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Pyridinium tribromidostannate(II)

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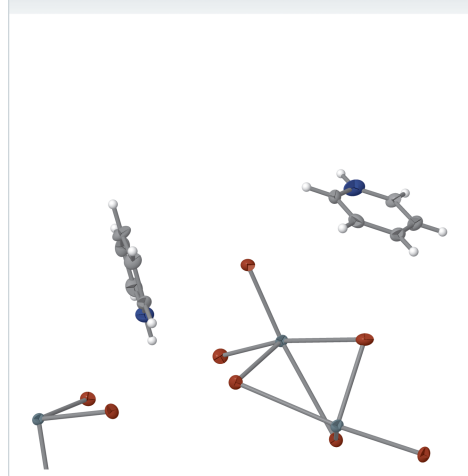
Keywords: crystal structure; tribromidostannate ion; tetrel bonds; π - π interaction; N—H...Br hydrogen bonds.

CCDC reference: 2592101

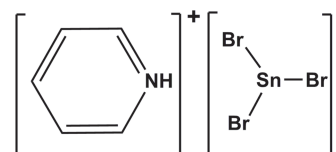
Structural data: full structural data are available from iucrdata.iucr.org

Single crystals of the title compound, (C₅H₆N)[SnBr₃] or [PyH][SnBr₃], were grown from aqueous solutions of pyridinium bromide, [PyH]Br, and tin dibromide, SnBr₂. The compound crystallizes in the monoclinic space group $P2_1/n$ with two formula units in the asymmetric unit. The cations have bond lengths and angles similar to those found in other pyridinium salts. In its first coordination sphere, the anions have a trigonal-pyramidal (*tpy*) shape with the Sn^{II} atoms at the apex and the three bromine atoms at the base. The tin–bromine bond lengths are all greater than 2.5 Å, and the bond angles are all less than 92°, which indicates the presence of *tetrel* bonds. These occur along the twofold screw axis and extend the coordination sphere of the tin atoms to highly distorted, 3₃-aaa octahedra. In the crystal, the two pyridinium cations are aggregated *via* weak π - π interactions into centrosymmetric dimers, which form angles of 61.4(4)° between them. Additional N—H...Br hydrogen bonds between cations and anions are bifurcated and weak.

3D view



Chemical scheme



Structure description

To date, no compounds of divalent tin with pyridinium cations are known. The title compound, pyridinium tribromidostannate(II), is the first example in this class of compounds and, at the same time, provides new insights into the *tetrel*-like interaction between the anions, on the one hand, and the π - π interactions between the cations, on the other.

The title compound crystallizes in the monoclinic space group $P2_1/n$ with $Z = 8$ and $Z' = 2$. Based on the observed internal structural parameters (Fig. 1), the two [SnBr₃][−] anions do not belong to the class of ‘isolated’ tribromidostannate anions, which are typically characterized by bond angles all larger than 92.7° and atomic distances all shorter than 2.654 Å as they appear in the compounds [Ph₄P][SnBr₃] (Müller *et al.*, 1982), [SnBr(crypt-222)][SnBr₃] (Avery *et al.*, 2012), or [Cy₃PH][SnBr₃] (Naglav *et al.*, 2021). Rather, they belong to the class of ‘associated’ anions. In this group, one, two or all three



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Table 1

Bond lengths and angles ($\text{\AA}$, $^\circ$), asymmetry parameters Q , bond valences BV and interpenetration indices p characterizing the tetrel bonds $X\cdots\text{Sn}\cdots Y$.

X/Y	$d(\text{Sn}-X)$	$d(\text{Sn}\cdots Y)$	$\langle(X-\text{Sn}\cdots Y)$	Q	BV($\text{Sn}\cdots Y$)	BV($\text{Sn}-X$)	$p(\text{Sn}\cdots Y)$	$\langle(\text{Sn}-\text{Br}\cdots\text{Sn})$
Br11/Br11 ²	2.7253 (4)	3.3638 (4)	166.07 (1)	1.23	0.10	0.54	0.45	81.88 (1)
Br12/Br12 ¹	2.7364 (4)	3.4665 (4)	167.63 (1)	1.27	0.07	0.53	0.38	79.83 (1)
Br13/Br13 ¹	2.7224 (4)	3.3833 (4)	169.03 (1)	1.24	0.09	0.55	0.44	81.56 (1)
sum					0.26	1.62		
Br21/Br21 ³	2.7061 (4)	3.5616 (4)	163.15 (1)	1.32		0.06	0.57	78.57 (1)
Br22/Br22 ⁴	2.7125 (4)	3.3892 (4)	172.04 (1)	1.25	0.09	0.56	0.43	81.69 (1)
Br31/Br31 ³	2.7483 (4)	3.3749 (4)	170.04 (1)	1.23	0.09	0.51	0.44	81.46 (1)
Sum					0.24	1.65		

Symmetry codes: (1) $-x + \frac{3}{2}, y - \frac{1}{2}, -z + \frac{1}{2}$; (2) $-x + \frac{3}{2}, y + \frac{1}{2}, -z + \frac{1}{2}$; (3) $-x + \frac{1}{2}, y + \frac{1}{2}, -z + \frac{1}{2}$; (4) $-x + \frac{1}{2}, y - \frac{1}{2}, -z + \frac{1}{2}$.

tin–bromine bonds are longer than 2.654 $\text{\AA}$, and one or more bond angles are less than 90°. Typical examples are: [3-MePipH][SnBr₃] (Wang *et al.*, 2025), [C₆H₁₀N₂][SnBr₃]₂ (Matheu *et al.*, 2022) or [PipH][SnBr₃] (Abrahams *et al.*, 1994). In this group of tribromidostannate anions, association occurs *via* the tin atoms, which form additional, so-called *tetrel* bonds (Bauzá *et al.*, 2019; Brammer *et al.*, 2023), characterized by the fact that these additional bonds occur in a *trans* position to existing strong, two-centre-two-electron (2c–2e) bonds. In the broadest sense, *tetrel* bonds can be regarded as extensive three-centre-four-electron (3c–4e) bonds based on an almost linear alignment of the *p*-orbitals of the three atoms involved in the $X-\text{Sn}\cdots Y$ arrangement (Reuter, 2025).

A look at the crystal structure (Fig. 2) shows that these intermolecular interactions occur along the *b*-axis direction

and are associated with the two twofold screw axes of the space group. This symmetry element, which determines the association of the [SnBr₃][−] ions into chains, is also found, for example, in the compound [3-CF₃PyH][SnBr₃] (Chen *et al.*, 2026). In the case of the anions, the interactions result in three *tetrel* bonds (Fig. 3, Table 1) for each of the two tin atoms. With the asymmetry quotients $Q = d(\text{Sn}\cdots\text{Br})/d(\text{Sn}-\text{Br})$ listed in Table 1, these 3c–4e bonds are highly asymmetric, causing the trigonal–pyramidal, 3₀ configuration (Schröder *et al.*, 2024) of the first coordination sphere being extended to a highly distorted octahedral, 3₃-aaa configuration. Similarly, the interpenetration indices ρ (Echeverría & Alvarez, 2023) using the van der Waals radii [$r_{\text{vdW}}(\text{Br}) = 1.83 \text{ \AA}$, $r_{\text{vdW}}(\text{Sn}) = 2.17 \text{ \AA}$; Cordero *et al.*, 2008] and the covalent radii [$r_{\text{cov}}(\text{Br}) = 1.20 \text{ \AA}$, $r_{\text{cov}}(\text{Sn}) = 1.39 \text{ \AA}$; Mantina *et al.*, 2009] support this concept. Furthermore, the calculation of bond valences (BV) according to Hu *et al.* (2012) [$R_{ij} = 2.50$, $b = 0.37$] shows that the intermolecular Sn $\cdots$ Br distances contribute only slightly [0.26/0.24 valence units for Sn1/Sn2] to the calculated overall bond valence sum [$\text{BVS}_{\text{cal}} = 1.85/1.89$] of the divalent tin atoms.

The pyridinium cations are each linked on one side *via* centers of symmetry to form dimers (Fig. 4). The centers of symmetry are located at Wyckhoff position *c* for the pyridinium ion PyH(1) and Wyckhoff position *d* for the pyridinium

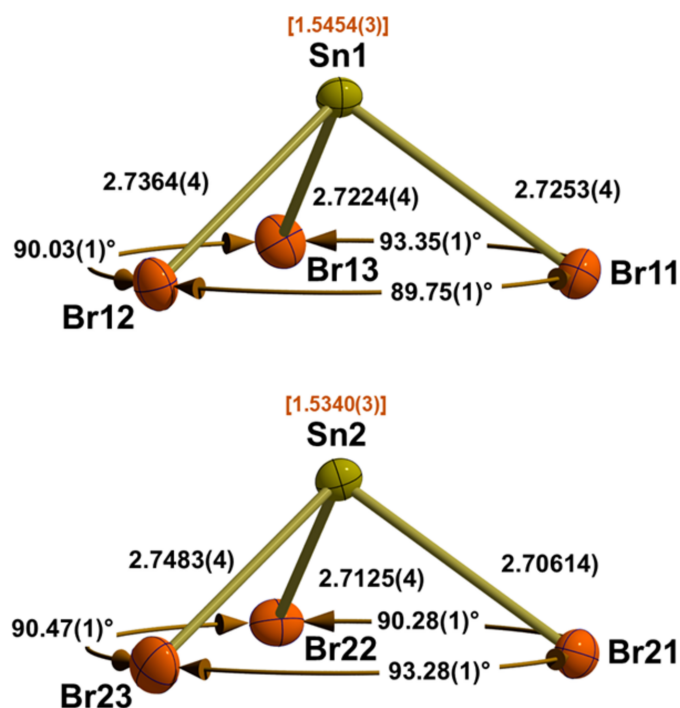


Figure 1

The two [SnBr₃][−] anions of the asymmetric unit with atom numbering, bond lengths ($\text{\AA}$), bond angles ($^\circ$) and distance ($\text{\AA}$) of the tin atom from the basal plane in square brackets. All atoms are drawn as anisotropic displacement ellipsoids at the 50% probability level.

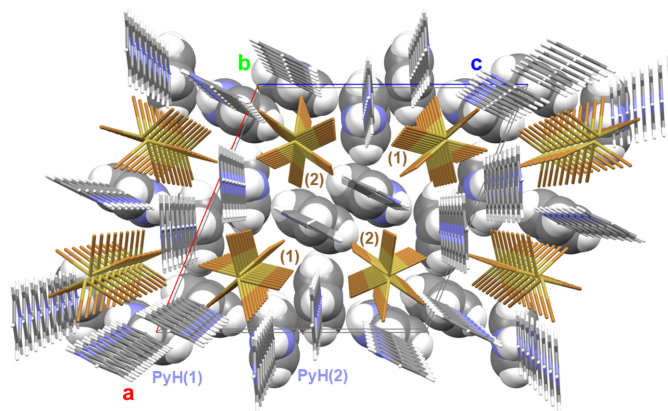


Figure 2

Perspective view into the crystal of [PyH][SnBr₃] looking down the *b* axis. All components are drawn as stick models with the cations in the background additionally represented as space-filling models. Colour code and van der Waals radii used: Sn = bronze, 1.70 $\text{\AA}$, H = white, 1.20 $\text{\AA}$, N = light blue, 1.55 $\text{\AA}$, Br = brown.

Table 2

Hydrogen-bond geometry (Å, °).

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
$N1-H1\cdots Br12$	0.88	3.00	3.517 (4)	119
$N1-H1\cdots Br23$	0.88	3.06	3.595 (4)	122
$N2-H2\cdots Br13^i$	0.88	3.10	3.647 (3)	123
$N2-H2\cdots Br23^{ii}$	0.88	2.94	3.623 (3)	136

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

ion PyH(2). The least-squares planes of the two pyridinium rings are at an angle of 61.4 (1)° to one another, excluding any additional π - π interactions between both. In the dimers, the distance between the least-squares planes is 3.123 Å in the case of PyH(1) and 3.085 Å in the case of PyH(2). Although, or rather because, these distances are relatively short, the

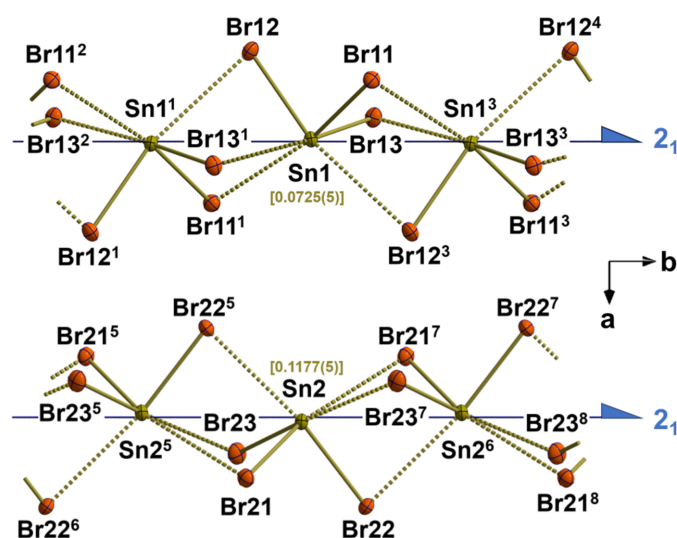


Figure 3

Side-view on the twofold screw axis causing the tetrel bond formation in case of Sn1 (top) and Sn2 (bottom) with their distances from the screw axis in square brackets. Tin-bromine bonds of the first coordination spheres are drawn as solid sticks, those characterizing the tetrel bonds are visualized as dashed sticks. [Symmetry codes: (1) $\frac{3}{2} - x, -\frac{1}{2} + y, \frac{1}{2} - z$; (2) $x, -1 + y, z$; (3) $\frac{3}{2} - x, \frac{1}{2} + y, \frac{1}{2} - z$; (4) $x, 1 + y, z$; (5) $\frac{1}{2} - x, -\frac{1}{2} + y, \frac{1}{2} - z$; (6) $x, -1 + y, z$; (7) $\frac{1}{2} - x, \frac{1}{2} + y, \frac{1}{2} - z$; (8) $x, 1 + y, z$.]

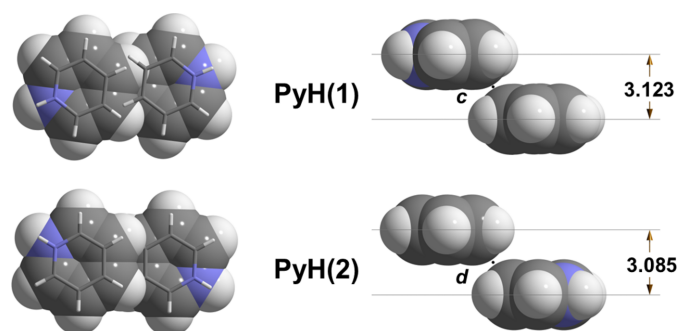


Figure 4

Different representations of the cation stacking. (left) Space-filling model with stick model overlaid viewed perpendicular to the least-squares planes showing the extend of the overlap as resulting from the different centres of symmetry in Wyckhoff positions *c* (PyH1) and *d* (PyH2). (right) Space-filling model of the centrosymmetric dimers in side-view with distances [Å] between the least-squares planes.

Table 3

Experimental details.

Crystal data	
Chemical formula	$(C_5H_6N)[SnBr_3]$
M_r	438.53
Crystal system, space group	Monoclinic, $P2_1/n$
Temperature (K)	100
a, b, c (Å)	16.3640 (5), 8.0330 (2), 16.4846 (5)
β (°)	112.458 (2)
V (Å ³)	2002.59 (10)
Z	8
Radiation type	Mo $K\alpha$
μ (mm ⁻¹)	14.46
Crystal size (mm)	0.25 × 0.08 × 0.05
Data collection	
Diffractometer	Bruker APEXII CCD
Absorption correction	Multi-scan (SADABS; Krause <i>et al.</i> , 2015)
T_{min}, T_{max}	0.414, 0.732
No. of measured, independent and observed [$I > 2\sigma(I)$] reflections	171951, 4844, 4040
R_{int}	0.073
$(\sin \theta/\lambda)_{max}$ (Å ⁻¹)	0.661
Refinement	
$R[F^2 > 2\sigma(F^2)], wR(F^2), S$	0.019, 0.040, 1.06
No. of reflections	4844
No. of parameters	183
H-atom treatment	Only H-atom displacement parameters refined
$\Delta\rho_{max}, \Delta\rho_{min}$ (e Å ⁻³)	0.62, -0.70

Computer programs: APEX2 and SAINT (Bruker, 2009), SHELXS (Sheldrick, 2008), SHELXL (Sheldrick, 2015), DIAMOND (Brandenburg, 2006), Mercury (Macrae *et al.*, 2020) and publCIF (Westrip, 2010).

overlap occurs essentially only in the region of the hydrogen atoms and not in the region of the ring atoms, so that π - π interactions are largely ruled out.

The hydrogen atoms on the nitrogen atoms of the two pyridinium cations are each involved in hydrogen bonds with two bromine atoms (Table 2). The donor $\cdots$ acceptor distances are quite long and these N-H $\cdots$ Br hydrogen bonds are weak, as they are bifurcated (Fig. 5).

Synthesis and crystallization

On a Petri dish, a small amount of pyridinium bromide, PyHBr, prepared from pyridine and hydrobromic acid, was added to a spatula-tip of tin(II) bromide, $SnBr_2$, and the mixture covered with two drops of water. This immediately led

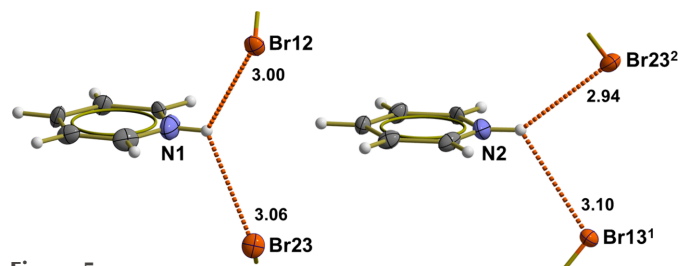


Figure 5

Bifurcated N-H $\cdots$ Br hydrogen bonds (dashed sticks, brown) between the pyridinium and tribromidostannate(II) ions with H $\cdots$ Br distances in Å. Br-Sn bonds are indicated as short, two-coloured sticks. All atoms are drawn as anisotropic displacement ellipsoids at the 50% probability level. [Symmetry codes: (1) $x - \frac{1}{2}, -y + \frac{1}{2}, z + \frac{1}{2}$; (2) $-x + \frac{1}{2}, y - \frac{1}{2}, -z + \frac{1}{2}$.]

to the formation of crystals of the title compound in question, which, however, decompose within a very short time.

Refinement

Crystal data, data collection and structure refinement details are summarized in Table 3.

Acknowledgements

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full crystallographic data

IUCrData (2026). **11**, x261018 [<https://doi.org/10.1107/S2414314626010187>]

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Crystal data

(C₅H₆N)[SnBr₃]

$M_r = 438.53$

Monoclinic, $P2_1/n$

$a = 16.3640(5) \text{ \AA}$

$b = 8.0330(2) \text{ \AA}$

$c = 16.4846(5) \text{ \AA}$

$\beta = 112.458(2)^\circ$

$V = 2002.59(10) \text{ \AA}^3$

$Z = 8$

$F(000) = 1584$

$D_x = 2.909 \text{ Mg m}^{-3}$

Mo $K\alpha$ radiation, $\lambda = 0.71073 \text{ \AA}$

Cell parameters from 9978 reflections

$\theta = 2.7\text{--}27.9^\circ$

$\mu = 14.46 \text{ mm}^{-1}$

$T = 100 \text{ K}$

Prism, colourless

$0.25 \times 0.08 \times 0.05 \text{ mm}$

Data collection

Bruker APEXII CCD

diffractometer

φ and ω scans

Absorption correction: multi-scan

(*SADABS*; Krause *et al.*, 2015)

$T_{\min} = 0.414$, $T_{\max} = 0.732$

171951 measured reflections

4844 independent reflections

4040 reflections with $I > 2\sigma(I)$

$R_{\text{int}} = 0.073$

$\theta_{\max} = 28.0^\circ$, $\theta_{\min} = 1.5^\circ$

$h = -21 \rightarrow 21$

$k = -10 \rightarrow 10$

$l = -21 \rightarrow 21$

Refinement

Refinement on F^2

Least-squares matrix: full

$R[F^2 > 2\sigma(F^2)] = 0.019$

$wR(F^2) = 0.040$

$S = 1.06$

4844 reflections

183 parameters

0 restraints

Primary atom site location: structure-invariant direct methods

Hydrogen site location: inferred from neighbouring sites

Only H-atom displacement parameters refined

$w = 1/[\sigma^2(F_o^2) + (0.0098P)^2 + 4.8363P]$

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

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

$\Delta\rho_{\max} = 0.62 \text{ e \AA}^{-3}$

$\Delta\rho_{\min} = -0.70 \text{ e \AA}^{-3}$

Special details

Geometry. All esds (except the esd in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell esds are taken into account individually in the estimation of esds in distances, angles and torsion angles; correlations between esds in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell esds is used for estimating esds involving l.s. planes.

Refinement. The H atoms were refined in idealized positions and allowed to ride on the parent carbon [$d(\text{C—H}) = 0.95 \text{ \AA}$] and nitrogen atoms [$d(\text{N—H}) = 0.88 \text{ \AA}$], with one common $U_{\text{iso}}(\text{H})$ factor for each of the two pyridinium cations.

Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters ($\text{\AA}^2$)

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
Sn1	0.74639 (2)	0.49613 (3)	0.24574 (2)	0.01520 (5)
Br11	0.64795 (2)	0.68624 (4)	0.31135 (2)	0.01976 (7)
Br12	0.60039 (2)	0.30687 (4)	0.15703 (2)	0.02148 (8)
Br13	0.71023 (2)	0.69213 (4)	0.10145 (2)	0.02061 (7)
Sn2	0.25755 (2)	0.48288 (3)	0.25112 (2)	0.01560 (5)
Br21	0.34456 (2)	0.30922 (4)	0.39993 (2)	0.02048 (7)
Br22	0.39956 (2)	0.68550 (4)	0.28617 (2)	0.01992 (7)
Br23	0.31740 (2)	0.28145 (4)	0.15074 (2)	0.02476 (8)
N1	0.5280 (2)	0.2781 (5)	0.3318 (2)	0.0435 (9)
H1	0.5070	0.3326	0.2817	0.049 (5)*
C11	0.5631 (2)	0.3630 (4)	0.4065 (2)	0.0235 (8)
H11	0.5658	0.4811	0.4051	0.049 (5)*
C12	0.5237 (3)	0.1085 (5)	0.3311 (3)	0.0339 (9)
H12	0.4985	0.0497	0.2772	0.049 (5)*
C13	0.5563 (2)	0.0243 (5)	0.4091 (3)	0.0294 (8)
H13	0.5542	−0.0938	0.4103	0.049 (5)*
C14	0.5921 (2)	0.1136 (4)	0.4855 (2)	0.0282 (9)
H14	0.6153	0.0566	0.5401	0.049 (5)*
C15	0.5948 (2)	0.2826 (4)	0.4841 (2)	0.0257 (8)
H15	0.6189	0.3436	0.5374	0.049 (5)*
N2	0.0994 (3)	0.1248 (4)	0.4380 (2)	0.0399 (9)
H2	0.1048	0.0160	0.4365	0.033 (5)*
C21	0.1725 (2)	0.2187 (5)	0.4724 (2)	0.0274 (8)
H21	0.2294	0.1686	0.4958	0.033 (5)*
C22	0.1632 (2)	0.3898 (5)	0.4730 (2)	0.0271 (8)
H22	0.2140	0.4586	0.4967	0.033 (5)*
C23	0.0802 (2)	0.4604 (4)	0.4392 (2)	0.0237 (8)
H23	0.0733	0.5778	0.4392	0.033 (5)*
C24	0.0079 (2)	0.3587 (5)	0.4057 (2)	0.0276 (8)
H24	−0.0497	0.4059	0.3825	0.033 (5)*
C25	0.0177 (2)	0.1928 (4)	0.4055 (2)	0.0212 (7)
H25	−0.0328	0.1231	0.3825	0.033 (5)*

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

	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
Sn1	0.01591 (10)	0.01134 (10)	0.01766 (11)	0.00070 (8)	0.00562 (8)	0.00067 (9)
Br11	0.02074 (16)	0.02002 (16)	0.02100 (16)	−0.00036 (13)	0.01074 (13)	−0.00295 (13)
Br12	0.02261 (17)	0.01927 (16)	0.02105 (17)	−0.00553 (13)	0.00665 (13)	−0.00294 (13)
Br13	0.02543 (17)	0.02005 (16)	0.01762 (16)	−0.00159 (14)	0.00964 (13)	0.00205 (13)
Sn2	0.01692 (11)	0.01060 (10)	0.01852 (11)	−0.00050 (8)	0.00591 (9)	−0.00026 (9)
Br21	0.02247 (17)	0.01933 (16)	0.02084 (17)	0.00069 (13)	0.00961 (13)	0.00407 (13)
Br22	0.01760 (15)	0.01548 (15)	0.02604 (18)	−0.00319 (12)	0.00764 (13)	0.00006 (13)
Br23	0.03087 (19)	0.02348 (18)	0.01994 (17)	0.00076 (15)	0.00974 (15)	−0.00550 (14)
N1	0.041 (2)	0.059 (3)	0.033 (2)	0.0116 (19)	0.0174 (17)	0.0185 (18)

C11	0.0214 (17)	0.0151 (16)	0.034 (2)	−0.0003 (14)	0.0109 (16)	0.0069 (15)
C12	0.035 (2)	0.043 (2)	0.026 (2)	−0.0012 (19)	0.0137 (18)	−0.0102 (18)
C13	0.0244 (18)	0.0227 (18)	0.039 (2)	−0.0003 (15)	0.0098 (17)	−0.0076 (17)
C14	0.0266 (19)	0.0218 (18)	0.0257 (19)	0.0005 (15)	−0.0020 (16)	0.0065 (15)
C15	0.0270 (19)	0.0205 (17)	0.0245 (19)	−0.0040 (15)	0.0043 (15)	−0.0046 (15)
N2	0.066 (3)	0.0248 (17)	0.0325 (19)	0.0105 (17)	0.0235 (18)	0.0001 (15)
C21	0.0221 (18)	0.034 (2)	0.028 (2)	0.0091 (16)	0.0126 (16)	0.0103 (17)
C22	0.0236 (18)	0.033 (2)	0.027 (2)	−0.0037 (16)	0.0119 (16)	0.0052 (16)
C23	0.0286 (19)	0.0177 (17)	0.0256 (19)	0.0025 (14)	0.0112 (15)	0.0029 (14)
C24	0.0231 (18)	0.0271 (19)	0.028 (2)	0.0020 (15)	0.0053 (16)	0.0055 (16)
C25	0.0198 (16)	0.0171 (16)	0.0184 (17)	−0.0045 (14)	−0.0019 (13)	−0.0025 (14)

Geometric parameters (Å, °)

Sn1—Br13	2.7224 (4)	C12—H12	0.9500
Sn1—Br11	2.7253 (4)	C13—C14	1.372 (5)
Sn1—Br12	2.7364 (4)	C13—H13	0.9500
Sn1—Br11 ⁱ	3.3638 (4)	C14—C15	1.359 (5)
Sn1—Br13 ⁱ	3.3833 (4)	C14—H14	0.9500
Sn1—Br12 ⁱⁱ	3.4665 (4)	C15—H15	0.9500
Sn2—Br21	2.7061 (4)	N2—C21	1.343 (5)
Sn2—Br22	2.7125 (4)	N2—C25	1.350 (5)
Sn2—Br23	2.7483 (4)	N2—H2	0.8800
Sn2—Br23 ⁱⁱⁱ	3.3749 (4)	C21—C22	1.383 (5)
Sn2—Br22 ^{iv}	3.3892 (4)	C21—H21	0.9500
Sn2—Br21 ⁱⁱⁱ	3.5616 (4)	C22—C23	1.378 (5)
N1—C11	1.330 (5)	C22—H22	0.9500
N1—C12	1.365 (5)	C23—C24	1.368 (5)
N1—H1	0.8800	C23—H23	0.9500
C11—C15	1.349 (5)	C24—C25	1.343 (5)
C11—H11	0.9500	C24—H24	0.9500
C12—C13	1.368 (5)	C25—H25	0.9500
Br13—Sn1—Br11	93.353 (12)	C11—N1—C12	121.5 (4)
Br13—Sn1—Br12	90.025 (12)	C11—N1—H1	119.2
Br11—Sn1—Br12	89.754 (12)	C12—N1—H1	119.2
Br13—Sn1—Br11 ⁱ	98.449 (11)	N1—C11—C15	120.4 (3)
Br12—Sn1—Br11 ⁱ	82.905 (11)	N1—C11—H11	119.8
Br11—Sn1—Br13 ⁱ	95.552 (11)	C15—C11—H11	119.8
Br12—Sn1—Br13 ⁱ	83.623 (11)	N1—C12—C13	119.0 (4)
Br11 ⁱ —Sn1—Br13 ⁱ	71.945 (9)	N1—C12—H12	120.5
Br13—Sn1—Br12 ⁱⁱ	82.234 (11)	C13—C12—H12	120.5
Br11—Sn1—Br12 ⁱⁱ	81.127 (11)	C12—C13—C14	118.8 (4)
Br11—Sn1—Br11 ⁱ	166.072 (12)	C12—C13—H13	120.6
Br12—Sn1—Br12 ⁱⁱ	167.628 (12)	C14—C13—H13	120.6
Br13—Sn1—Br13 ⁱ	169.026 (13)	C15—C14—C13	120.8 (4)
Br11 ⁱ —Sn1—Br12 ⁱⁱ	107.695 (10)	C15—C14—H14	119.6
Br13 ⁱ —Sn1—Br12 ⁱⁱ	105.458 (10)	C13—C14—H14	119.6

Sn1—Br11—Sn1 ⁱⁱ	81.883 (9)	C11—C15—C14	119.5 (3)
Sn1—Br12—Sn1 ⁱ	79.826 (9)	C11—C15—H15	120.3
Sn1—Br13—Sn1 ⁱⁱ	81.557 (9)	C14—C15—H15	120.3
Br21—Sn2—Br22	90.281 (12)	C21—N2—C25	121.9 (3)
Br21—Sn2—Br23	93.276 (13)	C21—N2—H2	119.1
Br22—Sn2—Br23	90.470 (13)	C25—N2—H2	119.1
Br21—Sn2—Br23 ⁱⁱⁱ	95.367 (11)	N2—C21—C22	118.5 (3)
Br22—Sn2—Br23 ⁱⁱⁱ	84.841 (11)	N2—C21—H21	120.7
Br21—Sn2—Br22 ^{iv}	84.321 (11)	C22—C21—H21	120.7
Br21—Sn2—Br21 ⁱⁱⁱ	163.151 (12)	C23—C22—C21	120.0 (3)
Br22—Sn2—Br22 ^{iv}	172.044 (12)	C23—C22—H22	120.0
Br23—Sn2—Br22 ^{iv}	84.025 (11)	C21—C22—H22	120.0
Br23 ⁱⁱⁱ —Sn2—Br22 ^{iv}	101.449 (11)	C24—C23—C22	119.0 (3)
Br23—Sn2—Br23 ⁱⁱⁱ	170.179 (13)	C24—C23—H23	120.5
Br22—Sn2—Br21 ⁱⁱⁱ	80.923 (10)	C22—C23—H23	120.5
Br23—Sn2—Br21 ⁱⁱⁱ	101.089 (12)	C25—C24—C23	120.5 (3)
Br23 ⁱⁱⁱ —Sn2—Br21 ⁱⁱⁱ	69.679 (9)	C25—C24—H24	119.7
Br22 ^{iv} —Sn2—Br21 ⁱⁱⁱ	105.736 (9)	C23—C24—H24	119.7
Sn2—Br21—Sn2 ^{iv}	78.569 (8)	C24—C25—N2	120.1 (3)
Sn2—Br22—Sn2 ⁱⁱⁱ	81.693 (9)	C24—C25—H25	119.9
Sn2—Br23—Sn2 ^{iv}	81.458 (10)	N2—C25—H25	119.9

Symmetry codes: (i) $-x+3/2, y-1/2, -z+1/2$; (ii) $-x+3/2, y+1/2, -z+1/2$; (iii) $-x+1/2, y+1/2, -z+1/2$; (iv) $-x+1/2, y-1/2, -z+1/2$.

Hydrogen-bond geometry ($\text{\AA}$, $^\circ$)

$D-H\cdots A$	$D-H$	$H\cdots A$	$D\cdots A$	$D-H\cdots A$
N1—H1 $\cdots$ Br12	0.88	3.00	3.517 (4)	119
N1—H1 $\cdots$ Br23	0.88	3.06	3.595 (4)	122
N2—H2 $\cdots$ Br13 ^v	0.88	3.10	3.647 (3)	123
N2—H2 $\cdots$ Br23 ^{iv}	0.88	2.94	3.623 (3)	136

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