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# 3-(2-Benzamidophenyl)-4-(4-hydroxyphenyl)-5-methyl-4H-1,2,4-triazol-1-ium chloride

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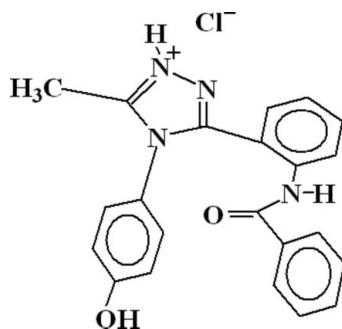
Received 8 July 2008; accepted 10 July 2008

 Key indicators: single-crystal X-ray study;  $T = 296$  K; mean  $\sigma(\text{C}-\text{C}) = 0.004$  Å;  $R$  factor = 0.035;  $wR$  factor = 0.098; data-to-parameter ratio = 10.3.

In the molecule of the title compound,  $\text{C}_{22}\text{H}_{19}\text{N}_4\text{O}_2^+\cdot\text{Cl}^-$ , the 1,2,4-triazole ring is oriented at dihedral angles of 75.57 (14), 53.23 (13) and 68.11 (13)° with respect to the benzamide, aniline and phenol atomic rings, respectively. An intramolecular  $\text{C}-\text{H}\cdots\text{O}$  hydrogen bond results in the formation of a non-planar ten-membered ring. In the crystal structure, intermolecular  $\text{O}-\text{H}\cdots\text{Cl}$  and  $\text{N}-\text{H}\cdots\text{Cl}$  hydrogen bonds link the molecules. There is a  $\text{C}-\text{H}\cdots\pi$  contact between the methyl group and the phenyl ring, and a  $\pi-\pi$  contact between the hydroxyphenyl and phenyl rings [centroid-centroid distance = 4.687 (2) Å].

## Related literature

For general background, see: Caira *et al.* (2004); Peeters *et al.* (1996). For related literature, see: Potts (1961).



## Experimental

### Crystal data

 $\text{C}_{22}\text{H}_{19}\text{N}_4\text{O}_2^+\cdot\text{Cl}^-$ 
 $M_r = 406.86$ 

 Orthorhombic,  $Pca2_1$ 
 $a = 17.1336$  (15) Å

 $b = 9.8967$  (9) Å

 $c = 12.1910$  (10) Å

 $V = 2067.2$  (3) Å<sup>3</sup>
 $Z = 4$ 

 Mo  $K\alpha$  radiation

 $\mu = 0.21$  mm<sup>-1</sup>
 $T = 296$  (2) K

 $0.25 \times 0.20 \times 0.18$  mm

### Data collection

Bruker Kappa APEXII CCD diffractometer

Absorption correction: multi-scan

 (*SADABS*; Bruker, 2005)

 $T_{\min} = 0.950$ ,  $T_{\max} = 0.960$ 

13329 measured reflections

2809 independent reflections

 2480 reflections with  $I > 2\sigma(I)$ 
 $R_{\text{int}} = 0.022$ 

### Refinement

 $R[F^2 > 2\sigma(F^2)] = 0.034$ 
 $wR(F^2) = 0.097$ 
 $S = 1.02$ 

2809 reflections

272 parameters

1 restraint

H atoms treated by a mixture of independent and constrained refinement

 $\Delta\rho_{\text{max}} = 0.20$  e Å<sup>-3</sup>
 $\Delta\rho_{\text{min}} = -0.21$  e Å<sup>-3</sup>

Absolute structure: Flack (1983), with 1677 Friedel pairs

Flack parameter: 0.06 (7)

**Table 1**

Hydrogen-bond geometry (Å, °).

 $\text{Cg}_2$  is the centroid of the C1–C6 phenyl ring.

$D-\text{H}\cdots A$	$D-\text{H}$	$\text{H}\cdots A$	$D\cdots A$	$D-\text{H}\cdots A$
$\text{N1}-\text{H1}\cdots\text{Cl}^{\text{i}}$	0.81 (3)	2.58 (3)	3.372 (2)	166 (3)
$\text{O2}-\text{H2A}\cdots\text{Cl}^{\text{ii}}$	0.76 (4)	2.34 (4)	3.090 (2)	171 (5)
$\text{N3}-\text{H3A}\cdots\text{Cl}^{\text{iii}}$	0.97 (3)	2.14 (3)	3.068 (2)	158 (3)
$\text{C18}-\text{H18}\cdots\text{O1}$	0.93	2.35	3.165 (3)	146
$\text{C16}-\text{H16A}\cdots\text{Cg}_2^{\text{iv}}$	0.96	2.84	3.367 (3)	115

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

Data collection: *APEX2* (Bruker, 2007); cell refinement: *APEX2*; data reduction: *SAINT* (Bruker, 2007); 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, 1997) and *PLATON* (Spek, 2003); software used to prepare material for publication: *WinGX* (Farrugia, 1999) and *PLATON*.

The authors acknowledge the Higher Education Commission, Islamabad, Pakistan, for funding the purchase of the diffractometer at GCU, Lahore.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: HK2490).

## References

- Bruker (2005). *SADABS*. Bruker AXS Inc. Madison, Wisconsin, USA.  
 Bruker (2007). *APEX2* and *SAINT*. Bruker AXS Inc. Madison, Wisconsin, USA.  
 Caira, M. R., Alkhamis, K. A. & Obaidat, R. M. (2004). *J. Pharm. Sci.* **93**, 601–611.  
 Farrugia, L. J. (1997). *J. Appl. Cryst.* **30**, 565.  
 Farrugia, L. J. (1999). *J. Appl. Cryst.* **32**, 837–838.  
 Flack, H. D. (1983). *Acta Cryst.* **A39**, 876–881.  
 Peeters, O. M., Blaton, N. M. & De Ranter, C. J. (1996). *Acta Cryst.* **C52**, 2225–2229.  
 Potts, K. T. (1961). *Chem. Rev.* **61**, 87–127.  
 Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.  
 Spek, A. L. (2003). *J. Appl. Cryst.* **36**, 7–13.

## supporting information

*Acta Cryst.* (2008). E64, o1505 [doi:10.1107/S160053680802148X]

## 3-(2-Benzamidophenyl)-4-(4-hydroxyphenyl)-5-methyl-4*H*-1,2,4-triazol-1-ium chloride

Mohammad Arfan, M. Nawaz Tahir, Rasool Khan and Mohammad S. Iqbal

### S1. Comment

1,2,4-Triazole is a basic aromatic heterocycle. Its derivatives, such as fluconazole (Caira *et al.*, 2004) and itraconazole (Peeters *et al.*, 1996), find use as antifungals and can be prepared using various routes including Einhorn-Brunner and Pellizzari reactions (Potts, 1961).

In the molecule of the title compound (Fig. 1) the bond lengths and angles are generally within normal ranges. Rings A (C1-C6), B (C8-C13), C (N2-N4/C14/C15) and D (C17-C22) are, of course, planar, and the dihedral angles between them are A/B = 66.39 (14)°, A/C = 75.57 (14)°, A/D = 39.96 (13)°, B/C = 53.23 (13)°, B/D = 78.57 (14)° and C/D = 68.11 (13)°. The intramolecular C-H...O hydrogen bond (Table 1) results in the formation of a non-planar ten-membered ring E (O1/N1/N4/C7/C8/C13/C14/C17/C18/H18).

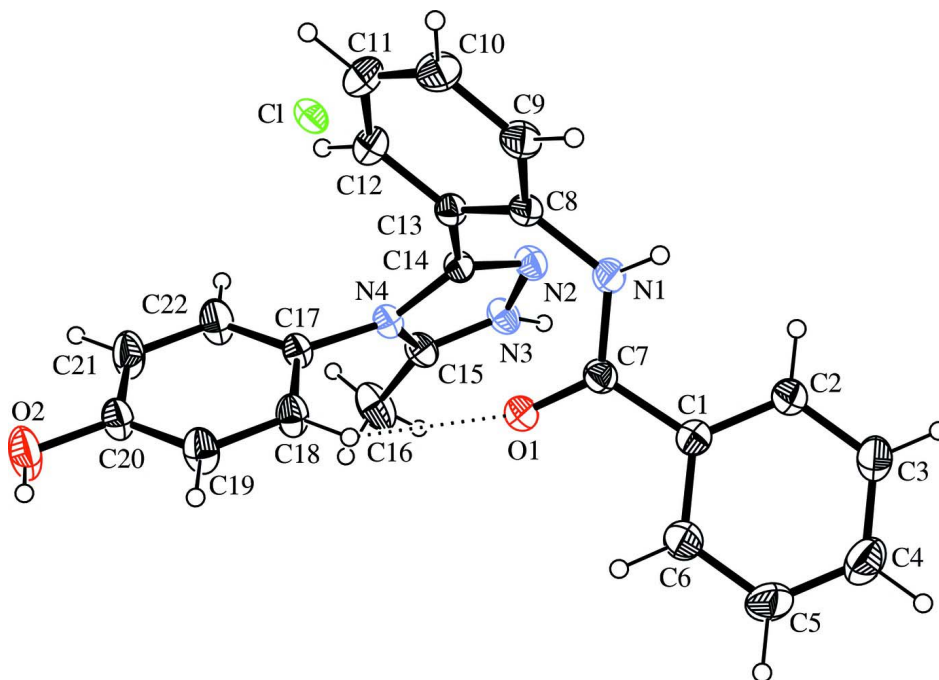
In the crystal structure, intermolecular O-H...Cl and N-H...Cl hydrogen bonds (Table 1) link the molecules (Fig. 2), in which they may be effective in the stabilization of the structure. The C—H... $\pi$  contact (Table 1) between the methyl group and the phenyl ring and  $\pi$ — $\pi$  contact between the two phenyl rings Cg2...Cg4<sup>i</sup> [symmetry code: (i) -x, 2 - y, 1/2 + z, where Cg2 and Cg4 are centroids of the rings (C1-C6) and (C17-C22), respectively] further stabilize the structure, with centroid-centroid distance of 4.687 (2) Å.

### S2. Experimental

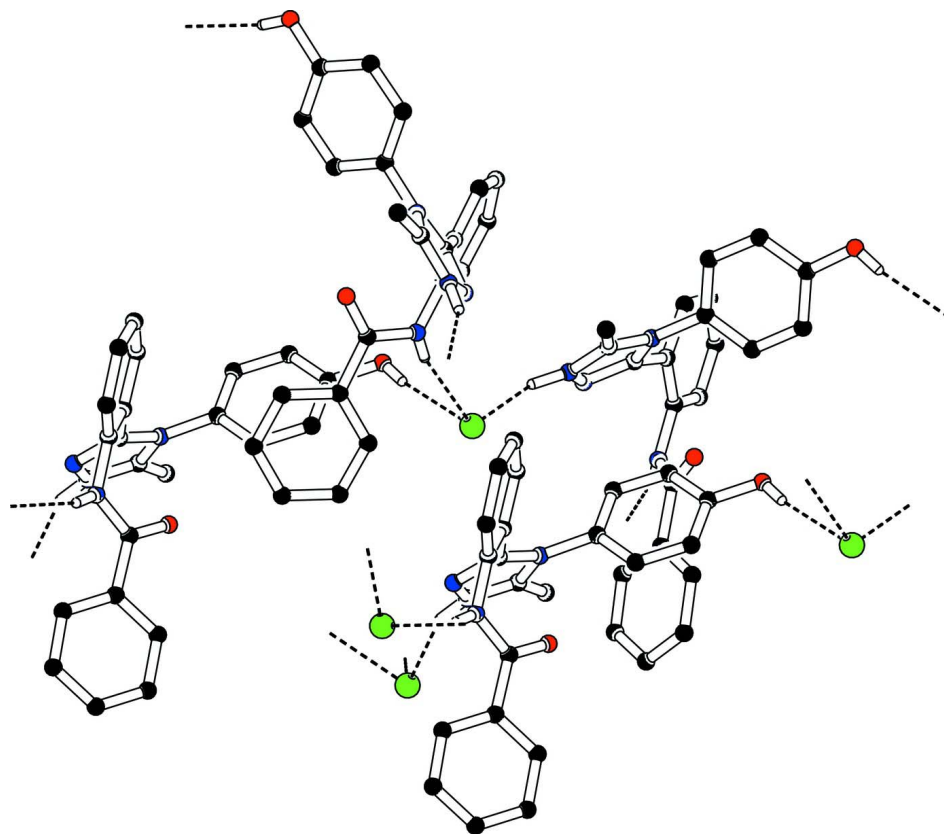
For the preparation of the title compound, N-[2-(hydrazinylcarbonyl)phenyl]- benzamide (0.25 g, 0.98 mmol) and triethyl orthoacetate (1 ml) were refluxed for 2 h. The reaction mixture was cooled to room temperature and 4-aminophenol (0.11 g, 0.98 mmol) was added. Acetic acid (1 ml) was added to the mixture and the contents were refluxed for 1 h. Then, the reaction mixture was added to HCl (8 M) solution. It was crystallized by adding dioxane portion-wise. The crystals were separated by filtration and washed with dioxane (yield; 77%, m.p. 498 K).

### S3. Refinement

H atoms, H2A (for OH), H1 and H3A (for NH), were located in difference syntheses and refined [O-H = 0.76 (4) Å,  $U_{\text{iso}}(\text{H}) = 0.0839 \text{ \AA}^2$  and N-H = 0.81 (3) and 0.97 (3) Å,  $U_{\text{iso}}(\text{H}) = 0.0628$  and  $0.0492 \text{ \AA}^2$ ]. The remaining H atoms were positioned geometrically, with C-H = 0.93 and 0.96 Å for aromatic and methyl H, respectively, and constrained to ride on their parent atoms with  $U_{\text{iso}}(\text{H}) = xU_{\text{eq}}(\text{C})$ , where  $x = 1.5$  for methyl H and  $x = 1.2$  for aromatic H atoms.

**Figure 1**

The molecular structure of the title molecule, with the atom-numbering scheme. Displacement ellipsoids are drawn at the 30% probability level. Hydrogen bond is shown as dotted line.

**Figure 2**

A partial packing diagram of the title compound. Hydrogen bonds are shown as dashed lines.

### 3-(2-Benzamidophenyl)-4-(4-hydroxyphenyl)-5-methyl-4H-1,2,4-triazol-1-ium chloride

#### Crystal data

$C_{22}H_{19}N_4O_2^+ \cdot Cl^-$

$M_r = 406.86$

Orthorhombic,  $Pca2_1$

Hall symbol: P 2c -2ac

$a = 17.1336$  (15) Å

$b = 9.8967$  (9) Å

$c = 12.191$  (1) Å

$V = 2067.2$  (3) Å<sup>3</sup>

$Z = 4$

$F(000) = 848$

$D_x = 1.307$  Mg m<sup>-3</sup>

Mo  $K\alpha$  radiation,  $\lambda = 0.71073$  Å

Cell parameters from 2009 reflections

$\theta = 2.1$ – $28.8^\circ$

$\mu = 0.21$  mm<sup>-1</sup>

$T = 296$  K

Prismatic, black

$0.25 \times 0.20 \times 0.18$  mm

#### Data collection

Bruker Kappa APEXII CCD  
diffractometer

Radiation source: fine-focus sealed tube

Graphite monochromator

Detector resolution: 7.40 pixels mm<sup>-1</sup>

$\omega$  scans

Absorption correction: multi-scan

(*SADABS*; Bruker, 2005)

$T_{\min} = 0.950$ ,  $T_{\max} = 0.960$

13329 measured reflections

2809 independent reflections

2480 reflections with  $I > 2\sigma(I)$

$R_{\text{int}} = 0.022$

$\theta_{\max} = 28.8^\circ$ ,  $\theta_{\min} = 2.1^\circ$

$h = -23 \rightarrow 18$

$k = -13 \rightarrow 10$

$l = -16 \rightarrow 12$

*Refinement*Refinement on  $F^2$ 

Least-squares matrix: full

 $R[F^2 > 2\sigma(F^2)] = 0.034$  $wR(F^2) = 0.097$  $S = 1.02$ 

2809 reflections

272 parameters

1 restraint

Primary atom site location: structure-invariant  
direct methodsSecondary atom site location: difference Fourier  
mapHydrogen site location: inferred from  
neighbouring sitesH atoms treated by a mixture of independent  
and constrained refinement $w = 1/[\sigma^2(F_o^2) + (0.0606P)^2 + 0.2556P]$ where  $P = (F_o^2 + 2F_c^2)/3$  $(\Delta/\sigma)_{\max} = 0.001$  $\Delta\rho_{\max} = 0.20 \text{ e } \text{\AA}^{-3}$  $\Delta\rho_{\min} = -0.21 \text{ e } \text{\AA}^{-3}$ Absolute structure: Flack (1983) with no Friedel  
pairs

Absolute structure parameter: 0.06 (7)

*Special details***Geometry.** Bond distances, angles etc have been calculated using the rounded fractional coordinates. All su's are estimated from the variances of the (full) variance-covariance matrix. The cell e.s.d.'s are taken into account in the estimation of distances, angles and torsion angles**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>	$U_{\text{iso}}^*/U_{\text{eq}}$
Cl	0.18901 (3)	0.41678 (5)	0.23611 (6)	0.0441 (2)
O1	0.08185 (11)	0.8416 (2)	0.61956 (15)	0.0523 (6)
O2	0.23156 (16)	1.1272 (2)	0.1626 (2)	0.0698 (9)
N1	-0.02194 (12)	0.7017 (2)	0.62595 (16)	0.0396 (6)
N2	0.12701 (11)	0.54036 (19)	0.55257 (17)	0.0394 (5)
N3	0.20680 (12)	0.5419 (2)	0.55843 (18)	0.0410 (6)
N4	0.17842 (10)	0.69261 (19)	0.44104 (16)	0.0345 (5)
C1	0.02424 (13)	0.8077 (2)	0.79409 (19)	0.0364 (6)
C2	-0.01415 (15)	0.7183 (3)	0.8629 (2)	0.0451 (8)
C3	-0.02023 (18)	0.7468 (4)	0.9741 (2)	0.0583 (10)
C4	0.0117 (2)	0.8628 (3)	1.0166 (3)	0.0640 (10)
C5	0.0506 (2)	0.9501 (3)	0.9485 (3)	0.0648 (10)
C6	0.05751 (18)	0.9231 (3)	0.8372 (2)	0.0513 (8)
C7	0.03122 (13)	0.7860 (2)	0.6732 (2)	0.0364 (6)
C8	-0.03057 (13)	0.6865 (2)	0.51128 (19)	0.0357 (6)
C9	-0.10597 (14)	0.6966 (3)	0.4680 (2)	0.0477 (8)
C10	-0.11851 (17)	0.6838 (3)	0.3569 (3)	0.0580 (9)
C11	-0.05706 (19)	0.6642 (3)	0.2866 (2)	0.0590 (10)
C12	0.01801 (16)	0.6538 (3)	0.3276 (2)	0.0476 (8)
C13	0.03172 (13)	0.6628 (2)	0.44022 (18)	0.0352 (6)
C14	0.11081 (12)	0.6336 (2)	0.48077 (18)	0.0340 (6)
C15	0.23791 (13)	0.6310 (2)	0.4926 (2)	0.0391 (6)
C16	0.32228 (14)	0.6578 (3)	0.4792 (3)	0.0637 (10)
C17	0.18724 (12)	0.8055 (2)	0.36715 (19)	0.0348 (6)

C18	0.16505 (16)	0.9329 (2)	0.3999 (2)	0.0441 (7)
C19	0.17852 (16)	1.0418 (3)	0.3320 (2)	0.0497 (8)
C20	0.21503 (14)	1.0236 (2)	0.2313 (2)	0.0456 (7)
C21	0.2375 (2)	0.8955 (3)	0.2002 (2)	0.0612 (9)
C22	0.22377 (19)	0.7867 (3)	0.2674 (2)	0.0575 (9)
H1	-0.061 (2)	0.684 (3)	0.661 (3)	0.0628*
H2	-0.03578	0.63946	0.83474	0.0541*
H2A	0.220 (2)	1.195 (4)	0.187 (4)	0.0839*
H3	-0.04612	0.68676	1.02018	0.0700*
H3A	0.2334 (17)	0.480 (3)	0.608 (3)	0.0492*
H4	0.00691	0.88200	1.09092	0.0768*
H5	0.07271	1.02826	0.97730	0.0778*
H6	0.08444	0.98261	0.79188	0.0616*
H9	-0.14797	0.71205	0.51465	0.0573*
H10	-0.16905	0.68850	0.32930	0.0696*
H11	-0.06583	0.65794	0.21149	0.0710*
H12	0.05962	0.64081	0.27972	0.0571*
H16A	0.33112	0.75352	0.47749	0.0956*
H16B	0.35037	0.61882	0.53950	0.0956*
H16C	0.34011	0.61830	0.41172	0.0956*
H18	0.14104	0.94552	0.46751	0.0529*
H19	0.16312	1.12783	0.35368	0.0596*
H21	0.26212	0.88257	0.13302	0.0734*
H22	0.23907	0.70060	0.24582	0.0689*

*Atomic displacement parameters (Å<sup>2</sup>)*

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
Cl	0.0360 (2)	0.0416 (3)	0.0547 (3)	-0.0066 (2)	0.0002 (3)	0.0095 (3)
O1	0.0540 (10)	0.0641 (11)	0.0389 (9)	-0.0263 (9)	0.0049 (8)	-0.0019 (9)
O2	0.104 (2)	0.0464 (10)	0.0590 (13)	0.0042 (12)	0.0244 (13)	0.0210 (11)
N1	0.0295 (9)	0.0549 (12)	0.0343 (10)	-0.0086 (8)	0.0027 (7)	-0.0004 (9)
N2	0.0373 (9)	0.0381 (9)	0.0428 (10)	-0.0018 (8)	-0.0011 (8)	0.0070 (9)
N3	0.0360 (9)	0.0375 (9)	0.0494 (11)	0.0008 (8)	-0.0005 (9)	0.0105 (9)
N4	0.0345 (9)	0.0309 (9)	0.0382 (10)	0.0006 (7)	0.0047 (7)	0.0034 (7)
C1	0.0332 (10)	0.0399 (11)	0.0362 (11)	0.0028 (8)	-0.0017 (9)	0.0000 (9)
C2	0.0452 (13)	0.0516 (14)	0.0386 (12)	-0.0102 (10)	-0.0013 (10)	0.0019 (11)
C3	0.0594 (16)	0.075 (2)	0.0406 (13)	-0.0120 (14)	0.0071 (12)	0.0054 (14)
C4	0.083 (2)	0.0655 (18)	0.0435 (14)	0.0084 (16)	0.0101 (15)	-0.0096 (14)
C5	0.094 (2)	0.0415 (13)	0.0588 (18)	-0.0032 (14)	0.0028 (17)	-0.0158 (13)
C6	0.0678 (17)	0.0380 (12)	0.0481 (14)	-0.0035 (11)	0.0037 (13)	0.0006 (10)
C7	0.0334 (11)	0.0384 (11)	0.0373 (11)	-0.0034 (8)	-0.0004 (9)	0.0022 (9)
C8	0.0325 (10)	0.0392 (11)	0.0353 (10)	-0.0063 (8)	-0.0030 (8)	0.0015 (9)
C9	0.0326 (10)	0.0598 (15)	0.0508 (14)	-0.0082 (10)	-0.0051 (10)	0.0026 (12)
C10	0.0462 (14)	0.0737 (18)	0.0540 (16)	-0.0104 (13)	-0.0210 (13)	0.0084 (14)
C11	0.0653 (18)	0.075 (2)	0.0367 (13)	-0.0117 (15)	-0.0159 (12)	0.0048 (13)
C12	0.0534 (14)	0.0549 (14)	0.0346 (12)	-0.0025 (11)	-0.0022 (10)	0.0006 (11)
C13	0.0366 (10)	0.0353 (10)	0.0337 (10)	-0.0039 (8)	-0.0027 (8)	0.0040 (9)

C14	0.0359 (10)	0.0325 (10)	0.0336 (10)	-0.0028 (8)	0.0028 (8)	0.0009 (8)
C15	0.0369 (12)	0.0323 (9)	0.0482 (12)	0.0022 (8)	0.0032 (10)	0.0050 (10)
C16	0.0338 (13)	0.0642 (18)	0.093 (2)	0.0031 (11)	0.0058 (14)	0.0277 (18)
C17	0.0365 (10)	0.0309 (10)	0.0369 (10)	0.0006 (8)	0.0046 (9)	0.0054 (9)
C18	0.0518 (13)	0.0379 (12)	0.0425 (12)	0.0099 (10)	0.0153 (11)	0.0057 (10)
C19	0.0625 (16)	0.0339 (11)	0.0527 (14)	0.0139 (10)	0.0168 (13)	0.0069 (11)
C20	0.0533 (12)	0.0394 (11)	0.0440 (12)	0.0020 (9)	0.0076 (12)	0.0113 (11)
C21	0.091 (2)	0.0481 (14)	0.0446 (14)	0.0031 (14)	0.0306 (15)	0.0036 (11)
C22	0.086 (2)	0.0351 (12)	0.0515 (16)	0.0072 (12)	0.0283 (14)	0.0009 (10)

*Geometric parameters (Å, °)*

O1—C7	1.218 (3)	C8—C9	1.399 (3)
O2—C20	1.354 (3)	C8—C13	1.395 (3)
O2—H2A	0.76 (4)	C9—C10	1.377 (4)
N1—C7	1.363 (3)	C9—H9	0.9300
N1—C8	1.414 (3)	C10—C11	1.371 (4)
N1—H1	0.81 (3)	C10—H10	0.9300
N2—N3	1.369 (3)	C11—C12	1.384 (4)
N2—C14	1.302 (3)	C11—H11	0.9300
N3—C15	1.306 (3)	C12—C13	1.396 (3)
N3—H3A	0.97 (3)	C12—H12	0.9300
N4—C14	1.385 (3)	C13—C14	1.471 (3)
N4—C15	1.344 (3)	C15—C16	1.479 (3)
N4—C17	1.443 (3)	C16—H16A	0.9600
C1—C2	1.385 (3)	C16—H16B	0.9600
C1—C6	1.380 (4)	C16—H16C	0.9600
C1—C7	1.494 (3)	C17—C18	1.376 (3)
C2—C3	1.389 (4)	C17—C22	1.380 (3)
C2—H2	0.9300	C18—C19	1.378 (4)
C3—C4	1.373 (5)	C18—H18	0.9300
C3—H3	0.9300	C19—C20	1.390 (3)
C4—C5	1.371 (5)	C19—H19	0.9300
C4—H4	0.9300	C20—C21	1.378 (4)
C5—C6	1.388 (4)	C21—C22	1.373 (4)
C5—H5	0.9300	C21—H21	0.9300
C6—H6	0.9300	C22—H22	0.9300
C1...O2 <sup>i</sup>	3.090 (2)	C21...O1 <sup>iii</sup>	3.291 (4)
C1...N1 <sup>ii</sup>	3.372 (2)	C22...C16	3.338 (4)
C1...C2 <sup>ii</sup>	3.627 (3)	C2...H19 <sup>ix</sup>	2.9700
C1...N3 <sup>iii</sup>	3.068 (2)	C2...H1	2.61 (4)
C1...H2 <sup>ii</sup>	2.9400	C4...H16A <sup>v</sup>	2.9400
C1...H9 <sup>ii</sup>	3.0700	C5...H16A <sup>v</sup>	2.8300
C1...H1 <sup>ii</sup>	2.58 (3)	C6...H16A <sup>v</sup>	3.0600
C1...H22	2.9400	C8...H5 <sup>vii</sup>	2.9400
C1...H10 <sup>iv</sup>	2.8800	C9...H5 <sup>vii</sup>	2.7800
C1...H2A <sup>i</sup>	2.34 (4)	C12...H2 <sup>ii</sup>	2.9200

Cl...H3A <sup>iii</sup>	2.14 (3)	C15...H21 <sup>v</sup>	3.0200
O1...N4	3.106 (3)	C15...H22	3.0900
O1...N2	3.187 (3)	C17...H16A	2.8600
O1...C18	3.165 (3)	C17...H12	2.9300
O1...C13	2.941 (3)	H1...H9	2.3400
O1...C14	2.710 (3)	H1...C2	2.61 (4)
O1...C21 <sup>v</sup>	3.291 (4)	H1...Cl <sup>viii</sup>	2.58 (3)
O2...Cl <sup>vi</sup>	3.090 (2)	H1...H2	2.2100
O1...H6	2.5200	H2...N1	2.6300
O1...H18	2.3500	H2...H1	2.2100
O1...H21 <sup>v</sup>	2.7100	H2...C12 <sup>viii</sup>	2.9200
O2...H9 <sup>vii</sup>	2.8000	H2...Cl <sup>viii</sup>	2.9400
N1...Cl <sup>viii</sup>	3.372 (2)	H2A...H19	2.3500
N1...N2	3.141 (3)	H2A...Cl <sup>vi</sup>	2.34 (4)
N2...C7	3.281 (3)	H3...H11 <sup>x</sup>	2.3700
N2...N4	2.212 (3)	H3...N2 <sup>viii</sup>	2.6700
N2...O1	3.187 (3)	H3A...H16B	2.5700
N2...N1	3.141 (3)	H3A...Cl <sup>v</sup>	2.14 (3)
N3...Cl <sup>v</sup>	3.068 (2)	H5...C9 <sup>ix</sup>	2.7800
N3...N4	2.124 (3)	H5...C8 <sup>ix</sup>	2.9400
N4...N3	2.124 (3)	H6...O1	2.5200
N4...O1	3.106 (3)	H9...Cl <sup>viii</sup>	3.0700
N1...H2	2.6300	H9...O2 <sup>ix</sup>	2.8000
N2...H3 <sup>ii</sup>	2.6700	H9...H1	2.3400
N3...H22 <sup>v</sup>	2.9200	H10...Cl <sup>xi</sup>	2.8800
N4...H12	2.8800	H11...H3 <sup>xii</sup>	2.3700
C2...Cl <sup>viii</sup>	3.627 (3)	H12...N4	2.8800
C3...C16 <sup>v</sup>	3.505 (4)	H12...C17	2.9300
C4...C16 <sup>v</sup>	3.524 (4)	H16A...C4 <sup>iii</sup>	2.9400
C7...N2	3.281 (3)	H16A...C17	2.8600
C7...C14	3.105 (3)	H16A...C5 <sup>iii</sup>	2.8300
C12...C17	3.301 (3)	H16A...C6 <sup>iii</sup>	3.0600
C13...O1	2.941 (3)	H16B...H3A	2.5700
C13...C18	3.550 (3)	H18...O1	2.3500
C14...O1	2.710 (3)	H19...C2 <sup>vii</sup>	2.9700
C14...C7	3.105 (3)	H19...H2A	2.3500
C16...C22	3.338 (4)	H21...C15 <sup>iii</sup>	3.0200
C16...C4 <sup>iii</sup>	3.524 (4)	H21...O1 <sup>iii</sup>	2.7100
C16...C3 <sup>iii</sup>	3.505 (4)	H22...C15	3.0900
C17...C12	3.301 (3)	H22...N3 <sup>iii</sup>	2.9200
C18...C13	3.550 (3)	H22...Cl	2.9400
C18...O1	3.165 (3)		
C20—O2—H2A	112 (3)	N4—C17—C18	120.0 (2)
C7—N1—C8	123.6 (2)	C17—C18—C19	119.7 (2)
N3—N2—C14	103.89 (18)	C18—C19—C20	120.3 (2)
N2—N3—C15	112.5 (2)	O2—C20—C19	122.9 (2)
C14—N4—C15	106.23 (18)	C19—C20—C21	119.2 (2)



C14—N4—C17	129.23 (18)	O2—C20—C21	117.9 (2)
C15—N4—C17	124.32 (18)	C20—C21—C22	120.6 (2)
C8—N1—H1	114 (3)	C17—C22—C21	119.8 (3)
C7—N1—H1	117 (2)	C1—C2—H2	120.00
N2—N3—H3A	119.5 (18)	C3—C2—H2	120.00
C15—N3—H3A	128.0 (18)	C2—C3—H3	120.00
C2—C1—C6	119.6 (2)	C4—C3—H3	120.00
C2—C1—C7	122.9 (2)	C3—C4—H4	120.00
C6—C1—C7	117.5 (2)	C5—C4—H4	120.00
C1—C2—C3	119.8 (3)	C4—C5—H5	120.00
C2—C3—C4	120.6 (3)	C6—C5—H5	120.00
C3—C4—C5	119.5 (3)	C1—C6—H6	120.00
C4—C5—C6	120.8 (3)	C5—C6—H6	120.00
C1—C6—C5	119.8 (3)	C8—C9—H9	120.00
N1—C7—C1	116.83 (19)	C10—C9—H9	120.00
O1—C7—N1	121.7 (2)	C9—C10—H10	120.00
O1—C7—C1	121.5 (2)	C11—C10—H10	120.00
C9—C8—C13	119.0 (2)	C10—C11—H11	120.00
N1—C8—C13	123.5 (2)	C12—C11—H11	120.00
N1—C8—C9	117.5 (2)	C11—C12—H12	120.00
C8—C9—C10	120.6 (2)	C13—C12—H12	120.00
C9—C10—C11	120.5 (3)	C15—C16—H16A	109.00
C10—C11—C12	119.9 (2)	C15—C16—H16B	109.00
C11—C12—C13	120.5 (2)	C15—C16—H16C	109.00
C12—C13—C14	118.2 (2)	H16A—C16—H16B	110.00
C8—C13—C12	119.5 (2)	H16A—C16—H16C	109.00
C8—C13—C14	122.0 (2)	H16B—C16—H16C	109.00
N2—C14—N4	110.84 (18)	C17—C18—H18	120.00
N2—C14—C13	124.17 (19)	C19—C18—H18	120.00
N4—C14—C13	124.76 (19)	C18—C19—H19	120.00
N3—C15—N4	106.5 (2)	C20—C19—H19	120.00
N4—C15—C16	127.5 (2)	C20—C21—H21	120.00
N3—C15—C16	126.0 (2)	C22—C21—H21	120.00
N4—C17—C22	119.5 (2)	C17—C22—H22	120.00
C18—C17—C22	120.3 (2)	C21—C22—H22	120.00
C8—N1—C7—O1	-9.5 (3)	C1—C2—C3—C4	-0.2 (4)
C8—N1—C7—C1	170.21 (19)	C2—C3—C4—C5	-0.7 (5)
C7—N1—C8—C9	-130.2 (2)	C3—C4—C5—C6	0.5 (5)
C7—N1—C8—C13	49.5 (3)	C4—C5—C6—C1	0.6 (5)
C14—N2—N3—C15	-0.6 (3)	N1—C8—C9—C10	179.5 (2)
N3—N2—C14—N4	0.5 (2)	C13—C8—C9—C10	-0.2 (4)
N3—N2—C14—C13	175.2 (2)	N1—C8—C13—C12	-177.8 (2)
N2—N3—C15—N4	0.4 (3)	N1—C8—C13—C14	8.3 (3)
N2—N3—C15—C16	-179.9 (2)	C9—C8—C13—C12	1.9 (3)
C15—N4—C14—N2	-0.2 (2)	C9—C8—C13—C14	-172.0 (2)
C15—N4—C14—C13	-174.9 (2)	C8—C9—C10—C11	-1.6 (4)
C17—N4—C14—N2	-175.0 (2)	C9—C10—C11—C12	1.6 (5)

C17—N4—C14—C13	10.4 (3)	C10—C11—C12—C13	0.2 (4)
C14—N4—C15—N3	-0.1 (2)	C11—C12—C13—C8	-1.9 (4)
C14—N4—C15—C16	-179.8 (2)	C11—C12—C13—C14	172.2 (2)
C17—N4—C15—N3	175.0 (2)	C8—C13—C14—N2	52.0 (3)
C17—N4—C15—C16	-4.7 (4)	C8—C13—C14—N4	-134.1 (2)
C14—N4—C17—C18	67.0 (3)	C12—C13—C14—N2	-122.0 (3)
C14—N4—C17—C22	-118.2 (3)	C12—C13—C14—N4	52.0 (3)
C15—N4—C17—C18	-106.9 (3)	N4—C17—C18—C19	175.6 (2)
C15—N4—C17—C22	67.8 (3)	C22—C17—C18—C19	0.9 (4)
C6—C1—C2—C3	1.3 (4)	N4—C17—C22—C21	-175.2 (3)
C7—C1—C2—C3	-178.2 (2)	C18—C17—C22—C21	-0.5 (4)
C2—C1—C6—C5	-1.5 (4)	C17—C18—C19—C20	-0.6 (4)
C7—C1—C6—C5	178.0 (3)	C18—C19—C20—O2	-178.2 (3)
C2—C1—C7—O1	-159.0 (2)	C18—C19—C20—C21	0.1 (4)
C2—C1—C7—N1	21.3 (3)	O2—C20—C21—C22	178.7 (3)
C6—C1—C7—O1	21.5 (3)	C19—C20—C21—C22	0.3 (4)
C6—C1—C7—N1	-158.2 (2)	C20—C21—C22—C17	-0.1 (5)

Symmetry codes: (i)  $x, y-1, z$ ; (ii)  $-x, -y+1, z-1/2$ ; (iii)  $-x+1/2, y, z-1/2$ ; (iv)  $x+1/2, -y+1, z$ ; (v)  $-x+1/2, y, z+1/2$ ; (vi)  $x, y+1, z$ ; (vii)  $-x, -y+2, z-1/2$ ; (viii)  $-x, -y+1, z+1/2$ ; (ix)  $-x, -y+2, z+1/2$ ; (x)  $x, y, z+1$ ; (xi)  $x-1/2, -y+1, z$ ; (xii)  $x, y, z-1$ .

*Hydrogen-bond geometry* ( $\text{\AA}, ^\circ$ )

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
N1—H1 $\cdots$ Cl <sup>iii</sup>	0.81 (3)	2.58 (3)	3.372 (2)	166 (3)
O2—H2A $\cdots$ Cl <sup>vi</sup>	0.76 (4)	2.34 (4)	3.090 (2)	171 (5)
N3—H3A $\cdots$ Cl <sup>v</sup>	0.97 (3)	2.14 (3)	3.068 (2)	158 (3)
C18—H18 $\cdots$ O1	0.9300	2.3500	3.165 (3)	146.00
C16—H16A $\cdots$ Cg2 <sup>iii</sup>	0.9600	2.8400	3.367 (3)	115.00

Symmetry codes: (iii)  $-x+1/2, y, z-1/2$ ; (v)  $-x+1/2, y, z+1/2$ ; (vi)  $x, y+1, z$ ; (viii)  $-x, -y+1, z+1/2$ .