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8,15-Dioxa-10,13-diazatetracyclo- [14.4.0.0^{2,7}.0^{9,14}]icosa-1(16),2,4,6,- 9(14),10,12,17,19-nonaene

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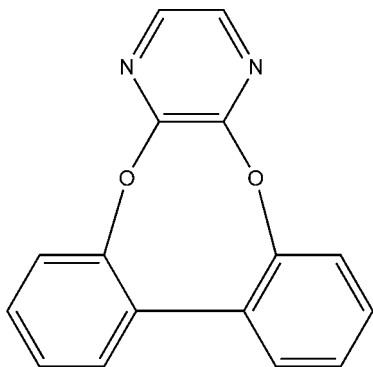
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Key indicators: single-crystal X-ray study; $T = 293$ K; mean $\sigma(\text{C}-\text{C}) = 0.002$ Å; R factor = 0.033; wR factor = 0.106; data-to-parameter ratio = 16.3.

The asymmetric unit of the title compound, $\text{C}_{16}\text{H}_{10}\text{N}_2\text{O}_2$, contains one half-molecule, the complete molecule being generated by twofold rotation symmetry. The plane of the pyrazine ring forms a dihedral angle of $64.87(6)^\circ$ with that of the benzene ring, and the planes of the two benzene rings are inclined to one another by $54.20(6)^\circ$. The O atom deviates from the plane of the benzene ring by $0.1549(8)$ Å. There are no significant intermolecular interactions in the crystal.

Related literature

For applications of the pyrazine ring system in drug development, see: Du *et al.* (2009); Dubinina *et al.* (2006); Ellsworth *et al.* (2007); Mukaiyama *et al.* (2007). For background to the fluorescence properties of related compounds, see: Kawai *et al.* (2001); Abdullah (2005) and for their biological activity, see: Seitz *et al.* (2002); Temple *et al.* (1970). For a related structure, see: Nasir *et al.* (2010).



Experimental

Crystal data

$\text{C}_{16}\text{H}_{10}\text{N}_2\text{O}_2$	$V = 1221.6(4)$ Å ³
$M_r = 262.26$	$Z = 4$
Orthorhombic, <i>Pbcn</i>	Mo $K\alpha$ radiation
$a = 14.429(3)$ Å	$\mu = 0.10$ mm ⁻¹
$b = 10.162(2)$ Å	$T = 293$ K
$c = 8.3313(18)$ Å	$0.30 \times 0.25 \times 0.20$ mm

Data collection

Bruker SMART APEXII area-detector diffractometer	6082 measured reflections
Absorption correction: multi-scan (SADABS; Bruker, 2008)	1502 independent reflections
$T_{\min} = 0.972$, $T_{\max} = 0.981$	1226 reflections with $I > 2\sigma(I)$
	$R_{\text{int}} = 0.029$

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.033$	92 parameters
$wR(F^2) = 0.106$	H-atom parameters constrained
$S = 1.03$	$\Delta\rho_{\text{max}} = 0.22$ e Å ⁻³
1502 reflections	$\Delta\rho_{\text{min}} = -0.13$ e Å ⁻³

Data collection: APEX2 (Bruker, 2008); cell refinement: SAINT (Bruker, 2008); data reduction: SAINT; program(s) used to solve structure: SHELXS97 (Sheldrick, 2008); program(s) used to refine structure: SHELXL97 (Sheldrick, 2008); molecular graphics: ORTEP-3 for Windows (Farrugia, 2012) and Mercury (Macrae *et al.*, 2008); software used to prepare material for publication: SHELXL97 and PLATON (Spek, 2009).

The authors thank the TBI X-ray facility, CAS in Crystallography and Biophysics, University of Madras, India, for the data collection. TS and DV thank the UGC (SAP-CAS) for the departmental facilities. TS also thanks the DST Inspire program for financial assistance.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: SU2586).

References

- Abdullah, Z. (2005). *Int. J. Chem. Sci.* **3**, 9–15.
 Bruker (2008). APEX2, SAINT and SADABS. Bruker AXS Inc., Madison, Wisconsin, USA.
 Du, X. H., Gustin, D. J., Chen, X. Q., Duquette, J., McGee, L. R., Wang, Z. L., Ebsworth, K., Henne, K., Lemon, B., Ma, J., Miao, S. C., Sabalan, E., Sullivan, T. J., Tonn, G., Collins, T. L. & Medina, J. C. (2009). *Bioorg. Med. Chem. Lett.* **19**, 5200–5204.
 Dubinina, G. G., Platonov, M. O., Golovach, S. M., Borysko, P. O., Tolmachov, A. O. & Volovenko, Y. M. (2006). *Eur. J. Med. Chem.* **41**, 727–737.
 Ellsworth, B. A., Wang, Y., Zhu, Y. H., Pendri, A., Gerritz, S. W., Sun, C. Q., Carlson, K. E., Kang, L. Y., Baska, R. A., Yang, Y. F., Huang, Q., Burford, N. T., Cullen, M. J., Johnghar, S., Behnia, K., Pelleymounter, M. A., Washburn, W. N. & Ewing, W. R. (2007). *Bioorg. Med. Chem. Lett.* **17**, 3978–3982.
 Farrugia, L. J. (2012). *J. Appl. Cryst.* **45**, 849–854.
 Kawai, M., Lee, M. J., Evans, K. O. & Norlund, T. (2001). *J. Fluoresc.* **11**, 23–32.
 Macrae, C. F., Bruno, I. J., Chisholm, J. A., Edgington, P. R., McCabe, P., Pidcock, E., Rodriguez-Monge, L., Taylor, R., van de Streek, J. & Wood, P. A. (2008). *J. Appl. Cryst.* **41**, 466–470.
 Mukaiyama, H., Nishimura, T., Kobayashi, S., Ozawa, T., Kamada, N., Komatsu, Y., Kikuchi, S., Oonota, H. & Kusama, H. (2007). *Bioorg. Med. Chem. Lett.* **15**, 868–885.
 Nasir, S. B., Abdullah, Z., Fairuz, Z. A., Ng, S. W. & Tiekink, E. R. T. (2010). *Acta Cryst.* **E66**, o2187.

Seitz, L. E., Suling, W. J. & Reynolds, R. C. (2002). *J. Med. Chem.* **45**, 5604–5606.
Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.

Spek, A. L. (2009). *Acta Cryst.* **D65**, 148–155.
Temple, C. Jr, Rose, J. D. & Montgomery, J. A. (1970). *J. Med. Chem.* **13**, 1234–1235.

supplementary materials

Acta Cryst. (2013). E69, o813–o814 [doi:10.1107/S1600536813011318]

8,15-Dioxa-10,13-diazatetracyclo- [14.4.0.0^{2,7}.0^{9,14}]icosa-1(16),2,4,6,9(14),10,12,17,19-nonaene

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Comment

The pyrazine ring system is a useful structural element in medicinal chemistry and has found broad applications in drug development which can be used as antiproliferative agent (Dubinina *et al.*, 2006), potent CXCR3 antagonists (Du *et al.*, 2009), CB1 antagonists (Ellsworth *et al.*, 2007) and c-Src inhibitory (Mukaiyama *et al.*, 2007). On-going structural studies of heterocyclic N-containing derivatives (Nasir *et al.*, 2010) are motivated by an investigation of their fluorescence properties (Kawai *et al.*, 2001; Abdullah, 2005). Pyrazine derivatives were shown to display antimycobacterial (Seitz *et al.*, 2002) and potential antimalarial (Temple *et al.*, 1970) activities. In view of different applications of this class of compounds, we have undertaken the crystal structure determination of the title compound.

The title compound, Fig. 1, contains one half molecule in the asymmetric unit; the complete molecule is generated by a two-fold rotation axis, about [010]; symmetry code: (i) $-x+1, y, -z+1/2$.

The central pyrazine ring (C1/N1/C2/C1ⁱ/N1ⁱ/C2ⁱ) forms a dihedral angle of 64.87 (6) ° with the phenyl ring (C3–C8). The dihedral angle between the symmetry related phenyl rings (C3–C8) and (C3ⁱ–C8ⁱ) is 54.20 (6) °. The deviation of the atom O1 from the phenyl ring (C3–C8) is 0.1549 (8) Å.

In the crystal, there are no significant intermolecular interactions present.

Experimental

To a stirred solution of Cs₂CO₃ (15 mmol) in CH₃CN (5 mL), was added dropwise independently a solution of corresponding diol (10 mmol) in CH₃CN (25 mL) and a solution of 2,3-dichloropyrazine (10 mmol) in CH₃CN (25 mL). The reaction mixture was stirred at reflux for 12 h. The reaction mixture was allowed to cool to room temperature and then poured into water (200 mL), and extracted with CH₂Cl₂ (2X100 mL). The combined organic layers were washed with water (100 mL), brine (50 mL) and dried over Na₂SO₄. The solvent was evaporated and the crude product was purified by column chromatography with CHCl₃ as an eluent to give the title compound. Single crystals suitable for X-ray diffraction were obtained by slow evaporation of a solution of the title compound in hexane at room temperature.

Refinement

The hydrogen atoms were placed in calculated positions and refined in the riding model approximation: C—H = 0.93 Å with $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$.

Computing details

Data collection: *APEX2* (Bruker, 2008); cell refinement: *SAINT* (Bruker, 2008); data reduction: *SAINT* (Bruker, 2008); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *ORTEP-3 for Windows* (Farrugia, 2012) and Mercury (Macrae *et al.*, 2008);

software used to prepare material for publication: *SHELXL97* (Sheldrick, 2008) and *PLATON* (Spek, 2009).

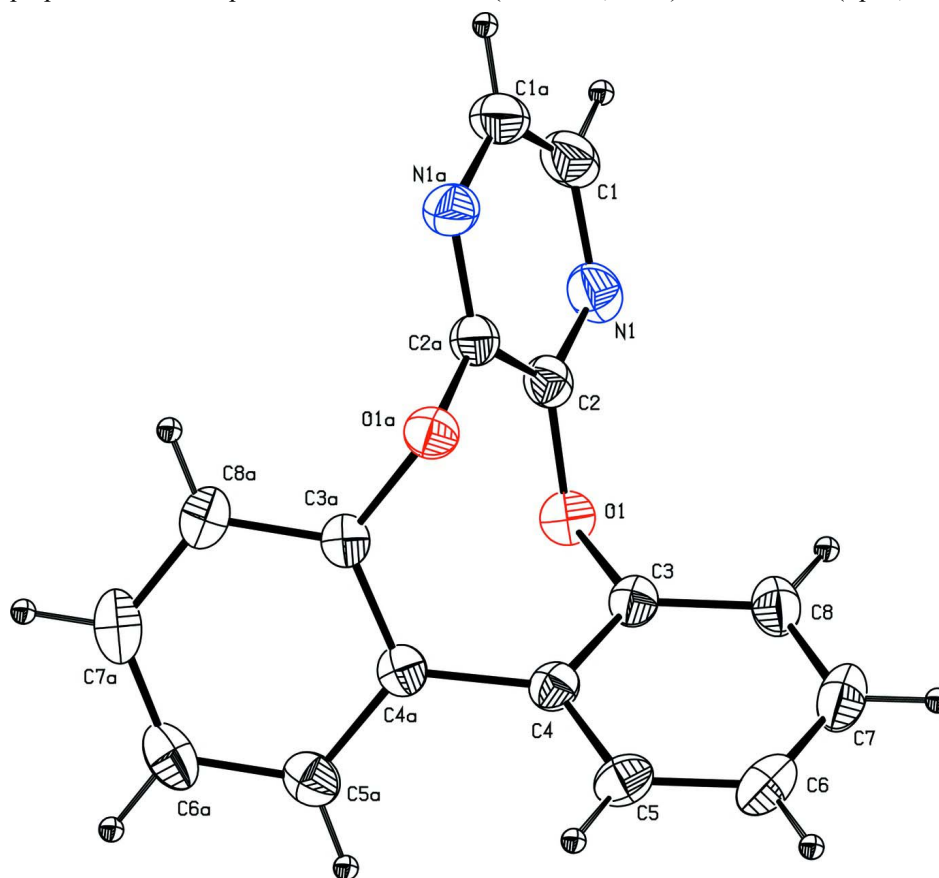


Figure 1

The molecular structure of the title molecule, with atom labelling (symmetry code: (a) $-x+1, y, -z+1/2$). Displacement ellipsoids are drawn at the 30% probability level.

8,15-Dioxa-10,13-diazatetracyclo[14.4.0.0^{2,7}.0^{9,14}]icosa-1(16),2,4,6,9(14),10,12,17,19-nonaene

Crystal data

$C_{16}H_{10}N_2O_2$

$M_r = 262.26$

Orthorhombic, *Pbcn*

Hall symbol: $-P\ 2n\ 2ab$

$a = 14.429\ (3)\ \text{\AA}$

$b = 10.162\ (2)\ \text{\AA}$

$c = 8.3313\ (18)\ \text{\AA}$

$V = 1221.6\ (4)\ \text{\AA}^3$

$Z = 4$

$F(000) = 544$

$D_x = 1.426\ \text{Mg m}^{-3}$

Mo $K\alpha$ radiation, $\lambda = 0.71073\ \text{\AA}$

Cell parameters from 1502 reflections

$\theta = 2.5\text{--}28.3^\circ$

$\mu = 0.10\ \text{mm}^{-1}$

$T = 293\ \text{K}$

Block, colourless

$0.30 \times 0.25 \times 0.20\ \text{mm}$

Data collection

Bruker SMART APEXII area-detector
diffractometer

Radiation source: fine-focus sealed tube

Graphite monochromator

ω and φ scans

Absorption correction: multi-scan
(*SADABS*; Bruker, 2008)

$T_{\min} = 0.972, T_{\max} = 0.981$

6082 measured reflections

1502 independent reflections

1226 reflections with $I > 2\sigma(I)$

$R_{\text{int}} = 0.029$
 $\theta_{\text{max}} = 28.3^\circ$, $\theta_{\text{min}} = 2.5^\circ$
 $h = -18 \rightarrow 19$

$k = -5 \rightarrow 13$
 $l = -7 \rightarrow 10$

Refinement

Refinement on F^2
 Least-squares matrix: full
 $R[F^2 > 2\sigma(F^2)] = 0.033$
 $wR(F^2) = 0.106$
 $S = 1.03$
 1502 reflections
 92 parameters
 0 restraints
 Primary atom site location: structure-invariant
 direct methods
 Secondary atom site location: difference Fourier
 map

Hydrogen site location: inferred from
 neighbouring sites
 H-atom parameters constrained
 $w = 1/[\sigma^2(F_o^2) + (0.0544P)^2 + 0.1721P]$
 where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\text{max}} < 0.001$
 $\Delta\rho_{\text{max}} = 0.22 \text{ e } \text{\AA}^{-3}$
 $\Delta\rho_{\text{min}} = -0.13 \text{ e } \text{\AA}^{-3}$
 Extinction correction: *SHELXL97* (Sheldrick,
 2008), $F_c^* = kF_c[1 + 0.001x F_c^2 \lambda^3 / \sin(2\theta)]^{-1/4}$
 Extinction coefficient: 0.012 (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.

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 (\AA^2)

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
C1	0.53624 (10)	1.14890 (12)	0.19682 (18)	0.0623 (4)
H1	0.5600	1.2289	0.1616	0.075*
C2	0.53746 (8)	0.92738 (11)	0.19677 (13)	0.0426 (3)
C3	0.60493 (7)	0.71770 (11)	0.24296 (13)	0.0395 (3)
C4	0.54878 (7)	0.61036 (10)	0.27797 (12)	0.0390 (3)
C5	0.58736 (8)	0.50933 (12)	0.36919 (14)	0.0480 (3)
H5	0.5523	0.4349	0.3922	0.058*
C6	0.67748 (9)	0.51846 (14)	0.42609 (16)	0.0568 (4)
H6	0.7020	0.4509	0.4883	0.068*
C7	0.73073 (8)	0.62674 (15)	0.39094 (15)	0.0594 (4)
H7	0.7908	0.6328	0.4305	0.071*
C8	0.69529 (8)	0.72654 (12)	0.29713 (15)	0.0505 (3)
H8	0.7317	0.7989	0.2706	0.061*
N1	0.57395 (7)	1.03683 (10)	0.14200 (14)	0.0546 (3)
O1	0.57275 (5)	0.81298 (8)	0.13462 (9)	0.0446 (2)

Atomic displacement parameters (\AA^2)

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
C1	0.0751 (9)	0.0430 (6)	0.0688 (9)	-0.0077 (6)	-0.0246 (6)	0.0065 (6)
C2	0.0464 (6)	0.0431 (6)	0.0383 (6)	-0.0018 (4)	-0.0088 (4)	0.0017 (4)

C3	0.0383 (5)	0.0458 (5)	0.0344 (5)	0.0021 (4)	0.0021 (4)	-0.0019 (4)
C4	0.0382 (5)	0.0429 (5)	0.0357 (5)	0.0033 (4)	0.0052 (4)	-0.0026 (4)
C5	0.0498 (6)	0.0476 (6)	0.0467 (6)	0.0092 (5)	0.0103 (5)	0.0029 (5)
C6	0.0547 (7)	0.0697 (8)	0.0461 (6)	0.0241 (6)	0.0024 (5)	0.0049 (6)
C7	0.0417 (6)	0.0870 (10)	0.0496 (7)	0.0130 (6)	-0.0066 (5)	-0.0073 (7)
C8	0.0394 (6)	0.0623 (7)	0.0497 (7)	-0.0040 (5)	-0.0005 (5)	-0.0078 (6)
N1	0.0593 (6)	0.0495 (6)	0.0548 (6)	-0.0094 (5)	-0.0118 (5)	0.0090 (5)
O1	0.0486 (5)	0.0467 (4)	0.0384 (4)	-0.0009 (3)	0.0040 (3)	0.0041 (3)

Geometric parameters (Å, °)

C1—N1	1.3423 (17)	C4—C5	1.3935 (16)
C1—C1 ⁱ	1.371 (3)	C4—C4 ⁱ	1.483 (2)
C1—H1	0.9300	C5—C6	1.3871 (17)
C2—N1	1.3124 (15)	C5—H5	0.9300
C2—O1	1.3707 (14)	C6—C7	1.374 (2)
C2—C2 ⁱ	1.398 (2)	C6—H6	0.9300
C3—C8	1.3826 (15)	C7—C8	1.3787 (18)
C3—C4	1.3897 (15)	C7—H7	0.9300
C3—O1	1.4029 (13)	C8—H8	0.9300
N1—C1—C1 ⁱ	121.95 (8)	C6—C5—H5	119.6
N1—C1—H1	119.0	C4—C5—H5	119.6
C1 ⁱ —C1—H1	119.0	C7—C6—C5	120.33 (12)
N1—C2—O1	116.01 (10)	C7—C6—H6	119.8
N1—C2—C2 ⁱ	122.05 (7)	C5—C6—H6	119.8
O1—C2—C2 ⁱ	121.79 (6)	C6—C7—C8	120.18 (11)
C8—C3—C4	122.16 (11)	C6—C7—H7	119.9
C8—C3—O1	118.51 (10)	C8—C7—H7	119.9
C4—C3—O1	118.93 (9)	C7—C8—C3	119.14 (11)
C3—C4—C5	117.38 (10)	C7—C8—H8	120.4
C3—C4—C4 ⁱ	119.18 (8)	C3—C8—H8	120.4
C5—C4—C4 ⁱ	123.41 (8)	C2—N1—C1	115.99 (12)
C6—C5—C4	120.77 (12)	C2—O1—C3	117.73 (8)
C8—C3—C4—C5	-0.82 (16)	C4—C3—C8—C7	-0.97 (17)
O1—C3—C4—C5	171.84 (9)	O1—C3—C8—C7	-173.66 (10)
C8—C3—C4—C4 ⁱ	177.25 (11)	O1—C2—N1—C1	176.77 (10)
O1—C3—C4—C4 ⁱ	-10.09 (16)	C2 ⁱ —C2—N1—C1	1.3 (2)
C3—C4—C5—C6	1.84 (16)	C1 ⁱ —C1—N1—C2	-0.2 (2)
C4 ⁱ —C4—C5—C6	-176.15 (12)	N1—C2—O1—C3	126.38 (10)
C4—C5—C6—C7	-1.07 (18)	C2 ⁱ —C2—O1—C3	-58.13 (16)
C5—C6—C7—C8	-0.78 (19)	C8—C3—O1—C2	-86.29 (12)
C6—C7—C8—C3	1.78 (18)	C4—C3—O1—C2	100.77 (11)

Symmetry code: (i) $-x+1, y, -z+1/2$.