Chapter-4 *Triorganotin (IV) amide*

Section –A: Synthetic Aspects

INTRODUCTION

It is well known that the studies on insect and pest behavior and their control are collectively proceeds in entomology [1]. Insects are found in almost all types of environment. They affect human interest in a number of ways; insects like mosquitoes and housefly spread large number of diseases like malaria, dengue and cholera in addition to painful bites. However, all insects are not harmful; some are beneficial such as honey bee which give us honey and silk worm which provide us silk.

Insecticide is mainly a substance intended for killing, repelling or otherwise preventing treated surface from insects [2]. The use of insecticides started with the discovery of Paris green [3], which was a synthetic compound of arsenic, in 1867 to control the Colorado potato beetle. Until 1939, most of the insecticides were inorganic chemicals [4]. There are a large number of organic [5] and metal organic [6] compounds as insecticides which have made revolutionary change in the field of chemical control. The phenolics [7] and carbamates [8] are the major organic derivatives used as potent insecticides. But later on the introduction of metal based organic derivatives as insecticides made a new revolution in entomology.

Organotin derivatives have emerged as potential biologically active compounds in last 15-20 years. The spectrum of the chemotherapeutic values of organotin compounds has been expanded as they have found their place among a class of potential biologically active compounds [9] exhibiting antimicrobial activity against different kinds of microbial strains [10]. They also show anti-inflammatory and cardiovascular activity [11], trypanosomal activity [12] along with anti-herpes [13] and anti-tubercular activity [14]. In case of control of insect and pest organotin compounds are not much explored because of their solubility reasons.

In order to make this kind of compounds more soluble in water, less complicated structure was designed which contains polar moieties [15]. The introduction of polar groups in the organotin molecules leads to some improvement in the solubility and efficacy of activity. Fluorine containing compounds are more soluble in water and still very soluble in non-polar solvents [16]. The solubility can be increased by preparing salts of organotin compounds [17]. In the present communication a series of new triorganotin compounds were synthesized and tested first time for their insecticidal and pesticidal activity against *Periplanata americana*, *Musca domestica* and *Spodoptera litura* and *Tetranichus urticae* of a pest crop mite and were found highly active against *Spodoptera litura.*

EXPERIMENTAL

The synthesis of organotin compounds was carried out by the earlier reported method [18]. The tetraorganotin compound as a base material can be synthesized by the reaction of respective haloarene with tintetrachloride and sodium metal in inert atmosphere. The preparation of triorganotin (IV) chloride was takes place by cleavage of the base material with anhydrous tintetrachloride by fixing an air condenser without using any solvent and the reaction temperature is maintained at 205-215°C for one hour and then 180°C temperature was maintained for a period of one and half hour. The compounds isolated in pet-ether and recrystalized with the same solvents.

$$4R\text{-}X + SnCl_4 + 8Na \xrightarrow{\text{Toluene/Benzene}} R_4Sn + 4NaX + 4NaCl$$

$$R_4Sn + SnCl_4 \xrightarrow{\text{205-215°C/180°C}} R_3SnCl + RSnCl_3$$

$$R_3SnCl + HL \xrightarrow{Et_3N} R_3SnL + Et_3N.HCl$$

R = (C_6H_5), (C_6F_5), (C_6H_4F),

HL = Succinimide, Phthalimide

The preparation of triorganotin (IV) amides was carried out by the reaction of R_3SnCl and suitable amide in presence of triethylamine, as HCl acceptor, at room temperature under nitrogen atmosphere. The method of preparation of some representative compounds is as follows:-

Reaction of $(C_6H_5)_3SnCl$ with Succinimide (1)

In an oxygen free nitrogen atmosphere, solution of triphenyltin (IV) chloride (0.385gm; 1mmol) in benzene and succinimide (0.099gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

Reaction of $(C_6H_5)_3SnCl$ with Phthalimide (2)

In an oxygen free nitrogen atmosphere, solution of triphenyltin (IV) chloride (0.385gm; 1mmol) in benzene and phthalimide (0.147gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

Reaction of $(C_6F_5)_3SnCl$ with Succinimide (3)

In an oxygen free nitrogen atmosphere, solution of tris (pentafluorophenyl) tin (IV) chloride (0.655gm; 1mmol) in benzene and succinimide (0.099gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in

vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

Reaction of $(C_6F_5)_3SnCl$ with Phthalimide (4)

In an oxygen free nitrogen atmosphere, solution of tris (pentafluorophenyl) tin (IV) chloride (0.655gm; 1mmol) in benzene and phthalimide (0.147gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

Reaction of $(C_6H_4F)_3SnCl$ with Succinimide (5)

In an oxygen free nitrogen atmosphere, solution of tris (*p*-fluorophenyl) tin (IV) chloride (0.439gm; 1mmol) in benzene and succinimide (0.099gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

Reaction of $(C_6H_4F)_3SnCl$ with Phthalimide (6)

In an oxygen free nitrogen atmosphere, solution of tris (*p*-fluorophenyl) tin (IV) chloride (0.439gm; 1mmol) in benzene and

phthalimide (0.147gm; 1mmol) in same solvent were stirred together in presence of triethylamine at room temperature for 4-5 hours. The off white color $Et_3N.HCl$ formed was filtered off and filtrate on evaporation in vaccum gives an off white colour crystaline solid mass which was further recrystalised in pet.ether.

RESULTS AND DISCUSSION

All the newly synthesized compounds were crystalline solids, air stable and soluble in common organic solvents. The compounds were further characterized by using analytical techniques such as elemental analysis, infrared spectroscopy to ascertain their structures and explore their biological properties.

IR Spectra

The IR spectra of new organotin compounds were recorded in a Perkin–Elmer spectrophotometer in 4000-200 cm^{-1}range. The IR spectra of compound show absorption bands due to phenyl, *p*-fluorophenyl and pentafluorophenyl groups. The absorption frequencies due to carbonyl group (both symmetric and asymmetric) in amide have been fully assigned. The Sn-C vibration in case of phenyl and pentafluorophenyl derivatives corresponding to the y mode and appears in the range of 448-460 cm^{-1}.

Table-1 Physicochemical properties of triorganotin (IV) amides

S.N.	Compounds	Formula	Formula Weight	M.P. (°C)	Yield (%)	Solvent
1	$(C_6H_5)_3Sn$(succinimide)	$C_{22}H_{19}NO_2Sn$	447.71	88	80	Pet.-ether (40-60 ºC)
2	$(C_6H_5)_3Sn$(phthalimide)	$C_{26}H_{19}NO_2Sn$	494.71	80	85	Pet.-ether (40-60 ºC)
3	$(C_6F_5)_3Sn$(succinimide)	$C_{22}H_4NO_2F_{15}Sn$	716.71	95	70	Pet.-ether (60-80 ºC)
4	$(C_6F_5)_3Sn$(phthalimide)	$C_{26}H_4NO_2F_{15}Sn$	764.71	90	75	Pet.-ether (40-60 ºC)
5	$(C_6H_4F)_3Sn$(succinimide)	$C_{22}H_{16}NO_2F_3Sn$	500.71	90	65	Pet.-ether (60-80 ºC)
6	$(C_6H_4F)_3Sn$(phthalimide)	$C_{26}H_{16}NO_2F_3Sn$	548.71	85	70	Pet.-ether (40-60 ºC)

Table -2 Analytical data of triorganotin compounds

S.N.	Molecular Formula	Elemental Analysis			IR (cm^{-1})	
		C (%)	H (%)	N (%)	$V_{asym}(CO)$	$V_{sym}(CO)$
1	$C_{22}H_{19}NO_2Sn$	59.09	4.25	3.13	1706 vs	1308ms
2	$C_{26}H_{19}NO_2Sn$	63.06	3.84	2.82	1758vs	1354ms
3	$C_{22}H_4NO_2F_{15}Sn$	52.72	3.19	2.79	1726ms	1326ms
4	$C_{26}H_4NO_2F_{15}Sn$	56.86	2.91	2.55	1729vs	1329ms
5	$C_{22}H_{16}NO_2F_3Sn$	36.83	0.55	1.95	1732vs	1332ms
6	$C_{26}H_{16}NO_2F_3Sn$	40.79	0.52	1.83	1740ms	1338ms

References:

1. V.G. Dethie, L.B. Browne, C.N. Smith, *J. Eco. Entomol.* 53, 134-136, 1960.
2. E.R. Oatman, J.A. McMurtry, V. Voth, *J. Eco. Entomol,* 60, 1344, 1968.
3. K. Chandrashekhar, N. Srinivas, *J. Entomological, Research,* 27(3), 197-201, 2003.
4. J.M. Bernes, L. Magos, *Organometal. Chem. Rev.*, 3, 137, 1968.
5. R.L. Metcalf, *Organic Insecticides, Interscience, London and New York*, 1995.
6. G.O. Doak, L.D. Freedman, *Wiley Interscience, New York*, 1973.
7. M.B. Isman, O. Koul, A. Luczynski, J. Kaminiski, *J. Agric. Food. Chem.* 38, 1406-1411, 1990.
8. H.R. Krueger, R.D. O'Brien, *J. Eco. Entomol,* 52, 1063, 1959.
9. R. Barbieri, F. Huber, C. Silvestru, G. Ruisi, M. Roosi, G. Barone, A. Paulsen, *Appl. Organomet. Chem.*, 13, 595, 1999.
10. Mala Nath, Rakesh Yadav, G. Eng, True Nguyen Thanh, Ashok Kumar, *J. Organomet.Chem*. 577 (1), 1-8, 1999.
11. C.R Chitamber, J.P. Wereley, *J. Biol. Chem.*, 272, 12151-12157, 1997.

12. P. Collery, H. Millart, M. Pluot, L.J. Anghileri, *Anticancer. Res*., 6, 1085-1088, 1986.

13. P. Collery, L.J. Anghileri, M. Morel, G. Tran, P. Rinjard, J.C. Etienne, *Metal ions in biology and medicine*, 2, 176-177, 1992.

14. H.A. Tajmir-Riahi, M. Naovi, R. Ahmad, *Toxicol. Appl. Pharmacol*; 106, 462-468, 1990.

15. M. Gielen, P. Lelieveld, Vos D. De, H. Pan, R. Willem, M. Biesemans, H.H. Fiebig, *Inorg. Chem. Acta*. 196, 115, 1992.

16. M. Gielen, H. Ma, A. Bouhdid, H. Dalil, M. Biesemans, R. Willem, *Metal Based Drugs*, 4, 193, 1997.

17. M. Gielen, M. Biesemans, A. Elkhloufi, J.M. Piret, R. Willem, *J. Fluorine Chemistry*, 64, 279, 1993.

18. F. Kayser, M. Biesemans, M. Gielen, R. Willem, *Magn. Reson. Chem*., 32, 358, 1994.

Section–B: Biological and Insecticidal Studies

The major interest to study and explore the biomedicinal and insecticidal activity of organotin compounds is considerable structural diversity [1]. The interest in organotin (IV) chemistry has arisen in the past two decades because of their significantly important biological properties. Several di- and tri-organotin species have shown potential as antimicrobial, antitumor and in insect/pest control [2-5]. The amides possess a wide range of biological activities, and their chemistry and pharmacological applications have been extensively investigated in recent past. The more significant bioactivities of a variety of amides and their metal complexes have been reviewed together with proposed mechanisms of action and structure-activity relationships [6, 8].

EXPERIMENTAL

The biomedicinal screening of the entire newly synthesized triorganotin compound was performed by the standard reported methods. The experimental details are as follows:-

Antitumor Activity

The *in-vitro* antitumor activity of these compounds was carried out by MTT-Method [9]. This method was performed to estimate the effect of compounds on the growth of cell. The human breast adenocarcinoma (MCF-7) and mammary cancer (EVSA-7) cell lines were used for this purpose. The

principle behind this assay depends upon the reduction of tetrazoleum salt. The yellow colored tetrazoleum MTT [3-(4,5-dimethylthiazolyl-2)-2, 5-diphenyl tetrazoleum bromide] was reduced partially by metabolically active cells by the action of dehydrogenase enzyme to generate NADH and NADPH as reducing equivalents. The resulting intracellular purple Colour zone was solubilized and quantified by spectrophotometer. The MTT was first dissolved in Phosphate buffer saline at a concentration of 5 mg/ml. The MTT solution (50 µl) was added to each well of 96 well culture plate containing 100 µl of culture medium and incubates at 37°C for 4 hrs. The medium was then removed carefully without disturbing the crystals of purple colored zone. 50 ml of DMSO was then added to each well and mixed thoroughly to dissolve the crystals of the zone. The plate was then read on a micro ELISA plate reader at a wavelength of 570 nm to find out the optical density and cell count value.

Antibacterial Activity

Antibacterial activity of the synthesized compound was carried out by disc diffusion method [10] using ampicilin as standard. The filter paper (Whatmann No.1) sterile disc of 5 mm diameter, impregnated with the test compounds (10 µg/ml of ethanol) along with standard were placed on the nutrient agar plate at 37°C for 24 hrs in BOD incubator. The inhibition zone around the dried impregnated disc was measured after 24 hrs. The activity

was classified as highly active (dia = > 15 mm), moderately active (dia = 10-15 mm) and slight active (dia = 5-10 mm). The diameter less than 5 mm was regarded as inactive.

Antifungal Activity

The antifungal activity of the compound was tested by agar plate diffusion method [11], using ampicilin as standard. Two concentrations of the test compounds viz., 50 and 100 μg/ml were prepared and tested against two pathogenic fungal strains, *Aspergillus flavus* and *Aspergillus nigar*. The one ml of each compound was poured into a Petri dish containing 20-25 ml of molten potato dextrose - agar medium. As the medium solidify, Petri dishes were inoculated at 37°C for 96 hrs in BOD incubator. After 96 hrs the colony diameter was measured and % inhibition was calculated using standard method.

Insecticidal Activity

The insecticidal activity of these compounds was determined against male and female cockroaches (*Periplanata americana*) and housefly (*Musca domestica*) following the method of Nash [12], using acetone as a standard. The 0.1% and 0.5% acetone solution of the compounds were injected between 4^{th} and 5^{th} abdominal segment on the ventral side of the body in cockroaches and sprays on the colony of housefly using microsyrings. A 0.02 ml of acetone was alone injected for control (standard). The treated

insects were kept under observation for 48 hrs at room temperature (No food was given in this period and their knock down value is calculated.

Contact Toxicity against Insect

The contact toxicity of these compounds was carried out by topical application method [13] against larvae of *Spodoptera litura*, which is harmful for Indian crops. First the given compounds were dissolved in acetone and different concentrations were prepared *viz*., 0.06%, 0.12%, 0.25%, 0.50%, and 1.00%. Now each concentration was applied on the dorsal surface of the larvae of insect. About 10 µl of each concentration was applied on each larva. Some of the larvae of insect was treated by acetone alone, were works as control. Now the mortality data was recorded after 24 hrs, and the treated mortality was corrected with control mortality. These corrected mortality data was used for calculation of LC_{50}/LD_{50}.

Stomach Toxicity against Insect

The stomach toxicity of these compounds was carried out by leaf dip method [14]. In this method we used fourth instars larvae of *Spodoptera litura* of an insect which is responsible for the damage of Indian agricultural crops. Ten larvae were used for each replication and three replications were maintained for each concentration. The given compounds were dissolved in acetone and different concentrations were prepared *viz*. 0.06%, 0.12%, 0.25%, 0.50%, and 1.00%. The leaf disc were prepared out of caster leaf and

dipped in various concentrations of the test compounds for thirty seconds. Now air dried the leaf discs to evaporate the excess acetone. (The leaf disc dipped only in acetone was served as control). The mortality data was recorded after 24 hrs, and the treatment mortality was corrected with control mortality. These mortality data was used for calculation of $LC_{50}/LD_{50.}$

Antifeedant Toxicity against Insect

The antifeedant activity of these compounds was also carried out by leaf dip method [14] using fourth instars larvae of *Spodoptera litura*, an insect responsible for the damage of Indian agricultural crops. There are ten larvae were used for each replications and three replications were maintained for each concentration. The given compounds were dissolved in acetone and different concentrations were prepared *viz*. 0.06%, 0.12%, 0.25%, 0.50% and 1.00%. The leaf discs of about 25 cm^2 were prepared and dipped for thirty seconds in various concentrations of the test compounds. Air dried the leaf discs to evaporate the excess acetone and the leaf discs offered for feeding. The insects were allowed to feed for 24 hrs. After 24 hrs leaf area uneaten was measured by using leaf area meter. The differences between leaf area provided and the leaf area uneaten is taken as amount of leaf area consumed. The feeding inhibition was calculated and used for calculation of effective concentration (EC_{50}/LD_{50}).

Acaricidal Toxicity against Mites

The acaricidal activity of these compounds was carried out by leaf dip method [14]. Compounds was dissolved in Acetone and different concentrations were prepared *viz*. 0.001%, 0.005%, 0.05%, 0.1%, 0.5% using 0.2% tween 20 as emulsifier. Leaf discs of Mulberry (5 cm^2 diameter) were dipped in different concentration for 30 seconds. Now air dried the leaf discs to remove the excess of acetone and placed over wet cotton in Petri plate. The adult female mites were released on treated leaf discs and mortality data were recorded after 48 hrs. Mites released on leaf treated only with Acetone and tween 20 emulsifier served as control. The mortality data was used for calculation of $LC_{50}/LD_{50.}$

RESULTS AND DISCUSSION

Antitumor Activity

The antitumor activity of triorganotin (IV) amides was studied against the human breast cancer (MCF-7) and mammary cancer cell lines (EVSA-7). Compound shows moderate to high antiproliferative activity against the cell lines. They inhibit the growth of about 35-40% of tumor. The variation in activity is due to variable kind of carboxylate as ligands. The carboxylate having fluorine contents show higher efficacy. It was found that the compounds generally interact with nitrogenous bases of nucleotides of nucleic acid and inhibit the cell division by interfering the replication and

transcription of DNA molecules. The compounds may also affect the multienzyme complexes responsible for replication and transcription of DNA thus causing a stop of proliferation of the cells.

Antibacterial Activity

The triorganotin compounds were tested for antibacterial activity against three bacterial strains *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Klebsiela pneumoniae* using 10 μg/ml concentration of test compound. All the compounds show moderate to higher activity against the bacterial strains. It was found that compounds having fluoro and pentafluorophenyl ring are more effective because of their water and lipid solubility. The fluorine-containing compounds may generally form complexes with metaloenzymes, particularly those which responsible in basic physiology such as cytochrome oxidase. These compounds may react with peptidoglycan layer of bacterial cell wall and damage it by penetrating in such a manner that the two phenyl ring gets entered inside the cell by puncturing it followed by death of bacterial cell. Some times these compounds in low concentration may cause bacteriostatic condition by slow down the growth of bacteria.

Antifungal Activity

The antifungal activity of these compounds were tested against *Aspergillus flavus* and *Aspergillus niger* using concentrations 50 and 100

μg/ml. Activity of the compound was found variable at lower concentration but at higher concentration compounds show high activity against fungal strains. Presence of nitrogen, phenyl and pentafluorophenyl ring are considered for fungal activity. Compounds generally damage the fungal strains by puncturing the cell wall similarly as in case of bacteria. Water and lipid solubility also increases the activity due to presence of fluorine.

Insecticidal Activity

Insecticidal activity of these compounds was checked against male and female cockroaches (*Periplanata americana*) and housefly (*Musca domestica*) using parathion as a standard. The compound shows higher to moderate activity. The variation in insecticidal activity was due to variation in amide group present in the molecule. They generally affect on nervous system of the insects and causes unconsciousness resulting to death.

Contact Toxicity

The contact activity of these compounds was also tested against the larvae of same insect, *Spodoptera litura,* using different concentration of the compounds. The corrected mortality was calculated to find out the LC_{50} value of the compounds. It was found that the compounds show better activity against the larvae of insects and shows low value of $LC_{50.}$

Stomach Toxicity

The stomach toxicity of these compounds was tested against the larvae of *Spodoptera litura* using different concentration of the compounds, 0.06%, 0.12%, 0.25%, 0.50% and 1.00% .The corrected mortality was calculated for the calculation of lethal concentration/lethal dose (LC_{50}). It was found that the compounds show good activity against the larvae of insect pest. The variation in activity was due to presence of different kinds of amide group as a ligand in the molecule.

Antifeedant Activity

The antifeedant activity of these compounds was tested against the insect *Spodopters litura* larvae using different concentration of the compound and the corrected mortality was calculated to find out the effective concentration (EC_{50}). It was found that compound shows higher to moderate antifeedant activity. It was found that compound having fluorine groups are more effective against the insects.

Acaricidal Activity

Acaricidal activity of these compounds was tested against *Tetranychus urticae* using different concentrations, 0.001 %, 0.005 %, 0.05 %, 0.1 % and 0.5 %. The percentage of corrected mortality was calculated to find out the LC_{50} of these compounds. The results were very surprising that all the compounds show high acaricidal activity against the mite. The

presence of different kind of amide group as ligand in organotin compounds enhances the activity.

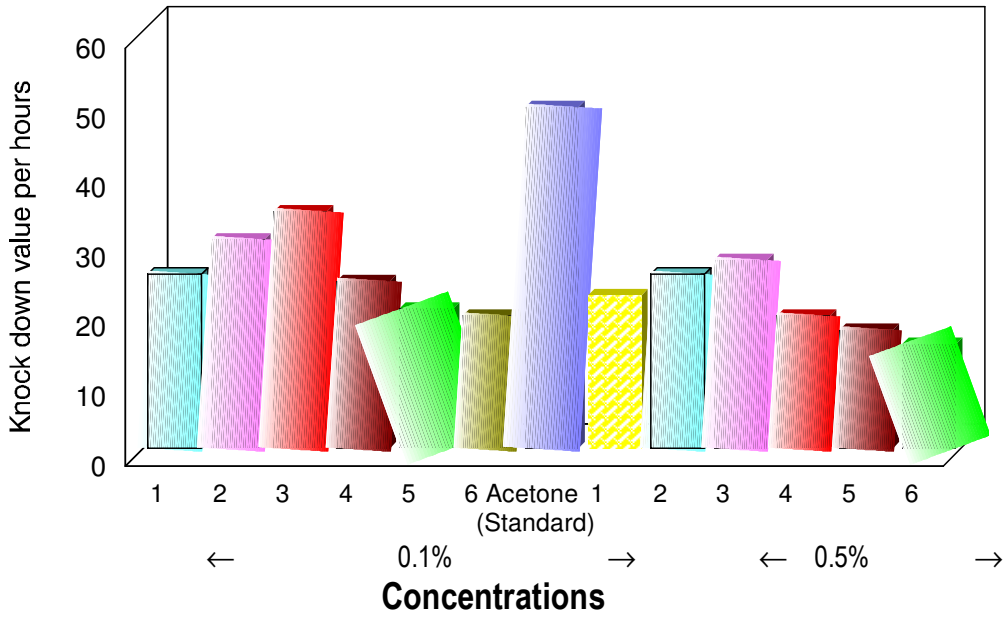

Fig.1 Insecticidal activity of triorganotin (IV) amides

Table-1 Antitumor activity of diorganotin (IV) diamides

S. N.	Compounds	MCF-7 Cell No. x 10^4	EVSA-7 Cell No. x 10^4	Activity
1	$(C_6H_5)_3Sn$(succinimide)	8.79 ± 0.52	8.42 ± 0.46	Positive
2	$(C_6H_5)_3Sn$(phthalimide)	11.59±1.06	11.29±1.02	Negative
3	$(C_6F_5)_3Sn$(succinimide)	9.19±0.92	9.29±0.88	Positive
4	$(C_6F_5)_3Sn$(phthalimide)	8.95±0.67	8.55±0.62	Positive
5	$(C_6H_4F)_3Sn$(succinimide)	9.17 ± 0.90	8.6 7 ± 0.69	Positive
6	$(C_6H_4F)_3Sn$(phthalimide)	8.79 ± 0.52	8.42 ± 0.46	Positive
7	Negative control	10.21±1.01	10.22±1.01	–
8	Positive control	40.26±3.23	41.23±3.28	–

Table-2: Antibacterial activity (Zone of Inhibition (mm) dia. ± S.E)

S. No.	Compounds	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Klebsiela pneumoniae*
1.	$(C_6H_5)_3Sn$(succinimide)	18.66±0.66	07.83±0.44	10.5±0.76
2.	$(C_6H_5)_3Sn$(phthalimide)	17.33±0.6	19.00±0.57	15.00±0.57
3.	$(C_6F_5)_3Sn$(succinimide)	15.66±0.33	16.00±0.57	17.00±0.57
4.	$(C_6F_5)_3Sn$(phthalimide)	08.0±0.28	19.00±0.57	13.00±0.50
5.	$(C_6H_4F)_3Sn$(succinimide)	11.33±0.66	11.00±0.57	08.5±0.29
6.	$(C_6H_4F)_3Sn$(phthalimide)	11.00±0.57	08.10±0.16	12.00±1.15
7.	Ampicilin (standard)	18.72±0.68	18.11±0.32	18.08±0.28

Table-3: Antifungal activity

S. No.	Compounds	*Con.* µg/ml.	*Aspergillus flavus* (dia.mm)	% Inhibition	*Aspergillus niger* (dia.mm)	% Inhibition
1	$(C_6H_5)_3Sn$(succinimide)	50	0.5	83.3	0.8	60.0
		100	0.1	96.7	0.5	75.0
2.	$(C_6H_5)_3Sn$(phthalimide)	50	0.4	86.7	0.5	75.0
		100	0.2	93.3	0.2	90.0
3.	$(C_6F_5)_3Sn$(succinimide)	50	0.6	80.0	0.5	75.0
		100	0.4	86.7	0.2	90.0
4.	$(C_6F_5)_3Sn$(phthalimide)	50	0.8	73.3	0.8	60.0
		100	0.5	83.3	0.4	80.0
5.	$(C_6H_4F)_3Sn$(succinimide)	50	0.7	76.6	0.6	70.0
		100	0.4	86.7	0.1	95.0
6.	$(C_6H_4F)_3Sn$(phthalimide)	50	1.0	66.6	0.5	75.0
		100	0.8	73.3	0.2	90.0
7.	Control		3.0	-	2.0	-

Table-4: Contact Toxicity

S. No.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50}
1.	$(C_6H_5)_3Sn$(succinimide)	1.87-12.07	1.09±0.19	1.62 (3)	3.53
2.	$(C_6H_5)_3Sn$(phthalimide)	1.57-9.32	1.07±0.17	0.72 (3)	2.83
3.	$(C_6F_5)_3Sn$(succinimide)	0.28-0.40	1.96±0.16	4.39 (3)	0.33
4.	$(C_6F_5)_3Sn$(phthalimide)	0.39-0.59	1.67±0.15	5.62 (3)	0.46
5.	$(C_6H_4F)_3Sn$(succinimide)	0.43-0.75	1.63±0.6	2.94 (3)	0.58
6.	$(C_6H_4F)_3Sn$(phthalimide)	1.87-12.07	1.09±0.19	1.63 (3)	3.52

Table-5: Stomach Toxicity

S. No.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1.	$(C_6H_5)_3Sn$(succinimide)	1.61-9.55	1.45±0.17	0.68 (3)	2.97
2.	$(C_6H_5)_3Sn$(phthalimide)	0.86-1.99	1.28±0.16	0.80 (3)	1.20
3.	$(C_6F_5)_3Sn$(succinimide)	0.49-0.76	1.57±0.16	2.78 (3)	0.60
4.	$(C_6F_5)_3Sn$(phthalimide)	0.55-0.90	1.48±0.16	3.37 (3)	0.67
5.	$(C_6H_4F)_3Sn$(succinimide)	0.56-0.97	1.33±0.15	0.63 (3)	0.75
6.	$(C_6H_4F)_3Sn$(phthalimide)	0.85-1.82	1.22±0.16	0.72 (3)	1.12

Table-6: Antifeedant Activity

S. No.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1.	$(C_6H_5)_3Sn$(succinimide)	0.82-3.41	1.81±0.14	0.43 (3)	1.35
2.	$(C_6H_5)_3Sn$(phthalimide)	0.68-1.72	1.03±0.14	0.66 (3)	0.98
3.	$(C_6F_5)_3Sn$(succinimide)	0.43-0.87	1.03±0.14	0.34 (3)	0.58
4.	$(C_6F_5)_3Sn$(phthalimide)	0.62-1.42	1.06±0.14	1.07 (3)	0.86
5.	$(C_6H_4F)_3Sn$(succinimide)	0.83-2.33	1.08±0.15	0.79 (3)	1.24
6.	$(C_6H_4F)_3Sn$(phthalimide)	0.72-2.41	0.93±0.14	0.22 (3)	1.13

Table-7: Acaricidal Activity

S. No.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1.	$(C_6H_5)_3Sn$(succinimide)	0.12-0.30	0.78±0.08	1.70 (3)	0.18
2.	$(C_6H_5)_3Sn$(phthalimide)	0.14-0.31	0.96±0.09	7.52 (3)	0.20
3.	$(C_6F_5)_3Sn$(succinimide)	0.05-0.10	0.93±0.08	13.22 (3)	0.06
4.	$(C_6F_5)_3Sn$(phthalimide)	0.04-0.09	0.69±0.06	4.64 (3)	0.05
5.	$(C_6H_4F)_3Sn$(succinimide)	0.05-0.09	0.16±0.09	12.67 (3)	0.07
6.	$(C_6H_4F)_3Sn$(phthalimide)	0.07-0.22	0.76±0.06	5.63 (3)	0.14

References:

1. R. Barbieri, F. Huber, A. Silvestru, G. Ruisi, M. Roosi, G. Barone, R. Barbieri, A. Paulsen, *Appl. Organomet. Chem*., 13, 595, 1999.
2. Mala Nath, Rakesh Yadav, G. Eng., Thanh-True-Nguyen, Ashok Kumar, J. Organomet.Chem. 577(1), 1-8, 1999.
3. D. Kovala-Demertzi, *Journal of Organometallic Chemistry*, vol. 691, no. 8, pp. 1767–1774, 2006.
4. V. Dokorou, D. Kovala Demertzi, J. P. Jasinski, A. Galani, and M. A. Demertzi, *Helvetica Chimica Acta*, vol. 87, no. 8, pp. 1940–1950, 2004.
5. D. Kovala Demertzi, V. N. Dokorou, J. P. Jasinski, et al., *Journal of Organometallic Chemistry*, vol. 690, no. 7, pp. 1800–1806, 2005.
6. S. Tabassum and C. Pettinari, *Journal of Organometallic Chemistry*, vol. 691, no. 8, pp. 1761–1766, 2006.
7. H. Beraldo and D. Gambino, *Mini-Reviews in Medicinal Chemistry*, vol. 4, no. 1, pp. 31–39, 2004.
8. A. G. Quiroga and C. N. Ranninger, *Coordination Chemistry Reviews*, vol. 248, no. 1-2, pp. 119–133, 2004.
9. A.A. Van-de-Loosdrecht. *J. Immunol. Meth.* 174, 311-320, 1994.
10. R.S. Verma, S.A. Imam. *Ind. J. Microbiol*. 13, 45, 1973.
11. J.G. Horshfall, *Bot. Rev.* 5, 357, 1945.

12. R. Nash, *Ann. Appl.* 41, 652, 1952.

13. V.G. Dethie, L.B. Browne, C.N. Smith: *J. Econ. Entomol*. 53, 134-136, 1960.

14. S.D. Deshmukh, M.N. Borle, *Ind. J. Entomol*. 37(1), 11-18, 1976.