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***trans*-2,5-Dimethylpiperazine-1,4-dium dinitrate**Sofian Gatfaoui,^a Thierry Roisnel,^b Hassouna Dhaouadi^{c*} and Houda Marouani^a^aLaboratoire de Chimie des Matériaux, Faculté des Sciences de Bizerte, 7021 Zarzouna Bizerte, Tunisia, ^bCentre de Diffractométrie X, UMR 6226 CNRS, Unité Sciences Chimiques de Rennes, Université de Rennes I, 263 Avenue du Général Leclerc, 35042 Rennes, France, and ^cLaboratoire des Matériaux Utiles, Institut National de Recherche et d'Analyse Physico-chimique, Pole Technologique de Sidi-Thabet, 2020 Tunis, Tunisia

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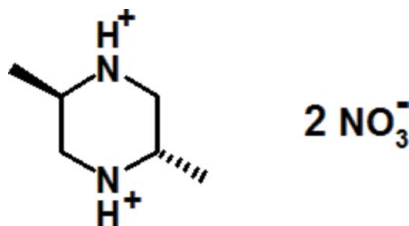
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Key indicators: single-crystal X-ray study; $T = 150$ K; mean $\sigma(\text{C}-\text{C}) = 0.002$ Å; R factor = 0.034; wR factor = 0.090; data-to-parameter ratio = 16.1.

In the structure of the title salt, $\text{C}_6\text{H}_{16}\text{N}_2^{2+} \cdot 2\text{NO}_3^-$, the cations are connected to the anions through bifurcated $\text{N}-\text{H} \cdots (\text{O}, \text{O})$ and weak $\text{C}-\text{H} \cdots \text{O}$ hydrogen bonds, generating corrugated layers parallel to the (100) plane. The organic cation is centrosymmetric and the diprotonated piperazine ring adopts a chair conformation, with the methyl groups occupying equatorial positions.

Related literature

For pharmacological properties of piperazine, see: Conrado *et al.* (2008). For related structures, see: Gatfaoui *et al.* (2013, 2014*a,b*); Marouani *et al.* (2012); Kefi *et al.* (2013). For a complex of the title cation, see: Rother *et al.* (1997). For puckering parameters, see: Cremer & Pople (1975).



Experimental

Crystal data

$\text{C}_6\text{H}_{16}\text{N}_2^{2+} \cdot 2\text{NO}_3^-$
 $M_r = 240.23$
 Monoclinic, $P2_1/c$
 $a = 7.0357$ (8) Å

$b = 10.0277$ (10) Å
 $c = 8.3112$ (8) Å
 $\beta = 116.149$ (8)°
 $V = 526.36$ (9) Å³

$Z = 2$
 Mo $K\alpha$ radiation
 $\mu = 0.13$ mm⁻¹

$T = 150$ K
 $0.58 \times 0.46 \times 0.23$ mm

Data collection

Bruker APEXII diffractometer
 Absorption correction: multi-scan
 (SADABS; Bruker, 2006)
 $T_{\min} = 0.827$, $T_{\max} = 0.970$

4126 measured reflections
 1195 independent reflections
 1059 reflections with $I > 2\sigma(I)$
 $R_{\text{int}} = 0.022$

Refinement

$R[F^2 > 2\sigma(F^2)] = 0.034$
 $wR(F^2) = 0.090$
 $S = 1.11$
 1195 reflections

74 parameters
 H-atom parameters constrained
 $\Delta\rho_{\max} = 0.30$ e Å⁻³
 $\Delta\rho_{\min} = -0.23$ e Å⁻³

Table 1

Hydrogen-bond geometry (Å, °).

| $D-\text{H} \cdots A$ | $D-\text{H}$ | $\text{H} \cdots A$ | $D \cdots A$ | $D-\text{H} \cdots A$ |
|-----------------------------------------------------|--------------|---------------------|--------------|-----------------------|
| $\text{N2}-\text{H2A} \cdots \text{O1}^{\text{i}}$ | 0.90 | 1.99 | 2.8471 (14) | 158 |
| $\text{N2}-\text{H2A} \cdots \text{O2}^{\text{ii}}$ | 0.90 | 2.45 | 2.9899 (13) | 119 |
| $\text{N2}-\text{H2B} \cdots \text{O1}$ | 0.90 | 2.07 | 2.9057 (13) | 153 |
| $\text{N2}-\text{H2B} \cdots \text{O3}$ | 0.90 | 2.42 | 3.2172 (14) | 149 |
| $\text{C1}-\text{H1} \cdots \text{O1}^{\text{iii}}$ | 0.98 | 2.50 | 3.2614 (14) | 134 |

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

Data collection: APEX2 (Bruker, 2006); cell refinement: SAINT (Bruker, 2006); data reduction: SAINT; program(s) used to solve structure: SIR97 (Altomare *et al.*, 1999); program(s) used to refine structure: SHELXL97 (Sheldrick, 2008); molecular graphics: ORTEP-3 for Windows (Farrugia, 2012) and DIAMOND (Brandenburg & Putz 2005); software used to prepare material for publication: WinGX (Farrugia, 2012) and CRYSCAL (T. Roisnel, local program).

Supporting information for this paper is available from the IUCr electronic archives (Reference: BG2529).

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supplementary materials

Acta Cryst. (2014). E70, o725 [doi:10.1107/S1600536814012100]

trans*-2,5-Dimethylpiperazine-1,4-dium dinitrate*Sofian Gatfaoui, Thierry Roisnel, Hassouna Dhauadi and Houda Marouani****1. Comment**

Piperazine and its derivatives are widely used due to their interesting biological and pharmacology proprieties (Conrado *et al.*, 2008). In this work, we report the preparation and the structural investigation of a new organic nitrate, C₆H₁₆N₂(NO₃)₂ (I). The asymmetric unit of (I) is composed of a half *trans*-2,5-dimehylpiperazine-1,4-dium cations and one nitrate anion (Figure 1). In the structure, the cations are connected to the anions through bifurcated N—H···O(O) and weak C—H···O hydrogen bonds, generating a corrugated layers parallel to the (001) plane (Fig. 2).

Interatomic bond lengths and angles of the nitrate anions spread respectively within the ranges [1.2398 (13)–1.2706 (13) Å] and [118.65 (10)–121.73 (10)°]. These geometrical features have also been noticed in other crystal structures (Marouani *et al.*, 2012; Kefi *et al.*, 2013; Gatfaoui *et al.*, 2013, 2014*a,b*). It is worth noting that the distance N1—O1 is significantly longer than the N1—O2 and N1—O3 distances because O1 is applied in three hydrogen bonds (table1) while O2 and O3 are applied in only one hydrogen bond. Inside such a structure, the complete organic entity is generated by inversion symmetry located at (0, 0, 0) and (0, 1/2, 1/2). So it is built up by only the half of the cation. Examination of the organic cations shows that the bond distances and angles show no significant difference from those obtained in other complex involving the same organic groups (Rother *et al.*, 1997). The diprotonated piperazine ring adopts a chair conformation, with the methyl groups occupying an equatorial position, with puckering parameters: Q = 0.6083 Å, $\theta = 90^\circ$ and $\varphi = 166^\circ$ (Cremer & Pople, 1975).

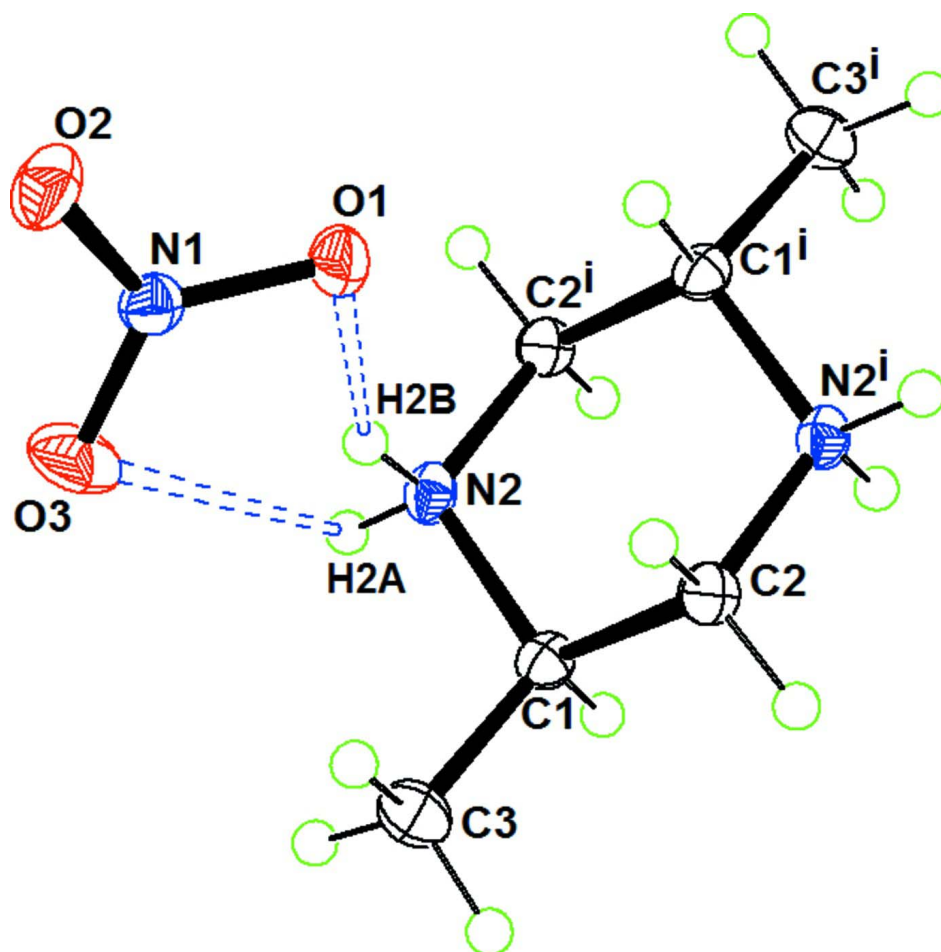
The established H-bonds of types N—H···O(O) and C—H···O involve oxygen atoms of the nitrate anions as acceptors, and protonated nitrogen atoms and methine groups of the *trans*-2,5-dimethylpiperazine-1,4-dium as donors.

2. Experimental

An aqueous solution containing 2 mmol of HNO₃ in 10 ml of water was added to 1 mmol of *trans*-2,5-dimethylpiperazine in 20 ml of water. The obtained solution was stirred for 1 h, filtered and then left to stand at room temperature. Colorless single crystals of the title compound were obtained after some days.

3. Refinement

All H atoms were located in a difference map. Nevertheless, they were geometrically placed and refined using a riding model, with C—H = 0.97 Å (methylene), or 0.96 Å (methyl), or 0.98 Å (methine), N—H = 0.90 Å (NH₂) with $U_{\text{iso}}(\text{H}) = 1.2U_{\text{eq}}(\text{C or N})$.

**Figure 1**

An *ORTEP* view of (I) with the atom-labelling scheme. Displacement ellipsoids are drawn at the 30% probability level. H atoms are represented as small spheres of arbitrary radii. Hydrogen bonds are shown as dotted lines. Symmetry code: $i: -x, -y, -z$.

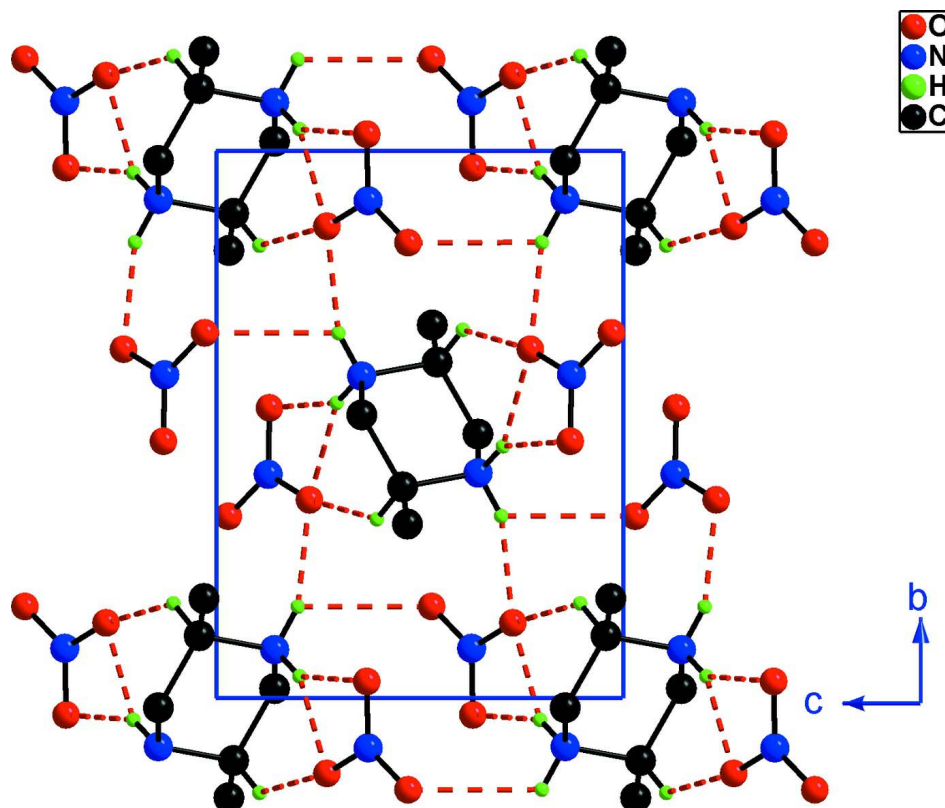


Figure 2

Projection of (I) along the a axis. The H-atoms not involved in H-bonding are omitted.

trans-2,5-Dimethylpiperazine-1,4-dium dinitrate

Crystal data

$C_6H_{16}N_2^{2+} \cdot 2NO_3^-$

$M_r = 240.23$

Monoclinic, $P2_1/c$

Hall symbol: $-P\ 2ybc$

$a = 7.0357$ (8) Å

$b = 10.0277$ (10) Å

$c = 8.3112$ (8) Å

$\beta = 116.149$ (8)°

$V = 526.36$ (9) Å³

$Z = 2$

$F(000) = 256$

$D_x = 1.516$ Mg m⁻³

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

Cell parameters from 2153 reflections

$\theta = 3.4$ – 27.4 °

$\mu = 0.13$ mm⁻¹

$T = 150$ K

Prism, colourless

$0.58 \times 0.46 \times 0.23$ mm

Data collection

Bruker APEXII

diffractometer

Graphite monochromator

CCD rotation images, thin slices scans

Absorption correction: multi-scan

(*SADABS*; Bruker, 2006)

$T_{\min} = 0.827$, $T_{\max} = 0.970$

4126 measured reflections

1195 independent reflections

1059 reflections with $I > 2\sigma(I)$

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

$\theta_{\max} = 27.5$ °, $\theta_{\min} = 3.4$ °

$h = -8 \rightarrow 9$

$k = -9 \rightarrow 12$

$l = -10 \rightarrow 10$

Refinement

Refinement on F^2
 Least-squares matrix: full
 $R[F^2 > 2\sigma(F^2)] = 0.034$
 $wR(F^2) = 0.090$
 $S = 1.11$
 1195 reflections
 74 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
 $w = 1/[\sigma^2(F_o^2) + (0.0438P)^2 + 0.1423P]$
 where $P = (F_o^2 + 2F_c^2)/3$
 $(\Delta/\sigma)_{\max} < 0.001$
 $\Delta\rho_{\max} = 0.30 \text{ e } \text{\AA}^{-3}$
 $\Delta\rho_{\min} = -0.23 \text{ e } \text{\AA}^{-3}$

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 (\AA^2)

| | x | y | z | $U_{\text{iso}}^*/U_{\text{eq}}$ |
|-----|---------------|---------------|---------------|----------------------------------|
| N1 | 0.20352 (15) | -0.09103 (10) | -0.37280 (12) | 0.0173 (2) |
| O1 | 0.12714 (14) | -0.13760 (9) | -0.27150 (11) | 0.0218 (2) |
| O2 | 0.24377 (15) | -0.16754 (10) | -0.47090 (11) | 0.0255 (2) |
| O3 | 0.23709 (16) | 0.03059 (9) | -0.36962 (13) | 0.0312 (3) |
| N2 | -0.02504 (15) | 0.08866 (10) | -0.14298 (12) | 0.0169 (2) |
| H2A | -0.0683 | 0.1671 | -0.2001 | 0.020* |
| H2B | 0.0282 | 0.0397 | -0.2044 | 0.020* |
| C1 | 0.14685 (18) | 0.11399 (12) | 0.04232 (15) | 0.0165 (3) |
| H1 | 0.0915 | 0.1730 | 0.1057 | 0.020* |
| C2 | 0.21154 (17) | -0.01747 (12) | 0.14274 (15) | 0.0176 (3) |
| H2C | 0.2778 | -0.0736 | 0.0869 | 0.021* |
| H2D | 0.3146 | -0.0007 | 0.2653 | 0.021* |
| C3 | 0.33291 (19) | 0.18189 (13) | 0.03060 (17) | 0.0224 (3) |
| H3A | 0.3930 | 0.1230 | -0.0257 | 0.034* |
| H3B | 0.4381 | 0.2036 | 0.1490 | 0.034* |
| H3C | 0.2854 | 0.2621 | -0.0389 | 0.034* |

Atomic displacement parameters (\AA^2)

| | U^{11} | U^{22} | U^{33} | U^{12} | U^{13} | U^{23} |
|----|------------|------------|------------|-------------|------------|-------------|
| N1 | 0.0184 (5) | 0.0158 (5) | 0.0155 (5) | 0.0005 (4) | 0.0054 (4) | 0.0005 (4) |
| O1 | 0.0288 (5) | 0.0212 (5) | 0.0202 (4) | -0.0019 (3) | 0.0153 (4) | -0.0007 (3) |
| O2 | 0.0331 (5) | 0.0274 (5) | 0.0203 (4) | 0.0033 (4) | 0.0158 (4) | -0.0025 (4) |
| O3 | 0.0356 (5) | 0.0134 (5) | 0.0400 (6) | -0.0040 (4) | 0.0125 (4) | 0.0023 (4) |
| N2 | 0.0199 (5) | 0.0162 (5) | 0.0150 (5) | 0.0030 (4) | 0.0081 (4) | 0.0023 (4) |
| C1 | 0.0185 (5) | 0.0144 (6) | 0.0161 (5) | 0.0018 (4) | 0.0071 (4) | -0.0010 (4) |

| | | | | | | |
|----|------------|------------|------------|------------|------------|------------|
| C2 | 0.0166 (5) | 0.0168 (6) | 0.0178 (5) | 0.0020 (4) | 0.0062 (4) | 0.0016 (4) |
| C3 | 0.0207 (6) | 0.0178 (6) | 0.0287 (6) | 0.0003 (5) | 0.0112 (5) | 0.0009 (5) |

Geometric parameters (Å, °)

| | | | |
|-------------------------|-------------|-------------------------|-------------|
| N1—O2 | 1.2398 (13) | C1—C2 | 1.5188 (17) |
| N1—O3 | 1.2403 (14) | C1—H1 | 0.9800 |
| N1—O1 | 1.2706 (13) | C2—N2 ⁱ | 1.4945 (15) |
| N2—C2 ⁱ | 1.4945 (15) | C2—H2C | 0.9700 |
| N2—C1 | 1.5024 (14) | C2—H2D | 0.9700 |
| N2—H2A | 0.9000 | C3—H3A | 0.9600 |
| N2—H2B | 0.9000 | C3—H3B | 0.9600 |
| C1—C3 | 1.5163 (17) | C3—H3C | 0.9600 |
| O2—N1—O3 | 121.73 (10) | C2—C1—H1 | 108.8 |
| O2—N1—O1 | 119.62 (10) | N2 ⁱ —C2—C1 | 111.39 (9) |
| O3—N1—O1 | 118.65 (10) | N2 ⁱ —C2—H2C | 109.4 |
| C2 ⁱ —N2—C1 | 112.95 (9) | C1—C2—H2C | 109.4 |
| C2 ⁱ —N2—H2A | 109.0 | N2 ⁱ —C2—H2D | 109.4 |
| C1—N2—H2A | 109.0 | C1—C2—H2D | 109.4 |
| C2 ⁱ —N2—H2B | 109.0 | H2C—C2—H2D | 108.0 |
| C1—N2—H2B | 109.0 | C1—C3—H3A | 109.5 |
| H2A—N2—H2B | 107.8 | C1—C3—H3B | 109.5 |
| N2—C1—C3 | 109.74 (9) | H3A—C3—H3B | 109.5 |
| N2—C1—C2 | 109.11 (9) | C1—C3—H3C | 109.5 |
| C3—C1—C2 | 111.53 (10) | H3A—C3—H3C | 109.5 |
| N2—C1—H1 | 108.8 | H3B—C3—H3C | 109.5 |
| C3—C1—H1 | 108.8 | | |

Symmetry code: (i) $-x, -y, -z$.

Hydrogen-bond geometry (Å, °)

| <i>D</i> —H \cdots <i>A</i> | <i>D</i> —H | H \cdots <i>A</i> | <i>D</i> \cdots <i>A</i> | <i>D</i> —H \cdots <i>A</i> |
|-----------------------------------|-------------|---------------------|----------------------------|-------------------------------|
| N2—H2A \cdots O1 ⁱⁱ | 0.90 | 1.99 | 2.8471 (14) | 158 |
| N2—H2A \cdots O2 ⁱⁱⁱ | 0.90 | 2.45 | 2.9899 (13) | 119 |
| N2—H2B \cdots O1 | 0.90 | 2.07 | 2.9057 (13) | 153 |
| N2—H2B \cdots O3 | 0.90 | 2.42 | 3.2172 (14) | 149 |
| C1—H1 \cdots O1 ⁱ | 0.98 | 2.50 | 3.2614 (14) | 134 |

Symmetry codes: (i) $-x, -y, -z$; (ii) $-x, y+1/2, -z-1/2$; (iii) $-x, -y, -z-1$.