

Cationic complexes of arylantimony(III) chlorides Ar_nSbCl_{3-n} with tetraphenylborate and ammonium hexafluorophosphate

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Abstract– A series of hitherto unknown solid salts of tricoordinated cations of the general formula $[ArSbL_2]^{2+}$ and $[Ar_2SbL]^{1+}$ [where Ar = C₆H₅, *p*-CH₃C₆H₄; L = Pyridine, β-picoline, HMPA, TPPO and thiourea (TU)] have been isolated in presence of tetraphenylborate (BPh₄⁻) and hexafluorophosphate (PF₆⁻). These newly synthesised two dozen complexes have been formulated and characterised on the basis of elemental analyses, molar conductances, molecular weights and, solid state IR and solution state ¹H NMR spectral data. The physico-chemical data are consistent with pyramidal structure of the complexes.

Index Terms– Arylantimony(III) cationic complexes, IR, ¹H NMR, molecular weights and molar conductances.

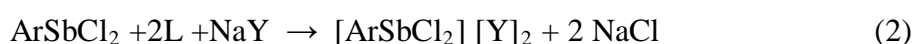
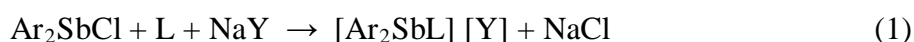
1 INTRODUCTION

There has been a considerable interest centred on the chemistry of organoantimony(III) halides over the past two decades. As a result a variety of parent, $\text{SbPh}_n\text{X}_{3-n}$ ($n = 1, 2$) compounds where X = halides, imide, amide, heterocyclic species [1], xanthates [2], thiophosphates [3], carboxylates [4] have been synthesized and studied. Lewis acidity of $\text{SbPh}_n\text{X}_{3-n}$ (X = halide) towards monodentate and bidentate neutral O and N sulphur donors and electronegatively charged donors has been investigated [5]. However, the existence and isolation of solid salts of complex cations of the type $[\text{RSbL}_2]^{+2}$ and $[\text{R}_2\text{SbL}]^+$ where L = monodentate neutral ligand in combination of anionic group such as perchlorate, tetrafluoroborate, tetraphenylborate etc. has not been reported to date. In sharp contrast to this organoantimony (V) cations of the type $[\text{R}_2\text{SbL}_3]^{+3}$ and $[\text{R}_2\text{SbL}_2]^{+2}$ are well documented [6-12].

In view of our interest on synthesis and isolation of molecular neutral adducts and anionic complexes of organoantimony(III) derivatives $\text{SbAr}_n\text{X}_{3-n}$, it was considered worthwhile to demonstrate the existence of currently unknown complex cations of the type $[\text{Ar}_2\text{SbL}]^{+1}$ and $[\text{ArSbL}_2]^{+2}$ isolated in combination of bulkier anion viz. PF_6^- and BPh_4^- where Ar = phenyl, p-toyl and L = pyridine, β -Picoline TPPO, HMPA and thiourea reported here in. Thus two dozen cationic complexes of the type $[\text{Ar}_2\text{SbL}][\text{Y}]$ and $\text{ArSbL}_2][\text{Y}]_2$ have been synthesised. These complexes were characterised on the basis of melting points, elemental analysis infrared and ^1H NMR spectra, molar conductance and molecular weight measurements.

2 RESULTS AND DISCUSSION

Under anhydrous oxygen free conditions arylantimony(III) cationic complexes of the type $[\text{Ar}_n\text{SbL}_{3-n}]^{3-n} [\text{Y}]_{3-n}$ can readily be obtained by the interaction of the preformed solution of the arylantimony(III) chlorides, neutral monodentate ligand and sodium salts of the anion in appropriate stoichiometry as shown below [Eqs. 1 & 2]



where Ar = C₆H₅, *p*-CH₃C₆H₄, L = C₅H₅N, β-Picoline, Ph₃PO, HMPA, TU and Y = BPF₄⁻, Ph₆⁻.

The reactions were found to proceed smoothly at room temperature affording quantitative yields of complexes. These compounds can be recrystallized with suitable organic solvent and are obtained as white crystalline solid.

The constancy in melting point after repeated crystallization as well as mixed melting points rules out the possibility of the presences of unreacted reactants. The analytical data given in Tables 1 and 2 correspond well to the proposed formulation of the complexes. Conductance measurement values 10⁻³ M solutions in acetonitrile for the complexes (**1,3,10,11,12**) are in good agreement with the reported values 1:1 electrolyte, while the complexes (**5,6,8,16**) behaves as 1:2 electrolytes in the solution [9,10]. The conductance values are listed in Table 2.

2.1 INFRARED SPECTRA

For all the complexes, listed in Table 3, infrared spectra data were obtained in the region 4000–200 cm⁻¹. Important frequencies with their assignment are listed in Table 3. The absorption frequencies inherent to aryl groups, bound to antimony do not differ significantly with those reported for uncomplexed arylantimony(III) chlorides, SbAr_nCl_{3-n} and hence need not to be discussed [1,4].

In case of nitrogen donor ligands the characteristic ν(C=N) vibration reported to appear in the range 1568-1575 cm⁻¹ in free ligand undergoes a positive shift on complexation and appear Ca. 1599-1610 cm⁻¹ suggesting coordinate through nitrogen atom on the base [5].

In the case of TPPO or (Ph₃PO), the characteristics ν(P-O), vibration is lowered in each complex as compared to its position in free ligand (1192 cm⁻¹). This band now appears in the range Ca. 1120-1140 cm⁻¹, suggesting coordination through oxygen atom of the Lewis base [13].

In case of HMPA, the characteristics $\nu(\text{P}=\text{O})$, vibration appearing at 1212 cm^{-1} in free ligand is considerably lowered to Ca. 1140 cm^{-1} on complexation indicating coordination through oxygen atom of the Lewis base [14].

A band of strong intensity in the IR spectra of thiourea (**17 & 18**) at 1045 ± 24 is reported to possess contribution from $\nu(\text{C}=\text{N})$ and $\nu(\text{C}=\text{S})$ modes. On coordination through the sulphur atom, $\nu(\text{C}=\text{N})$ suffers a positive shift while $\nu(\text{C}=\text{S})$ undergoes almost equal negative shift. These resulting spectra of the complexes, therefore, do not show any peculiar change on coordination through sulphur atom and the resulting absorption remains apparently unchanged. The positive shift of $\nu(\text{N}-\text{H})$ from 3300 cm^{-1} in free thiourea to approx. 3380 cm^{-1} in the complexes indicates coordination through nitrogen atom of the ligand [15].

The $\nu(\text{Sb}-\text{O})$ frequency for the cations, $[\text{ArSb}(\text{Ph}_3\text{PO})_2]^{+2}$ and $[\text{Ar}_2\text{Sb}(\text{Ph}_3\text{PO})]^{+1}$ is located in the range $410-425\text{ cm}^{-1}$. The proposed assignments for the $\nu(\text{Sb}-\text{O})$ frequency for these complex cations are consistent with the $\nu(\text{Sb}-\text{O})$ frequencies reported for the complexes containing Sb-O linkage [16].

The assignment for $\nu(\text{Sb}-\text{N})$ bond could not be made with certainty due to complex nature of the spectra. However, it is tentatively assigned in the range $350-370\text{ cm}^{-1}$.

The Sb-C bond corresponding to γ mode of the phenyl groups appears in the range $460-480\text{ cm}^{-1}$ [16].

The characteristics vibration due to anionic groups BPh_4^- (1280 vs. 1280s) and PF_6^- (840 vs. 560 s) do not show any significant shifting as compared to free anions vibration and are given in Tables-3 [8-13].

2.2 ^1H NMR SPECTRA

The ^1H NMR spectra of the representative compound $[(p\text{-CH}_3\text{C}_6\text{H}_4)\text{Sb}(\text{TPPO})_2][\text{BPh}_4]_2$ (**20**) showed a singlet at $\delta 2.40$ ppm (due to $-\text{CH}_3$ group) and multiplets for phenyl protons centred at $\delta 7.90$ ppm, $\delta 7.20$ ppm and $\delta 7.05$ ppm of which the former (lower field multiplet) is attributed to *ortho* and later two (high field multiplet) are attributed to *meta* and *para* protons of phenyl groups.

Thus on the basis of IR, ^1H NMR spectra, molar conductance and molecular weight measurements, the newly synthesised complex cations are assigned a pyramidal structure as shown below (figure-1):

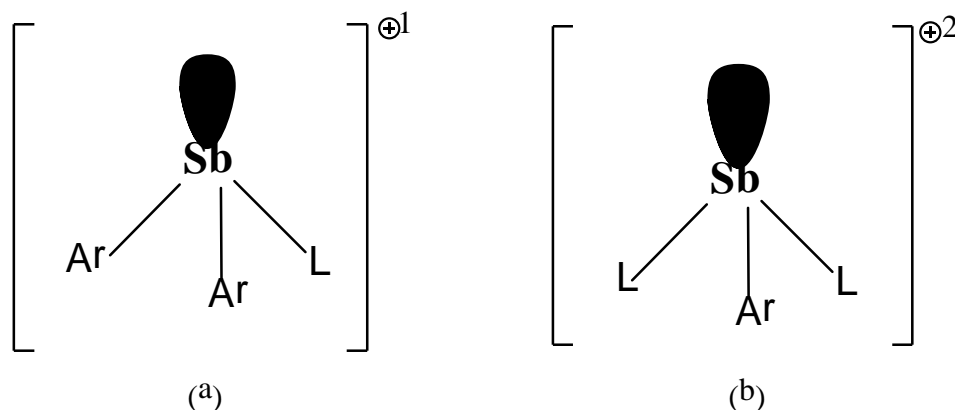


Fig 1. Suggested structure for $[\text{Ar}_2\text{SbL}]^{+1}$ and $[\text{ArSbL}_2]^{+2}$ cations.

3 EXPERIMENTAL

Preparation of diarylantimony(III) chloride, (Ar_2SbCl) , arylantimony(III) dichloride (ArSbCl_2) ($\text{Ar} = \text{C}_6\text{H}_5$, $p\text{-CH}_3\text{C}_6\text{H}_4$) were prepared by the reported method [17]. Aldrich were used as such without further purification.

Typical experimental details of the few reactions are discussed below. Relevant IR assignments, ^1H NMR spectra, analytical data and molar conductance values are listed in Tables 2 and 3. Special precautions were taken to exclude the moisture.

3.1 Reactions of the Diphenylantimony(III) Chloride with β -picoline and Sodium Tetraphenyl Borate:

$[\text{Ph}_2\text{Sb}(\beta\text{-pic})]\text{BPh}_4$ (1)

In an oxygen free environment diphenylantimony (III) chloride (0.311 g, 1 mmol) and neutral ligand β -picoline (0.093g, 1mmol) was taken in dry chloroform and sodium tetraphenylborate (0.342 g, 1 mmol) in dry methanol was added to this solution. After stirring the mixture for about 6 hr it was refluxed for 2h and NaCl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Petroleum ether ($40^\circ\text{-}60^\circ\text{C}$).

Yield: 0.41 g (61%);

M.p. : 150 °C.

3.2 Reactions of the Di-(*p*-toyl) antimony(III) Chloride with β -picoline and Ammonium Hexafluorophosphate: [(*p*-toyl)₂Sb (β -Pic)] PF₆(4)

Di-(*p*-toyl) antimony (III) chloride (0.339 g, 1 mmol) and neutral ligand β -picoline (0.093 g, 1 mmol) was taken in dry chloroform and ammonium Hexafluorophosphate (0.163 g, 1 mmol) in dry methanol was added to this solution. After stirring the mixture for about 7 hr., it was refluxed for 1h and NH₄Cl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by benzene.

Yield: 0.41 g (77%);

M.p.: 200 °C.

3.3 Reactions of the Penhylantimony(III) DiChloride with Pyridine and Sodium Tetraphenyl Borate: [PhSb (Py)₂] [BPh₄]₂ (13)

In an anhydrous condition, penhylantimony (III) dichloride (0.270 g, 1 mmol) and neutral ligand Pyridine (0.158 g, 2 mmol) was taken in dry chloroform and sodium tetraphenylborate (0.648 g, 2 mmol) in dry methanol was added to this solution. After stirring the mixture for about 5 hr., it was refluxed for 3h and NaCl so formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Petroleum ether (40°-60°C).

Yield: 0.65 g (66%);

M.p.: 165 °C.

3.4 Reactions of the Phenylantimony(III) Dichloride with Pyridine and Ammonium Hexafluorophosphate: [PhSb (Py)₂][PF₆]₂ (15)

In an anhydrous condition, phenylantimony (III) dichloride (0.270 g, 1 mmol) and neutral ligand Pyridine (0.158 g, 2 mmol) was taken in dry chloroform and Ammonium Hexafluorophosphate (0.326 g, 2 mmol) in dry methanol was added to this solution. After stirring the mixture for about 6 hr., it was refluxed for 3h and NH₄Cl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a cream solid which was crystallised by Petroleum ether (40°-60°C).

Yield: 0.49 g (71%);

M.p.: 174°C.

3.5 Reactions of the (*p*-toyl) antimony(III) Dichloride with Thiourea and Sodium Tetraphenyl Borate :[(*p*-Tol)Sb(TU)₂][BPh₄]₂(18)

In an oxygen free environment (*p*-toyl) antimony (III) dichloride (0.284g , 1 mmol) and neutral ligand thiourea (0.152 g , 2 mmol) was taken in dry chloroform and sodium tetraphenylborate (0.684 g, 1 mmol) in dry methanol was added to this solution. After stirring the mixture for about 7 hr, it was refluxed for 2h more and NaCl thus formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Benzene.

Yield: 0.87 g (75%);

M.p.: 200°C.

3.6 Reactions of the Di(*p*-toyl) antimony(III) Chloride with Triphenylphosphine Oxide and Sodium Tetra phenyl Borate :[(*p*-Tol)₂Sb (Ph₃PO)]BPh₄ (20)

In an oxygen free environment Di(*p*-toyl) antimony (III) Chloride (0.339g, 1 mmol) and neutral ligand Triphenylphosphine Oxide (0.278 g, 1 mmol) was taken in dry chloroform and sodium tetraphenylborate (0.342g, 1 mmol) in dry methanol was added to this solution. After stirring the mixture for about 6 hr., it was refluxed for 2h and NaCl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Petroleum ether (40°-60°C).

Yield: 0.62g (68%);

M.p.: 180 °C.

3.7 Reactions of the Diphenylantimony(III) Chloride with HMPA and Sodium Tetraphenyl Borate: [Ph₂Sb (HMPA)] BPh₄ (22)

In an anhydrous condition, diphenylantimony (III) chloride (0.311 g, 1 mmol) and neutral ligand HMPA (0.179g, 1 mmol) was taken in dry chloroform and sodium tetraphenylborate (0.342 g, 1 mmol) in methanol was added to this solution. After stirring the mixture for about 7 hr., it was refluxed for 2h and NaCl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Petroleum ether (40°-60°C).

Yield: 0.49 g (64%);

M.p.: 180°C.

3.8 Reactions of the Phenylantimony(III) Dichloride with HMPA and Sodium Tetraphenyl Borate: [PhSbCl₂ (HMPA)₂] [BPh₄]₂(24)

In an anhydrous condition, the phenylantimony (III) dichloride (0.270 g, 1 mmol) and neutral ligand HMPA (0.358 g, 2 mmol) was taken in dry chloroform and sodium tetraphenylborate (0.648 g, 2 mmol) in methanol was added to this solution. After stirring the mixture for about 7 hr., it was refluxed for 2h and NaCl formed as a precipitate was filtered off. The filtrate on concentration *in vacuo*, afforded a white solid which was crystallised by Petroleum ether (40°-60°C).

Yield: 0.08 g (70%);

M.p.: 90°C

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Table 1 Preparation and properties of arylantimony(III) cationic complexes

C.No.	Complex	Ar _n SbCl _(3-n) (g) n=1&2 Solvent	NaY(g) Solvent	Ligand (g)Solvent	M.p (°C)	Colour	Yield (g)	(%)
L = β-picoline								
1.	[Ph ₂ SbL][BPh ₄]	Ph ₂ SbCl(0.311g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	β–Picoline(0.813g) (CHCl ₃)	150°	White	0.41	61
2.	[Ph ₂ SbL][PF ₆]	Ph ₂ SbCl(0.311g) (CHCl ₃)	NH ₄ PF ₆ (0.163g) (MeOH)	β–Picoline(0.093g) (CHCl ₃)	85°	Off White	0.37	72
3.	[(p-toyl) ₂ SbL ₂][BPh ₄]	(p-toyl) ₂ SbCl(0.339g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	β–Picoline(0.093g) (CHCl ₃)	124°	Off White	0.55	77
4.	[(p-toyl) ₂ SbL][PF ₆]	(p-toyl) ₂ SbCl (0.339g) (CHCl ₃)	NH ₄ PF ₆ (0.163g) (MeOH)	β–Picoline(0.093g) (CHCl ₃)	200°	White	0.41	77
5.	[PhSbL ₂][BPh ₄] ₂	PhSbCl ₂ (0.270g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	β–Picoline(0.093g) (CHCl ₃)	165°	White	0.5	71
6.	[PhSbL ₂][PF ₆] ₂	Ph SbCl ₂ (0.270g) (CHCl ₃)	NH ₄ PF ₆ (0.326g) (MeOH)	β–Picoline(0.186g) (CHCl ₃)	180° d	Light Orange	0.77	77
7.	[(p-toyl)SbL ₂][PF ₆] ₂	(p-toyl) ₂ SbCl ₂ (0.248g) (CHCl ₃)	NaBPh ₄ (0.684g) (MeOH)	β–Picoline(0.186g) (CHCl ₃)	180°	Light Pink	0.57	79
8.	[(p-toyl)SbL ₂][PF ₆] ₂	(p-toyl) ₂ SbCl ₂ (0.248g) (CHCl ₃)	NH ₄ PF ₆ (0.326g) (MeOH)	β–Picoline(0.186g) (CHCl ₃)	-	Oily		
9.	[Ph ₂ SbL][BPh ₄]	Ph ₂ SbCl (0.311g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	C ₅ H ₅ N(0.079 g) (CHCl ₃)	140	Off White	0.52	78
10.	[(p-toyl) ₂ SbL][PF ₆]	(p-toyl) ₂ SbCl (0.339g) (CHCl ₃)	NH ₄ PF ₆ (0.163g) (MeOH)	C ₅ H ₅ N(0.079 g) (CHCl ₃)	150	Off White	0.42	80
11.	[Ph ₂ SbL][PF ₆]	Ph ₂ SbCl (0.311g) (CHCl ₃)	NH ₄ PF ₆ (0.163g) (MeOH)	C ₅ H ₅ N(0.079 g) (CHCl ₃)	185	Light Green	0.41	81
12.	[(p-toyl) ₂ SbL][BPh ₄]	(p-toyl) ₂ SbCl(0.339g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	C ₅ H ₅ N(0.079 g) (CHCl ₃)	124	Off White	0.53	76
13.	[PhSbL ₂][BPh ₄] ₂	Ph SbCl ₂ (0.270g) (CHCl ₃)	NaBPh ₄ (0.684g) (MeOH)	C ₅ H ₅ N(0.158 g) (CHCl ₃)	165	White	0.65	66
14.	[(p-toyl) SbL ₂][BPh ₄] ₂	(p-toyl)SbCl (0.284g)	NaBPh ₄ (0.326g)	C ₅ H ₅ N(0.158 g)	180	Light	0.51	71

		(CHCl ₃)	(MeOH)	(CHCl ₃)		Pink		
15.	[PhSbL ₂][PF ₆] ₂	Ph SbCl ₂ (0.270g) (CHCl ₃)	NH ₄ PF ₆ (0.326g) (MeOH)	C ₅ H ₅ N(0.158 g) (CHCl ₃)	190	Cream	0.49	76
16.	[(p-toyl) SbL ₂][PF ₆] ₂	(p-toyl)SbCl ₂ (0.248g) (CHCl ₃)	NH ₄ PF ₆ (0.326g) (MeOH)	C ₅ H ₅ N(0.158 g) (CHCl ₃)	-	Oily Cream		
L=Thiourea								
(H₂NCSNH₂)								
17.	[Ph ₂ SbL][BPh ₄]	Ph ₂ SbCl (0.311g) (CHCl ₃)	NaBPh ₂ (0.342g) (MeOH)	H ₂ NCSNH ₂ (0.076g) (CHCl ₃)	174	Yellow	0.46	70
18.	[(p-toyl) SbL ₂][BPh ₄] ₂	(p-toyl)SbCl ₂ (0.248g) (CHCl ₃)	NaBPh ₄ (0.684g) (MeOH)	H ₂ NCSNH ₂ (0.152g) (CHCl ₃)	200	white	0.87	75
L=Ph₃PO								
19.	[Ph ₂ SbL][BPh ₄]	Ph ₂ SbCl (0.311g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	Ph ₃ PO(0.278) (CHCl ₃)	175	white	0.64	74
20.	[(p-toyl) ₂ SbL][BPh ₄]	(p-toyl) ₂ SbCl(0.339g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	Ph ₃ PO(0.278) (CHCl ₃)	60	white	0.38	55
21.	[Ph ₂ SbL][PF ₆]	Ph SbCl ₂ (0.311g) (CHCl ₃)	NH ₄ PF ₆ (0.163g) (MeOH)	Ph ₃ PO(0.278) (CHCl ₃)	180	white	0.49	64
L=HMPA								
22.	[Ph ₂ SbL][BPh ₄]	Ph ₂ SbCl (0.311g) (CHCl ₃)	NaBPh ₄ (0.342g) (MeOH)	HMPA(0.358) (CHCl ₃)	190	white	0.49	64
23.	[(p-toyl) ₂ SbL][BPh ₄]	(p-toyl) ₂ SbCl(0.339g) (CHCl ₃)	NaBPh ₄ (0.339g) (MeOH)	HMPA(0.358) (CHCl ₃)	220	white	0.55	69
24.	[PhSbL ₂][BPh ₄] ₂	Ph SbCl ₂ (0.270g) (CHCl ₃)	NaBPh ₄ (0.648g) (MeOH)	HMPA(0.358) (CHCl ₃)	90	white	0.09	70

Table 2 Elemental analysis of molar conductance values of organoantimony(III) cationic complexes

C.No.	Complex	Empirical Formula	Found (Calcd.) %			Molecular conductance in Nitrobenzene ($\text{Ohm}^{-1}\text{cm}^2\text{mole}^{-1}$)
			C	H	N	
1	$[\text{Ph}_2\text{SbL}][\text{BPh}_4]$	$\text{C}_{42}\text{H}_{37}\text{NB Sb}$	72.8 (73.2)	5.31 (5.37)	1.99(2.03)	52.6
2	$[\text{Ph}_2\text{SbL}][\text{PF}_6]$	$\text{C}_{18}\text{H}_{17}\text{NPF}_6 \text{ Sb}$	41.70 (42.20)	3.25 (3.31)	2.65 (2.72)	55.1
3	$[(\text{p-toyl})_2\text{SbL}_2][\text{BPh}_4]$	$\text{C}_{44}\text{H}_{41}\text{NB Sb}$	72.8 (73.7)	5.69 (5.76)	1.89 (1.95)	50.4
4	$[(\text{p-toyl})_2\text{SbL}][\text{PF}_6]$	$\text{C}_{20}\text{H}_{21}\text{F}_6\text{NP Sb}$	42.8 (44.8)	3.81(3.87)	2.50 (2.58)	51.8
5	$[\text{PhSbL}_2][\text{BPh}_4]_2$	$\text{C}_{66}\text{H}_{59}\text{B}_2\text{N}_2 \text{ Sb}$	76.8 (77.4)	5.70 (5.76)	2.68 (2.74)	57.2
6	$[\text{PhSbL}_2][\text{PF}_6]_2$	$\text{C}_{18}\text{H}_{19}\text{F}_{12}\text{N}_2\text{P}_2 \text{ Sb}$	31.3 (32.0)	2.74 (2.81)	4.07 (4.14)	59.6
7	$[(\text{p-toyl})\text{SbL}_2][\text{BPh}_4]_2$	$\text{C}_{67}\text{H}_{61}\text{F}_{12}\text{N}_2\text{P}_2\text{Sb}$	76.9 (77.5)	5.80 (5.88)	2.63 (2.70)	56.2
8	$[(\text{p-toyl})\text{SbL}_2][\text{PF}_6]_2$	$\text{C}_{19}\text{H}_{21}\text{F}_{12}\text{N}_2\text{P}_2\text{Sb}$	32.8 (33.1)	3.00 (3.04)	4.01 (4.06)	50.7
9	$[\text{Ph}_2\text{SbL}][\text{BPh}_4]$	$\text{C}_{41}\text{H}_{35}\text{BNSb}$	72.1 (73.0)	5.08 (5.19)	5.87 (5.95)	53.4
10	$[(\text{p-toyl})_2\text{SbL}][\text{PF}_6]$	$\text{C}_{19}\text{H}_{19}\text{F}_6\text{NPSb}$	42.7 (43.2)	3.51 (3.59)	2.60 (2.65)	52.9
11	$[\text{Ph}_2\text{SbL}][\text{PF}_6]$	$\text{C}_{17}\text{H}_{15}\text{F}_6\text{NPSb}$	40 (40.8)	2.94 (3.00)	2.1 (2.8)	58.2
12	$[(\text{p-toyl})_2\text{SbL}][\text{BPh}_4]$	$\text{C}_{43}\text{H}_{39}\text{BNSb}$	72.8 (73.5)	5.49 (5.55)	1.91 (1.99)	57.7

13	[PhSbL ₂][BPh ₄] ₂	C ₆₄ H ₅₅ B ₂ N ₂ Sb	76.5 (77.2)	5.47 (5.52)	2.73 (2.81)	59.6
14	[(p-toyl) SbL ₂][BPh ₄] ₂	C ₆₅ H ₅₇ B ₂ N ₂ Sb	72.8 (77.3)	5.59 (5.65)	2.70 (2.77)	54.6
15	[PhSbL ₂][PF ₆] ₂	C ₁₆ H ₁₅ F ₁₂ N ₂ P ₂ Sb	29.0 (29.6)	2.27 (2.23)	4.26 (4.32)	57.8
16	[(p-toyl) SbL ₂][PF ₆] ₂	C ₁₇ H ₁₇ F ₁₂ N ₂ P ₂ Sb	30.9 (31.0)	2.41 (2.57)	4.18 (4.23)	51.2
17	[Ph ₂ SbL][BPh ₄]	S ₃₇ H ₃₄ BN ₂ SSb	65.0 (66.1)	5.01 (5.07)	4.07(4.17)	58.5
18	[(p-toyl) SbL ₂][BPh ₄] ₂	C ₅₇ H ₅₅ B ₂ N ₄ S ₂ Sb	67.4(68.2)	5.40(5.48)	5.51(5.48)	53.6
19	[Ph ₂ SbL][BPh ₄]	C ₅₄ H ₄₅ BOPSb	73.7(74.2)	5.10(5.15)	-	51.6
20	[(p-toyl) ₂ SbL][BPh ₄]	C ₅₆ H ₄₉ BOPSb	73.9(74.6)	5.38 74.6	-	54.1
21	[Ph ₂ SbL][PF ₆]	C ₃₀ H ₂₅ F ₆ OP ₂ Sb	50.9(51.5)	3.50 3.57	-	49.4
22	[Ph ₂ SbL][BPh ₄]	C ₄₂ H ₄₈ BN ₃ OPSb	64.6(65.1)	6.13 6.20	-	50.8
23	[(p-toyl) ₂ SbL][BPh ₄]	C ₄₄ H ₅₂ BN ₃ OPSb	64.9(65.8)	6.40(6.48)	6.40(6.48)	56.2
24	[PhSbL ₂][BPh ₄] ₂	C ₆₆ H ₈₁ B ₂ N ₆ O ₂ P ₂ Sb	65.8(66.3)	6.0(6.7)	6.9(7.02)	58.6

Table 3 IR data of arylantimony(III) cationic complexes

C. No	$\nu(\text{C}=\text{N})/\nu(\text{N}-\text{H})/\nu(\text{P}-\text{O})$		$\Delta\nu$	$\nu(\text{Sb}-\text{C})$	Anion Frequencies
	Complex	free			
1	1600	1570	30	460	1280 vs. 12605
2	1610	1570	40	467	840 vs. 5605
3	1609	1570	39	465	1279 vs. 12585
4	1600	1570	30	480	839 vs. 5595
5	1603	1570	33	475	1280 vs. 12605
6	1607	1570	37	480	840 vs. 5605
7	1610	1570	40	478	1278 vs. 2575
8	1611	1570	41	476	838 vs. 5585
9	1605	1570	35	479	1280 vs. 12605
10	1601	1570	31	462	840 vs. 5605
11	1599	570	29	461	836 vs. 5585
12	1602	1570	32	469	1276 vs. 2565
13	1600	1570	30	460	1280 vs. 12605
14	1608	1570	38	475	1276 vs. 12585
15	1605	1570	35	480	840 vs. 5605
16	1610	1570	40	461	838 vs. 5565
17	3380	3300	80	465	1280 vs. 12605
18	3380	3300	80	475	1278 vs. 12565
19	1120	1192	72	480	1280 vs. 12605
20	1135	1192	57	465	1276 vs. 12545
21	1140	1192	52	471	838 vs. 5585
22	1140	1212	72	460	1280 vs. 12605
23	1138	1212	74	480	12795 vs. 12585
24	1134	1212	78	475	1280 vs. 12605

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