

Naphthalene-1,5-diammonium  
bis[trifluoridostannate(II)]Sihem Boufas,<sup>a\*</sup> Hocine Merazig,<sup>a</sup> Anna Grazia Moliterni<sup>b</sup>  
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The structure of the title compound, (C<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)[SnF<sub>3</sub>]<sub>2</sub>, is made up of alternating layers of cations and anions, where the anion layers form extended polymeric sheets through a series of secondary Sn···F bonds. Strong N—H···F hydrogen bonds crosslink adjacent cation and anion layers, thereby building a three-dimensional network.

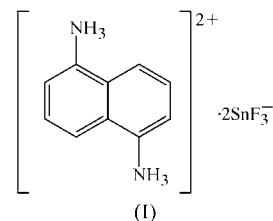
## Comment

Studies of organic–inorganic hybrid materials are of considerable interest (Elleuch *et al.*, 2007). These materials enable the integration of useful organic and inorganic characteristics within a single molecular-scale composite; for example, unique electronic and optical properties have been observed (Hill, 1998; Kagan *et al.*, 1999). Furthermore, divalent Sn-containing halides can exhibit peculiar electrical properties, depending on the other cations present in the solid and on the electro-negativity of the halogen.

In recent years, a number of hybrid compounds based on tin(IV) have been isolated and characterized (Billing *et al.*, 2007). The structure of naphthalene-1,5-diammonium bis[trifluoridostannate(II)], (I), presented here, is the first example of a salt containing tin(II) and naphthalene-1,5-diammonium. The only previously reported hybrid based on tin(II) is hydrazinium(2+) bis[trifluorostannate(II)], studied by Kaučič *et al.* (1988). That structure was described as being composed of monomeric [SnF<sub>3</sub>]<sup>−</sup> units and N<sub>2</sub>H<sub>6</sub><sup>2+</sup> ions, held together by hydrogen bonds. However, we have noted the presence of additional strong interionic Sn···F interactions in this structure, with Sn···F distances of 2.663 (3) and 2.752 (3) Å, which suggest that the anions actually form an extended structure through these secondary bonds.

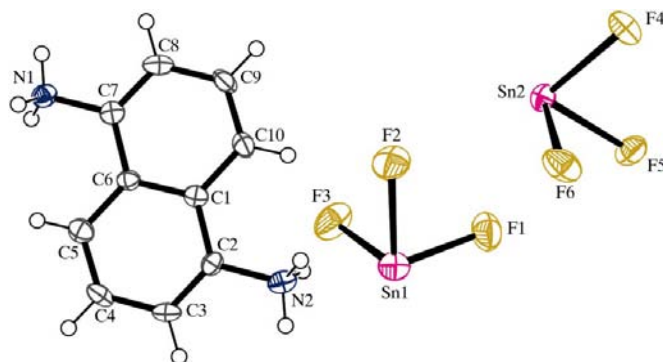
The asymmetric unit of the title compound has two independent sites for Sn atoms and a protonated naphthalene-1,5-diammonium cation (Fig. 1). Atom Sn1 is surrounded by four F atoms, forming a distorted pseudo-trigonal-bipyramidal geometry in which one equatorial site is uncoordinated.

Atoms F1 and F1<sup>i</sup> [symmetry code: (i)  $-x + 1, -y + 1, -z + 1$ ] asymmetrically bridge two Sn1 atoms to produce a centrosymmetric Sn<sub>2</sub>F<sub>6</sub> dimer in which the Sn1···F1<sup>i</sup> distance is



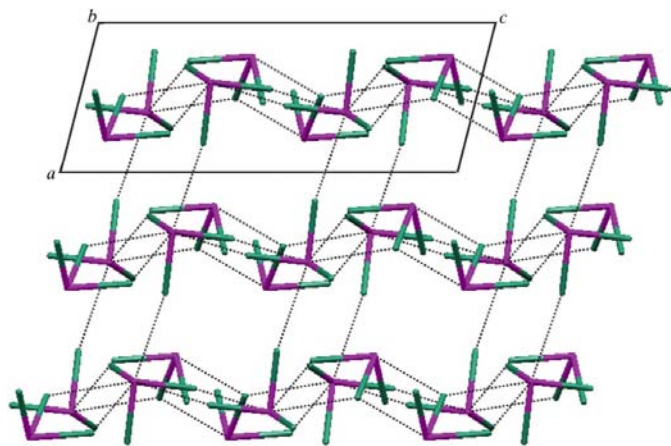
significantly longer than the Sn1–F1 bond (Table 1). The Sn1···F1<sup>i</sup> distance is similar to the shortest Sn···F interaction found in hydrazinium(2+) bis[trifluorostannate(II)]. Atom Sn2 is also part of a centrosymmetric Sn<sub>2</sub>F<sub>6</sub> dimer involving an even more asymmetric bridging interaction through atoms F4 and F4<sup>ii</sup> [symmetry code: (ii)  $-x + 1, -y + 1, -z$ ]. The two dimeric entities are further connected through Sn2···F1 and Sn2···F2 interactions (Table 1), which lead to extended anionic chains involving both Sn centres with bridging F atoms. These chains run parallel to the [001] direction and atom F1 has a triply bridging function. Finally, an Sn2···F6<sup>iv</sup> [symmetry code: (iv)  $x - 1, y, z$ ] interaction crosslinks the chains to give an extended polymeric sheet which lies parallel to the (010) plane (Fig. 2). As a result of the secondary interactions, atom Sn2 is surrounded by seven F atoms in a distorted pentagonal-bipyramidal geometry. The presence of the secondary Sn···F bonds results in short Sn···Sn distances (Table 1). The Sn1···Sn1<sup>i</sup> distance is similar to the Sn···Sn distance in the structure of K<sub>3</sub>Sn<sub>5</sub>Cl<sub>3</sub>F<sub>10</sub> (Merazig *et al.*, 2005), which can be described as consisting of corrugated bilayers separated by K<sup>+</sup> cations and Cl<sup>−</sup> anions.

The anion layers are interspersed with layers of cations (Fig. 3). The diammonium cation in (I) is planar, with an r.m.s. deviation of the non-H atoms of 0.03 Å, and lies parallel to the (102) plane. The cations stack in a tilted fashion along the [001] direction, which leads to an interplanar spacing of 6.337 Å. Very few studies on naphthalene-1,5-diammonium ions have been reported, these being limited to naphthalene-1,5-diammonium diiodide dihydrate (Lemmerer & Billing, 2006) and, very recently, naphthalene-1,5-diammonium

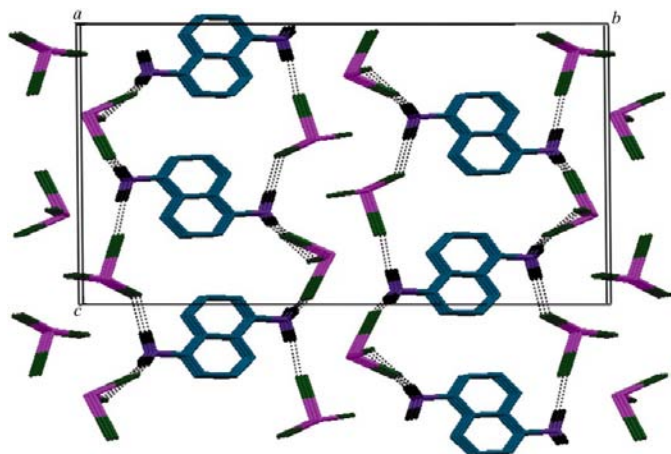


**Figure 1**

The asymmetric unit of the title compound, showing the atom-labelling scheme. Displacement ellipsoids for non-H atoms are drawn at the 50% probability level.



**Figure 2**  
A packing diagram of the anionic structure, viewed down the *b* axis, showing how the secondary Sn...F bonds (dotted lines) form Sn<sub>2</sub>F<sub>6</sub> dimers, chains along [001] and layers parallel to (010).



**Figure 3**  
A packing diagram of the title compound, viewed down the *a* axis, showing the alternating layers of cations and anions and the N—H...F hydrogen bonds (dotted lines).

dichloride (Boufas *et al.*, 2006). In both structures, the organic component lies on an inversion centre, while in the title compound the cation lies in a general position.

Strong N—H...F hydrogen bonds crosslink adjacent cation and anion layers and thereby complete a three-dimensional network (Table 2 and Fig. 3). Atom F6 is engaged in three hydrogen bonds, while atoms F4 and F5 each accept two hydrogen bonds, and atoms F2 and F3 are each involved in just one hydrogen bond, these being the strongest ones. Atom F1 does not accept any hydrogen bonds because it is engaged in two Sn...F secondary bonds, as shown in Fig. 2.

### Experimental

The title compound was crystallized from a supersaturated hydrochloric acid solution (50%, 5 ml) prepared using doubly distilled water and a mixture of tin(II) fluoride (1.567 g) and naphthalene-1,5-

diamine (1.558 g). Thin brown needle-shaped single crystals of (I) were obtained at ambient temperature by slow evaporation of the solution.

### Crystal data

(C<sub>10</sub>H<sub>12</sub>N<sub>2</sub>)[SnF<sub>3</sub>]<sub>2</sub> V = 1363.10 (14) Å<sup>3</sup>  
*M<sub>r</sub>* = 511.6 Z = 4  
 Monoclinic, *P*2<sub>1</sub>/*c* Mo Kα radiation  
*a* = 4.8983 (2) Å μ = 3.72 mm<sup>-1</sup>  
*b* = 22.8232 (13) Å T = 298 (2) K  
*c* = 12.5799 (9) Å 0.35 × 0.10 × 0.025 mm  
 β = 104.249 (7)°

### Data collection

Nonius KappaCCD diffractometer 16372 measured reflections  
 Absorption correction: empirical 3109 independent reflections  
 (using intensity measurements) 2399 reflections with *I* > 2σ(*I*)  
 (SADABS; Sheldrick, 1996) *R*<sub>int</sub> = 0.063  
*T*<sub>min</sub> = 0.807, *T*<sub>max</sub> = 0.929

### Refinement

*R*[*F*<sup>2</sup> > 2σ(*F*<sup>2</sup>)] = 0.033 189 parameters  
*wR*(*F*<sup>2</sup>) = 0.070 H-atom parameters constrained  
*S* = 1.02 Δρ<sub>max</sub> = 0.55 e Å<sup>-3</sup>  
 3109 reflections Δρ<sub>min</sub> = -1.15 e Å<sup>-3</sup>

**Table 1**

Selected geometric parameters (Å, °).

Sn1—F1	2.040 (3)	Sn2...F4 <sup>ii</sup>	3.214 (3)
Sn1...F1 <sup>i</sup>	2.665 (3)	Sn2—F5	2.083 (2)
Sn1—F2	2.065 (2)	Sn2—F6	2.031 (2)
Sn1—F3	2.031 (3)	Sn2...F6 <sup>iii</sup>	3.049 (2)
Sn2...F1	2.830 (3)	Sn1...Sn1 <sup>i</sup>	3.8473 (7)
Sn2...F2	3.117 (3)	Sn1...Sn2	4.1272 (5)
Sn2—F4	2.121 (2)	Sn2...Sn2 <sup>ii</sup>	4.5149 (5)
F1—Sn1—F3	93.77 (13)	F5—Sn2...F1	76.13 (9)
F1—Sn1—F2	84.88 (11)	F4—Sn2...F1	152.83 (9)
F2—Sn1—F3	84.54 (11)	F6—Sn2...F2	70.89 (9)
F1—Sn1...F1 <sup>i</sup>	71.04 (11)	F5—Sn2...F2	129.23 (8)
F2—Sn1...F1 <sup>i</sup>	147.26 (10)	F4—Sn2...F2	131.72 (8)
F3—Sn1...F1 <sup>i</sup>	75.53 (10)	F1...Sn2...F2	55.28 (7)
Sn1—F1...Sn1 <sup>i</sup>	108.97 (10)	F6—Sn2...F4 <sup>ii</sup>	92.72 (9)
Sn1—F1...Sn2	114.90 (11)	F5—Sn2...F4 <sup>ii</sup>	151.59 (8)
Sn1—F2...Sn2	103.72 (10)	F4—Sn2...F4 <sup>ii</sup>	65.94 (10)
F6—Sn2—F5	85.22 (10)	F1...Sn2...F4 <sup>ii</sup>	130.88 (7)
F6—Sn2—F4	82.37 (9)	F2...Sn2...F4 <sup>ii</sup>	75.77 (6)
F5—Sn2—F4	85.73 (10)	Sn2—F4...Sn2 <sup>ii</sup>	114.06 (10)
F6—Sn2...F1	76.19 (9)	Sn2—F6...Sn2 <sup>iv</sup>	148.64 (12)

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

**Table 2**

Hydrogen-bond geometry (Å, °).

D—H...A	D—H	H...A	D...A	D—H...A
N1—H1A...F2 <sup>v</sup>	0.89	1.75	2.630 (4)	168
N1—H1B...F4 <sup>vi</sup>	0.89	1.90	2.744 (4)	158
N1—H1B...F6 <sup>vii</sup>	0.89	2.45	2.863 (4)	109
N1—H1C...F4 <sup>viii</sup>	0.89	1.90	2.792 (4)	178
N1—H1C...F6 <sup>vii</sup>	0.89	2.50	2.863 (4)	105
N2—H2A...F5 <sup>viii</sup>	0.89	1.86	2.747 (4)	178
N2—H2B...F5 <sup>i</sup>	0.89	1.95	2.805 (4)	160
N2—H2B...F6 <sup>i</sup>	0.89	2.44	2.988 (4)	121
N2—H2C...F3	0.89	1.75	2.633 (4)	174

Symmetry codes: (i)  $-x + 1, -y + 1, -z + 1$ ; (v)  $x + 1, -y + \frac{1}{2}, z + \frac{1}{2}$ ; (vi)  $-x + 2, y - \frac{1}{2}, -z + \frac{1}{2}$ ; (vii)  $-x + 1, y - \frac{1}{2}, -z + \frac{1}{2}$ ; (viii)  $-x + 2, -y + 1, -z + 1$ .

The ammonium H atoms were constrained to an ideal geometry (N—H = 0.89 Å), but were allowed to rotate freely about the C—N bonds, while their isotropic displacement parameters were refined. All remaining H atoms were placed in geometrically idealized positions (C—H = 0.93 Å) and constrained to ride on their parent atoms, with  $U_{\text{iso}}(\text{H})$  values of  $1.2U_{\text{eq}}(\text{C})$ .

Data collection: *COLLECT* (Nonius, 2002); cell refinement: *DIRAX* (Duisenberg, 1992); data reduction: *EVAL* (Nonius, 2002); program(s) used to solve structure: *SIR92* (Altomare *et al.*, 1993); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEP-3* (Farrugia, 1997) and *Mercury* (Macrae *et al.*, 2006); software used to prepare material for publication: *WinGX* (Farrugia, 1999) and *PARST* (Nardelli, 1995).

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: LN3053). Services for accessing these data are described at the back of the journal.

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