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A low-temperature refinement of tris[N,N'-bis(2-hydroxyethyl)dithiocarbamato-κ^2S,S']antimony(III)

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Key indicators

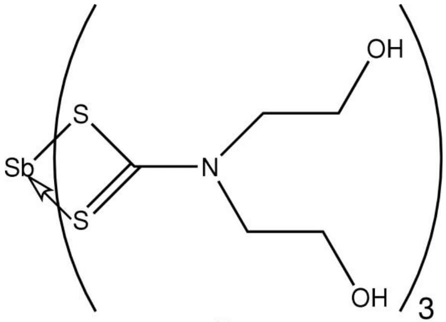
Single-crystal X-ray study
T = 93 K
Mean σ(C–C) = 0.002 Å
R factor = 0.020
wR factor = 0.051
Data-to-parameter ratio = 19.1

For details of how these key indicators were automatically derived from the article, see http://journals.iucr.org/e.

The title compound, $[Sb(C_5H_{10}NO_2S_2)_3]$, has been redetermined at 93 K, allowing a detailed analysis of the crystal packing, which is dominated by O—H···O hydrogen bonding. Each terminal hydroxyl group participates in a 12-membered $[\cdots O—H]_6$ ring, leading to a three-dimensional array.

Comment

The binary antimony(III) dithiocarbamates, $Sb(S_2CNR_2)_3$, usually associate into dimers *via* Sb···S interactions (Liu & Tiekink, 2005). Exceptions to this behaviour are found only when the steric bulk of the R groups precludes close association, such as in the example where $NR_2 = N(CH_2)_6$ (Liu & Tiekink, 2005). Indeed, steric bulk in remote substituents has been found to be an important factor in supramolecular aggregation in these and related systems (*e.g.* Lai *et al.*, 2002, 2004; Tiekink, 2003, 2006*a*,*b*). In the $Sb(S_2CNR_2)_3$ structures for which hydrogen-bonding functionality exists in one of the R groups, the same principle of steric control holds (Liu & Tiekink, 2005). However, in the case of $Sb[S_2CN(CH_2CH_2OH)_2]_3$, (I), no Sb···S interactions were evident, despite being present in the n-propyl analogue $Sb[S_2CN(CH_2CH_2OH)_2]_3$ (Kavounis *et al.*, 1982). In the original crystallographic analysis of (I) (Venkatachalam *et al.*, 1997), there were ambiguities in the positions of the –OH groups. Here, a new analysis of (I) is reported from data measured at 93 K.



(I)

The molecular structure of (I) (Fig. 1 and Table 1) shows the expected features for compounds of this type (Liu & Tiekink, 2005). The molecule has non-crystallographic symmetry, at least in terms of the S_2CNC_2 residues, so that the S1,S2-dithiocarbamate ligand defines an approximate mirror plane. This ligand forms the most asymmetric chelate of the three dithiocarbamate ligands and this is reflected in the associated C—S distances (Table 1). The coordination geometry is based on a pentagonal bipyramid, with atoms S2/S3–S6 defining a distorted pentagon and with atom S1 and the lone pair of electrons occupying axial positions. This conformation allows

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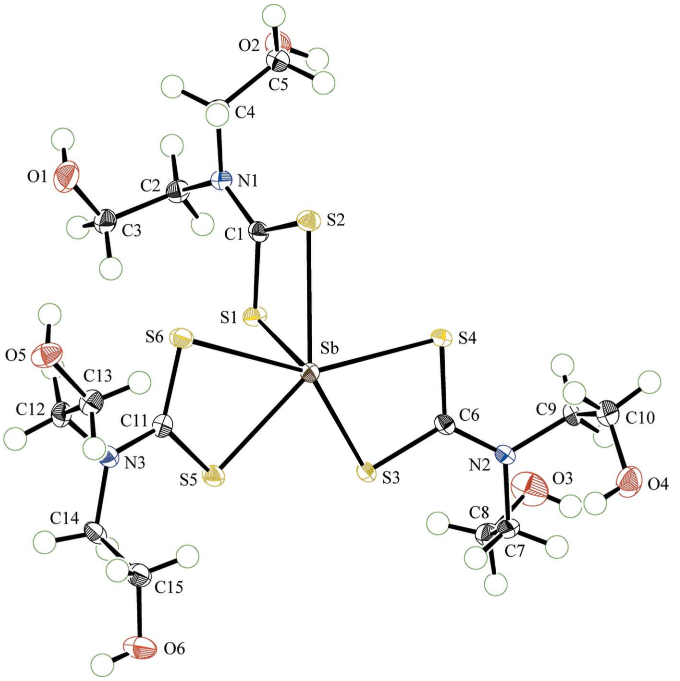

Figure 1
The molecular structure of (I), showing the crystallographic numbering scheme. Displacement ellipsoids are shown at the 50% probability level.

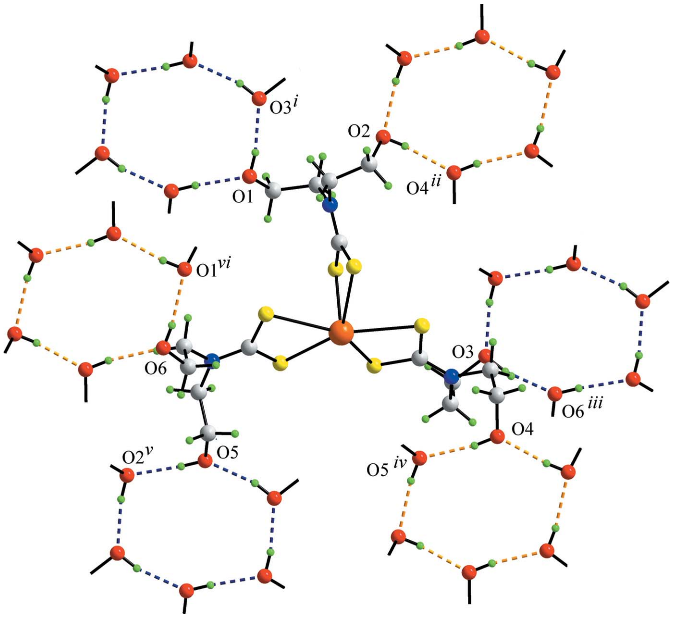

Figure 2
Hydrogen-bonding interactions in (I) mediated by O—H···O interactions, shown as dashed lines; see Table 2 for symmetry operations. Colour code: Sb orange, S yellow, O red, N blue, C grey and H green.

for the formation of intermolecular Sb···S interactions in many related systems, but no such interaction is present in (I).

Details of the hydrogen-bonding parameters are summarized in Table 2, from which it can be seen that each OH group functions as a hydrogen-bonding donor and acceptor. As shown in Fig. 2, each hydroxyl group is associated with an essentially planar 12-membered $[\cdots O—H]_6$ ring. Those rings, highlighted with blue dashed lines in Fig. 2, involve atoms O1, O3 and O6. The net result of these interactions is the formation of a three-dimensional array, as shown in Fig. 3. Also shown in this figure is the relative disposition of a pair of centrosymmetric molecules which are aligned so as to form, potentially, the commonly observed dimeric motif. In Fig. 3, a potential point of aggregation is indicated with an asterisk, but the intermolecular Sb···S separation is greater than 5.7 Å. Association *via* Sb···S interactions leading to dimers is precluded in (I) due to the intervention of the hydrogen-bonded residues.

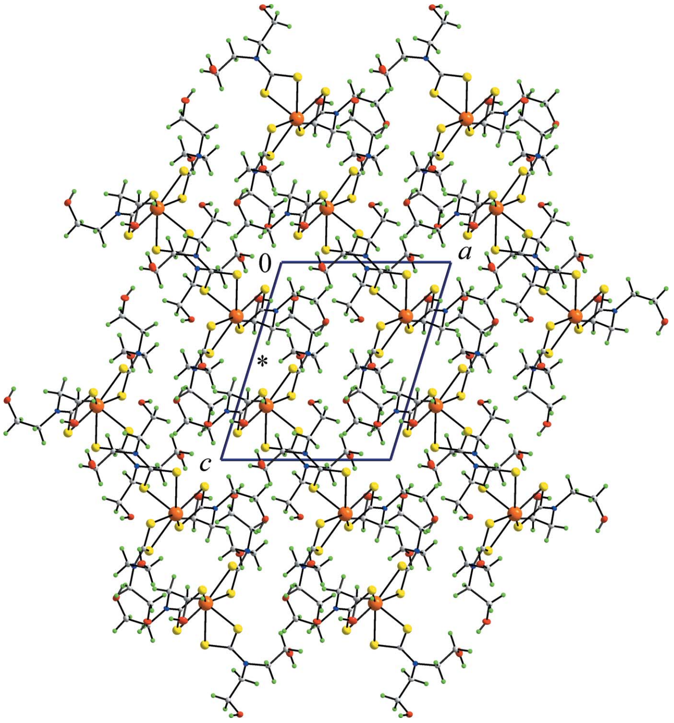

Figure 3
The crystal packing in (I); the colour code is as for Fig. 2.

Experimental

Compound (I) was prepared in a manner that differed from the literature procedure (Venkatachalam *et al.*, 1997). A suspension of ammonium bis(hydroxyethyl)dithiocarbamate (5.94 g, 3.0 mmol), prepared after the procedure of Ramos *et al.* (2005), in methanol (200 ml) was added to a solution of $SbCl_3$ (Acros Organics, 2.29 g, 1.0 mmol) in methanol (30 ml) with stirring. The ligand dissolved and the solution turned iridescent yellow. The product was filtered off and recrystallized from an ethanol solution to provide 3.78 g (65.1%) of (I) [m.p. 413.5–414.5 K; literature 403–405 K (Venkatachalam *et al.*, 1997)].

Crystal data

$[Sb(C_5H_{10}NO_2S_2)_3]$
$M_r = 662.53$
Triclinic, $P\overline{1}$
$a = 9.942$ (2) Å
$b = 11.011$ (2) Å
$c = 12.458$ (3) Å
$\alpha = 104.422$ (4)°
$\beta = 105.294$ (4)°
$\gamma = 94.445$ (3)°

$V = 1258.9$ (5) Å^3
$Z = 2$
$D_x = 1.748$ Mg m^{-3}
Mo $K\alpha$ radiation
$\mu = 1.63$ mm^{-1}
$T = 93$ (2) K
Block, yellow
0.20 × 0.20 × 0.20 mm

Data collection

Rigaku AFC12K/SATURN724 diffractometer
ω scans
Absorption correction: multi-scan (*ABSCOR*; Higashi, 1995)
$T_{\min} = 0.736$, $T_{\max} = 1.000$ (expected range = 0.531–0.722)
31926 measured reflections
5694 independent reflections
5555 reflections with $I > 2\sigma(I)$
$R_{\rm int} = 0.033$
$\theta_{\max} = 27.5°$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)] = 0.020$
$wR(F^2) = 0.051$
$S = 1.08$
5694 reflections
298 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0275P)^2 + 0.8849P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{\max} = 0.002$
$\Delta\rho_{\max} = 0.69$ e Å^{-3}
$\Delta\rho_{\min} = -0.52$ e Å^{-3}

Table 1
Selected geometric parameters (Å, °).

Sb—S1	2.4628 (6)	S3—C6	1.7340 (15)
Sb—S2	2.8733 (7)	S4—C6	1.7173 (16)
Sb—S3	2.6384 (6)	S5—C11	1.7322 (16)
Sb—S4	2.7548 (5)	S6—C11	1.7053 (17)
Sb—S5	2.6714 (6)	N1—C1	1.329 (2)
Sb—S6	2.8451 (6)	N2—C6	1.331 (2)
S1—C1	1.7664 (16)	N3—C11	1.348 (2)
S2—C1	1.6962 (16)		
S1—Sb—S2	67.359 (15)	S3—Sb—S6	141.007 (14)
S1—Sb—S3	91.326 (16)	S4—Sb—S5	142.877 (13)
S1—Sb—S4	89.770 (19)	S4—Sb—S6	152.124 (12)
S1—Sb—S5	92.367 (19)	S5—Sb—S6	64.852 (12)
S1—Sb—S6	85.095 (18)	Sb—S1—C1	92.07 (6)
S2—Sb—S3	138.619 (12)	Sb—S2—C1	80.36 (5)
S2—Sb—S4	78.059 (17)	Sb—S3—C6	88.54 (5)
S2—Sb—S5	136.185 (15)	Sb—S4—C6	85.13 (5)
S2—Sb—S6	74.674 (15)	Sb—S5—C11	89.64 (5)
S3—Sb—S4	66.339 (17)	Sb—S6—C11	84.54 (5)
S3—Sb—S5	76.559 (14)		

Table 2
Hydrogen-bond geometry (Å, °).

D—H···A	D—H	H···A	D···A	D—H···A
O1—H1o···O3$^{\rm i}$	0.84	1.84	2.671 (2)	170
O2—H2o···O4$^{\rm ii}$	0.84	1.91	2.718 (2)	162
O3—H3o···O6$^{\rm iii}$	0.84	1.88	2.701 (2)	166
O4—H4o···O5$^{\rm iv}$	0.84	1.92	2.751 (2)	171
O5—H5o···O2$^{\rm v}$	0.84	1.99	2.8188 (19)	172
O6—H6o···O1$^{\rm vi}$	0.84	1.87	2.710 (2)	176

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

The methylene H atoms were included in a riding-model approximation, with C—H = 0.99 Å and with $U_{\rm iso}$(H) = 1.2$U_{\rm eq}$(C). The hydroxyl H atoms were located in a difference map and treated as riding, with O—H = 0.84 Å and $U_{\rm iso}$(H) = 1.5$U_{\rm eq}$(O).

Data collection: *CrystalClear* (Rigaku/MSC, 2005); cell refinement: *CrystalClear*; data reduction: *CrystalClear*; program(s) used to solve structure: *SIR92* (Altomare *et al.*, 1994); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEPII* (Johnson, 1976) and *DIAMOND* (Crystal Impact, 2006); software used to prepare material for publication: *SHELXL97*.

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References

Altomare, A., Cascarano, G., Giacovazzo, C., Guagliardi, A., Burla, M. C., Polidori, G. & Camalli, M. (1994). *J. Appl. Cryst.* **27**, 435–436.
Crystal Impact (2006). *DIAMOND*. Version 3.1. Crystal Impact GbR, Bonn, Germany.
Higashi, T. (1995). *ABSCOR*. University of Tokyo, Japan.
Johnson, C. K. (1976). *ORTEPII*. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee, USA.
Kavounis, C. A., Kokkou, S. C., Rentzeperis, P. J. & Karagiannidis, P. (1982). *Acta Cryst.* B**38**, 2686–2689.
Lai, C. S., Lim, Y. X., Yap, T. C. & Tiekink, E. R. T. (2002). *CrystEngComm*, **4**, 596–600.
Lai, C. S., Liu, S. & Tiekink, E. R. T. (2004). *CrystEngComm*, **6**, 221–226.
Liu, Y. & Tiekink, E. R. T. (2005). *CrystEngComm*, **7**, 20–27.
Ramos, L. A., Cavalheiro, E. T. G. & Chierice, G. O. (2005). *J. Therm. Anal. Calor.* **79**, 349–353.
Rigaku/MSC (2005). *CrystalClear* User Manual, Rigaku/MSC Inc., The Woodlands, Texas, USA.
Sheldrick, G. M. (1997). *SHELXL97*. University of Göttingen, Germany.
Tiekink, E. R. T. (2003). *CrystEngComm*, **5**, 101–113.
Tiekink, E. R. T. (2006*a*). *Frontiers in Crystal Engineering*, edited by E. R. T. Tiekink & J. J. Vittal, pp. 117–134. Chichester: John Wiley & Sons Ltd.
Tiekink, E. R. T. (2006*b*). *CrystEngComm*, **8**, 104–118.
Venkatachalam, V., Ramalingam, K., Casellato, U. & Graziani, R. (1997). *Polyhedron*, **16**, 1211–1221.