# Synthesis, Spectroscopic Studies and Biological Applications of Organotin(IV) Derivatives of 3-[N-(4-Nitrophenyl)-amido]propenoic Acid and 3-[N-(4-Nitrophenyl)-amido]propanoic Acid

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New organotin(IV) derivatives with general formulae $R_2SnL_2$ and $R_3SnL$, where R = methyl, n-butyl, n-octyl and phenyl and HL is either 3-[N-(4-nitrophenyl)amido]-propenoic acid or 3-[N-(4-nitrophenyl)amido] propanoic acid have been synthesized in 1 : 2 and 1 : 1 molar ratio by different methods. The FTIR spectra clearly demonstrated that the organotin(IV) moieties react with [O,O] atoms of the ligands. The bonding and coordination behavior in these complexes are discussed on the basis of multinuclear ($^1H$, $^{13}C$, $^{119}Sn$) NMR and mass spectrometric studies. Antibacterial, and antifungal screening tests were performed for these compounds and reported here. These values were compared to those of the precursors and it was found that diorganotin(IV) complexes exhibit less activity as compared to triorganotin(IV) complexes . $LD_{50}$ data were obtained by Brine Shrimp assay method. Insecticidal activity was performed for selective compounds by contact toxicity method.

**Key Words :** Organotin(IV) carboxylates, Spectroscopic characterization, Biological activity

## Introduction

The synthesis of organotin(IV) carboxylates has received considerable attention during the last three decades.[1-10] Increasing interest in generating these complexes lies in the possibility to enhance biological activities associated with the respective organotin(IV) and unreacted carboxylate compounds.

The biological importance of organotins has been supported by studies concentrating on structure-activity correlations[11-18] that dealt mainly with structural aspects and antitumour activity, and also linked with possible tumorigenic activity. Indeed, butyltins present genotoxic effects,[19,20] and may predispose animals to malignancy. Several studies have reported that ligands containing oxygen and nitrogen atoms as donor sites are often involved in compounds with potential antitumour activity.[21-27]

In order to obtain better insight into how the metallic species behave inside biological systems, it is necessary to study their coordination behaviour with ligands that can occur in the biological medium, and hence to formulate the structure-activity correlations to devise new derivatives with potential antitumour activity. This explains why attention has shifted towards metal derivatives of amino acids and peptides.

Our current interest in the synthesis of organotin(IV) carboxylates[28-32] prompted us to extend our investigation in the synthesis of new organotin(IV) carboxylates, which could have biological properties. This paper describes the synthesis of new organotin(IV) carboxylates of 3-[N-(4-nitrophenyl)amido]propenoic acid and 3-[N-(4-nitrophenyl)amido]propanoic acid.

All compounds were characterized by IR, $^1H$, $^{13}C$, $^{119}Sn$ NMR and mass spectrometry. These complexes were screened against various bacteria, fungi and insects to investigate their possible as antibacterial and antifungal agents. $LD_{50}$ values were obtained for these compounds by using Brine Shrimp assay method and the data are reported in this paper.

## Experimental Section

**Materials and Instrumentation.** All the glass apparatus with standard quick fit joints was used throughout the work after cleaning and drying at 120 °C. Maleic anhydride, succinic anhydride, *p*-nitroaniline, chloroform and petroleum ether from Aldrich, glacial acetic acid from Merck and toluene from Fluka were purchased. Solvents were purified by standard methods[33] while other chemicals were used as supplied. Melting points were determined with a Mitamura Rikero Kogyo (Japan) and are uncorrected. Mass spectra were recorded on a MAT 8500 Finngin (Germany). The $^1H$ and $^{13}C$ NMR spectra were recorded on a Brucker AM-250 MHz spectrometer using $CDCl_3$ as internal reference. $^{119}Sn$ NMR spectra were obtained on a Brucker 250 ARX instrument with $Me_4Sn$ as external reference.

**Preparation of 3-[N-(4-Nitrophenyl)-amido]propenoic Acid ($HL^1$).** A solution of maleic anhydride (10 g, 0.1 mol) in acetic acid (300 mL) was added to a solution of *p*-nitroaniline (13.8 g, 0.1 mol) in acetic acid (150 mL) and the mixture was stirred at room temperature overnight. The light yellow precipitates were filtered, washed with cold distilled $H_2O$ (200 mL) and air dried. Yield 85%, m.p. °C. Analysis: Calculated for $C_{10}H_8N_2O_5$: C, 50.85; H, 3.41; N, 11.86. Found: C, 50.80; H, 3.45; N, 11.80. $^1H$ NMR ($CDCl_3$, ppm), 8.03-8.06 $\delta$ (9.17); 8.14-8.18d (9.17) (-CH=CH-), 7.64-7.68m ($NO_2$-$C_6H_4$), 6.9s (-NH). $^{13}C$ NMR ($CDCl_3$, ppm), 137.8 (C-1), 132.3 (C-2/6), 134.6 (C-3/5), 126.3 (C-4),

166.0 (C-7), 124.4 (C-8), 114.1 (C-9), 196.6 (C-10).

**3-[N-(4-Nitrophenyl)-amido]propanoic Acid ($HL^2$).** A solution of succinic anhydride (9.8 g, 0.1 mol) in acetic acid (300 mL) was added to a solution of *p*-nitroaniline (13.80 g, 0.099 mol) in acetic acid (150 mL) and the mixture was stirred at room temperature overnight. The light yellow precipitates were filtered, washed with cold distilled $H_2O$ (200 mL) and air dried. Yield 85%, m.p. °C. Analysis: Calculated for $C_{10}H_{10}N_2O_5$: C, 50.42; H, 4.23; N, 11.76. Found: C, 50.45; H, 4.19; N, 11.71. $^1$H NMR ($CDCl_3$, ppm), 8.07-8.11d (9.2); 8.34-8.36d (9.2) (-$CH_2$-$CH_2$-), 7.60-7.63m ($NO_2$-$C_6H_4$), 7.28s (-NH). $^{13}$C NMR ($CDCl_3$, ppm), 136.9 (C-1), 132.0 (C-2/6), 134.4 (C-3/5), 126.8 (C-4), 167.0 (C-7), 124.3 (C-8), 118.2 (C-9), 192.1 (C-10).

**Preparation of Complexes. $Me_2Sn(L^1)_2$ (1):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.59 mL, 4.23 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propenoate in dry toluene, dimethyltin dichloride (2.11 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 85%, m.p. 105 °C. Analysis: Calculated for $C_{20}H_{20}N_4O_{10}Sn$: C, 38.77; H, 3.23; N, 9.04. Found: C, 38.65; H, 3.20; N, 9.12. $^1$H NMR ($CDCl_3$, ppm), 8.02-8.06d (8.98); 8.14-8.32d (8.98) (-CH=CH-), 7.63-7.67m ($NO_2$-$C_6H_4$), 6.9s (-NH), 1.2s [78.5] (Sn-$CH_3$). $^{13}$C NMR ($CDCl_3$, ppm), 138.0 (C-1), 132.6 (C-2/6), 134.6 (C-3/5), 126.3 (C-4), 168.4 (C-7), 124.4 (C-8), 113.3 (C-9), 178.4 (C-10), 29.68 (C-11).

IR (KBr, cm$^{-1}$), 3392s $\nu$(NH), 1720s $\nu$(C=O), 1555s $\nu$($COO_{asym}$), 1402s $\nu$ ($COO_{sym}$), $\Delta\nu$ 155, 580m $\nu$(Sn-C), 405m $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 368 (n.o), SnOOCR' 353 (n.o), $R_2Sn^+$ 149 (n.o), $C_6H_5^+$ 76 (8), $[Sn]^+$ 120 (22), $C_7H_5O_3N^+$ 165 (6), $CNHO^+$ 43 (6), $[C_6H_5]^+$ 77 (2), $C_6H_5N_2O_2^+$ 138 (100). $\delta$($^{119}$Sn) ppm; −98.3.

**$Ph_2Sn(L^1)_2$ (2):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.59 mL, 4.23 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propenoate in dry toluene, diphenyltin dichloride (2.11 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 70%, m.p. 121-122 °C. Analysis: Calculated for $C_{32}H_{24}N_4O_{10}Sn$: C, 51.68; H, 3.23; N, 7.53. Found: C, 51.32; H, 3.30; N, 7.49.

$^1$H NMR ($CDCl_3$, ppm), 8.05-8.06d (9.08); 8.35-8.36d (9.08) (-CH=CH-), 7.68-7.71m ($NO_2$-$C_6H_4$), 6.9s (-NH), 7.28m (Sn-$C_6H_5$). $^{13}$C NMR ($CDCl_3$, ppm), 137.1 (C-1), 132.4 (C-2/6), 134.6 (C-3/5), 126.7 (C-4), 168.5 (C-7), 124.4 (C-8), 113.3 (C-9), 176.8 (C-10), 137.1 (C-11), 136.1 (C-12), 129.1 (C-13), 128.4 (C-14).

IR (KBr, cm$^{-1}$), 3378s $\nu$(NH), 1725s $\nu$(C=O), 1599s $\nu$($COO_{asym}$), 1424s $\nu$($COO_{sym}$), $\Delta\nu$ 175, 440s $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 429 (5), SnOOCR' 353 (4), $R_2Sn^+$ 271 (7), $C_6H_5^+$ 76 (n.o), $[Sn]^+$ 120 (2), $C_7H_5O_3N^+$ 165 (2), $CNHO^+$ 43 (9), $[C_6H_5]^+$ 77 (6), $C_6H_5N_2O_2^+$ 138 (100). $\delta$ ($^{119}$Sn) ppm; −98.4.

**$Oct_2Sn(L^1)_2$ (3):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100 mL) and treated with equimolar in a reaction flask with constant stirring and mixture was refluxed for 8-10 hours. Water formed was removed via Dean and Stark trap. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 86%, m.p. 98 °C. Analysis: Calculated for $C_{36}H_{48}N_4O_{10}Sn$: C, 53.00; H, 5.88; N, 6.87. Found: C, 53.20; H, 5.77; N, 6.84.

$^1$H NMR ($CDCl_3$, ppm), 8.02-8.05d (9.08) 8.32-8.36d (9.08) (-CH=CH-), 7.60-7.68m ($NO_2$-$C_6H_4$), 6.9s (-NH), 0.83-1.9m (Sn-$C_8H_{13}$). $^{13}$C NMR ($CDCl_3$, ppm), 138.2 (C-1), 132.5 (C-2/6), 134.6 (C-3/5), 126.3 (C-4), 168.4 (C-7), 124.4 (C-8), 114.5 (C-9), 175.0 (C-10), 34.1 (C-11), 31.9 (C-12), 29.5 (C-13), 26.3 (C-14), 26.3 (C-15), 25.8 (C-16), 23.4 (C-17), 14.9 (C-18).

IR (KBr, cm$^{-1}$), 3349s $\nu$(NH), 1701m $\nu$(C=O), 1560s $\nu$($COO_{asym}$), 1412s $\nu$($COO_{sym}$), $\Delta\nu$ 148, 520m $\nu$(Sn-C), 410m $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 465 (n.o), SnOOCR' 353 (2), $R_2Sn^+$ 345 (10), $C_6H_5^+$ 76 (n.o), $[Sn]^+$ 120 (n.o), $C_7H_5O_3N^+$ 165 (n.o), $CNHO^+$ 43 (12), $[C_6H_5]^+$ 77 (n.o), $C_6H_5N_2O_2^+$ 138 (100).

**$Me_2Sn(L^2)_2$ (4):** 3-[N-(4-nitro-phenylamido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.58 mL, 4.20 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propanoate in dry toluene, dimethyltin dichloride (2.10 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 86%, m.p. 92 °C. Analysis: Calculated for $C_{22}H_{24}N_4O_{10}Sn$: C, 42.37; H, 3.85; N, 8.98. Found: C, 41.98; H, 3.79; N, 9.10.

$^1$H NMR ($CDCl_3$, ppm), 8.11-8.15d (9.0); 8.38-8.42d (9.0) (-$CH_2$-$CH_2$-), 7.64-7.67m ($NO_2$-$C_6H_4$), 7.32s (-NH), 1.31s [79.1] (Sn-$CH_3$). $^{13}$C NMR ($CDCl_3$, ppm), 137.8 (C-1), 132.6 (C-2/6), 134.5 (C-3/5), 126.3 (C-4), 167.6 (C-7), 124.4 (C-8), 118.3 (C-9), 175.3 (C-10), 29.7 (C-11).

IR (KBr, cm$^{-1}$), 3362s $\nu$(NH), 1752s $\nu$(C=O), 1586s $\nu$($COO_{asym}$), 1440s $\nu$($COO_{sym}$), $\Delta\nu$ 146, 542m $\nu$(Sn-C), 452m $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 608 (n.o), SnOOCR' 593 (n.o), $R_2Sn^+$ 149 (6), $C_6H_5^+$ 76 (5), $[Sn]^+$ 120

(6), $C_3H_4O^+$ 55 (68), $[R_2SnOOCCH_2CH_2]^+$ 220 (100), $C_7H_5O_3N^+$ 165 (10), $CNHO^+$ 43 (18), $C_3H_5NO^+$ 71 (19), $[C_6H_5]^+$ 77 (1), $C_6H_5N_2O_2^+$ 138 (5).

**$Bu_2Sn(L^2)_2$ (5):** 3-[N-(4-nitro-phenylamido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.58 mL, 4.20 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propanoate in dry toluene, dibutyltin dichloride (2.10 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 90%, m.p. 62 °C. Analysis: Calculated for $C_{28}H_{36}N_4O_{10}Sn$: C, 47.52; H, 5.09; N, 7.92. Found: C, 47.45; H, 5.11; N, 8.01.

$^1H$ NMR ($CDCl_3$, ppm), 8.10-8.13d (9.0); 8.37-8.41d (9.0) (-$CH_2$-$CH_2$-), 7.63-7.71m ($NO_2$-$C_6H_4$), 7.32s (-NH), 0.8t, 1.30-1.55m (Sn-$C_4H_9$). $^{13}C$ NMR ($CDCl_3$, ppm), 137.6 (C-1), 132.8 (C-2/6), 134.2 (C- 3/5), 126.3 (C-4), 167.8 (C-7), 124.4 (C-8), 113.3 (C-9), 175.3 (C-10), 29.7 (C-11), 27.3 (C-12), 26.7 (C-13), 13.6 (C-14).

IR (KBr, $cm^{-1}$), 3351s $\nu$(NH), 1742s $\nu$(C=O), 1578s $\nu$($COO_{asym}$), 1420s $\nu$($COO_{sym}$), $\Delta\nu$ 158, 552w $\nu$(Sn-C), 480m $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 650 (n.o), SnOOCR' 593 (n.o), $R_2Sn^+$ 233 (n.o), $C_6H_5^+$ 76 (n.o), $[Sn]^+$ 120 (8), $C_3H_4O^+$ 55 (3), $[R_2SnOOCCH_2CH_2]^+$ 220 (8), $C_7H_5O_3N^+$ 165 (2), $CNHO^+$ 43 (8), $C_3H_5NO^+$ 71 (13), $[C_6H_5]^+$ 77 (9), $C_6H_5N_2O_2^+$ 138 (9), $C_4H_9^+$ 57 (100). $\delta(^{119}Sn)$ ppm; −88.3.

**$Oct_2Sn(L^2)_2$ (6):** 3-[N-(4-Nitrophenyl)amido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with equimolar in a reaction flask with constant stirring and mixture was refluxed for 8-10 hours. Water formed was removed via Dean and Stark trap. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1).

Yield 78%, m.p. 170 °C. Analysis: Calculated for $C_{36}H_{52}N_4O_{10}Sn$: C, 52.74; H, 6.34; N, 6.83. Found: C, 52.63; H, 6.39; N, 6.81.

$^1H$ NMR ($CDCl_3$, ppm), 8.07-8.10d (9.0); 8.34-8.37d (9.0) (-$CH_2$-$CH_2$-), 7.60-7.69m ($NO_2$-$C_6H_4$), 7.28s (-NH), 0.89-1.73m (Sn-$C_6H_5$). $^{13}C$ NMR ($CDCl_3$, ppm), 137.2 (C-1), 132.4 (C-2/6), 134.9 (C-3/5), 126.9 (C-4), 167.2 (C-7), 124.4 (C-8), 118.6 (C-9), 175.8 (C-10), 33.9 (C-11), 31.9 (C-12), 29.6 (C-13), 29.3 (C-14), 26.3 (C-15), 25.3 (C-16), 24.2 (C-17), 12.3 (C-18).

IR (KBr, $cm^{-1}$), 3395s $\nu$(NH), 1732s $\nu$(C=O), 1580s $\nu$($COO_{asym}$), 1400s $\nu$($COO_{sym}$), $\Delta\nu$ 180, 532m $\nu$(Sn-C), 472m $\nu$(Sn-O). Mass data m/z(%); RSnOOCR' 706 (n.o), SnOOCR' 356 (100), $R_2Sn^+$ 345 (n.o), $C_6H_5^+$ 76 (6), $[Sn]^+$ 120 (5), $C_3H_4O^+$ 55 (100), $[R_2SnOOCCH_2CH_2]^+$ 220 (97), $C_7H_5O_3N^+$ 165 (16), $CNHO^+$ 43 (11), $C_3H_5NO^+$ 71 (18), $[C_6H_5]^+$ 77 (6), $C_6H_5N_2O_2^+$ 138 (12). $\delta(^{119}Sn)$ ppm; −148.7.

**$Me_3Sn(L^1)$ (7):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.59 mL, 4.23 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propenoate in dry toluene, trimethyltin chloride (4.23 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 77%, m.p. 45-46 °C. Analysis: Calculated for $C_{13}H_{17}N_2O_5Sn$: C, 39.00; H, 4.25; N, 7.00. Found: C, 39.22; H, 4.19; N, 7.11.

$^1H$ NMR ($CDCl_3$, ppm), 8.00-8.03d (9.08); 8.09-8.13d (9.08) (-CH=CH-), 7.63-7.66m ($NO_2$-$C_6H_4$), 6.9s (-NH), 0.74s [57.17] (Sn-$CH_3$). $^{13}C$ NMR ($CDCl_3$, ppm), 137.9 (C-1), 132.5 (C-2/6), 134.2 (C-3/5), 126.3 (C-4), 168.5 (C-7), 124.4 (C-8), 113.3 (C-9), 181.6 (C-10), 29.68 (C-11). IR (KBr, $cm^{-1}$), 3334s $\nu$(NH), 1724s $\nu$(C=O), 1597s $\nu$($COO_{asym}$), 1415s $\nu$($COO_{sym}$), $\Delta\nu$ 182, 550m $\nu$(Sn-C), 420m $\nu$(Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 385 (43), RSnOOCR' 370 (35), SnOOCR' 354 (2), $R_3Sn^+$ 164 (5), $R_2Sn^+$ 149 (12), $C_6H_5^+$ 76 (9), $[Sn]^+$ 120 (4), $C_7H_5O_3N^+$ 165 (n.o), $CNHO^+$ 43 (20), $[C_6H_5]^+$ 77 (n.o), $C_6H_5N_2O_2^+$ 138 (100). $\delta(^{119}Sn)$ ppm; 113.14.

**$Bu_3Sn(L^1)$ (8):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.59 mL, 4.23 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propenoate in dry toluene, trimethyltin chloride (4.23 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 89%, m.p. 79-80 °C. Analysis: Calculated for $C_{32}H_{34}N_2O_5Sn$: C, 50.28; H, 6.47; N, 5.33. Found: C, 50.31; H, 6.38; N, 5.40.

$^1H$ NMR ($CDCl_3$, ppm), 8.06-8.10d (9.08); 8.20-8.24d (9.08) (-CH=CH-), 7.79-7.85m ($NO_2$-$C_6H_4$), 6.79s (-NH), 0.89t, 1.27-1.69m (Sn-$C_4H_9$). $^{13}C$ NMR ($CDCl_3$, ppm), 136.9 (C-1), 130.3 (C-2/6), 134.7 (C-3/5), 126.4 (C-4), 167.2 (C-7), 124.9 (C-8), 113.6 (C-9), 176.8 (C-10), 29.6 (C-11), 27.9 (C-12), 16.8 (C-13), 13.6 (C-14). IR (KBr, $cm^{-1}$), 3366s $\nu$(NH), 1710s $\nu$(C=O), 1587s $\nu$($COO_{asym}$), 1430s $\nu$($COO_{sym}$), Dn 142, 575m $\nu$(Sn-C), 430w $\nu$(Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 469 (100), RSnOOCR' 411 (n.o), SnOOCR' 351 (2), $R_3Sn^+$ 291 (4), $R_2Sn^+$ 233 (7), $C_6H_5^+$ 76 (9), $[Sn]^+$ 120 (3), $C_7H_5O_3N^+$ 165 (n.o), $CNHO^+$ 43 (22), $[C_6H_5]^+$ 77 (9), $C_6H_5N_2O_2^+$ 138 (13), $[C_4H_9]^+$ 57 (4). $\delta(^{119}Sn)$ ppm; 59.5.

**$Ph_3Sn(L^1)$ (9):** 3-[N-(4-Nitrophenyl)amido]propenoic acid (1 g, 4.23 mmol) was suspended in dry toluene (100

mL) and treated with triethylamine (0.59 mL, 4.23 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propenoate in dry toluene, trimethyltin chloride (4.23 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 87%, m.p. 63 °C. Analysis: Calculated for $C_{28}H_{23}N_2O_5Sn$: C, 57.33; H, 3.92; N, 4.77. Found: C, 57.41; H, 3.96; N, 4.71.

$^1$H NMR ($CDCl_3$, ppm), 8.02-8.05d (8.98); 8.29-8.33d (8.98) (-CH=CH-), 7.65-7.66m ($NO_2$-$C_6H_4$), 6.88s (-NH), 7.44-7.45m ($C_6H_5$). $^{13}$C NMR ($CDCl_3$, ppm), 137.2 (C-1), 130.5 (C-2/6), 134.5 (C-3/5), 126.3 (C-4), 167.2 (C-7), 124.9 (C-8), 114.3 (C-9), 174.4 (C-10), 136.5 (C-11), 135.7 (C-12), 129.1 (C-13), 125.4 (C-14). IR (KBr, $cm^{-1}$), 3382s $\nu$ (NH), 1729s $\nu$ (C=O), 1587s $\nu$ ($COO_{asym}$), 1430s $\nu$ ($COO_{sym}$), $\Delta\nu$ 157, 425m $\nu$ (Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 505 (2), $RSnOOCR'$ 429 (3), $SnOOCR'$ 351 (n.o), $R_3Sn^+$ 347 (26), $R_2Sn^+$ 271 (n.o), $C_6H_5^+$ 76 (3), $[Sn]^+$ 120 (4), $C_7H_5O_3N^+$ 165 (n.o), $CNHO^+$ 43 (9), $[C_6H_5]^+$ 77 (4), $C_6H_5N_2O_2^+$ 138 (100). $\delta$($^{119}$Sn) ppm; −98.2.

**$Me_3Sn(L^2)$ (10):** 3-[N-(4-nitro-phenylamido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.58 mL, 4.20 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propanoate in dry toluene, trimethyltin chloride (4.20 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 80%, m.p. 75 °C. Analysis: Calculated for $C_{13}H_{18}N_2O_5Sn$: C, 38.90 ; H, 4.48; N, 6.98. Found: C, 39.11; H, 4.45; N, 6.88.

$^1$H NMR ($CDCl_3$, ppm), 8.07-8.10d (9.0); 8.34-8.38d (9.0) (-$CH_2$-$CH_2$-), 7.59-7.63m ($NO_2$-$C_6H_4$), 7.28s (-NH), 0.73s [58.2] (Sn-$CH_3$). $^{13}$C NMR ($CDCl_3$, ppm), 137.8 (C-1), 132.5 (C-2/6), 134.6 (C-3/5), 126.3 (C-4), 167.5 (C-7), 124.3 (C-8), 118.6 (C-9), 175.3 (C-10), −1.3 (C-11).

IR (KBr, $cm^{-1}$), 3345s $\nu$ (NH), 1760s $\nu$ (C=O), 1590s $\nu$ ($COO_{asym}$), 1425s $\nu$ ($COO_{sym}$), $\Delta\nu$ 165, 562w $\nu$ (Sn-C), 428m $\nu$ (Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 386 (2), $RSnOOCR'$ 371 (n.o), $SnOOCR'$ 356 (n.o), $R_3Sn^+$ 164 (8), $R_2Sn^+$ 149 (n.o), $C_6H_5^+$ 76 (n.o), $[Sn]^+$ 120 (4), $C_3H_4O^+$ 55 (7), $[R_2SnOOCCH_2CH_2]^+$ 220 (11), $C_7H_5O_3N^+$ 165 (72), $CNHO^+$ 43 (7), $C_3H_5NO^+$ 71 (18), $[C_6H_5]^+$ 77 (3), $C_6H_5N_2O_2^+$ 138 (100). $\delta$($^{119}$Sn) ppm; 170.7.

**$Bu_3Sn(L^2)$ (11):** 3-[N-(4-nitro-phenylamido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.58 mL, 4.20 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propanoate in dry toluene, tributyltin chloride (4.20 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 60%, m.p. 132-133 °C. Analysis: Calculated for $C_{22}H_{36}N_2O_5Sn$: C, 50.09; H, 6.83; N, 5.31. Found: C, 50.21; H, 6.91; N, 5.28.

$^1$H NMR ($CDCl_3$, ppm), 8.05-8.09d (9.0); 8.33-8.36d (9.0) (-$CH_2$-$CH_2$-), 7.59-7.71m ($NO_2$-$C_6H_4$), 7.28s (-NH), 0.89t, 1.26-1.67m (Sn-$C_4H_9$). $^{13}$C NMR ($CDCl_3$, ppm), 137.5 (C-1), 132.9 (C-2/6), 134.7 (C-3/5), 126.5 (C-4), 167.9 (C-7), 124.9 (C-8), 118.7 (C-9), 175.6 (C-10), 29.6 (C-11), 27.7 (C-12), 26.8 (C-13), 13.5 (C-14).

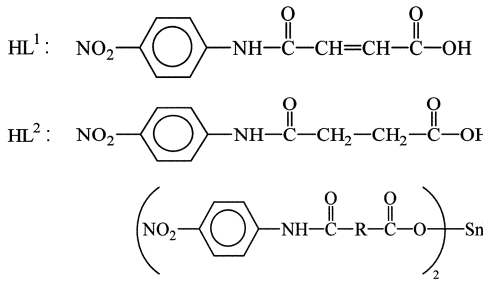
IR (KBr, $cm^{-1}$), 3356s $\nu$ (NH), 1701s $\nu$ (C=O), 1558s $\nu$ ($COO_{asym}$), 1379s $\nu$ ($COO_{sym}$), $\Delta\nu$ 179, 520m $\nu$ (Sn-C), 433w $\nu$ (Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 470 (17), $RSnOOCR'$ 413 (2), $SnOOCR'$ 356 (6), $R_3Sn^+$ 290 (14), $R_2Sn^+$ 233 (41), $C_6H_5^+$ 76 (2), $[Sn]^+$ 120 (13), $C_3H_4O^+$ 55 (49), $[R_2SnOOCCH_2CH_2]^+$ 220 (14), $C_7H_5O_3N^+$ 165 (18), $CNHO^+$ 43 (47), $C_3H_5NO^+$ 71 (19), $[C_6H_5]^+$ 77 (11), $C_6H_5N_2O_2^+$ 138 (17), $C_4H_9^+$ 57 (100). $\delta$ ($^{119}$Sn) ppm; 157.2.

**$Ph_3Sn(L^2)$ (12):** 3-[N-(4-nitro-phenylamido]propanoic acid (1 g, 4.20 mmol) was suspended in dry toluene (100 mL) and treated with triethylamine (0.58 mL, 4.20 mmol). The mixture was refluxed for 2-3 hours. To a solution of triethylammonium 3-[N-(4-nitrophenyl)amido]propanoate in dry toluene, triphenyltin chloride (4.20 mmol) was added as a solid to a reaction flask with constant stirring and reaction mixture was refluxed for 8-10 hours. The reaction mixture contained $Et_3NHCl$ was filtered off such that filtrate had the organotin(IV) derivative. The solvent was removed through rotary apparatus under reduced pressure. The mass left behind was recrystallized from $CHCl_3$ and pet.ether (1 : 1). Yield 88%, m.p. 105 °C. Analysis: Calculated for $C_{28}H_{24}N_2O_5Sn$: C, 57.24; H, 4.08; N, 4.77. Found: C, 57.29; H, 4.02; N, 4.73.

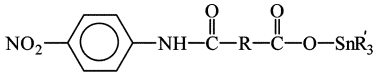
$^1$H NMR ($CDCl_3$, ppm), (8.07-8.10d (9.0); 8.32-8.34d (9.0) (-$CH_2$-$CH_2$-), 7.61-7.65m ($NO_2$-$C_6H_4$), 7.27s (-NH), 7.43-7.44m (Sn-$C_6H_5$). $^{13}$C NMR ($CDCl_3$, ppm), 137.3 (C-1), 132.2 (C-2/6), 134.8 (C-3/5), 126.3 (C-4), 167.4 (C-7), 124.6 (C-8), 118.9 (C-9), 177.6 (C-10), 136.1 (C-11), 135.8 (C-12), 129.1 (C-13), 125.4 (C-14).

IR (KBr, $cm^{-1}$), 3386s $\nu$ (NH), 1720s $\nu$ (C=O), 1599s $\nu$ ($COO_{asym}$), 1429s $\nu$ ($COO_{sym}$), $\Delta\nu$ 170, 446m $\nu$ (Sn-O). Mass data m/z(%); $R_2SnOOCR'$ 510 (n.o), $RSnOOCR'$ 433 (n.o), $SnOOCR'$ 356 (20), $R_3Sn^+$ 347 (53), $R_2Sn^+$ 271 (12), $C_6H_5^+$ 76 (3), $[Sn]^+$ 120 (24), $C_3H_4O^+$ 55 (n.o), $[R_2SnOOCCH_2CH_2]^+$ 220 (n.o), $C_7H_5O_3N^+$ 165 (n.o), $CNHO^+$ 43 (3), $C_3H_5NO^+$ 71 (5), $[C_6H_5]^+$ 77 (100), $C_6H_5N_2O_2^+$ 138 (21). $\delta$($^{119}$Sn) ppm; −46.7.

General chemical reactions are given in Scheme 1 and numbering for NMR is given in Scheme 2.



| Comp. No. | R | R′ |
|---|---|---|
| (**1**) | –CH=CH– | Me($CH_3$) |
| (**2**) | –CH=CH– | Ph($C_6H_5$) |
| (**3**) | –CH=CH– | Oct($C_8H_{17}$) |
| (**4**) | –$CH_2$–$CH_2$– | Me($CH_3$) |
| (**5**) | –$CH_2$–$CH_2$– | Bu($C_4H_9$) |
| (**6**) | –$CH_2$–$CH_2$– | Oct($C_8H_{17}$) |



| Comp. No. | R | R′ |
|---|---|---|
| (**7**) | –CH=CH– | Me($CH_3$) |
| (**8**) | –CH=CH– | Bu($C_4H_9$) |
| (**9**) | –CH=CH– | Ph($C_6H_5$) |
| (**10**) | –$CH_2$–$CH_2$– | Me($CH_3$) |
| (**11**) | –$CH_2$–$CH_2$– | Bu($C_4H_9$) |
| (**12**) | –$CH_2$–$CH_2$– | Ph($C_6H_5$) |

**Scheme 1**

$$R_2SnO + 2HL \xrightarrow[\text{Reflux 8-10 hrs.}]{\text{Toluene}} R_2SnL_2 + H_2O \quad (1)$$

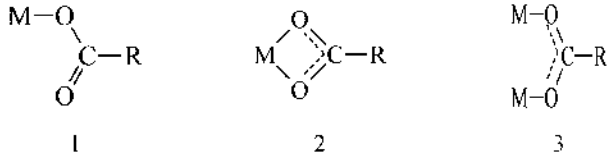
$$R_2SnCl_2 + 2Et_3NHL \xrightarrow[\text{Reflux 8-10 hrs.}]{\text{Toluene}} R_2SnL_2 + 2Et_3NHCl \quad (2)$$

$$R_3SnCl + Et_3NHL \xrightarrow[\text{Reflux 8-10 hrs.}]{\text{Toluene}} R_3SnL + Et_3NHCl \quad (3)$$

HL = $HL^1$ and $HL^2$

## Results and Discussion

With few exceptions all the complexes are coloured solids.



**Scheme 3**. Possible coordination modes of carboxylate group to metal.

They are slightly soluble in cold methanol and *n*-hexane but freely soluble in DMSO and $CHCl_3$. The complexes have sharp melting points. The metal derivatives are stable at room temperature and are non-hygroscopic.

**Infrared Spectra.** The FTIR data are consistent with the formation of compounds with the composition $R_2SnL_2$ and $R_3SnL$. The carboxylate group ligands coordinate to metal ions by different modes as shown in Scheme 3.[34]

Disappearance of a broad band in the spectra of the complexes in the region 2800-2200 $cm^{-1}$, which was present in free ligands as a weak intensity band, suggests the deprotonation of the free COOH group upon complexation.

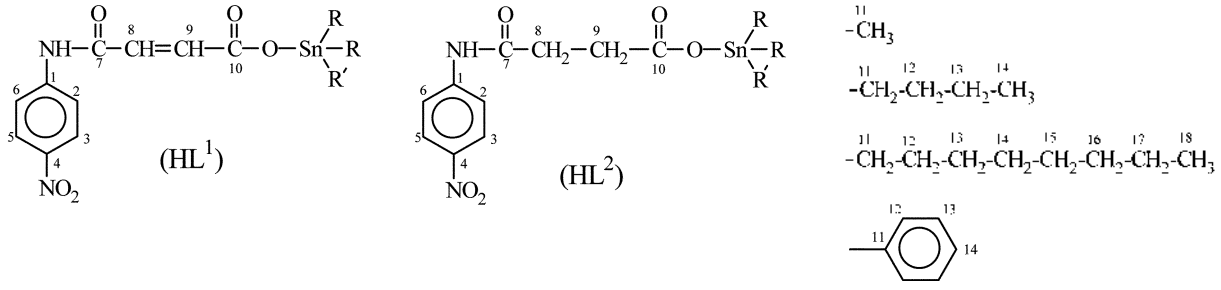
The presence of Sn-C absorption bands in all complexes in the region 520-580 $cm^{-1}$ confirms the formation of Sn-C bond in all complexes.

The appearance of very weak and wide band in the region of 405-480 $cm^{-1}$ assigned to $\nu_{asym}$(Sn-O), indicate the formation of Sn-O bond.

The carboxylate group generally adopts a bridged structure in the solid state unless the organic substituents at the tin atom are bulky or the carboxylate group is branched at $\alpha$-carbon.[35] The IR absorption spectra indicate that $\nu_{asym}$(COO) values (1520-1599 $cm^{-1}$) and $\nu_{sym}$(COO) values (1379-1465 $cm^{-1}$) reveal the strong interaction between the oxygens and the tin atom. The magnitude of the ($\nu_{asym}$-$\nu_{sym}$)COO = ($\Delta\nu$) separation, which has been shown to be useful in identifying structural features, lies in the range 142-182 $cm^{-1}$ which confirm the bidentate nature of the ligand.[36]

**Mass Spectrometry.** Molecular ion peak was exceptionally observed in some of the complexes. All compounds lose an alky or aryl group first, followed by elimination of $CO_2$ and other neutral species which ultimately gives $C_6H_5^-$. Another possible route is disintegration of the ligand and stepwise elimination of R groups to give $Sn^-$ as the end product.

Base peak in the compounds (**1**)-(**3**) is due to fragment $[C_6H_5O_2N_2]^+$ at m/z 138 (100), while in compounds (**4**), (**5**)

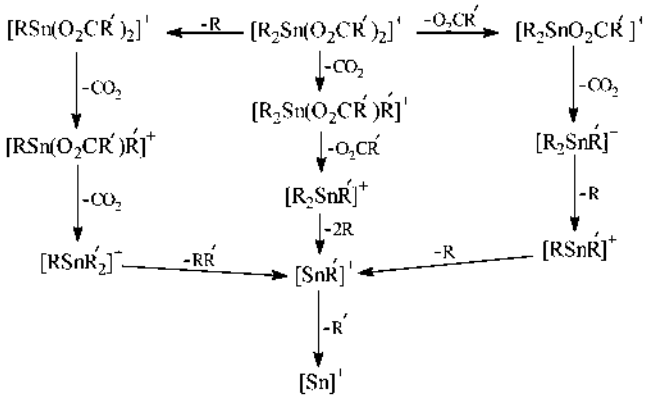


**Scheme 2**

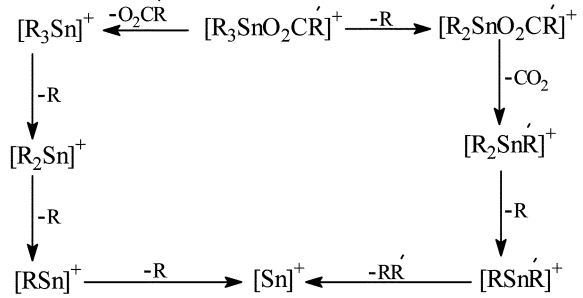
and (**6**), it is due to $[R_2SnOOCCH_2CH_2]^+$ at m/z 220 (100), $[C_4H_9]^+$ at m/z 57 (100), $[CH_2CH_2CO]^-$ at m/z 55 (100), respectively. In triorganotin(IV) derivatives, (**7**)-(**12**), base peak is due to fragment $[SnOOCR']$ at m/z 356 (100), $[R_2SnOOCR']$ at m/z 469 (100), $[SnOOCR']$ at m/z 351 (100), $[NHC_6H_4NO_2]^+$ at m/z 138 (100), $[C_4H_9]^+$ at m/z 57 (100) and $[C_6H_5]^+$ at m/z 77 (100), respectively. General fragmentation patterns are given as Schemes 4 and 5.

**Nuclear Magnetic Resonance Spectra.** The $^1H$ NMR spectra of the complexes exhibit the useful features and observed chemical shifts are reported in Experimental Section.

In studied complexes, the CO(OH) resonance of the ligands is absent which suggests the replacement of the carboxylic proton by the organotin(IV) moiety. $^3J$ ($^1H$, $^1H$) values for $HL^1$ compounds (**1**)-(**3**) and (**7**)-(**9**) suggests that protons of acetylene group (HC=HC) are in the cis position. In all diorganotin(IV) and triorganotin(IV) derivatives, the –NH resonance observed as a broad or a sharp weak signal. The aromatic carbon resonances were assigned by comparing experimental chemical shifts with those calculated by the incremental method.[37] In triorganotin carboxylates $^2J[^{119}Sn$-$^1H]$ for compounds (**7**) and (**8**) suggests tetrahedral geometry (Fig. 1(a)) around the tin atom. Unlike the triorganotin carboxylates in solution, the geometry of diorganotin dicarboxylates cannot be defined with certainty because of dynamic process involving in carboxylate oxygens due to competition in their coordination behaviour with the tin atom.[38] However, in the solid state the tin atom is mostly




**Scheme 4**. General fragmentation pattern for $R_2SnL_2^1/R_2SnL_2^2$.




**Scheme 5**. General fragmentation pattern for $R_3SnL^1/R_3SnL^2$.

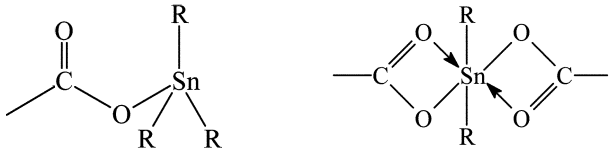



**Figure 1**. Suggested structures of the complexes.

hexa-coordinated in such systems (Fig. 1(b)).[39]

The $^{13}C$ NMR characteristic resonance peaks of the complexes along with the ligands, recorded in $CDCl_3$ are presented in Experimental Section.

The spectra of the organotin(IV) derivatives are consistent with the following observations:

- The resonance of the carboxylic carbon (C-10) in all the compounds move to lower field as compared with the ligands, suggesting the coordination of the ligand, through carboxylic oxygen, to the organotin(IV) moiety.
- The carbon of phenyl and alkyl groups attached to tin are observed at almost similar positions in the experimental data as calculated from incremental method[38] and reported in the literature.[28-32]

In all complexes, $^{119}Sn$ spectra show only a sharp singlet indicating the formation of single species. In general $^{119}Sn$ chemical shifts move to lower frequency with increasing coordination number. Although the shift ranges are somewhat dependent on the nature of the substituents at the tin

**Table 1**. Brine Shrimp (Artemia Salina) Lethality Bioassay[a] for $R_2SnL_2^1/R_2SnL_2^2$ and $R_3SnL^1/R_3SnL^2$

| Comp. No. | Dose (μg/mL) | No. of Shrimps | No. of Survivors | $LD_{50}$ (μg/mL) |
|---|---|---|---|---|
| $HL^1$ | 100 | 30 | 5 | 74.16 |
| | 10 | 30 | 9 | |
| | 1 | 30 | 10 | |
| (**1**) | 100 | 30 | 0 | < 1 |
| | 10 | 30 | 0 | |
| | 1 | 30 | 0 | |
| (**2**) | 100 | 30 | 0 | 7.14 |
| | 10 | 30 | 10 | |
| | 1 | 30 | 30 | |
| (**3**) | 100 | 30 | 10 | – |
| | 10 | 30 | 10 | |
| | 1 | 30 | 10 | |
| (**7**) | 100 | 30 | 10 | – |
| | 10 | 30 | 10 | |
| | 1 | 30 | 10 | |
| (**8**) | 100 | 30 | 0 | 25.94 |
| | 10 | 30 | 8 | |
| | 1 | 30 | 10 | |
| (**9**) | 100 | 30 | 0 | 1.90 |
| | 10 | 30 | 1 | |
| | 1 | 30 | 9 | |

Standard drug; Etoposide
$LD_{50}$ (μg/mL); 7.4625.

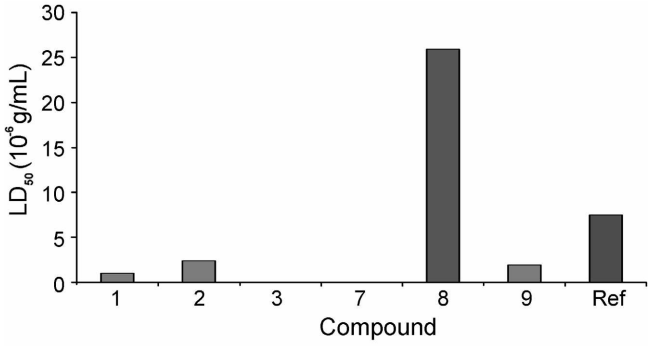



**Figure 2.** Cytotoxic study of organotin(IV) derivatives.

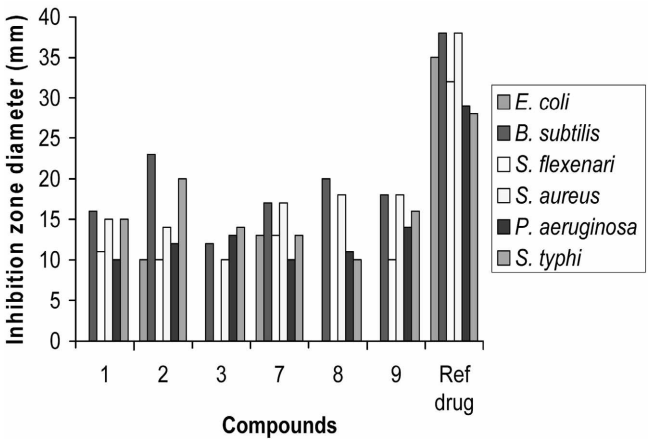



**Figure 3.** Antibacterial activity of organotin(IV) derivatives against various bacteria.

atom. In all the complexes, $^{119}$Sn chemical shifts values lie in the tetrahedral environment around the tin atom in non-coordinated solvents.

**Biological Activity:** $LD_{50}$ data of the compound **(1)**-**(3)** and **(7)**-**(9)** have been determined by the Brine-Shrimp assay method[40] and the results are summarized in Table 1 and Figure 2. Previous reports[41,42] show that the nature of organic group is responsible for the toxicity of organotin compounds. The highest toxicity being shown by the ligand with $LD_{50}$ value 74.16 $\mu$g/mL while the compounds **(3)** and **(7)** do not show any toxicity at all. Antibacterial activity tests of compounds **(1)**-**(3)** and **(7)**-**(9)** were carried out against various bacteria by the "agar diffusion technique".[43] The screening tests show that phenyltin carboxylates are the most potent candidates against the tested bacteria. The activity of the other derivatives varies according to their R groups. However, all of these compounds are active against *Bacillus subtilis*. The results are given in Table 2 and Figure 3.

Compounds **(1)**-**(11)** were also tested for their antifungal activity by the tube diffusion method.[44] The results of antifungal assay are given in Table 3 and Figure 4. It has been shown that the ligand along with its organotin carboxylates are significantly active against all of the tested fungal strains. It has been reported that, within the given series, the triorganotin(IV) derivatives are more active against fungi[45] as compared to diorganotin(IV) derivatives. The insecticidal activity data of the compounds **(4)**-**(6)** and **(10)**-**(12)** are given in Table 4 and Figure 5. It shows that diorganotin(IV) dicarboxylates are found to be inactive against the tested insects while the triorganotin(IV) carboxylates shows the activity. It can be explained as the length or number of R group increases, activity also increases. That's why triorganotin(IV) derivatives show more activity as compared to diorganotin derivatives and butyl derivatives show more activity than methyl derivatives.

**Table 2.** Antibacterial Activity for $R_2SnL_2^1$/$R_2SnL_2^2$ and $R_3SnL^1$/$R_3SnL^2$

| Name of Bacteria | Compound No. | | | | | | | Standard Drug |
|---|---|---|---|---|---|---|---|---|
| | $HL^1$ | **(1)** | **(2)** | **(3)** | **(7)** | **(8)** | **(9)** | |
| *Escherichia coli* | 11 | – | 10 | – | 13 | – | – | Ampicilline $(H_2O)_3$ Cephalexin Na |
| *Bacillus subtilis* | 17 | 16 | 23 | 12 | 17 | 20 | 18 | " |
| *Shigella flexenari* | 11 | 11 | 10 | – | 13 | – | 10 | " |
| *Stephlococcus aureus* | 14 | 15 | 14 | 10 | 17 | 18 | 18 | " |
| *Pseudomonoas aeruginosa* | 10 | 10 | 12 | 13 | 10 | 11 | 14 | " |
| *Salmonella typhi* | 11 | 15 | 20 | 14 | 13 | 10 | 16 | " |

**Table 3.** Antifungal Activity for $R_2SnL_2^1$/$R_2SnL_2^2$ and $R_3SnL^1$/$R_3SnL^2$

| Name of Fungi | Compound No. | | | | | | | | | | | | | Standard Drug |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $HL^1$ | $HL^2$ | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** | **(11)** | |
| *Trichophyton longifusus* | 57.8 | 70 | 78.9 | 45 | 47.3 | 75 | 75 | 75 | 78.9 | 100 | 84.2 | 70 | 70 | Miconazole, Ketoconazole |
| *Candida albicans* | 63.1 | 10 | 0 | 0 | 0 | 10 | 0 | 10 | 68.4 | 100 | 100 | 25 | 0 | Miconazole, Ketoconazole |
| *Aspergillus flavies* | 0 | 60 | 0 | 0 | 10 | 60 | 60 | 70 | 0 | 100 | 100 | 70 | 60 | Ampotericin B, Flucytosine |
| *Microsporum canis* | 40 | 30 | 0 | 40 | 47.3 | 30 | 35 | 40 | 73 | 90 | 88 | 30 | 30 | Miconazole, Ketoconazole |
| *Fusarium solani* | 15 | 30 | 50 | 70 | 0 | 30 | 0 | 10 | 70 | 90 | 80 | 0 | 0 | Ketoconazole |
| *Candida glaberata* | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 10 | 0 | 100 | 94.7 | 0 | 0 | Ketoconazole |

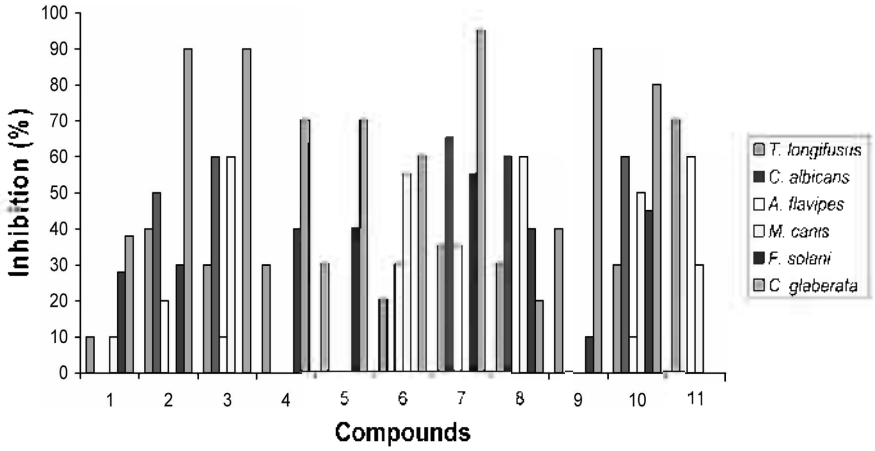



**Figure 4.** Antifungal activity of organotin(IV) derivatives against various fungi.

**Table 4.** Insecticidal activity data for $R_2SnL_2^2$ and $R_3SnL^2$

| Name of Insect | % Mortality (−ve Control) | | | | | | | −ve Control | Standard Drug |
|---|---|---|---|---|---|---|---|---|---|
| | $HL^2$ | (4) | (5) | (6) | (10) | (11) | (12) | | |
| *Tribolium castaneum* | 0 | 0 | 0 | 0 | 20 | 25 | 0 | 100 | Premethrin |
| *Sitophilus oryzae* | 25 | 0 | 0 | 0 | 0 | 25 | 25 | 100 | Premethrin |
| *Rhyzopertha dominica* | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 100 | Premethrin |
| *Callosbrchus analis* | 0 | 0 | 0 | 0 | 20 | 25 | 0 | 100 | Premethrin |

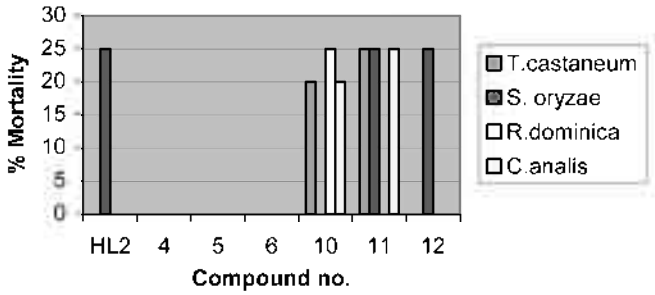



**Figure 5.** Insecticidal activity of organotin(IV) derivatives.

## Conclusion

It was concluded that in solid state organotin(IV) carboxylates have five or six coordination around tin , due to bidentate nature of carboxylates group, while in solution the bidentate carboxylate group is cleaved and the resulting monomer contains four coordinated tin with a tetrahedral arrangement. All complexes show the primary fragmentation due to the loss of the alkyl group followed by elimination of $CO_2$ and the remaining part of the ligand, which leaves $Sn^{+}$ as the end product. Organotin(IV) carboxylates are found to be active against tested Brine Shrimp larvae, bacteria, fungi and the insects.

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