

Acta Crystallographica Section E

## Structure Reports

Online

ISSN 1600-5368

## 4-Hydrazinopyridinium chloride

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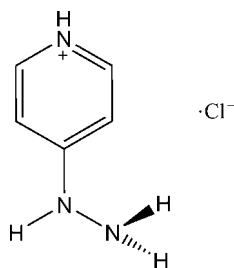
Received 5 July 2009; accepted 7 July 2009

 Key indicators: single-crystal X-ray study;  $T = 173$  K,  $P = 0.0$  kPa; mean  $\sigma(\text{C}-\text{C}) = 0.002$  Å;  $R$  factor = 0.022;  $wR$  factor = 0.060; data-to-parameter ratio = 13.6.

In the title compound,  $\text{C}_5\text{H}_8\text{N}_3^+\cdot\text{Cl}^-$ , the cation and the anion lie on a mirror plane and are hydrogen bonded in a three-dimensional network *via* the H atoms of the two hydrazine N atoms. The pyridine N atom is protonated and hydrogen bonded to the terminal hydrazine N atom.

## Related literature

For related structures, see: Lima *et al.* (2008); Hammerl *et al.* (2001). For background to the synthesis, see: Mann *et al.* (1959).



## Experimental

## Crystal data

 $\text{C}_5\text{H}_8\text{N}_3^+\cdot\text{Cl}^-$ 
 $M_r = 145.59$ 

 Monoclinic,  $P2_1/m$ 
 $a = 6.9526$  (11) Å

 $b = 6.434$  (1) Å

 $c = 7.7432$  (12) Å

 $\beta = 95.316$  (1)°

 $V = 344.89$  (9) Å<sup>3</sup>
 $Z = 2$ 

 Mo  $K\alpha$  radiation

 $\mu = 0.46$  mm<sup>-1</sup>
 $T = 173$  K

 $0.27 \times 0.19 \times 0.18$  mm

## Data collection

Bruker APEXII CCD area-detector diffractometer

Absorption correction: multi-scan (SADABS; Bruker, 2006)

 $T_{\min} = 0.884$ ,  $T_{\max} = 0.920$ 

4968 measured reflections

855 independent reflections

 840 reflections with  $I > 2\sigma(I)$ 
 $R_{\text{int}} = 0.016$ 

## Refinement

 $R[F^2 > 2\sigma(F^2)] = 0.022$ 
 $wR(F^2) = 0.060$ 
 $S = 1.13$ 

855 reflections

63 parameters

H atoms treated by a mixture of independent and constrained refinement

 $\Delta\rho_{\text{max}} = 0.32$  e Å<sup>-3</sup>
 $\Delta\rho_{\text{min}} = -0.20$  e Å<sup>-3</sup>

Table 1

Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
$\text{N7}-\text{H7}\cdots\text{Cl1}$	0.89 (2)	2.25 (2)	3.1358 (14)	176.7 (19)
$\text{N8}-\text{H8}\cdots\text{Cl1}^{\text{i}}$	0.849 (14)	2.905 (14)	3.1970 (14)	102.4 (11)
$\text{N1}-\text{H1}\cdots\text{N8}^{\text{ii}}$	0.89 (2)	1.92 (2)	2.8069 (19)	172.0 (19)

 Symmetry codes: (i)  $x - 1, y, z$ ; (ii)  $x, y, z - 1$ .

Data collection: APEX2 (Bruker, 2006); cell refinement: SAINT-Plus (Bruker, 2006); data reduction: SAINT-Plus; program(s) used to solve structure: SHELXD (Sheldrick, 2008); program(s) used to refine structure: SHELXTL (Sheldrick, 2008); molecular graphics: Mercury (Macrae *et al.*, 2006); software used to prepare material for publication: publCIF (Westrip, 2009).

The Natural Sciences and Engineering Research Council of Canada (NSERC) is gratefully acknowledged for a Discovery Grant and the Alberta Ingenuity Fund for a studentship (MRH). The diffractometer was purchased with the help of NSERC and the University of Lethbridge.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: PV2178).

## References

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## supporting information

*Acta Cryst.* (2009). E65, o1833 [doi:10.1107/S1600536809026348]

## 4-Hydrazinopyridinium chloride

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### S1. Comment

In the structure of the title compound, (I), (Figure 1.) both ions crystallize on the mirror plane perpendicular to  $b$  with a separation of  $b/2$  (3.217 Å). In consequence, the N7, N8 and N7—H atom are coplanar with the aromatic ring, and thus the out-of-plane H atoms on N8 are in a staggered conformation with respect to the N7—H atom. The local conformation of the aryl-hydrazine is similar to that observed in only two known crystal structures, both of phenylhydrazine, namely [(C<sub>6</sub>H<sub>5</sub>NHNH<sub>2</sub>)H]<sub>2</sub>(N<sub>3</sub>), (II), Hammerl *et al.* (2001) and [C<sub>6</sub>H<sub>5</sub>NHNH<sub>3</sub>]Cl, (III), Lima *et al.* (2008). The former contains both PhNHNH<sub>2</sub> and PhNHNH<sub>3</sub><sup>+</sup> in the lattice. However, in (I) it is the more basic pyridine N1 that is protonated, but which also forms a strong H bond to the terminal hydrazinyl N8 ( $D\cdots A = 2.8069$  (19) Å). This bond is comparable in strength to the linking H bond between PhNHNH<sub>2</sub> and PhNHNH<sub>3</sub><sup>+</sup> in (II). The structures of (II) and (III) are also composed of essentially flat sheets of Aryl—N units, with inter-planar separations of 3.497 and 3.378 Å, respectively.

There are additional H bonds between the N7—H and the N8—H atoms and the chloride anion which, in conjunction with the infinite chains of N1—H to N8 bonds, result in the formation of planar hydrogen-bonded sheets (Figure 2), with N $\cdots$ Cl distances very comparable to those found in (III).

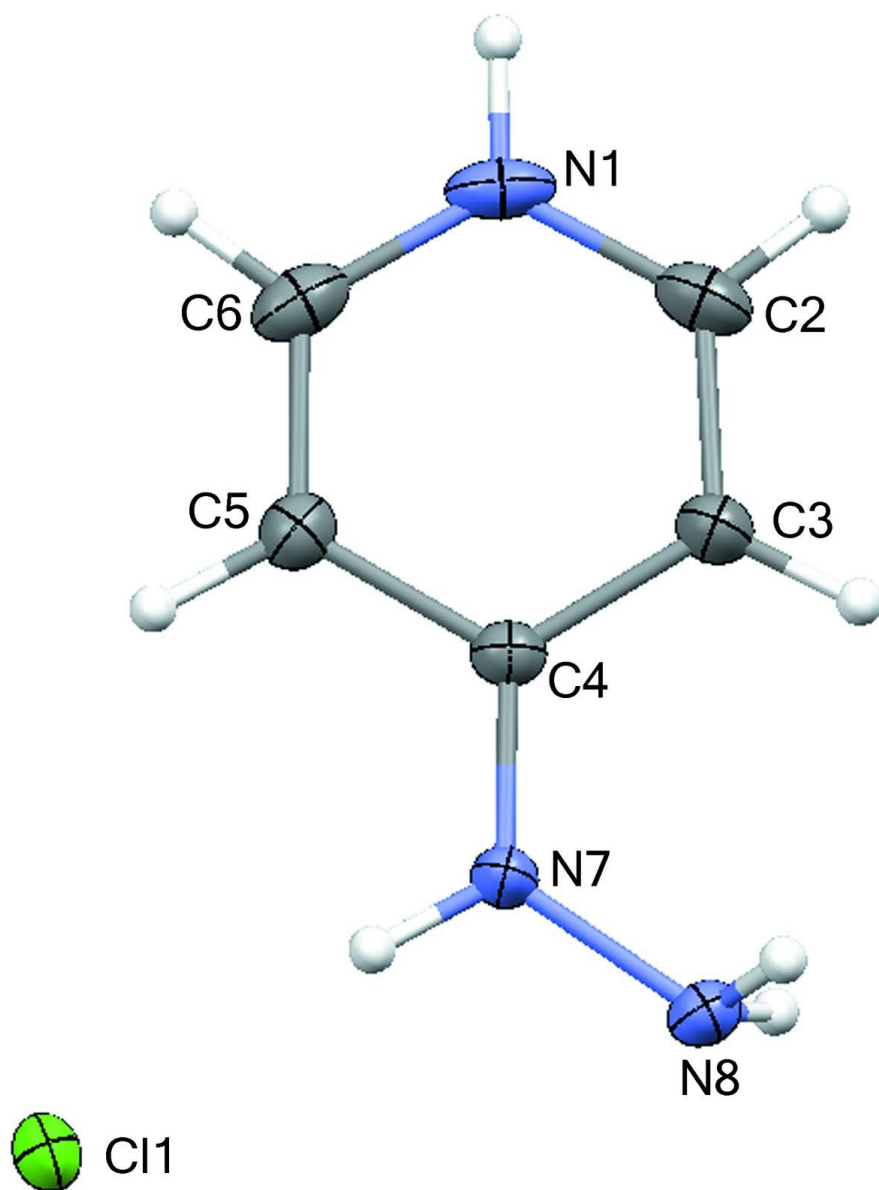
In summary, the structure of (I) has a higher symmetry than (II) and (III) and is tightly packed due to a network of strong H bonds.

### S2. Experimental

4-Chloropyridine (1.1 mmol, 4.20 g) and pure hydrazine hydrate (1.1 mmol, 1.63 g) were added to 10 ml of 1-propanol. After refluxing for 48 h, the mixture was cooled to 273 K and washed with cold 1-propanol. Recrystallization from methanol yielded 3.6 g of the title compound (I) as colorless needles in 65% yield. The compound (I) has a melting point of 516–517 K, which was in agreement with published values (Mann *et al.* 1959).

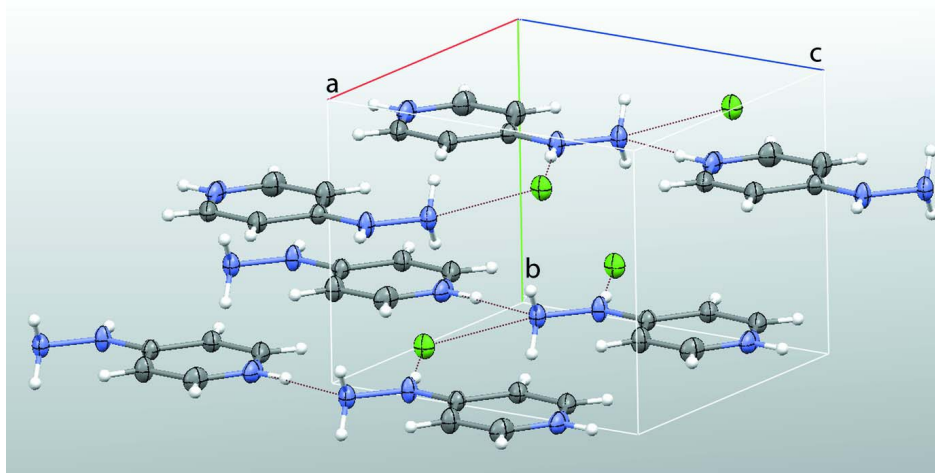
### S3. Refinement

Space group determination was ambiguous between  $P2_1$  and  $P2_1/m$  because of poor E-statistics. However, the structure was successfully solved using the SHELXD procedure (Sheldrick, 2008) and refined in  $P2_1/m$ . The origin of the ambiguous E-statistics became obvious after structure solution, as every atom except for the two N8 hydrogen atoms are found on a crystallographic mirror plane. All H atoms were located in a difference map. N-bound H atoms were freely refined with the constraint  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{N})$ . The C-bound H atoms were placed in calculated positions (C—H = 0.95 Å) and refined as riding with  $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C})$ .



**Figure 1**

A view of (I) plotted with displacement ellipsoids at 50% probability level.

**Figure 2**

Packing diagram of (I) showing the network of H-bonds.

#### 4-Hydrazinopyridinium chloride

##### Crystal data

$C_5H_8N_3^+Cl^-$

$M_r = 145.59$

Monoclinic,  $P2_1/m$

Hall symbol:  $-P\ 2_1yb$

$a = 6.9526$  (11) Å

$b = 6.434$  (1) Å

$c = 7.7432$  (12) Å

$\beta = 95.316$  (1)°

$V = 344.89$  (9) Å<sup>3</sup>

$Z = 2$

$F(000) = 152$

$D_x = 1.402$  Mg m<sup>-3</sup>

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

Cell parameters from 4500 reflections

$\theta = 2.6$ – $27.5^\circ$

$\mu = 0.46$  mm<sup>-1</sup>

$T = 173$  K

Block, colourless

$0.27 \times 0.19 \times 0.18$  mm

##### Data collection

Bruker APEXII CCD area-detector  
diffractometer

Radiation source: fine-focus sealed tube

Graphite monochromator

$\varphi$  and  $\omega$  scans

Absorption correction: multi-scan

(*SADABS*; Bruker, 2006)

$T_{\min} = 0.884$ ,  $T_{\max} = 0.920$

4968 measured reflections

855 independent reflections

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

$R_{\text{int}} = 0.016$

$\theta_{\max} = 27.5^\circ$ ,  $\theta_{\min} = 2.6^\circ$

$h = -9 \rightarrow 9$

$k = -8 \rightarrow 8$

$l = -10 \rightarrow 10$

##### Refinement

Refinement on  $F^2$

Least-squares matrix: full

$R[F^2 > 2\sigma(F^2)] = 0.022$

$wR(F^2) = 0.060$

$S = 1.13$

855 reflections

63 parameters

0 restraints

Primary atom site location: dual

Secondary atom site location: notdet

Hydrogen site location: difference Fourier map

H atoms treated by a mixture of independent  
and constrained refinement

$w = 1/[\sigma^2(F_o^2) + (0.0256P)^2 + 0.1361P]$

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

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

$\Delta\rho_{\max} = 0.32$  e Å<sup>-3</sup>

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

Extinction correction: *SHELXTL* (Sheldrick,  
2008),  $F_c^* = kF_c[1 + 0.001x F_c^2 \lambda^3 / \sin(2\theta)]^{-1/4}$

Extinction coefficient: 0.038 (6)

*Special details*

**Geometry.** All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s 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  $F^2 > \sigma(F^2)$  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 ( $\text{\AA}^2$ )*

	$x$	$y$	$z$	$U_{\text{iso}}^*/U_{\text{eq}}$
C11	0.83751 (5)	0.2500	0.59397 (4)	0.02334 (14)
N1	0.3602 (2)	0.2500	-0.14229 (17)	0.0266 (3)
N7	0.42703 (18)	0.2500	0.38856 (16)	0.0210 (3)
N8	0.27431 (18)	0.2500	0.49629 (16)	0.0212 (3)
C2	0.2020 (3)	0.2500	-0.0545 (2)	0.0274 (3)
H2	0.0779	0.2500	-0.1172	0.033*
C3	0.2159 (2)	0.2500	0.12280 (19)	0.0238 (3)
H3	0.1027	0.2500	0.1827	0.029*
C4	0.4010 (2)	0.2500	0.21599 (18)	0.0183 (3)
C5	0.5645 (2)	0.2500	0.11846 (19)	0.0213 (3)
H5	0.6912	0.2500	0.1762	0.026*
C6	0.5387 (3)	0.2500	-0.0580 (2)	0.0253 (3)
H6	0.6483	0.2500	-0.1227	0.030*
H1	0.345 (3)	0.2500	-0.257 (3)	0.030*
H7	0.545 (3)	0.2500	0.443 (3)	0.030*
H8	0.209 (2)	0.139 (2)	0.4769 (18)	0.030*

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

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
C11	0.01569 (19)	0.0324 (2)	0.0216 (2)	0.000	-0.00012 (12)	0.000
N1	0.0429 (8)	0.0248 (7)	0.0120 (6)	0.000	0.0026 (5)	0.000
N7	0.0150 (6)	0.0346 (7)	0.0133 (5)	0.000	0.0005 (4)	0.000
N8	0.0191 (6)	0.0297 (7)	0.0151 (6)	0.000	0.0041 (5)	0.000
C2	0.0305 (8)	0.0311 (8)	0.0191 (7)	0.000	-0.0058 (6)	0.000
C3	0.0201 (7)	0.0335 (8)	0.0174 (7)	0.000	-0.0003 (5)	0.000
C4	0.0197 (7)	0.0202 (7)	0.0150 (6)	0.000	0.0012 (5)	0.000
C5	0.0206 (7)	0.0228 (7)	0.0209 (7)	0.000	0.0044 (5)	0.000
C6	0.0345 (8)	0.0216 (7)	0.0215 (7)	0.000	0.0114 (6)	0.000

*Geometric parameters ( $\text{\AA}$ ,  $^\circ$ )*

N1—C2	1.345 (2)	C2—H2	0.9500
N1—C6	1.348 (2)	C3—C4	1.416 (2)
N1—H1	0.89 (2)	C3—H3	0.9500
N7—C4	1.3317 (18)	C4—C5	1.422 (2)

N7—N8	1.4097 (17)	C5—C6	1.361 (2)
N7—H7	0.89 (2)	C5—H5	0.9500
N8—H8	0.849 (14)	C6—H6	0.9500
C2—C3	1.368 (2)		
C2—N1—C6	120.97 (13)	C2—C3—H3	120.4
C2—N1—H1	118.7 (13)	C4—C3—H3	120.4
C6—N1—H1	120.3 (13)	N7—C4—C3	122.96 (14)
C4—N7—N8	123.64 (12)	N7—C4—C5	119.47 (13)
C4—N7—H7	120.4 (13)	C3—C4—C5	117.58 (13)
N8—N7—H7	115.9 (13)	C6—C5—C4	119.71 (15)
N7—N8—H8	108.3 (10)	C6—C5—H5	120.1
N1—C2—C3	121.48 (15)	C4—C5—H5	120.1
N1—C2—H2	119.3	N1—C6—C5	121.05 (15)
C3—C2—H2	119.3	N1—C6—H6	119.5
C2—C3—C4	119.21 (15)	C5—C6—H6	119.5
C6—N1—C2—C3	0.0	C2—C3—C4—C5	0.0
N1—C2—C3—C4	0.0	N7—C4—C5—C6	180.0
N8—N7—C4—C3	0.0	C3—C4—C5—C6	0.0
N8—N7—C4—C5	180.0	C2—N1—C6—C5	0.0
C2—C3—C4—N7	180.0	C4—C5—C6—N1	0.0

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>
N7—H7...C11	0.89 (2)	2.25 (2)	3.1358 (14)	177 (2)
N8—H8...C11 <sup>i</sup>	0.849 (14)	2.905 (14)	3.1970 (14)	102.4 (11)
N1—H1...N8 <sup>ii</sup>	0.89 (2)	1.92 (2)	2.8069 (19)	172 (2)

Symmetry codes: (i)  $x-1, y, z$ ; (ii)  $x, y, z-1$ .