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Inner coordination sphere tin(IV) complexes with some *O,N,N*-terdentate {*N*-(2-hydroxybenzaldehyde)-1-amino-2-phenyleneimine and *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine} and *O,N,N,O*-quadridentate {*N,N′*-bis(2-hydroxybenzaldehyde)-1,2-phenylenediimine and *N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine} Schiff bases

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Abstract—From the reactions of $SnCl_4$ with organotin(IV) chlorides ($RSnCl_3$, R_2SnCl_2 and R_3SnCl, where R = Bu, Me and Ph) with *N*-(2-hydroxybenzaldehyde)-1-amino-2-phenyleneimine, *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine, *N,N′*-bis(2-hydroxybenzaldehyde)-1,2-phenylenediimine and *N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine a series of complexes have been synthesized and characterized, respectively, by microanalytical, IR and ^{1}H NMR spectroscopic methods. The Ph_2SnCl_2 reacted with *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine giving Ph_2Sn(NAPPDI) [where NAPPDI = deprotonated *N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine], wherein the former Schiff base exhibit a facile intramolecular C=N bond cleavage and intermolecular C=N bond formation. © 1997 Elsevier Science Ltd

Keywords: Organotin(IV) chlorides, (*N*-(2-hydroxybenzaldehyde-1-amino-2-phenyleneimine, (*N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine, (*N,N′*-bis(2-hydroxybenzaldehyde)-1,2-phenylenediimine, (*N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine, diphenyl[*N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediiminato] tin(IV).

The hitherto known adducts derived from the reactions of inorganic tin(IV) and organotin(IV) halides with quadridentate salicylaldehydediamine (2 : 1) have been documented over the last three decades, wherein the symmetrical multidentate Schiff bases coordinate to the Sn atom *via* the O and N atoms [1–5]. The Schiff bases salicylaldehydediamine (2 : 1) were found to be introduced into the inner coordination sphere and thus function as quadridentate chelates with O,N,N,O atoms occupying suitable positions for coordination.

Although the involvement of steric hindrance and positional factors of the C=N and O—H surrounding

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the central Sn atom have been extensively studied using various aliphatic and aromatic diamines, yet the steric and electronic effects from the aldehyde in the quadridentate Schiff bases possessing 1 : 1 and 1 : 2 ratio of aldehyde to diimine have received scant attention. In this paper, we report the reactions of inorganic tin(IV) and organotin(IV) chlorides with *N*-(2-hydroxybenzaldehyde)-1-amino-2-phenyleneimine (**1**), *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine (**12**), *N*,*N*′-bis(2-hydroxybenzaldehyde)-1,2-phenylenediimine (**7**) and *N*,*N*′-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine (**17**). The crystal structure of $Ph_2Sn(NAPPDI)$ (**16**) is reported. All synthesized compounds were characterized by microanalysis, IR and ^1H NMR spectroscopy.

The molecular structures of Schiff bases **1**, **7**, **12** and **17** are shown with the abbreviations as follows:

The molecular structure of the deprotonated Schiff bases **7** and **17** are also shown as follows:

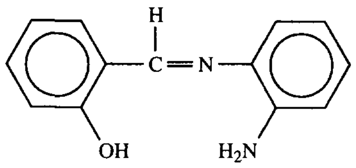
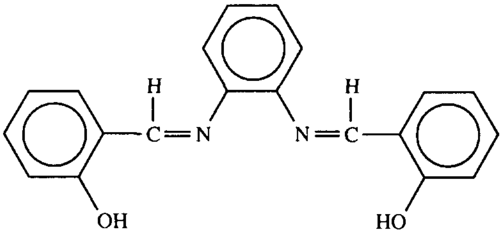
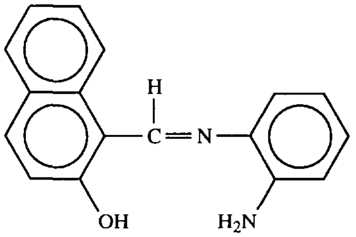
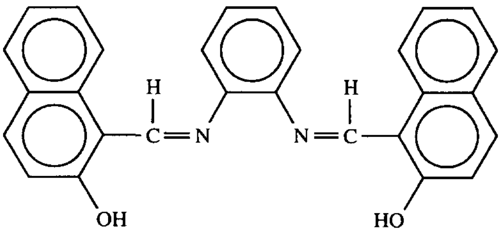
EXPERIMENTAL

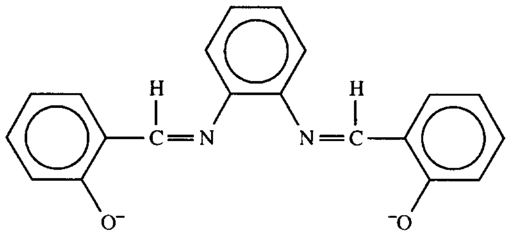
Reagents

1,2-Phenylenediamine, salicylaldehyde and 2-hydroxy-1-naphthaldehyde were obtained from Fluka Chemie AG, whilst the inorganic tin(IV) and organotin(IV) chlorides were supplied by Aldrich Chemical Company.

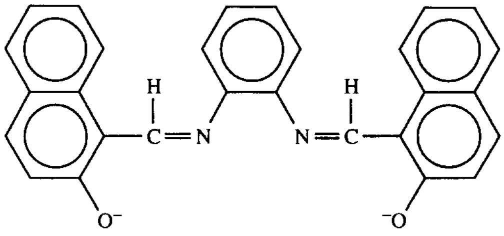
Preparation of ligands

N-(2-Hydroxybenzaldehyde)-1-amino-2-phenyleneimine (**1**) and *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine (**12**) were prepared by adding equimolar amounts of the appropriate salicylaldehyde or 2-hydroxy-1-naphthaldehyde to 1,2-phenylenediamine, whilst *N*,*N*′-bis(2-hydroxybenz-

Compound	Molecular structure	Abbreviation
1		SALAPIH
7		SALPDIH
12		NAPAPIH
17		NAPPDIH



SALPDI



NAPPDI

aldehyde)-1,2-phenylenediimine (**7**) and *N*,*N*′-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine (**17**) were obtained from the reactions of salicylaldehyde or 2-hydroxy-1-naphthaldehyde with 1,2-phenylenediamine in 2 : 1 ratio in 95% ethanol.

Preparation of complexes

All the complexes were similarly prepared by the reactions of the tin compounds with the appropriate ligand. The preparation of diphenyl[*N*,*N*′-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediiminato]tin (IV) is described as an example.

Diphenyltin dichloride (1.03 g, 3 mmol) was added to the ligand **12** (1.57 g, 6 mmol) in 95% ethanol. The mixture was left standing at room temperature overnight, whereupon yellowish crystals were obtained. The isolated compound was recrystallized from *n*-hexane.

Characterization

Carbon, hydrogen and nitrogen analyses were carried out on a Control Equipment Corporation model 240 XA elemental analyser at School of Chemical Sciences, Universiti Sains Malaysia, Penang, Malaysia. Tin was estimated using an Instrumentation Laboratory 357 Atomic Absorption Spectrophotometer. The results are shown in Table 1.

The spectra of the ligand and complexes (data shown in Table 2) were recorded using a Beckman IR 20A spectrophotometer in the frequency range 4000–250 cm^{-1} with samples as KBr discs. ^{1}H NMR spectral data were collected using a Bruker AC-P 300 MHz NMR spectrometer with deuterated DMSO-d_6 as the solvent and tetramethylsilane as the internal standard. Selected ^{1}H NMR peaks are presented in Table 3.

Crystallography: determination of X-ray crystal structure of diphenyl[N,N′-*bis*(2-*hydroxy*-1-*naphthaldehyde*)-1,2-*phenylenediiminato*]*tin*(IV) (**16**)

Intensity data for a crystal with dimensions 0.5 × 0.3 × 0.2 mm were measured at room temperature on a Syntex P2$_1$ diffractometer fitted with graphite monochromated Mo-K_α radiation, $\lambda = 0.71069$ Å. The θ–2θ scan was employed to measure a total of 7927 reflections such that $\theta_{max} < 26°$. Corrections were applied for Lorentz and polarization effects, but not for absorption. There were 3785 unique data, of which 3360 satisfied the $F > 4\sigma(F)$ criterion of observability and were used in the subsequent analysis. The structure was solved by using SHELXS-86 [6] and refined by a full matrix least squares procedure based on F using SHELX-76 [7]. All non-hydrogen atoms were refined with anisotropic thermal parameters and hydrogen atoms were included in their idealized positions (C—H = 0.96 Å) and refined isotropically. A weighting scheme of the form $w = k/[\sigma^2(F) + gF^2]$ was used and the refinement continued to final $R = 0.0579$, $R_w = 0.0596$ for $k = 1.000$ and $g = 0.0013$. The analysis of variance showed no special features and the maximum residual electron density peak in the final difference map was 1.54 e Å^{-3}. The scattering factors for all the atoms were used as incorporated in SHELX-76. Crystal data and refinement parameters are summarized in Table 4 and bond lengths and angles in Table 5. Lists of atomic coordinates, thermal parameters and observed and calculated structure factors have been deposited as supplementary material with the Cambridge Crystallographic Data Centre, from whom copies are available on request.

RESULTS AND DISCUSSION

The Schiff bases **1**, **7**, **12** and **17** were obtained *via* the condensations of 1,2-phenylenediamine with salicylaldehyde or 2-hydroxy-1-naphthaldehyde in the corresponding molar ratio of 1 : 1 and 1 : 2. All the Schiff bases and their respective complexes (**1**–**19**) are air and thermally stable at ambient temperature. A generalization as inferred from the formulations of the complexes thus obtained (Table 1) is that the dissociation of Cl atoms from the tin moieties upon reaction with Schiff bases is dependent on the nature of the ligands. Whilst the addition of tin compounds to Schiff bases **1** and **7** derived from the reactions of salicylaldehyde with 1,2-phenylenendiamine result in the complexes with the Cl atoms remaining intact, the reactions of tin compounds with the analogous ligands **12** and **17** obtained by condensing 2-hydroxy-1-naph-

Table 1. Melting points (°C) and microanalytical data for **1**, **7**, **12**, **17** and their complexes

Compound	Melting point (°C)	Calculated (%) Sn	C	H	N	Found (%) Sn	C	H	N
1 SALAPIH	224–226	—	73.6	5.7	13.2	—	74.1	5.6	13.5
2 $\mathrm{SnCl_4\cdot(SALAPIH)_2}$	>250	17.3	46.6	3.5	8.2	17.2	46.8	3.4	8.4
3 $\mathrm{BuSnCl_3\cdot(SALAPIH)}$	197–199	24.0	41.3	4.3	5.7	24.4	41.0	4.3	5.8
4 $\mathrm{Bu_2SnCl_2\cdot(SALAPIH)}$	91–93	23.0	48.9	5.9	5.4	23.4	48.4	5.8	5.2
5 $\mathrm{Ph_2SnCl_2\cdot(SALAPIH)}$	152–155	21.3	54.0	4.0	5.0	21.8	54.9	4.1	5.1
6 $\mathrm{Ph_3SnCl\cdot(SALAPIH)}$	170–172	19.9	62.3	4.6	4.7	21.6	63.9	4.2	4.8
7 SALPDIH	161–163	—	75.9	5.1	8.9	—	75.3	4.8	8.8
8 $\mathrm{SnCl_4\cdot(SALPDIH)}$	>250	20.6	41.6	2.8	4.9	20.6	41.9	2.7	4.8
9 $\mathrm{MeSnCl_3\cdot(SALPDIH)}$	>250	22.3	45.3	3.4	5.0	23.0	45.8	3.1	5.2
10 $\mathrm{BuSnCl_3\cdot(SALAPIH)}$	200–202	24.0	41.3	4.3	5.7	23.2	42.0	3.4	5.9
11 $\mathrm{PhSnCl_3\cdot(SALAPIH)}$	240–241	23.1	44.4	3.3	5.4	23.1	44.9	3.2	5.2
12 NAPAPIH	150–152	—	77.8	5.3	10.7	—	77.4	5.1	10.4
13 $\mathrm{SnCl_4\cdot(NAPAPIH)}$	>250	22.8	39.0	2.7	5.4	22.5	39.2	2.4	5.2
14 $\mathrm{SnCl_3\cdot(NAPAPI)}$	>250	24.5	41.9	2.7	5.8	25.0	41.4	2.4	5.8
15 $\mathrm{PhSnCl_2\cdot(NAPAPI)}$	200–202	23.1	51.2	3.5	5.4	23.0	51.0	3.4	5.9
16 $\mathrm{Ph_2Sn\cdot(NAPPDI)}$	240–241	17.3	69.9	4.1	4.1	16.8	69.0	4.1	3.8
17 NAPPDIH	197–198	—	80.8	4.8	6.7	—	79.6	4.7	7.0
18 [Sn(NAPADI)]·**2HCl**	>**250**	**22.4**	**63.3**	**3.0**	**5.3**	**22.9**	**62.9**	**3.3**	**5.2**
19 $\mathrm{[Sn(NAPPDI)Cl_2]\cdot 2HCl}$	>250	19.8	55.8	2.7	4.6	20.7	55.1	2.9	4.5

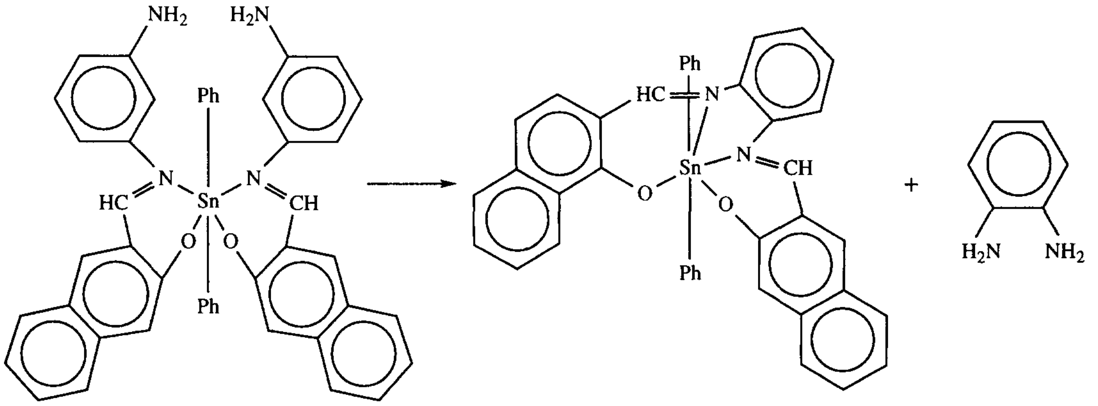
Table 2. Selected IR data ($\mathrm{cm^{-1}}$) for **1**, **7**, **12**, **17** and their complexes

Compound	ν_{N-H}	$\nu_{C=N}$	ν_{C-O}	ν_{Sn-O}	ν_{Sn-N}
SALAPIH	3330	1607	1306	–	–
$\mathrm{SnCl_4\cdot(SALAPIH)_2}$	3421	1620	1307	604–	–
$\mathrm{BuSnCl_3\cdot(SALAPIH)}$	3211	1607	1307	613	387
$\mathrm{Bu_2SnCl_2\cdot(SALAPIH)}$	3237	1593	1313	600	361
$\mathrm{Ph_2SnCl_2\cdot(SALAPIH)}$	3368	1629	1293	580	413
$\mathrm{Ph_3SnCl\cdot(SALAPIH)}$	3079	1600	1307	587	361
SALPDIH	–	1622	1280	–	–
$\mathrm{SnCl_4\cdot(SALPDIH)}$	–	1607	1307	613	–
$\mathrm{MeSnCl_3\cdot(SALPDIH)}$	–	1607	1307	613	–
$\mathrm{BuSnCl_3\cdot(SALAPIH)}$	3211	1607	1307	613	387
$\mathrm{PhSnCl_3\cdot(SALAPIH)}$	3211	1607	1307	613	374
NAPAPIH	3395	1611	1320	–	–
$\mathrm{SnCl_4\cdot(NAPAPIH)}$	3190	1607	1379	528	342
$\mathrm{SnCl_3\cdot(NAPAPI)}$	3180	1616	1382	528	330
$\mathrm{PhSnCl_2\cdot(NAPAPI)}$	3190	1603	1395	520	330
$\mathrm{Ph_2Sn\cdot(NAPPDI)}$	–	1616	1364	550	343
NAPPDIH	–	1622	1326	–	–
[Sn(NAPAPI)]·2HCl	3180	1616	1365	520	315
$\mathrm{[Sn(NAPPDI)Cl_2]\cdot 2HCl}$	–	1626	1373	515	320

thaldehyde with 1,2-phenylenediamine result in the formation of complexes wherein the Cl atoms are displaced from the tin moiety upon complexation.

The molecular structure of the tin complex **16** derived from the reaction of $\mathrm{Ph_2SnCl_2}$ with Schiff base **12** is shown in Fig. 1. A noteworthy feature in the interaction of ligand **12** with $\mathrm{Ph_2SnCl_2}$ is exemplified by the occurrence of intermolecular C═N bond formation mediated by diphenyltin(IV) chloride when the two ligands, **12** treated by the diphenyltin(IV) moiety led to the formation of an inner coordination sphere complex consisting $\mathrm{Ph_2Sn}$ moiety and deprotonated ligand **17**. The generation of ligand **17** from the corresponding Schiff base **12** upon reaction with

Ph_2SnCl_2 may be ascribed to the concomitant C=N bond cleavage and C=N formation between amine N atom and exocyclic carbon of the *N*-(2-hydroxy-1-naphthaldehyde)-1-amino-2-phenyleneimine (**12**). This reaction is similar to the route leading to the formation of (2-hydroxy-1-naphthalideneanilin-2-yl)-2-hydroxy-1-naphthylmethyl sulfide from (2-hydroxy-1-naphthaldehyde)benzothiazoline induced by Bu_2SnCl_2 [8]. The reaction is shown as follows:



The average Sn—O bond distance [2.174(6) Å] falls within the range 2.163–2.228(3) Å of octahedral tin complexes as reported in the literature [9,10]. The average Sn—N bond distance [2.235(6) Å] compares well with that in Me_2Sn(salen) derived from the reaction of Me_2SnCl_2 with bis(salicylaldehyde)ethylenediimine [1]. The shortening of the Sn—N bond distance in **16** as compared with that in Me_2Sn(salen) can be ascribed to the conjugation within the benzene ring of 1,2-phenylenediamine, which increases the basicity of imine N atoms. In addition, the Sn—N bond distance in **16** is also found to be much shorter than that in [*N*,*N*′-(4,5-dimethyl-1,2-phenylene) bis(salicylideneiminato)]tin(II) [11]. This observation can be explained by the hard and soft acid and base (HSAB) concept, wherein the hard N atom prefers hard Lewis acid Sn^{IV} resulting in the stronger electrostatic force in the acid–base interaction [12]. All Sn—C(Ph) bond distances [2.126(8)–2.154(9) Å] are

Table 3. Selected ^{1}H chemical shifts (ppm) for **1**, **7**, **12**, **17** and their complexes

Compound	δ_{O-H}	$\delta_{CH=N}$	δ_{N-H}
SALAPIH	13.19	8.87	5.10
$SnCl_4\cdot(SALAPIH)_2$	14.14	8.60	4.33
$BuSnCl_3\cdot$(SALAPIH)	12.83	9.11	5.09
$Bu_2SnCl_2\cdot$(SALAPIH)	13.19	8.54	4.84
$Ph_2SnCl_2\cdot$(SALAPIH)	13.18	9.04	5.36
$Ph_3SnCl\cdot$(SALAPIH)	13.19	8.34	5.26
SALPDIH	13.22	8.94	—
$SnCl_4\cdot$(SALPDIH)	13.21	9.50	—
$MeSnCl_3\cdot$(SALPDIH)	13.22	9.51	—
$BuSnCl_3\cdot$(SALAPIH)	13.20	9.11	—
$PhSnCl_3\cdot$(SALAPIH)	13.21	9.23	—
NAPAPIH	15.64	9.60	5.09
$SnCl_4\cdot$(NAPAPIH)	15.13	10.02	—
$SnCl_3\cdot$(NAPAPI)	^{a}	^{a}	^{a}
$PhSnCl_2\cdot$(NAPAPI)	—	9.74	—
$Ph_2Sn\cdot$(NAPPDI)	—	9.42	—
NAPPDIH	15.12	9.70	—
[Sn(NAPAPI)]·2HCl	—	10.82	—
[Sn(NAPPDI)Cl_2]·2HCl	—	10.02	—

^{a}Not soluble.

Table 4. Crystal data and details of structure refinement for $(C_6H_5)_2Sn\cdot(OC_{10}H_6CH:NC_6H_4N:CHC_{10}H_6O)$ (**16**)

Formula	$C_{40}H_{28}N_2O_2Sn$
Formula weight	687.33
Crystal system	Tetragonal
Space group	$I4_1cd$
a (Å)	33.051 (3)
b (Å)	33.051 (3)
c (Å)	12.305 (3)
α (°)	90
β (°)	90
γ (°)	90
V (Å^3)	13442 (3)
Z	16
D_c (g cm^{-3})	1359
F (000)	5568
μ (mm^{-1})	0.797
Data collected	7927
Unique data	3785
Data with $F > \sigma(F)$	3360
R	0.0579
R_w	0.0596
W	$k/[\sigma^2(F)+gF^2]$
k	1
g	0.0013
$(\Delta p)_{max.}$	0.52

in good agreement with those reported in the literature (2.105–2.106 Å) [13].

The central tin atom possesses a distorted octahedral geometry with a C(7)—Sn—C(1) angle of 141(5)° due to the phenyl groups bending away from the equatorial O atoms. The opening of the O(2)—Sn—O(1) angle [125.5(2)°] seemingly conforms with the closing of N(1)—Sn—N(2) [75.3(8)°] with a major deviation of O—Sn—N angle from 180°. The evidence of the distortion can be rationalized by the strain imposed on the tetradentate ligand which entails the formation of the chelate rings *via* the permanent angular compression on O,N and N,N. The similar behaviour of this distorted quadridentate Schiff bases has been reported for [*N,N′-o*-phenylenebis(salicylideneiminato)UO_2(EtOH)], wherein the O—O bond distance increases leading to the coordination of ethanol molecule to the uranium atom within the equatorial plane [14].

Microanalytical data (Table 1) shows that the complex derived from the interaction of Ph_2SnCl_2 with **12** is in accordance with the formation of **16**. A band assignable to the stretching vibration of C=N at 1611 cm^{-1} in the IR spectrum of **12** (Table 2) was found to be shifted to 1616 cm^{-1} upon reaction with Ph_2SnCl_2. The major shift of νC=N is also observable in the IR spectrum of **16** as compared with that in **17**, indicating the participation of N atoms in the coordination to the Sn atom. The stretching frequency is lowered owing to the displacement of electron density from N to Sn atom resulting in the weakening of the C=N bond as reported in the literature [15].

A comparison between the IR spectrum of **17** and **16** also shows that a band characteristic of νC—O at 1326 cm^{-1} is shifted remarkably to 1364 cm^{-1}, suggesting that the phenolic O atoms participate in the coordination to the Sn atom.

^{1}H NMR spectral data (Table 3) shows that a peak attributed to the hydroxyl proton (OH) in the uncoordinated ligand **12** is absent after reaction with Ph_2SnCl_2, indicating the involvement of the phenolic O atoms in the coordination to Sn atom. A peak which was originally observed in the ^{1}H NMR spectrum of **12** at $\delta = 5.09$ ppm disappeared upon complexation and this piece of evidence strongly suggests that the amine group is absent in the resulting complex **16**.

However, with the exception of **16**, the reactions of $SnCl_4$ and $PhSnCl_3$ with **12** result in the formation of **13** and **15**, respectively, and, analogously, the reactions of $SnCl_4$, $BuSnCl_3$. Bu_2SnCl_2, Ph_2SnCl_2 and Ph_3SnCl with **1** led to the formation of **2**–**6**, wherein the Schiff bases **12** and **1** remain intact upon complexation. Microanalytical data (Table 1) compare well with the elemental compositions compounds **2**–**6**, **13** and **15**.

The 1 : 2 (Sn : ligand) adduct (**2**) was obtained from the reaction of $SnCl_4$ with **1**, whereas the other compounds **3**–**6** derived respectively from the reactions of $BuSnCl_3$, Bu_2SnCl_2, Ph_2SnCl_2 and Ph_3SnCl with **1** crystallized in Sn : ligand molar ratio of 1 : 1. Similarly, the adducts of $SnCl_4$ and $PhSnCl_3$ with Schiff base **12** are also found to be crystallized in a Sn : ligand molar ratio of 1 : 1. A comparison between the adducts **2** and **13** reflects the influence of the steric effect due to the size of the aldehyde fragment upon complexation. On changing the aldehyde from salicylaldehyde to 2-hydroxy-1-naphthaldehyde, the ratio of Sn : ligand seems to vary from 1 : 2 to 1 : 1.

Inspection of the microanalytical data shows that the reactions of $SnCl_4$ and $MeSnCl_3$ with Schiff base **7** resulted in complexes with Sn : ligand ratio of 1 : 1. However, the reaction of $SnCl_4$ with **17** results in the formation of complex salt whereby two Cl atoms originally in the tin moiety dissociate entailing the coordination of dianionic *N,N′*-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediimine to the central tin atom. Besides, an indication of the dissociation of *N,N′*-bis(2-hydroxybenzaldehyde)-1,2-phenylenediimine to *N*-(2-hydroxybenzaldehyde)-1-amino-2-phenyleneimine can be inferred from the microanalytical data of the product of the reactions of $BuSnCl_3$ and $PhSnCl_3$ with **7**.

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Table 5. Bond distances (Å) and angles (°) of $(C_6H_5)_2Sn\cdot(OC_{10}H_6CH:NC_6H_4N:CHC_{10}H_6O)$ (**16**)

Sn—C(1)	1.25(11)	Sn—O(2)	2.13(2)
Sn—C(7)	2.18(3)	Sn—O(1)	2.18(2)
Sn—N(1)	2.22(2)	Sn—N(2)	2.20(2)
N(1)—C(23)	1.37(4)	N(1)—C(40)	1.38(3)
N(2)—C(34)	1.34(3)	N(2)—C(35)	1.44(3)
O(1)—C(14)	1.27(4)	O(2)—C(25)	1.23(6)
C(1)—C(6)	3.6(2)	C(1)—C(2)	1.2(2)
C(2)—C(3)	2.15(7)	C(3)—C(4)	1.82(8)
C(4)—C(5)	1.71(8)	C(5)—C(6)	3.83(14)
C(7)—C(8)	1.36(5)	C(7)—C(12)	1.48(5)
C(8)—C(9)	1.53(5)	C(9)—C(10)	1.32(7)
C(10)—C(11)	1.19(9)	C(11)—C(12)	1.48(8)
C(13)—C(14)	1.44(5)	C(13)—C(23)	1.46(4)
C(13)—C(22)	1.43(4)	C(14)—C(15)	1.30(4)
C(15)—C(16)	1.45(5)	C(16)—C(17)	1.41(5)
C(17)—C(22)	1.38(4)	C(17)—C(18)	1.55(5)
C(18)—C(19)	2.21(14)	C(19)—C(20)	1.61(10)
C(20)—C(21)	1.22(8)	C(21)—C(22)	1.98(8)
C(24)—C(25)	1.48(5)	C(24)—C(34)	1.43(4)
C(24)—C(33)	1.55(3)	C(25)—C(26)	1.34(6)
C(26)—C(27)	1.51(5)	C(27)—C(28)	1.34(4)
C(28)—C(33)	1.43(4)	C(28)—C(29)	1.44(5)
C(29)—C(30)	1.34(6)	C(30)—C(31)	1.26(7)
C(31)—C(32)	1.38(6)	C(32)—C(33)	1.58(4)
C(35)—C(40)	1.43(4)	C(35)—C(36)	1.42(4)
C(36)—C(37)	1.36(4)	C(37)—C(38)	1.61(5)
C(38)—C(39)	1.32(4)	C(39)—C(40)	1.44(3)
C(1)—Sn—O(2)	86(4)	C(1)—Sn—C(7)	141(5)
O(2)—Sn—C(7)	84.9(11)	C(1)—Sn—O(1)	68(4)
O(2)—Sn—C(1)	124.9(7)	C(7)—Sn—O(1)	86.4(10)
C(1)—Sn—N(1)	105(4)	O(2)—Sn—N(1)	157.1(8)
C(7)—Sn—N(1)	97.0(11)	O(1)—Sn—N(1)	78.0(8)
C(1)—Sn—N(2)	120(5)	O(2)—Sn—N(2)	81.8(8)
C(7)—Sn—N(2)	95.8(10)	O(1)—Sn—N(2)	153.2(7)
N(1)—Sn—N(2)	75.3(8)	C(23)—N(1)—C(40)	121(2)
C(23)—N(1)—Sn	126(2)	C(40)—N(1)—Sn	112(2)
C(34)—N(2)—C(35)	121(2)	C(34)—N(2)—Sn	125(2)
C(35)—N(2)—Sn	115(2)	C(14)—O(1)—Sn	129(2)
C(25)—O(2)—Sn	128(2)	C(6)—C(1)—C(2)	143(6)
C(6)—C(1)—Sn	86(6)	C(2)—C(1)—Sn	124(7)
C(3)—C(2)—C(1)	163(5)	C(4)—C(3)—C(2)	77(3)
C(5)—C(4)—C(3)	105(3)	C(4)—C(5)—C(6)	166(3)
C(1)—C(6)—C(5)	31(2)	C(8)—C(7)—C(12)	116(4)
C(8)—C(7)—Sn	116(3)	C(12)—C(7)—Sn	127(3)
C(7)—C(8)—C(9)	122(4)	C(10)—C(9)—C(8)	122(4)
C(11)—C(10)—C(9)	107(6)	C(10)—C(11)—C(12)	146(7)
C(11)—C(12)—C(7)	106(4)	C(14)—C(13)—C(23)	120(3)
C(14)—C(13)—C(22)	122(3)	C(23)—C(13)—C(22)	118(3)
O(1)—C(14)—C(15)	121(40)	O(1)—C(14)—C(13)	122(3)
C(15)—C(14)—C(13)	117(4)	C(16)—C(15)—C(14)	122(3)
C(15)—C(16)—C(17)	123(2)	C(16)—C(17)—C(22)	114(3)
C(16)—C(17)—C(18)	130(3)	C(22)—C(17)—C(18)	116(3)
C(19)—C(18)—C(17)	149(3)	C(18)—C(19)—C(20)	65(6)
C(21)—C(20)—C(19)	153(7)	C(20)—C(21)—C(22)	125(5)
C(17)—C(22)—C(21)	98(3)	C(17)—C(22)—C(13)	122(3)
C(21)—C(22)—C(13)	140(3)	N(1)—C(23)—C(13)	126(3)
C(25)—C(24)—C(34)	118(3)	C(25)—C(24)—C(33)	125(3)
C(34)—C(24)—C(33)	117(3)	O(2)—C(25)—C(24)	125(3)
O(2)—C(25)—C(26)	128(4)	C(24)—C(25)—C(26)	106(5)
C(27)—C(26)—C(25)	132(4)	C(26)—C(27)—C(28)	120(3)
C(33)—C(28)—C(29)	119(3)	C(33)—C(28)—C(27)	117(3)
C(29)—C(28)—C(27)	124(3)	C(30)—C(29)—C(28)	125(3)
C(31)—C(30)—C(29)	124(5)	C(30)—C(31)—C(32)	117(6)

Table 5. *Continued*

C(31)—C(32)—C(33)	126(4)	C(32)—C(33)—C(28)	109(3)
C(32)—C(33)—C(24)	132(3)	C(28)—C(33)—C(24)	119(3)
N(2)—C(34)—C(24)	129(3)	C(40)—C(35)—C(36)	124(3)
C(40)—C(35)—N(2)	114(2)	C(36)—C(35)—N(2)	123(2)
C(37)—C(36)—C(35)	120(4)	C(36)—C(37)—C(38)	117(4)
C(39)—C(38)—C(37)	120(3)	C(40)—C(39)—C(38)	122(3)
C(39)—C(40)—C(35)	118(3)	C(39)—C(40)—N(1)	122(2)
C(35)—C(40)—N(1)	120(2)		

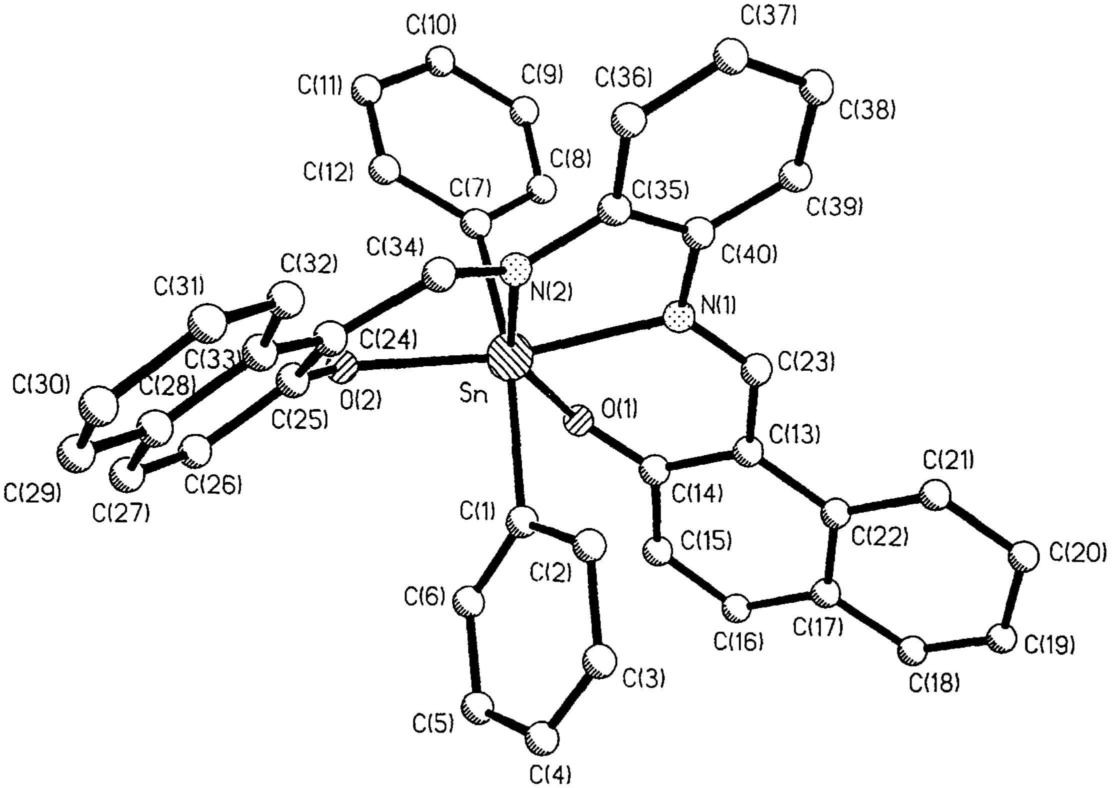

Fig. 1. Molecular structure of diphenyl[*N*,*N*′-bis(2-hydroxy-1-naphthaldehyde)-1,2-phenylenediiminato]tin(IV).

REFERENCES

1. Calligaris, M., Nardin, G. and Randaccio, L., *J. Chem. Soc., Dalton Trans.*, 1972, 2003.
2. Biradar, N. S. and Kulkarni, V. H., *J. Inorg. Nucl. Chem.* 1971, **33,** 3781.
3. Ruddick, J. N. R. and Sams, J. R., *J. Organomet. Chem.* 1973, **60,** 233.
4. Smith, P. J. and Dodd, D., *J. Organomet. Chem.* 1971, **32,** 195.
5. Saraswat, B. S., Srivastava, G., Mehrotra, R. C., Sawhney, G. and Baijal, J. S., *J. Inorg. Nucl. Chem.* 1980, **42,** 805.
6. Sheldrick, G. M., *SHELXS*-86. *A Program for Crystal Structure Determination.* University of Gottingen, Germany, 1976.
7. Sheldrick, G. M., *SHELX*-76. *A Program for Crystal Structure Determination and Refinement.* University of Cambridge, U.K., 1976.
8. Teoh, S. G., Teo, S. B., Yeap, G. Y. and Fun, H. K., *Main Group Metal Chem.* 1992, **15,** 19.
9. Issacs, W. W. and Kennard, C. H. L., *J. Chem. Soc.* (*A*) 1970, 1257.
10. Fun, H. K., Teo, S. B., Teoh, S. G., Yeap, G. Y. and Yeoh, T. S., *Acta Cryst.* 1991, **C47,** 1991.

11. Bergen, A. M., Cashion, J. D., Fallon, G. D. and West, B. O., *Aust. J. Chem.* 1990, **43,** 1559.
12. Pearson, R. G., *Inorg. Chim. Acta* 1995, **240,** 93.
13. Harrison, P. G., King, T. J. and Richards, J. A., *J. Chem. Soc., Dalton Trans.* 1974, 1723.
14. Bandoli, G., Clemente, D. A., Croatto, U., Vidali, M. and Vigato, P. A., *J. Chem. Soc., Chem. Commun.* 1971, **21,** 1330.
15. Bellamy, L. H., *Infrared Spectra of Complex Molecules.* Wiley, New York, 1966.