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## Key indicators

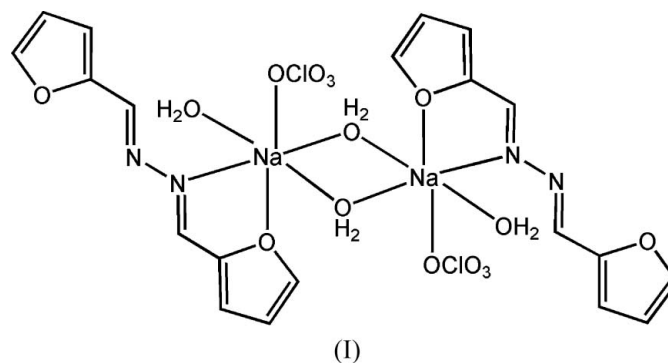
Single-crystal X-ray study  
 $T = 293$  K  
Mean  $\sigma(\text{C}-\text{C}) = 0.005$  Å  
Disorder in main residue  
 $R$  factor = 0.041  
 $wR$  factor = 0.120  
Data-to-parameter ratio = 11.1For details of how these key indicators were  
automatically derived from the article, see  
<http://journals.iucr.org/e>.Di- $\mu$ -aqua-bis{aqua[ $N,N'$ -bis(furan-2-ylmethylene)-hydrazine- $\kappa^2N,O$ ](perchlorato- $\kappa O$ )sodium}

The Na atom of the title complex,  $[\text{Na}_2(\text{ClO}_4)_2(\text{C}_{10}\text{H}_8\text{N}_2\text{O}_2)_2(\text{H}_2\text{O})_4]$ , is six-coordinate in a distorted octahedron. The  $N,N'$ -bis(furan-2-ylmethylene)hydrazine ligand is approximately planar, with a *transoid* configuration. Two coordinated water molecules bridge two Na atoms, with an  $\text{Na}\cdots\text{Na}$  separation of 3.542 (2) Å. The molecule lies on an inversion centre. Intermolecular  $\pi$ - $\pi$  stacking interactions and  $\text{O}-\text{H}\cdots\text{O}$ ,  $\text{O}-\text{H}\cdots\text{N}$  and  $\text{C}-\text{H}\cdots\text{O}$  hydrogen bonds link the molecules together to form a three-dimensional structure.

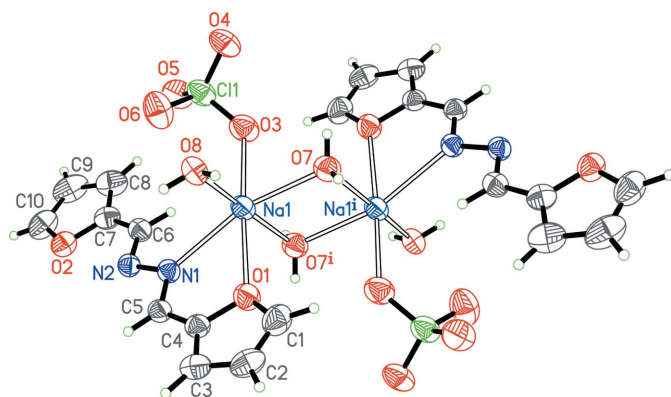
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## Comment

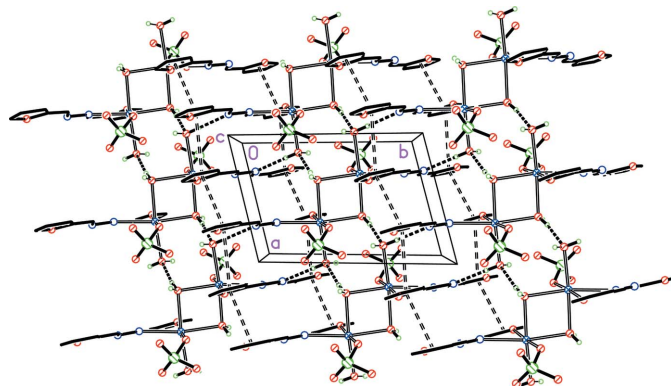
Schiff base ligands are excellent ligands and are commonly used in metal-organic chemistry, owing to their ease of synthesis and high yield in a single-step reaction from commercially inexpensive reagents. Among them, diazine Schiff base ligands, with two coordination portions linked by a single N-N bridge, display several possible mono- and multinucleating coordination modes, due to the flexibility of the ligand around the N-N single bond (Xu *et al.*, 2000). Their coordination to  $d$  group metals leads to a variety of different structural motifs, such as chains, metallomacrocycles and metallocrowns (Abedin *et al.* 2003; Onions *et al.* 2003; Zhao *et al.*, 2004). Such complexes formed by self-assembly exhibit many special functional properties, such as chirality, magnetism, optical activity and redox activity (Bai, Dang *et al.*, 2005; Gao *et al.*, 2003; Grove *et al.*, 2004; Sun *et al.*, 2006). As part of our continuing investigation of this type of diazine ligands and their transition metal compounds (Bai, Duan *et al.*, 2005; Bai *et al.*, 2006), we have used the ligand  $N,N'$ -bis-(furan-2-ylmethylene)-hydrazine ( $L$ ) to construct the title three-dimensional sodium coordination polymer, (I).



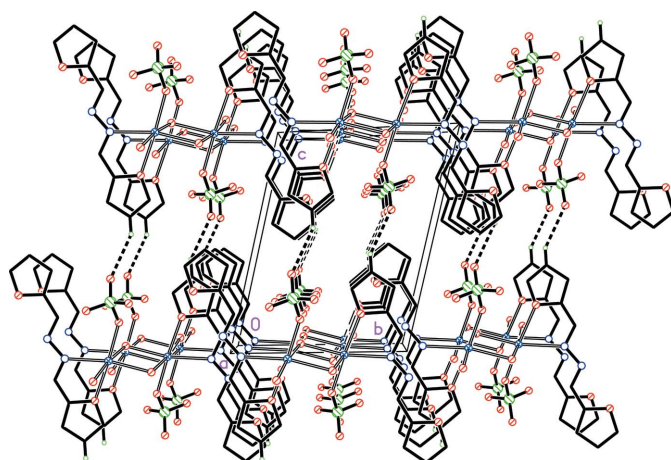
In complex (I), the ligand  $L$  is approximately planar, with the furan rings adopting a *transoid* configuration. It acts as a bidentate donor and coordinates to Na through one furanyl O



**Figure 1**  
The molecular structure of the title complex, with displacement ellipsoids drawn at the 50% probability level. Half of the disordered O atoms have been omitted. [Symmetry code: (i)  $1 - x, 1 - y, -z$ ].



**Figure 2**  
A perspective view of the two-dimensional sheets, showing the intermolecular  $\pi$ - $\pi$  stacking (open dashed lines) and O-H...O and O-H...N hydrogen-bond (solid dashed lines) interactions. H atoms other than those involved in hydrogen bonding have been omitted.



**Figure 3**  
A perspective view of the three-dimensional structure formed through the C-H...O hydrogen bonds (solid dashed lines) between the sheets. H atoms other than those involved in C-H...O hydrogen bonds have been omitted for clarity.

and one imine N atom. Two coordinated water molecules bridge two Na centres, with an Na...Na separation of

3.541 (2) Å. The dincular complex is disposed about an inversion centre located mid-way along the Na1...Na1<sup>i</sup> vector [Fig. 1; symmetry code: (i)  $1 - x, 1 - y, -z$ ]. The asymmetric unit consists of one ligand, one Na<sup>+</sup> cation, one coordinated perchlorate anion and two coordinated water molecules. Each Na centre is bound to one imine N atom, one furan O atom, three O atoms from three water molecules and one O atom from a disordered perchlorate anion to attain a distorted octahedral coordination geometry.

Intermolecular O-H...O and O-H...N hydrogen bonds (Table 2) and  $\pi$ - $\pi$  stacking interactions between adjacent molecules link the molecules together to form a sheet parallel to the *ab* plane (Fig. 2). These sheets are further connected through C-H...O hydrogen bonds (Table 2) to form a three-dimensional structure (Fig. 3). For the  $\pi$ - $\pi$  stacking, the five-membered furan ring is approximately parallel to the two neighbouring furan rings [centroid-to-centroid distances are 3.748 (1) Å between rings C1-C4/O1 and C7<sup>ii</sup>-C10<sup>ii</sup>/O2<sup>ii</sup>, and 3.677 (2) Å between rings C1-C4/O1 and C7<sup>iii</sup>-C10<sup>iii</sup>/O2<sup>iii</sup> [symmetry codes: (ii)  $1 - x, -y, -z$ ; (iii)  $2 - x, -y, -z$ ].

## Experimental

All chemicals were of reagent grade quality obtained from commercial sources. *N,N'*-Bis-(furan-2-ylmethylene)hydrazine was readily prepared by the reaction of hydrazine hydrate with furfural in a 1:2 ratio in methanol solution (50 ml). The ligand (0.50 mmol, 0.095 g) and NaClO<sub>4</sub>·6H<sub>2</sub>O (0.40 mmol, 0.115 g) were mixed in ethanol (20 ml). The solution was left for a few weeks at room temperature to afford yellow crystals of (I) (yield 76%). Analysis, calculated for C<sub>20</sub>H<sub>24</sub>Cl<sub>2</sub>N<sub>4</sub>Na<sub>2</sub>O<sub>16</sub>: C 34.7, H 3.5, N 8.1%; found: C 34.2, H 3.7, N 7.9%.

### Crystal data

[Na <sub>2</sub> (ClO <sub>4</sub> ) <sub>2</sub> (C <sub>10</sub> H <sub>8</sub> N <sub>2</sub> O <sub>2</sub> ) <sub>2</sub> (H <sub>2</sub> O) <sub>4</sub> ]	$V = 746.73$ (2) Å <sup>3</sup>
$M_r = 693.31$	$Z = 1$
Triclinic, $P\bar{1}$	$D_x = 1.542$ Mg m <sup>-3</sup>
$a = 6.5565$ (1) Å	Mo K $\alpha$ radiation
$b = 9.9647$ (2) Å	$\mu = 0.33$ mm <sup>-1</sup>
$c = 12.4108$ (2) Å	$T = 293$ (2) K
$\alpha = 73.882$ (1)°	Block, yellow
$\beta = 81.473$ (1)°	$0.20 \times 0.15 \times 0.15$ mm
$\gamma = 74.058$ (1)°	

### Data collection

Bruker SMART CCD area-detector diffractometer	2621 independent reflections
$\phi/\omega$ scans	2407 reflections with $I > 2\sigma(I)$
Absorption correction: none	$R_{int} = 0.020$
8844 measured reflections	$\theta_{max} = 25.0^\circ$

### Refinement

Refinement on $F^2$	$w = 1/[\sigma^2(F_o^2) + (0.072P)^2 + 0.3846P]$
$R[F^2 > 2\sigma(F^2)] = 0.041$	where $P = (F_o^2 + 2F_c^2)/3$
$wR(F^2) = 0.120$	$(\Delta/\sigma)_{max} < 0.001$
$S = 1.01$	$\Delta\rho_{max} = 0.56$ e Å <sup>-3</sup>
2621 reflections	$\Delta\rho_{min} = -0.36$ e Å <sup>-3</sup>
237 parameters	Extinction correction: <i>SHELXTL</i> (Bruker, 2000)
H-atom parameters constrained	Extinction coefficient: 0.095 (10)

**Table 1**

Selected geometric parameters (Å, °).

Na1—O3	2.292 (5)	Na1—O3'	2.496 (12)
Na1—O7	2.381 (2)	Na1—O1	2.499 (2)
Na1—O7 <sup>i</sup>	2.421 (2)	Na1—N1	2.522 (2)
Na1—O8	2.424 (2)		
O3—Na1—O7	84.99 (18)	O7—Na1—O1	98.60 (8)
O3—Na1—O7 <sup>i</sup>	88.71 (17)	O7 <sup>i</sup> —Na1—O1	90.52 (8)
O7—Na1—O7 <sup>i</sup>	84.99 (7)	O8—Na1—O1	84.87 (7)
O3—Na1—O8	96.22 (17)	O3'—Na1—O1	165.0 (3)
O7—Na1—O8	90.51 (7)	O3—Na1—N1	109.44 (18)
O7 <sup>i</sup> —Na1—O8	173.02 (9)	O7—Na1—N1	164.34 (9)
O7—Na1—O3'	92.2 (3)	O7 <sup>i</sup> —Na1—N1	89.16 (7)
O7 <sup>i</sup> —Na1—O3'	80.0 (3)	O8—Na1—N1	93.83 (7)
O8—Na1—O3'	105.5 (3)	O3'—Na1—N1	101.1 (3)
O3—Na1—O1	176.25 (19)	O1—Na1—N1	66.88 (7)

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

**Table 2**

Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
O7—H7A $\cdots$ O4 <sup>ii</sup>	0.85	2.49	3.155 (8)	136
O7—H7B $\cdots$ O8 <sup>iii</sup>	0.85	1.98	2.822 (3)	172
O8—H8B $\cdots$ O4 <sup>ii</sup>	0.85	2.14	2.941 (6)	157
O8—H8A $\cdots$ N2 <sup>iii</sup>	0.85	2.04	2.893 (3)	178
C2—H2 $\cdots$ O5 <sup>iv</sup>	0.93	2.57	3.415 (6)	151

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

The O atoms of the ClO<sub>4</sub><sup>-</sup> anion were refined as disordered over two positions, O3, O4, O5 and O6, and O3', O4', O5' and O6'; these two positions were refined to occupancies of 0.70 (1) and 0.30 (1), respectively. Displacement parameters of adjacent atoms in the disordered units were restrained to be similar (48 restraints). H atoms bonded to C and O atoms were constrained to ride on their parent

atoms, at distances of 0.93 and 0.85 Å, respectively. All  $U_{iso}(H)$  values were constrained to be 1.2 times  $U_{eq}$  of the carrier atom.

Data collection: *SMART* (Bruker, 2000); cell refinement: *SMART*; data reduction: *SAINT* (Bruker, 2000); program(s) used to solve structure: *SHELXTL* (Bruker, 2000); program(s) used to refine structure: *SHELXTL*; molecular graphics: *SHELXTL*; software used to prepare material for publication: *SHELXTL*.

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