11	123.37 (15)
C2—C3—H3A	119.7	N2—C12—C11	115.62 (13)
C3—C4—C5	119.21 (18)	N2—C13—C14	112.56 (16)
C3—C4—H4	120.4	N2—C13—H13A	109.1
C5—C4—H4	120.4	C14—C13—H13A	109.1
C4—C5—C6	121.87 (19)	N2—C13—H13B	109.1
C4—C5—H5	119.1	C14—C13—H13B	109.1
C6—C5—H5	119.1	H13A—C13—H13B	107.8
C5—C6—C1	118.02 (17)	O5—C14—O4	125.18 (19)
C5—C6—C7	116.15 (16)	O5—C14—C13	124.73 (17)
C1—C6—C7	125.82 (14)	O4—C14—C13	110.08 (18)
O1—C7—N1	120.98 (18)	O4—C15—C16	108.4 (2)
O1—C7—C6	120.85 (16)	O4—C15—H15A	110.0
N1—C7—C6	118.12 (16)	C16—C15—H15A	110.0
N1—C8—C9	103.94 (16)	O4—C15—H15B	110.0
N1—C8—H8A	111.0	C16—C15—H15B	110.0
C9—C8—H8A	111.0	H15A—C15—H15B	108.4
N1—C8—H8B	111.0	C15—C16—H16A	109.5
C9—C8—H8B	111.0	C15—C16—H16B	109.5
H8A—C8—H8B	109.0	H16A—C16—H16B	109.5
O3—C9—C8	112.32 (18)	C15—C16—H16C	109.5
O3—C9—C10	113.62 (19)	H16A—C16—H16C	109.5
C8—C9—C10	103.30 (14)	H16B—C16—H16C	109.5
O3—C9—H9	109.1		

C12—N2—C1—C2	137.2 (2)	N1—C8—C9—O3	90.74 (19)
C13—N2—C1—C2	−38.4 (3)	N1—C8—C9—C10	−32.09 (19)
C12—N2—C1—C6	−48.8 (3)	O3—C9—C10—C11	−90.0 (2)
C13—N2—C1—C6	135.63 (19)	C8—C9—C10—C11	32.0 (2)
C6—C1—C2—C3	−2.3 (3)	C7—N1—C11—C12	−69.2 (2)
N2—C1—C2—C3	171.88 (19)	C8—N1—C11—C12	118.12 (16)
C1—C2—C3—C4	−0.4 (3)	C7—N1—C11—C10	171.13 (18)
C2—C3—C4—C5	1.9 (4)	C8—N1—C11—C10	−1.53 (19)
C3—C4—C5—C6	−0.8 (3)	C9—C10—C11—N1	−19.1 (2)
C4—C5—C6—C1	−1.8 (3)	C9—C10—C11—C12	−136.39 (17)
C4—C5—C6—C7	178.27 (19)	C1—N2—C12—O2	−178.8 (2)
C2—C1—C6—C5	3.3 (3)	C13—N2—C12—O2	−3.2 (3)
N2—C1—C6—C5	−170.55 (18)	C1—N2—C12—C11	2.2 (3)
C2—C1—C6—C7	−176.78 (18)	C13—N2—C12—C11	177.84 (17)
N2—C1—C6—C7	9.4 (3)	N1—C11—C12—O2	−111.0 (2)
C11—N1—C7—O1	−176.41 (17)	C10—C11—C12—O2	3.1 (3)
C8—N1—C7—O1	−4.5 (3)	N1—C11—C12—N2	68.0 (2)
C11—N1—C7—C6	1.1 (3)	C10—C11—C12—N2	−177.93 (18)

C8—N1—C7—C6	173.01 (16)	C12—N2—C13—C14	−69.9 (2)
C5—C6—C7—O1	32.0 (3)	C1—N2—C13—C14	106.03 (19)
C1—C6—C7—O1	−147.9 (2)	C15—O4—C14—O5	−2.1 (3)
C5—C6—C7—N1	−145.53 (19)	C15—O4—C14—C13	176.49 (19)
C1—C6—C7—N1	34.6 (3)	N2—C13—C14—O5	−17.2 (3)
C7—N1—C8—C9	−151.47 (18)	N2—C13—C14—O4	164.23 (16)
C11—N1—C8—C9	21.4 (2)	C14—O4—C15—C16	177.9 (2)

Hydrogen-bond geometry (Å, º)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O3—H3···O1^{i}	0.84 (1)	1.95 (1)	2.782 (2)	173 (4)

Symmetry code: (i) *x*+1/2, −*y*+5/2, −*z*.