Pak. j. sci. ind. res., vol.34, no. 4, April 1991

ORGANOTIN COMPLEXES OF DONOR LIGANDS

Part - I. Synthesis, Characterization and Biological Activity of Organotin Complexes of 1-Nitroso-2-Naphthol

SAQIB ALI, M. MAZHAR, ABIDA KALSOOM AND A. QADEER

Department of Chemistry, Quaid-i-Azam University , Islamabad, Pakistan

(Received November 21, 1990; revised May 6, 1991)

A number of organotin derivatives of general formula (1-nitroso-2-naphthoxy) SnR_3 where R = phenyl, butyl, chloride have been synthesized and characterized by different instrumental techniques such as, elemental analysis, ^1H nmr, ir, uv and thermal analysis. The biological activity of these compounds is reported.

Key words: Organotin complexes, Elemental analysis, Biological activity.

Introduction

The use of organotin compounds has grown significantly in the last fifteen years. These compounds are characterized by the presence of at least one tin-carbon bond and are of the type $R_n Sn X_{4-n}$ where R is an alkyl or aryl group, n is 1 to 4 and X may be anions like halide, hydroxide, acetate, etc. Organotin compounds have a host of industrial, commercial and agricultural application. The use of organotins in various fields is dependent on both the nature and number or organic groups bonded with tin atoms. For example, mono and diorganotins are primarily used as heat and light stabilizers in PVC [1,2] whereas triorganotins have biological activity against various species. A number of investigators [3]have shown that several classes of organotins possess antitumor activity against P-388 lymphocytic leukemia in mouse cell. Eng and Engle [4] synthesized diaminoalkyl complexes of tin halides and found that toxicity of these compounds was too high to use them as anticancer agents. Barbieri *et al.* [5] studied in depth antitumor activity of tin derivatives of amino acids and corelated activity with structures of these complexes. Gielen and coworkers [6-14] synthesized a number of organotin (IV) complexes of various donor ligands and studied their activity *in vitro* and *in vivo* against P. 388 and L 1210 leukernia.

Due to diverse applications of organotin compounds, we were tempted to synthesis new organotin complexes and investigate their antibacterial activity. We wish to report the synthesis of 1-nitroso-2-naphthol complexes of tin tetrachloride, tributyltin chloride and triphenyltin chloride. These complexes have been characterized by elemental analysis, thermal analysis, proton nmr, electronic and infrared studies. Their biological activity has been studied against bacteria *Staphylococcus aureus, Salmonella typhae* and *Bacillus subtillis* using streptomycine sulphate as a standard.

Experimental

Reagents and apparatus. 1-Nitroso-2-naphthol, tin (IV) chloride, triphenyltinchloride and tributyltinchloride, Aldrich Chemical Co., USA were used. Other organic solvents were used after proper drying.

Electronic spectra were recorded on uv-vis spectrophotometer Model 160 Shimadzu, Japan. Infrared studies were carried out on infrared spectrophotometer Model 270-50 Hitachi, Japan. Proton nmr spectra were obtained on nmr spectrometer Model JNP-PMX-60, Jeol, Japan. Thermal properties were studied on Simultaneous Thermal Analyzer STA-429, Netzsch, W. Germany.

Elemental analysis for C,H and N were obtained from microanalytical labs. of University of Science, Malaysia while tin contents were measured on atomic absorption spectrophotometer Model Z 8000, Hitachi, Japan. The results are given in Table 1.

General procedure for synthesis. All the compounds were prepared in dry organic solvents and inert atmosphere by stirring or refluxing 1:1 or 1:2 molar ratio of the precursors (details are given in Table 2). The resulting compounds were either filtered or extracted from the solvents on removing the solvent by rotary evaporator. All the compounds were recrystalized and purified by thin-layer chromotography for further characterization.

Results and Discussion

These complexes are quite stable, high molecular weight crystalline solids having sharp melting points. Chloroderivative showed higher melting point than phenyl and butyl derivatives which is probably due to increased ionic character of tin-chlorine bond in these compounds. All these compounds are soluble in most of the common organic solvents.

The infrared spectra of the synthesized complexes were compared with their precursors to assess the extent of any structural changes resulting from complexation. The prominent infrared bands are shown in Table 3. Stretching vibrations due to Sn-C, Sn-Cl and N=O —> Sn are the most important bands and provide conclusive evidence of complexation.

The bands in 440-480 cm^{-1} region, characteristic of the Sn-C bond, [15-16] have not undergone any appreciable

TABLE 1. ELEMENTAL ANALYSIS DATA FOR THE INVESTIGATED COMPOUNDS*.

Compound	Mol. formula (mol. wt.)	%C		%H		%N		%Sn	
		Th.	Ex.	Th.	Ex.	Th.	Ex.	Th.	Ex.
1-Nitroso-2-naphthoxy triphenyltin	$C_{28}H_{21}NO_2Sn$ (522.17)	64.41	64.38	4.05	4.01	2.68	2.52	22.73	22.50
1-Nitroso-2-naphthoxy trichlorotin	$C_{10}H_6NO_2Cl_3Sn$ (397.21)	30.24	30.20	1.52	1.49	3.53	3.43	29.88	29.56
Bis-(1-nitroso-2-naphthoxy) dichlorotin	$C_{20}H_{12}N_2O_4Cl_2Sn$ (533.92)	44.99	44.89	2.27	2.10	5.25	5.18	22.23	22.56
1-Nitroso-2-naphthoxy tributyltin	$C_{22}H_{31}NO_2Sn$ (460.18)	57.42	57.19	6.78	6.68	3.04	2.97	25.79	24.94

* Th = theoretical and Ex = experimental

TABLE 2. DIFFERENT EXPERIMENTAL CONDITIONS.

Compound	Molar ratio*	Solvent	Reflux/ Stirr time	Compound ppted./in Solvent	m.p. (°C)
1-Nitroso-2-naphtoxy triphenyltin	1:1	$CHCl_3$	4 hr. (s)	in solvent	68- 70
1-Nitroso-2-naphthoxy-trichlorotin	1:1	Petroleum ether	4 hr. (s)	ppted	185-188
Bis-(1-nitroso-2-naphthoxy)-dichlorotin	1:2	Petroleum ether	4 hr. (s)	ppted	165-168
1-Nitroso-2-naphthoxy-tributyltin	1:1	DMF	24 hr. (R)	in solvent	80-82

* Molar ratio order, tin salt : ligand.

TABLE 3. INFRARED CHARACTERISTICS OF COMPLEXES AND LIGAND.

Compound	Band position (υ) in cm^{-1}				
	C=C(Ar-)	C-N=O	Sn-C	Sn-O	Sn-Cl
1-Nitroso-2-naphthol	1623(s) 1524(s)	852(s)	–	–	–
Triphenyltin-chloride	1479(s) 1431(s)	–	447(s)	–	330(s)
Tributyltin-chloride	–	–	452(s)	–	337(s)
1-Nitroso-2-naphthoxy triphenyltin	1596(s) 1524(m)	837(s)	447(s)	651(s)	–
1-Nitroso-2-naphthoxy-trichlorotin	1674(s) 1554(s)	837(s)	–	621(s)	333(s)
Bis-(1-nitroso-2-naphthoxy) dichlorotin	1650(w) 1590(s)	834(s)	–	618(m)	340(sh)
1-Nitroso-2-naphthoxy-tributyltin	1650(w) 1572(s)	810(s)	453(m)	606(s)	–

S= strong, m = medium, w= weak, sh = shoulder.

change after complexation. This is due to uniform distribution of electron density on this bond. The stretching vibration band due to Sn-O has been reported by different authors in range of 560-675 cm^{-1} [17-20]. For these complexes, an intense band was observed between 600-651 cm^{-1} which is a strong evidence for the formation of complexes. The tin-nitroso (n=O —> Sn) stretching frequency is also of interest. The stretching vibration due to the ligand was observed at 855 cm^{-1} whereas in different tin complexes this band has shifted to lower frequency i.e. 832-801 cm^{-1}. This is due to relatively heavy mass of metal and low bond order which provides information about coordinate bond formed between tin and nitroso group. The intense and sharp band at 324-340 cm^{-1} is assigned to Sn-Cl bond [21,22]. This band is only present in chloro derivatives.

The electronic spectra of the ligand and complexes in different solvents are given in Table 4. λ_{max} of each chromophore, transition and type of band associated with each transition are assigned.

Assignment of the nmr spectra in deuterated solvent $CDCL_3$ were made on the basis of chemical shift with respect to tetramethyl silane, intensity and multiplicity of the signals as shown in Table 5.

Resonance spectrum of 1-nitroso-2-naphthol shows that six protons of aromatic rings are resonating at 7-8.5 ppm as multiplet signal. Hydroxyl proton resonates at very high frequency and low field (9.5 ppm) due to shielding of proton by oxygen.

In nmr spectrum of 1-nitroso-2-naphthoxy-triphenyltin, the multiplet signal at 7-8.5 ppm region is assigned to six protons of 1-nitroso-2-napthoxy group and fifteen protons of phenyl groups. In the spectrum of triphenyl tin chloride fifteen protons of phenyl groups are resonating at low field and at higher frequency (8-9 ppm). The low frequency range in complex is due to shielding effect of tin and the higher

TABLE 4. ULTRAVIOLET ABSORPTION CHARACTERISTICS OF COMPLEX AND LIGAND.

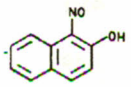
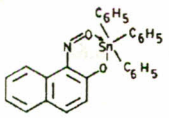
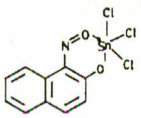
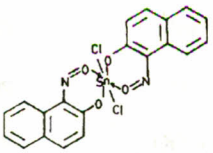
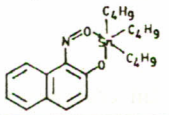
Compound	Chromophore	Solvent	Band position in nm		Transition band
1-Nitroso-2-naphthol		EtOH	360 262	max	—> * (E_2) —> * (B)
1-Nitroso-2-naphthoxytriphenyltin		$CHCl_3$	240 259.2	max	—> * (E_2) —> * (B)
1-Nitroso-2-naphthoxytrichlorotin		EtOH	222.6 255	max	—> * (E_2) —> * (B)
Bis (1-nitroso-2-naphthoxy) dichlorotin		EtOH	222.8 258.6	max	—> * (E_2) —> * (B)
1-Nitroso-2-naphthoxytributyltin		$CHCl_3$	240.8 257	max	—> * (E_2) —> * (B)

TABLE 5. NUCLEAR MAGNETIC RESONANCE CHARACTERISTICS OF LIGAND AND COMPLEXES.

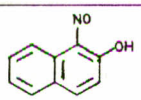
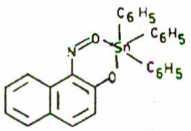
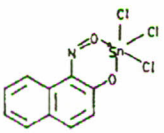
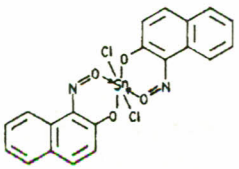
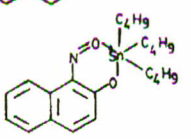
Compounds		Chemical shift (in ppm)	Assignment
(1)		7-8.5 multiplet 9.5 singlet	Six protons of naphthyl rings One proton of hydroxyl group
(2)		7-8.5 multiplet	Six protons of naphthyl rings and fifteen protons of phenyl groups.
(3)		7-8.5 multiplet	Six protons of naphthyl rings
(4)		7-8.5 multiplet	Twelve protons of naphthyl rings
(5)		7-8.5 multiplet 1-3 multiplet	Six protons of naphthyl rings Twenty seven protons of butyl groups.

TABLE 6. THERMAL ANALYSIS DATA OF THE INVESTIGATED COMPOUNDS.

Compound	Temp. range (°C)	% Wt. loss Found	% Wt. loss Cal.	Volatile evolved	Inter-mediate	Residue
1-Nitroso-2-naphthoxytri-phenyltin	125-260	16.68	15.94	C_6H_5	$C_{22}H_{16}NO_2Sn$	
	260-430	16.66	15.94	C_6H_5	$C_{16}H_{11}NO_2Sn$	
($C_{28}H_{21}NO_2Sn$)	430-725	42.75	44.63	$C_{16}H_{11}NO$	—	SnO
1-Nitroso-2-naphthoxy-trichlorotin	170-190	38.00	39.24	$C_{10}H_6NO$	Cl_3OSn	
	190-400	24.00	26.79	3Cl	—	SnO
($C_{10}H_6NO_2Cl_3Sn$)						
Bis- (1-nitroso-2-naphthoxy)dichlorotin	140-175	29.16	29.21	$C_{10}H_6NO$	$C_{10}H_6NO_3Cl_2Sn$	
	175-555	27.83	29.21	$C_{10}H_6NO$	Cl_2O_2Sn	
($C_{20}H_{12}N_2O_4Cl_2Sn$)	555-790	15.12	13.30	Cl_2	—	SnO_2
1-Nitroso-2-naphthoxy-tributyltin ($C_{22}H_{31}NO_2Sn$)	110-515	32.41	33.90	$C_{10}H_6NO$	$C_{12}H_{25}OSn$	
	515-920	74.59	76.10	$C_{12}H_{25}OSn$	—	—

TABLE 7. RESULTS OF SCREENING FOR INHIBITION GROWTH OF THE INVESTIGATED COMPOUNDS.

Compound	Bacteria type and inhibition growth in cm *S.aureus*	*B.subtillis*	*S.typhae*	Solvent	Conc.(mg/ml)
1-Nitroso-2-naphthoxy triphenyltin	2.25	1.86	2.08	$CHCl_3$	25
1-Nitroso-2-naphthoxy trichlorotin	3.71	3.01	3.41	$CHCl_3$	25
Bis (1-nitroso-2-naphthoxy) dischlorotin	3.62	2.73	3.92	$CHCl_3$	25
Streptomycin sulphate (Standard)	2.87	2.45	2.96	$CHCl_3$	100 (µg/ml)
1-Nitroso-2-naphthoxy tributyltin	3.79	2.83	3.56	$CHCl_3$	25

frequency in triphenyl tin chloride is due to deshielding effect of chlorine atom [23].

Spectra of 1-nitroso-2-naphthoxy trichlorotin and bis (1-nitroso-2-naphthoxy) dichlorotin show no remarkable change as the protons in both complexes are resonating in the same region as 1-nitroso-2-naphthol (7-8.5 ppm).

In the nmr spectrum of 1-nitroso-2-naphthoxy tributyltin, multiplet signals in two regions are observed. The signals at high frequency (7-8.5 ppm) are assigned to six protons of the 1-nitroso-2-naphthoxy group, whereas low frequency multiplet signal at 1-3 ppm is assigned to protons of butyl groups as observed in similar butyltin compounds [24].

Thermal decomposition of the complexes was studied in the temperature range 50-1400°, in order to investigate their thermal stability, purity and fragmentation pattern. The results are given in Table 6. All complexes exhibit thermal stability upto 100-140°. It was also observed from the loss in weight that SnO or SnO_2 were the final products, except in case of 1-nitroso-2-naphthoxytributyltin, which was completely volatilized and no residue was remained. In certain cases decomposition with melting were observed in complexes having high melting points.

The results for biological activity of the complexes against various species of bacteria are given in Table 7. 1-Nitroso-2-naphthoxy triphenyltin has the least activity among all the four studied complexes. On the other hand 1-nitroso-2-naphthoxy trichlorotin is rather equally good for all the three types of bacteria whereas the maximum activity was observed for bis (1-nitroso-2-naphthoxy) dichlorotin against *Salmonella typhae*. The greater activity of chloro derivatives against bacteria is probably due to the presence of chlorine which itself is antibacterial. Another interesting observation is that the inhibition growth for *S. aureus* and *S. typhae* is > 3 cm for all compounds whereas for *B.Subtillis*, it is < 3 cm for all except one compound which has a value 3.01 cm.

Acknowledgement. We are thankful to National Scientific Research and Development Board, Islamabad for providing funds for this work.

References

1. L. R. Brecker, Pure Appl. Chem., **53,** 577 (1981).
2. M. Mazhar, N. Sehir and N. Iqbal, Pak. j. sci. ind. res., **27** (3), (1984).
3. (a). M. Gielen, In: *Tin as a Vital Nutrient,* N.F. Cardarelli, (ed.), (CRC Press, Boca Raton, FL, 1986), pp. 169. (b). F. Huber and R. Barbieri, *Ibid*, 175 (1986).
4. G. Eng and T. W. Engle, Bull. Soc. Chim. Belg., **96** (1), 69 (1987).

5. G. Ruisi, A. Silvestri, M. T. Lo Giudice, R. Barbieri, G. Atassi, F. Huber, K. Gratz and L. Lamartina, J. Inorg. Biochem., **25**, 229 (1985).
6. M. Gielen, R. Willem, A. Delmotte, E. Jooser, A. Meriem, M. Melotte, C. Vanbellinghen, B. Mahieu, P. Lelieveld, D. de Vos and G. Attasi, Main Group Metal Chem., **12** (1), 55 (1989).
7. I. Haidue, C. Silvistru and M. Gielen, Bull. Soc. Chim. Belg., **92** (2), 187 (1983).
8. L. Declercq, R. Willem, M. Gielen and G. Atassi, Bull. Soc. Chim. Belg., **93** (12), 1089 (1984).
9. K. Jurkschat, A. Tzschach, C. Mugge, J. P. Meunier, M.V. Meerssche, G. V. Binst, C. Wynants, M. Gielen and R. Willem, Organometallics, **7**, 593 (1988).
10. M. Gielen, K. Jurkschat and G. Atassi, Bull. Soc. Chim. Belg., **93** (2), 153 (1984).
11. M. Gielen, C. Vanbellinghen, J. Gelan and R. Willem, *Ibid*, **97** (11-12), 973 (1988).
12. M. Gielen, M. Melotte, G. Atassi and R. Willem, Tetrahedron, **45** (4), 1219 (1989).
13. A. Meriem, M. Gielen and R. Willem, J. Organometal. Chem., **365**, 91 (1989).
14. M. Gielen, T. Mancilla, J. Ramharter and R. Willem, *Ibid*, **328**, 61 (1987).
15. W. P. Neumann, *The Organic Chemistry of Tin* (Ferdinand Enke Verlag, Stuttgart, 1967).
16. N. A. Chumoyeusk, *Oscillation Spectra of Hetro Organic Compounds with IVB and VB Elements*, (Nauka Publisher, Moscow, 1971).
17. C. Domazetis and R. J. Magee, J. Inorg. Nucl. Chem., **41**, 1547 (1979).
18. F. R. Butcher, W. Gerrad, E.F. Mooney, R. G. Rees and H. A. Wills, Spectrochim. Acta, **20**, 51 (1964).
19. R. E. Hester, J. Organometal. Chem., **23** , 123 (1970).
20. A. K. Sawyer, *Organotin Compounds* (Marcel Dekker, New York, 1971), Vol. 2, pp. 253-295
21. R. A. Cummis, Aust., J. Chem., **16**, 985 (1963).
22. P. Taimsalu and J. C. Wood, Spectrochim. Acta, **20**, 1043 (1964).
23. A. G. Davies, Chem. Brit., **4**, 403 (1968).
24. Sadtler-NMR Atlas (1968).