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Tetrachloro-(acetylacetonato)stannate(IV) and tri-iodocadmate(II) stabilized by a heptacyclic cation: Synthesis, characterization, and crystal structure

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ABSTRACT

The tin (IV) and cadmium (II) complexes were synthesized in mixture, the ligand 4,4'-(ethane-1,2-diylbis(azanylylidene))bis(pent-2-en-2-ol), and the halide metal (SnCl₂ or CdI₂). Complex synthesis involves partial hydrolysis of the ligand followed by condensation cyclization. The new tin complex obtained crystallizes in the monoclinic space group *P2₁/n* with *a* = 8.5468(5) Å, *b* = 17.9907(9) Å, *c* = 12.7227(7) Å, β = 94.220(5)°, *V* = 1950.98(18) Å³ and *Z* = 4. The asymmetric unit consists of an anion tetrachloro-(acetylacetonato)stannate(IV) and a heptacyclic cation. The geometry of the complex is octahedral with *cis* coordination of the two oxygens of the acetylacetonate. The cadmium complex crystallizes in the orthorhombic space group *Pbca* with *a* = 14.7395(9) Å, *b* = 8.5914(5) Å, *c* = 23.2825(13) Å, *V* = 2948.3(3) Å³, *Z* = 8. The geometry around cadmium is a deformed tetrahedron. The heptacyclic cation and the anionic complex are interconnected through hydrogen bonding interactions, specifically N–H···Cl or N–H···I, forming a network.

KEYWORDS

Crystal structure
 Tin (IV) complex
 Heptacyclic cation
 Hydrogen bonding
 Tri-iodocadmate (II)
 Hybrid organic-inorganic

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1. Introduction

In recent years, the attention to organic/inorganic compounds has increased, and tin (IV) complexes containing mono- and bidentate O-donor ligands are becoming increasingly important because of a number of compounds [1]. Hybrid organic-inorganic compounds are an emerging class of new materials that hold significant promise [2]. These complex structures, based on a molecular-scale composite of organic and inorganic components, allow the combination of the properties of organic and inorganic elements in a unique material [3]. Organic and inorganic compounds are embedded, and only weak bonds (hydrogen, van der Waals, or ionic bonds) give the cohesion to the whole structure. Inorganic compounds, typically characterized by covalent and ionic interactions, exhibit a wide range of electronic properties, including high electrical mobility and a broad spectrum of band gaps (*e.g.*, insulators, semiconductors, and metals). They also possess notable magnetic and dielectric properties, thermal stability, and mechanical hardness [4]. Organic compounds, which typically interact through weaker interactions, with van der Waals or hydrogen bonding, offer the potential of high

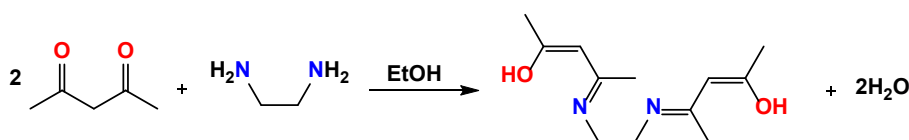
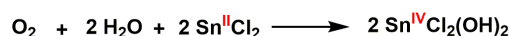
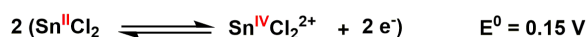
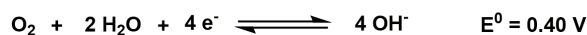
luminescence efficiency, large polarizability, plastic mechanical properties, and in some cases exhibit conducting properties [3,5]. Hybrid organic/inorganic compounds are considered innovative advanced materials. Promising applications are expected in many fields including optics, electronics, mechanics, protective coatings, catalysis, sensors, biology, and others [6-16]. Recently, organic/inorganic hybrid semiconductor materials with a perovskite structure have attracted attention as light sensitizers for solar cells due to their superb photovoltaic characteristics [17]. In this present study, we report the synthesis of a tetradentate ligand (4,4'-(ethane-1,2-diylbis(azanylylidene))bis(pent-2-en-2-ol)) and two new complexes tetrachloro-(acetylacetonato)stannate(IV) and tri-iodocadmate(II) stabilized by a heptacyclic cation. These new complexes will be characterized by infrared spectroscopy (IR) and single-crystal X-ray diffraction (SCXRD).

2. Experimental

2.1. Materials and physical measurements

Table 1. Crystallographic data of the prepared complexes.

Compound	Tin complex	Cadmium complex
Empirical formula	C ₁₂ H ₂₀ Cl ₄ N ₂ O ₂ Sn	C ₇ H ₁₃ CdI ₃ N ₂
Formula weight (g/mol)	484.79	618.29
Temperature (K)	297(2)	120.01
Crystal system	Monoclinic	Orthorhombic
Space group	<i>P</i> 2 ₁ / <i>n</i>	<i>Pbca</i>
<i>a</i> , (Å)	8.5468(5)	14.7395(9)
<i>b</i> , (Å)	17.9907(9)	8.5914(5)
<i>c</i> , (Å)	12.7227(7)	23.2825(13)
β (°)	94.220(5)	90
Volume (Å ³)	1950.98(18)	2948.3(3)
<i>Z</i>	4	8
ρ _{calc} (g/cm ³)	1.65	2.786
μ (mm ⁻¹)	1.861	7.733
F(000)	960.0	2208.0
Crystal size (mm ³)	0.41 × 0.17 × 0.13	0.18 × 0.18 × 0.04
Radiation	MoKα (λ = 0.71073)	MoKα (λ = 0.71073)
2θ range for data collection (°)	3.92 to 52.74	5.528 to 54.96
Index ranges	-10 ≤ <i>h</i> ≤ 9, -22 ≤ <i>k</i> ≤ 22, -15 ≤ <i>l</i> ≤ 15	-19 ≤ <i>h</i> ≤ 19, -11 ≤ <i>k</i> ≤ 11, -30 ≤ <i>l</i> ≤ 30
Reflections collected	21391	72979
Independent reflections	3984 [R _{int} = 0.0537, R _{sigma} = 0.0324]	3377 [R _{int} = 0.0278, R _{sigma} = 0.0083]
Data/restraints/parameters	3984/6/202	3377/0/120
Goodness-of-fit on F ²	1.059	1.183
Final R indexes [I ≥ 2σ (I)]	R ₁ = 0.0347, wR ₂ = 0.0847	R ₁ = 0.0196, wR ₂ = 0.0476
Final R indexes [all data]	R ₁ = 0.0456, wR ₂ = 0.0932	R ₁ = 0.0205, wR ₂ = 0.0481
Largest diff. peak/hole (e.Å ⁻³)	0.69/-0.43	0.72/-0.57

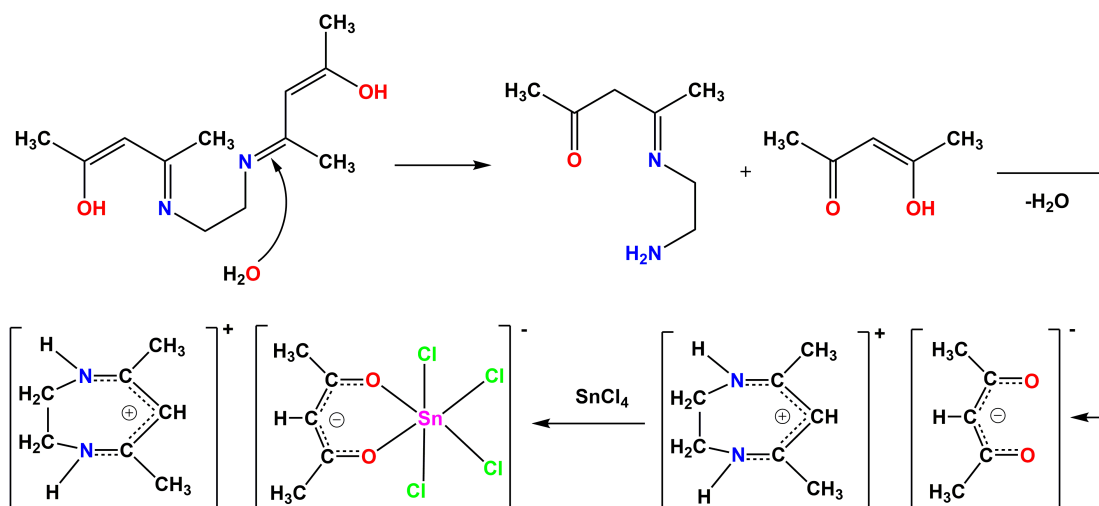
**Scheme 1.** Synthesis of ligand (4,4'-(ethane-1,2-diylbis(azanylylidene))bis(pent-2-en-2-ol)).**Oxidation of tin: Sn²⁺ to Sn⁴⁺****Jørgensen's biosynthesis****Scheme 2.** Oxidation of tin: Sn²⁺ to Sn⁴⁺.

Chemicals (acetylacetone, ethylenediamine, SnCl₂, CdI₂) were purchased from Sigma-Aldrich and used without further purification. The solvent used for the synthesis is absolute ethanol. Infrared spectra were recorded on a FT-IR Bruker Tensor 27 spectrometer in the range of 4000-200 cm⁻¹. ¹H and ¹³C NMR spectra were recorded on a Bruker AV2 (400 MHz) spectrometer in DMSO-*d*₆. X-ray crystallographic data were collected using a Crys Alis PRO 1.171.41.93a diffractometer operating at T = 297 K for the tin complex and 120 K for the cadmium complex. Data were measured using φ and ω scans with MoKα radiation (λ = 0.71073 Å). The structure was solved by direct methods using SIR92 [18] and was refined by least squares minimization with SHELXL [19]. The program used for the representation of molecular and crystal structures: OLEX2 [20]. Crystal data, data collection, and structure refinement details for the complexes are summarized in Table 1.

2.2. Synthesis**2.2.1. Synthesis of the ligand**

The ligand was synthesized by mixing in a round bottom flask containing ethanol, 6 g (60 mmol) of pentane-2,4-dione and 1.8 g (30 mmol) of ethylenediamine. This mixture is refluxed for 5 h at a temperature of 80 °C; the yellow coloration of the mixture is obtained. After 5 hours of stirring and heating, the mixture is filtered and slowly evaporated for a few days, and the yield obtained is 82% (Scheme 1).

4, 4'-(Ethane-1, 2-diylbis(azanylylidene))bis(pent-2-en-2-ol): Color: White. Yield: 82%. FT-IR (ν, cm⁻¹): 3261 (OH), 2980 (CH), 1602 (C=N). ¹H NMR (400 MHz, DMSO-*d*₆, δ, ppm): 1.86 (s, 6H, CH₃-C-OH), 1.89 (s, 6H, CH₃-C=N), 3.39 (s, 4H, CH₂-CH₂), 4.94 (s, 2H, CH=C), 14.00 (s, 2H, -OH). ¹³C NMR (100 MHz, DMSO-*d*₆,



Scheme 3. Synthesis of the tin complex.

δ , ppm): 193.67 (C2, C2'), 163.40 (C4, C4'), 95.57 (C3, C3'), 43.33 (C6, C6'), 29.07 (C5, C5'), 18.71 (C1, C1'). Solubility: Ethanol, methanol, dimethylsulfoxide, DMF, acetonitrile, acetone, and chloroform.

2.2.2. Synthesis of complexes

2.2.2.1. Synthesis of tin (IV) complex

The complex was synthesized by mixing 0.222 g (1 mmol) of the ligand and 0.379 g (2 mmol) of tin(II) chloride in absolute ethanol in a 1:1 ratio. The precipitate mixture obtained is then refluxed for 14 h at a temperature of 80 °C. The yellow solution was then slowly cooled to room temperature and then filtered. After a few days of evaporation of the filtrate, a small yellow crystal was obtained for X-ray diffraction. The crystallographic and IR spectra study of the complex showed a hydrolysis of the ligand as well as an oxidation of tin (II) to tin (IV) (Scheme 2), the hydrolysis of the ligand giving two molecules of acetylacetone and ethylenediamine. Acetylacetone reacts with ethylenediamine by dehydration followed by condensation to give a heptacyclic cation and the acetylacetonate ion. These react with SnCl_4 from the Jorgensen symbiosis (Scheme 3), to give the anionic tetrachloro-(acetylacetonato)stannate (IV) complex and a heptacyclic cation (5,7-dimethyl-2,3-dihydro-1H-1,4-diazepin-4-ium).

5, 7-Dimethyl-2, 3-dihydro-1H-1, 4-diazepin-4-ium tetra chloro-(acetylacetonato)stannate(IV): Color: Yellow. Yield: 32%. FT-IR (ν , cm^{-1}): 3289 (NH) (amine), 3000 (CH), 1659 (C=O) (ketone), 1595 (C=N) (imine).

2.2.2.2. Synthesis of cadmium (II) complex

The complex was synthesized by mixing 0.222 g (1 mmol) of the ligand and 2 mmol of CdI_2 in absolute ethanol in a 1:1 ratio. This precipitate mixture obtained is then refluxed for a minimum of 5 h at 80 °C. The solutions were then slowly cooled to room temperature and then filtered. After a few days of evaporation of the filtrate, small yellow crystals were obtained for SCXRD. The crystallographic study of the complexes showed that the ligand was partially hydrolyzed. The crystallographic study of the complex showed the hydrolysis of the ligand. The latter reacts with the ketone group of the imine to give a heptacyclic cation (Scheme 4).

5,7-Dimethyl-2,3-dihydro-1H-1,4-diazepin-4-ium tri-iodo cadmate(II): Color: Yellow. Yield: 26%. FT-IR (ν , cm^{-1}): 3271 (NH) (amine), 3097 (CH), 1620 (C=N) (imine).

3. Results and discussion

3.1. IR spectra of complexes

The infrared spectrum of the tin complex shows an absorption band at 3289 cm^{-1} attributed to $\nu(\text{NH})$ of a secondary amine, we also observe the presence of small bands around 3000 cm^{-1} corresponding to the $\nu(\text{CH})$. The band at 1659 cm^{-1} is attributed to $\nu(\text{C}=\text{O})$ of a ketone, the reduction of this band compared to that of a free ketone expected around 1720 cm^{-1} shows that C=O participates in the coordination of tin [21]. The vibration band $\nu(\text{C}=\text{N})$ of the cation appears at 1595 cm^{-1} . For the cadmium complex, the infrared spectrum of the complex shows a band at 1620 cm^{-1} attributed to the vibration band of the azomethine group $\nu(\text{C}=\text{N})$ contained in the cation. We also note the presence of aliphatic $\nu(\text{CH})$ bands at 2929 and 3097 cm^{-1} and an absorption band relative to $\nu(\text{NH})$ at 3271 cm^{-1} [22].

3.2. Crystallographic study of tin complex

Crystal structure analysis reveals that the tin complex crystallizes in a monoclinic system with $P2_1/n$ space group. The parameters of unit cell are: $a = 8.5468(5)$ Å, $b = 17.9907(9)$ Å, $c = 12.7227(7)$ Å, and $\beta = 94.220(5)^\circ$ (Table 1). The asymmetric unit consists of an anion tetrachloro-(acetylacetonate)stannate (IV) and a heptacyclic cation (Figure 1). The anion contains an ion acetylacetonate and a fraction of SnCl_4 . The CO bond lengths in the ion acetylacetonate (O1-C2 = 1.281 Å and O2-C4 = 1.282 Å) indicate that these are double bonds (C=O the ketone group) (Table 2) [23]. The geometry around the tin complex is octahedral with cis coordination of the C=O groups of the acetylacetonate ion. The equatorial positions of the octahedron are occupied by two oxygen atoms of the acetylacetonate ion (O1 and O2) and two chlorine atoms (Cl1 and Cl2). The values of the angles around the tin are: Cl2-Sn1-O1 = 89.05(8)°, O1-Sn1-O2 = 86.044(10)°, O2-Sn1-Cl1 = 87.95(7)° and Cl2-Sn1-Cl1 = 96.57(4)° (Table 2). The deformation of the bond angles around the tin compared to the ideal angle shows that the geometry is a deformed octahedron [24], the axial positions are occupied by the chlorine atoms Cl3 and Cl4. Thus, the distances Sn1-O (Sn1-O1 = 2.095 Å and Sn1-O2 = 2.093 Å) and Sn1-Cl (Sn1-Cl1 = 2.3763 Å, Sn1-Cl2 = 2.3749 Å, Sn1-Cl3 = 2.4129 Å, Sn1-Cl4 = 2.4097 Å) are in good agreement with that reported in the literature [25-29].

Table 2. Bond lengths and angles for the tin complex.

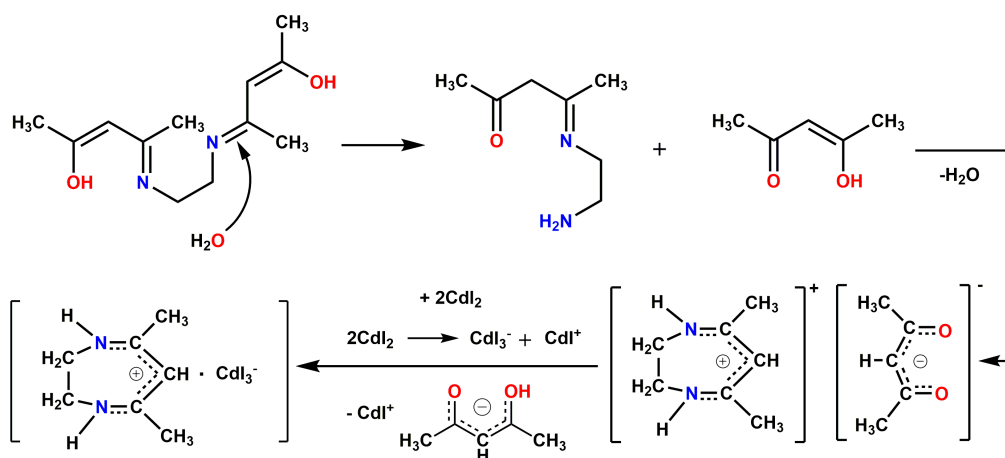
Atom	Atom	Length (Å)	Atom	Atom	Length (Å)
C1	C2	1.500(6)	C14	Sn1	2.4097(11)
C2	C3	1.368(6)	C6	C7	1.505(6)
C2	O1	1.281(5)	C7	C8	1.386(6)
C3	C4	1.382(6)	C7	N1	1.306(6)
C4	C5	1.494(5)	C8	C9	1.391(6)
C4	O2	1.282(4)	C9	C10	1.482(6)
O1	Sn1	2.095(2)	C9	N2	1.305(5)
O2	Sn1	2.093(2)	C11	C12	1.478(6)
Cl1	Sn1	2.3763(10)	C11	N1	1.456(6)
Cl2	Sn1	2.3749(10)	C12	N2	1.445(6)
Cl3	Sn1	2.4129(11)			

Atom	Atom	Atom	Angle (°)	Atom	Atom	Atom	Angle (°)
C3	C2	C1	120.3(4)	Cl1	Sn1	Cl3	92.93(4)
O1	C2	C1	114.2(4)	Cl1	Sn1	Cl4	92.01(4)
O1	C2	C3	125.5(4)	Cl2	Sn1	Cl1	96.57(4)
C2	C3	C4	127.4(4)	Cl2	Sn1	Cl3	90.90(4)
C3	C4	C5	121.0(4)	Cl2	Sn1	Cl4	91.64(4)
O2	C4	C3	125.0(4)	Cl4	Sn1	Cl3	174.15(4)
O2	C4	C5	114.0(4)	C8	C7	C6	118.3(4)
C2	O1	Sn1	127.1(3)	N1	C7	C6	115.4(4)
C4	O2	Sn1	127.1(2)	N1	C7	C8	126.2(4)
O1	Sn1	Cl1	174.36(8)	C7	C8	C9	131.8(4)
O1	Sn1	Cl2	89.05(8)	C8	C9	C10	119.1(4)
O1	Sn1	Cl3	86.45(8)	N2	C9	C8	125.4(4)
O1	Sn1	Cl4	88.32(8)	N2	C9	C10	115.4(4)
O2	Sn1	O1	86.44(10)	N1	C11	C12	114.4(5)
O2	Sn1	Cl1	87.95(7)	N2	C12	C11	111.9(4)
O2	Sn1	Cl2	175.48(7)	C7	N1	C11	125.7(4)
O2	Sn1	Cl3	88.87(8)	C9	N2	C12	126.0(4)
O2	Sn1	Cl4	88.18(8)				

Table 3. Geometric parameters of hydrogen bonds of the tin complex.

D-H...A *	d(D-H), Å	d(H-A), Å	d(D-A), Å	∠ D-H-A, °
N1-H1... Cl3 ¹	0.859(19)	2.69(2)	3.502(4)	159(3)
N2-H2... Cl4 ²	0.851(19)	2.52(2)	3.350(4)	164(3)

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



Scheme 4. Synthesis of the cadmium complex.

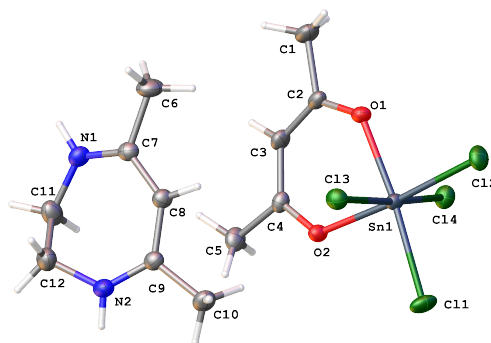


Figure 1. Crystal structure of the tin complex.

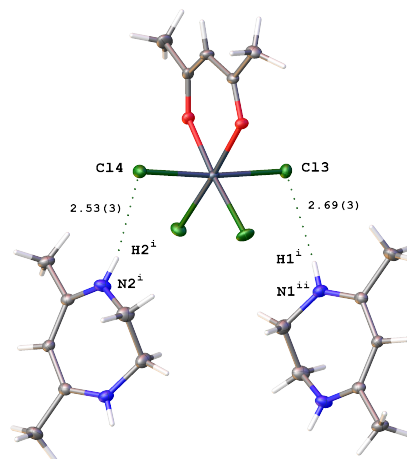
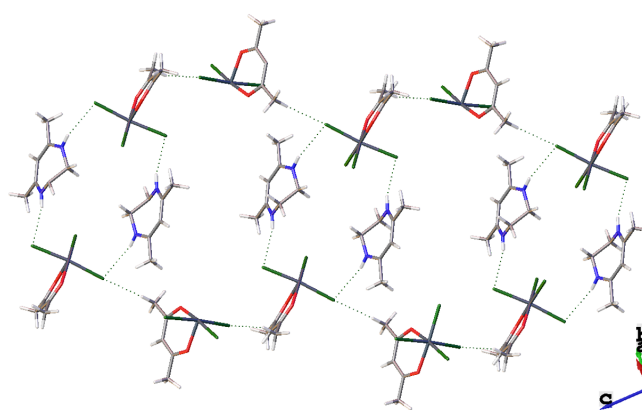
Table 4. Bond lengths and angles for the cadmium complex *.

Atom	Atom	Length (Å)	Atom	Atom	Length (Å)
I1	Cd	2.7231(4)	N2	C4	1.449(5)
I2	Cd ¹	2.8789(4)	C1	C2	1.398(6)
I2	Cd	2.8256(4)	C1	C6	1.504(6)
I3	Cd	2.7275(4)	C2	C3	1.392(6)
N1	C1	1.314(5)	C3	C7	1.505(6)
N1	C5	1.451(5)	C4	C5	1.524(6)
N2	C3	1.323(5)			

Atom	Atom	Atom	Angle (°)	Atom	Atom	Atom	Angle (°)
Cd	I2	Cd ¹	102.608(12)	N1	C1	C2	126.0(4)
I1	Cd	I2	111.910(13)	N1	C1	C6	115.5(4)
I1	Cd	I2 ²	109.756(12)	C2	C1	C6	118.5(4)
I1	Cd	I3	121.276(13)	C3	C2	C1	131.2(4)
I2	Cd	I2 ²	101.225(12)	N2	C3	C2	126.8(4)
I3	Cd	I2	108.178(13)	N2	C3	C7	114.9(4)
I3	Cd	I2 ²	102.255(12)	C2	C3	C7	118.2(4)
C1	N1	C5	125.0(3)	N2	C4	C5	111.8(3)
C3	N2	C4	126.6(4)	N1	C5	C4	113.0(3)

* Symmetry codes: ¹ 1/2-x, 1/2+y, +z; ² 1/2-x, -1/2+y, +z.**Table 5.** Geometric parameters of hydrogen bonds of the cadmium complex.

D-H...A	d(D-H), Å	d(H-A), Å	d(D-A), Å	∠ D-H-A, °
N1-H1...I1	0.879(5)	2.977(3)	3.742(3)	1146.6(3)
N2-H2...I3	0.881(5)	2.735(3)	3.528(3)	150.4(3)

**Figure 2.** The N-H...Cl hydrogen bonds of the tin complex. Symmetry codes: ⁱ x+1/2, -y+1/2, z-1/2; ⁱⁱ -x+1/2, y+1/2, -z+1/2.**Figure 3.** Infinite chain of the tin complex.

The anionic complex is linked to the heptacyclic cation by hydrogen bonds of type Cl3ⁱ...H1-N1 and Cl4ⁱⁱ...H2-N2 (Table 3) that form an infinite chain (Figures 2 and 3).

3.3. Crystallographic study of cadmium complex

The complex of cadmium crystallizes in the orthorhombic system with the *Pbca* space group. The parameters of unit cell are $a = 14.7395(9)$ Å, $b = 8.5914(5)$ Å, $c = 23.2825(13)$ Å, $V = 2948.3(3)$ Å³, $Z = 8$. This structure reveals that cadmium is tetracoordinated with four iodine atoms (Figure 4).

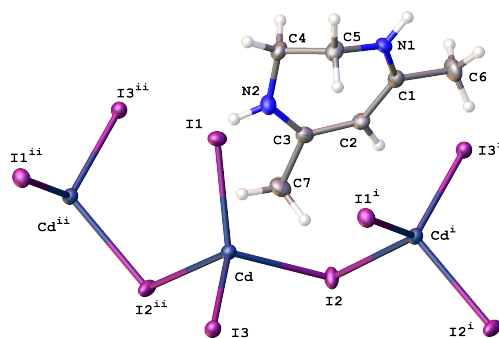


Figure 4. Crystal structure of the cadmium complex, Symmetry codes: $^i 1/2-x, 1/2+y, +z$; $^{ii} 1/2-x, -1/2+y, +z$.

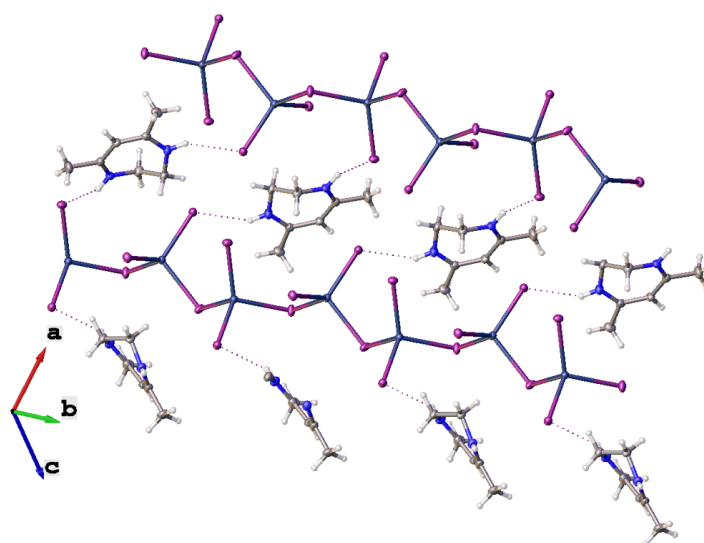


Figure 5. Infinite three-dimensional structure of the cadmium complex stabilized by hydrogen bonds (dotted line).

Three non-equivalent iodine atoms are noted in the crystal structure, the terminal atoms I1 and I3, and one atom I2 serve as a bridge between two cadmium atoms. The geometry around cadmium is a distorted tetrahedron with the following bond lengths and angles: Cd-I1 = 2.7231(4); Cd-I2 = 2.8789(4); Cd-I2 = 2.8256(4); Cd-I3 = 2.7275(4); I1-Cd-I2² = 109.756(12)°, I1-Cd-I2 = 111.910(13)°; I3-Cd-I2² = 102.255(12)° and I3-Cd-I1 = 121.276(13)° (Table 4). These values obtained are similar to those reported by Gesing *et al.* [30]. The CdI₃⁻ ion is linked to the heptacyclic cation by interatomic hydrogen bonds between the terminal iodine and the hydrogens of the imine groups forming an infinite three-dimensional structure; N1-H1...I1 = 2.976 Å, N2-H2...I3 = 2.735 Å (Table 5) and C5-H1...I3 = 3.144 Å (Figure 5).

4. Conclusion

In summary, two new coordination complexes C₁₂H₂₀N₂O₂·SnCl₄ and CdI₃·C₇H₁₃N₂ were obtained, and their structures were characterized by IR spectra and X-ray diffraction. In the tin complex, the atom Sn(IV) was coordinated by two O atoms of the acetylacetonate anion acting as bidentate ligands and four ion chlorides. The geometry of the tin complex is octahedral and that of the cadmium complex is tetrahedral. The heptacyclic cation and the complex anionic are interlinked by hydrogen bonding interactions, namely N-H...Cl and N-H...I, forming a chain network.

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Supporting information

CCDC-2112975 (C₁₂H₂₀N₂O₂·SnCl₄) and CCDC-2115928 (CdI₃·C₇H₁₃N₂) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, or by e-mailing data_request@ccdc.cam.ac.uk, or by contacting The Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44(0)1223-336033.

Disclosure statement

Conflict of interest: The authors declare that they have no conflict of interest. Ethical approval: All ethical guidelines have been adhered. Sample availability: Samples of the compounds are available from the author.

CRedit authorship contribution statement

Conceptualization: Tidiane Diop, Aminata Diasse-Sarr; Methodology: Adrienne Ndiolene, Tidiane Diop; Software: Mouhamadou Sembene Boye; Validation: Adrienne Ndiolene, Tidiane Diop; Formal Analysis: Adrienne Ndiolene; Investigation: Adrienne Ndiolene, Tidiane Diop; Resources: Tidiane Diop, Aminata Diasse-Sarr; Data Curation: Adrienne Ndiolene; Writing - Original Draft: Adrienne Ndiolene, Tidiane Diop; Writing - Review and Editing: Mouhamadou Sembene Boye, Aminata Diasse-Sarr; Visualization: Adrienne Ndiolene; Supervision: Tidiane Diop, Aminata Diasse-Sarr; Project Administration: Aminata Diasse-Sarr.

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References

- BelhajSalah, S.; Abdelbaky, M.; García-Granda, S.; Essalah, K.; Ben Nasr, C.; Mrad, M. Synthesis, crystal structure, vibrational, optical properties, thermal analysis and theoretical study of a new Sn(IV) complex (C₅H₁₄N₂)₂[SnCl₆]₂·5H₂O. *Solid State Sci.* **2018**, *86*, 77–85.
- Sanchez, C.; Julián, B.; Belleville, P.; Popall, M. Applications of hybrid organic-inorganic nanocomposites. *J. Mater. Chem.* **2005**, *15* (35-36), 3559.
- Borriello, I.; Cantele, G.; Ninno, D. *Ab initio* investigation of hybrid organic-inorganic perovskites based on tin halides. *Phys. Rev. B.* **2008**, *77* (23), 235214 <https://doi.org/10.1103/PhysRevB.77.235214>.
- Ding, X.; Wang, S.; Li, Y.; Huang, W. Inorganic anion-assisted supramolecular assemblies of bent dipyrindines: effects of anionic geometries on hydrogen-bonding networks. *Inorg. Chem. Front.* **2015**, *2* (3), 263–272.
- Ndiaye, M.; Pouye, S. F.; Diop, M. B.; Diop, L.; Samb, A.; Oliver, A. G. Tin(IV) Halides Zero-dimensional based Inorganic-Organic Hybrid Materials: Crystal Structures and Hirshfeld Surface Analysis. *Earthline J. Chem. Sci.* **2023**, 57–76.
- Liu, Y.; Summers, M.; Edder, C.; Fréchet, J.; McGehee, M. Using Resonance Energy Transfer to Improve Exciton Harvesting in Organic-Inorganic Hybrid Photovoltaic Cells. *Adv. Mater.* **2005**, *17* (24), 2960–2964.
- Man, X.; Li, S.; Xu, G.; Li, W.; Zhu, M.; Zhang, Z.; Liang, H.; Yang, F. Developing a Copper(II) Isopropyl 2-Pyridyl Ketone Thio semicarbazone Compound Based on the IB Subdomain of Human Serum Albumin-Indomethacin Complex: Inhibiting Tumor Growth by Remodeling the Tumor Microenvironment. *J. Med. Chem.* **2024**, *67* (7), 5744–5757.
- Man, X.; Li, W.; Zhu, M.; Li, S.; Xu, G.; Zhang, Z.; Liang, H.; Yang, F. Anticancer Tetranuclear Cu(I) Complex Catalyzes a Click Reaction to Synthesize a Chemotherapeutic Agent in situ to Achieve Targeted Dual-Agent Combination Therapy for Cancer. *Angew. Chem. Int. Ed.* **2024**, <https://doi.org/10.1002/anie.202411846>.
- Li, W.; Li, T.; Pan, Y.; Li, S.; Xu, G.; Zhang, Z.; Liang, H.; Yang, F. Designing a Mitochondria-Targeted Theranostic Cyclometalated Iridium(III) Complex: Overcoming Cisplatin Resistance and Inhibiting Tumor Metastasis through Necroptosis and Immune Response. *J. Med. Chem.* **2024**, *67* (5), 3843–3859.
- Hermi, S.; Alotaibi, A. A.; Lefebvre, F.; Ben Nasr, C.; Mrad, M. H. Elaboration, crystal structure, physico-chemical characterization and theoretical investigation of a new non-centrosymmetric Sn(IV) complex (C₄H₁₂N₂)[SnCl₆]₂·3H₂O. *J. Mol. Struct.* **2020**, *1216*, 128296.
- Shaheen, S. E.; Brabec, C. J.; Sariciftci, N. S.; Padinger, F.; Fromherz, T.; Hummelen, J. C. 2.5% Efficient organic plastic solar cells. *Appl. Phys. Lett.* **2001**, *78* (6), 841–843.
- Ilayabarathi, P.; Chandrasekaran, J.; Maadeswaran, P. Synthesis, growth and characterization of l-tyrosine hydrochloride a semi-organic nonlinear optical crystal. *Optik* **2013**, *124* (12), 1125–1127.
- Chandran, S. K.; Paulraj, R.; Ramasamy, P. Crystal growth, spectral, optical, laser damage, photoconductivity and dielectric properties of semiorganic l-cystine hydrochloride single crystal. *Spectrochim. Acta A: Mol. Biomol. Spectrosc.* **2015**, *151*, 432–437.
- Liu, X.; Ji, C.; Wu, Z.; Li, L.; Han, S.; Wang, Y.; Sun, Z.; Luo, J. [C₅H₁₂N]₂SnCl₃: A Tin Halide Organic-Inorganic Hybrid as an Above-Room-Temperature Solid-State Nonlinear Optical Switch. *Chemistry A: European J.* **2019**, *25* (10), 2610–2615.
- Zhou, C.; Lin, H.; Tian, Y.; Yuan, Z.; Clark, R.; Chen, B.; van de Burgt, L. J.; Wang, J. C.; Zhou, Y.; Hanson, K.; Meisner, Q. J.; Neu, J.; Besara, T.; Siegrist, T.; Lambers, E.; Djurovich, P.; Ma, B. Luminescent zero-dimensional organic metal halide hybrids with near-unity quantum efficiency. *Chem. Sci.* **2018**, *9* (3), 586–593.
- Ndiolene, A.; Diop, T.; Boye, M. S.; Diasse-Sarr, A.; Englert, U. A new organic-inorganic compound, ethylenediammonium hexachlorido stannate(IV) p-anisaldehyde disolvate. *Acta Crystallogr. E: Cryst. Commun.* **2021**, *77* (7), 696–699.
- Guo, X.; McCleese, C.; Kolodziej, C.; Samia, A. C.; Zhao, Y.; Burda, C. Identification and characterization of the intermediate phase in hybrid organic-inorganic MAPbI₃perovskite. *Dalton Trans.* **2016**, *45* (9), 3806–3813.
- Altomare, A.; Cascarano, G.; Giacovazzo, C.; Guagliardi, A. Completion and refinement of crystal structures with SIR92. *J. Appl. Crystallogr.* **1993**, *26* (3), 343–350.
- Sheldrick, G. M. Crystal structure refinement with SHELXL. *Acta Crystallogr. C: Struct. Chem.* **2015**, *71* (1), 3–8.
- Dolomanov, O. V.; Bourhis, L. J.; Gildea, R. J.; Howard, J. A. K.; Puschmann, H. OLEX2: a complete structure solution, refinement and analysis program. *J. Appl. Crystallogr.* **2009**, *42*, 339–341.
- El-Ansary, A. L.; Abdel-Kader, N. S. Synthesis, Characterization of La(III), Nd(III), and Er(III) Complexes with Schiff Bases Derived from Benzopyran-4-one and Thier Fluorescence Study. *Int. J. Inorg. Chem.* **2012**, *2012*, 1–13.
- El-Boraey, H. A. Structural and thermal studies of some arylhydrazone Schiff's bases-transition metal complexes. *J. Therm. Anal. Calorim.* **2005**, *81* (2), 339–346.
- Ramadan, R. M.; Abdel-Rahman, L. H.; Ismael, M.; Youssef, T. A.; Ali, S. A. Synthesis and spectroscopic studies of some chromium and molybdenum derivatives of bis-(acetylaceton)ethylenediamine ligand. *J. Mol. Struct.* **2013**, *1049*, 7–12.
- Elinburg, J. K.; Hyre, A. S.; McNeely, J.; Alam, T. M.; Klenner, S.; Pöttgen, R.; Rheingold, A. L.; Doerrer, L. H. Formation of monomeric Sn(II) and Sn(IV) perfluoropinacolate complexes and their characterization by ¹¹⁹Sn Mössbauer and ¹¹⁹Sn NMR spectroscopies. *Dalton Trans.* **2020**, *49* (39), 13773–13785.
- Pettinari, C.; Marchetti, F.; Cingolani, A.; Lorenzotti, A.; Mundorff, E.; Rossi, M.; Caruso, F. Tin(IV) and organotin(IV) derivatives of novel β-diketones. *Inorg. Chim. Acta* **1997**, *262* (1), 33–46.
- Zhou, Y.; Richeson, D. S. Bulky Amidinate Complexes of Tin(IV). Synthesis and Structure of Sn(RNC(R')NR)₂Cl₂ (R = Cyclohexyl, R' = H, Me; R = SiMe₃, R' = tBu). *Inorg. Chem.* **1997**, *36* (4), 501–504.
- Diop, T.; Lee, A. v.; Diop, L. Tetrabutylammonium butyltetra chloridostannate(IV). *Acta Crystallogr. E: Struct. Rep. Online* **2013**, *69* (10), m562–m563.
- Pettinari, C.; Marchetti, F.; Gregori, A.; Cingolani, A.; Tanski, J.; Rossi, M.; Caruso, F. Tin(IV) and organotin(IV) derivatives of novel β-diketones I. Dialkyltin(IV) complexes of 1-phenyl-3-methyl-4-R'(CO)-pyrazol-5-one (R' = CCl₃, OCH₃, OC₂H₅, O_iC₃H₇, OC₇H₇). Crystal and molecular structure of trans-dimethylbis[1-phenyl-3-methyl-4-i-propoxycarbonyl-pyrazolon-5-ato]tin(IV). *Inorg. Chim. Acta* **1997**, *257* (1), 37–48.
- Hajlaoui, S.; Chaabane, I.; Oueslati, A.; Guidara, K.; Boulou, A. A theoretical study on the molecular structure and vibrational (FT-IR and Raman) spectra of new organic-inorganic compound [N(C₃H₇)₄]₂SnCl₆. *Spectrochim. Acta A: Mol. Biomol. Spectrosc.* **2014**, *117*, 225–233.
- Gesing, T. M.; Lork, E.; Terao, H.; Ishihara, H. NQR and X-ray crystal structure studies of cadmium halide complexes: [C(NH₂)₃]₂CdI₂ and [4-ClC₆H₄NH₃]₃CdBr₂. *Z. fur Naturforsch. B* **2016**, *71* (3), 241–248.



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