Chapter-7 Diorganotin (IV) dicarboxylate

Section –A: Synthetic Aspects

INTRODUCTION

Diorganotin carboxylate derived from carboxylic acids are among the most extensively studied class of compounds owing to their rich structural chemistry. The diverse structural motifs known in this family of compounds are attributed to the ambidentate character of the carboxylate ligands. Steric and electronic attributes of organic substations on tin and/or the carboxylate moiety impart significant influence on the structural characteristics in tin carboxylate. Information on the structures of organotin carboxylate continues to accumulate, and at the same time new applications of such compounds are being discovered in industry, ecology and medicine. Recently, much attention has been focused on their use as metal-based drugs [1-13]. In order to obtain a better insight into how the organotin species behave inside biological system, it is necessary to study their coordination behavior with ligands that can occur in the biological medium. In view of the above we have synthesized some new diorganotin (IV) dicarboxylate of the type R_2SnL_2; where [R= C_6H_5, C_6F_5, C_6H_4F; and L = CH_3COO, CH_2ClCOO, $CHCl_2COO$, CCl_3COO, CF_3COO]. The synthesis of fluorine containing compounds was preferred

due to their high water and lipid solubility which plays a major role in biomedicinal characterization.

EXPERIMENTAL

The synthesis of diorganotin (IV) dicarboxylate was performed in our laboratory with the help of earlier reported methods [14] and following reactions performed step by step.

1. **Synthesis of base materials**

The synthesis of base material would be done by using Wurtz-Fittig reaction. A mixture of tin tetrachloride and freshly distilled organic halide was gradually added to 125 ml of anhydrous boiling benzene/toluene containing suitable amount of freshly drawn sodium wire. The reaction mixture was refluxed for about 2 hrs with occasional shaking and then filtered hot. The residue was extracted twice with boiling benzene. Removal of benzene yielded the white crystalline solid, which was recrystalized with the same solvent.

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

R= C_6H_5, C_6F_5, C_6H_4F;

2. **Synthesis of diorganotin (IV) dichloride**

The synthesis of diaryltin (IV) dichloride was carried out by cleavage of the base material, tetraaryltin, with metal halides at 180°C for two hour by

fixing an air condenser. The semisolid mass was extracted with hot pet-ether (40-60°C) and recrystalized with same solvent.

$$R_4Sn + SnCl_4 \xrightarrow{180°C} 2R_2SnCl_2$$

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

3. Synthesis of diorganotin (IV) dicarboxylate

In an oxygen free inert atmosphere the compounds were synthesized by using the suitable diorganotin (IV) dihalide and respective carboxylic acid in presence of triethylamine at room temperature for about 4-5 hours. The $Et_3N.HCl$ formed would be filtered off and the filtrate on concentration in vacuum yielded crystalline solid, which was recrystalized from petroleum ether (40-60°C) to afford the pure compounds.

$$R_2SnCl_2 + 2HL \xrightarrow{2Et_3N} R_2SnL_2 + 2Et_3N.HCl$$

HL = Carboxylic acids

The method of preparation of compounds is as follows:-

Reaction of $(C_6H_5)_2SnCl_2$ with CH_3COOH (1)

In an oxygen free nitrogen atmosphere, a solution of diphenyltin (IV) dichloride (0.344gm; 1mmol) in benzene and acetic acid (0.120gm; 2mmol) 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 $(C_6H_5)_2SnCl_2$ with $CH_2ClCOOH$ (2)

In an oxygen free nitrogen atmosphere, a solution of diphenyltin (IV) dichloride (0.344gm; 1mmol) in benzene and chloroacetic acid (0.190gm; 2mmol) 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 $(C_6H_5)_2SnCl_2$ with $CHCl_2COOH$ (3)

In an oxygen free nitrogen atmosphere, a solution of diphenyltin (IV) dichloride (0.344gm; 1mmol) in benzene and dichloroacetic acid (0.258gm; 2mmol) 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 $(C_6H_5)_2SnCl_2$ with CCl_3COOH (4)

In an oxygen free nitrogen atmosphere, a solution of diphenyltin (IV) dichloride (0.344gm; 1mmol) in benzene and trichloroacetic acid (0.328gm; 2mmol) 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 $(C_6H_5)_2SnCl_2$ with CF_3COOH (5)

In an oxygen free nitrogen atmosphere, a solution of diphenyltin (IV) dichloride (0.344gm; 1mmol) in benzene and trifluoroacetic acid (0.228gm; 2mmol) 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 $(C_6F_5)_2SnCl_2$ with CH_3COOH (6)

In an oxygen free nitrogen atmosphere, a solution of bis(pentafluorophenyl)tin (IV) dichloride (0.524gm; 1mmol) in benzene and acetic acid (0.120gm; 2mmol) 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 $(C_6F_5)_2SnCl_2$ with $CH_2ClCOOH$ (7)

Under nitrogen atmosphere, a solution of bis (pentafluorophenyl) tin (IV) dichloride (0.524gm; 1mmol) in benzene and chloroacetic acid (0.190gm; 2mmol) 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 $(C_6F_5)_2SnCl_2$ with $CHCl_2COOH$ (8)

In an oxygen free nitrogen atmosphere, a solution of bis(pentafluorophenyl)tin (IV) dichloride (0.524gm; 1mmol) in benzene and dichloroacetic acid (0.258gm; 2mmol) 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 $(C_6F_5)_2SnCl_2$ with CCl_3COOH (9)

In an oxygen free nitrogen atmosphere, a solution of bis(pentafluorophenyl)tin (IV) dichloride (0.524gm; 1mmol) in benzene and trichloroacetic acid (0.328gm; 2mmol) 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 $(C_6F_5)_2SnCl_2$ with CF_3COOH (10)

In an oxygen free nitrogen atmosphere, a solution of bis(pentafluorophenyl)tin (IV) dichloride (0.524gm; 1mmol) in benzene and trifluoroacetic acid (0.228gm; 2mmol) 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 $(C_6H_4F)_2SnCl_2$ with CH_3COOH (11)

In an oxygen free nitrogen atmosphere, a solution of bis (*p*-fluorophenyl)tin (IV) dichloride (0.380gm; 1mmol) in benzene and acetic acid (0.120gm; 2mmol) 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 $(C_6H_4F)_2SnCl_2$ with $CH_2ClCOOH$ (12)

In an oxygen free nitrogen atmosphere, a solution of bis (*p*-fluorophenyl)tin (IV) dichloride (0.380gm; 1mmol) in benzene and chloroacetic acid (0.190gm; 2mmol) 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 $(C_6H_4F)_2SnCl_2$ with $CHCl_2COOH$ (13)

In an oxygen free nitrogen atmosphere, a solution of bis (*p*-fluorophenyl)tin (IV) dichloride (0.380gm; 1mmol) in benzene and dichloroacetic acid (0.258gm; 2mmol) 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 $(C_6H_4F)_2SnCl_2$ with CCl_3COOH (14)

In an oxygen free nitrogen atmosphere, a solution of bis (*p*-fluorophenyl)tin (IV) dichloride (0.380gm; 1mmol) in benzene and trichloroacetic acid (0.328gm; 2mmol) 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 $(C_6H_4F)_2SnCl_2$ with CF_3COOH (15)

In an oxygen free nitrogen atmosphere, a solution of bis (*p*-fluorophenyl)tin (IV) dichloride (0.380gm; 1mmol) in benzene and trifluoroacetic acid (0.228gm; 2mmol) 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, NMR spectrometry, to ascertain their structures and explore their properties.

Infrared Spectroscopy

The Infrared spectra of the carboxylic acids and synthesized compounds have been recorded from their KBr pellets in range 4000-400 cm^{-1}. The coordinating mode of the carboxylic acids towards the diorganotin (IV) moieties can be compared by the infrared spectra of free acids and synthesized organotin compounds. Frequencies assigned to $\nu_{asym}(COO)$ and $\nu_{sym}(COO)$ have been identified in free acids and the synthesized

compounds. The main feature observed in the spectra of all the compound is the absence of the broadband in range 2504-3034 cm^{-1}, which appears in free acid as ν(O-H)-position thus indicating the metal-acid bond formation through this site. The values of IR stretching vibration frequencies of carboxyl groups [ν_{asym}(COO) and ν_{sym}(COO)] in diorganotin(IV) dicarboxylate are helpful in the elucidation of the structures and bonding behavior of the ligands. Therefore, attempts have been taken to correlate the values of characteristic vibration frequencies with their precursors.

^{1}H NMR Spectroscopy

^{1}H NMR spectra for synthesized compounds and free acids have been recorded in $CDCl_3$ and DMSO solution. The data are consistent with those reported earlier. ^{1}H NMR signals of protons attached to the phenyl, *p*-fluorophenyl moieties have been assigned for determination of structure of the compounds.

^{19}F NMR Spectral Studies

In fluorine containing compounds as for the F-4, two signals appeared at δ143.72 and 144.70 ppm for one and two pentafluorophenyl rings respectively. The coupling of F4 with F2, F6 could not be observed though it was expected. Similarly for F3, F5, two signals appeared at δ 155.48 and 157.8 ppm which are double the intensity of F4 signals. The F2,

F6 also showed two signals at δ124.8 and 128.10ppm. The coupling due to F4 is not observed.

Conclusion

The IR data, $\Delta v = \nu_{asym}(COO) - \nu_{sym}(COO)$ suggest a bidentate coordination mode of the carboxylate ligands. The IR results thus suggested that Sn atom in each diorganotin (IV) carboxylate approaches six coordination. The NMR data in non coordinating solvents revealed that diorganotin (IV) dicarboxylate occur as monomeric entities with hexa-coordinated geometries around the Sn atom.

Table-1 Physicochemical Properties of diorganotin(IV)dicarboxylates

S.N.	Compounds	Formula	M.P (°C)	Yield (%)	Color	Solvent
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	$C_{16}H_{16}O_4Sn$	186	65	Off-white	Pet.Ether
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	$C_{16}H_{14}O_4SnCl_2$	178	68	Off-white	Pet.Ether
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	$C_{16}H_{12}O_4SnCl_4$	182	80	Off-white	Pet.Ether
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	$C_{16}H_{16}O_4SnCl_6$	180	75	Off-white	Pet.Ether
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	$C_{16}H_{16}O_4SnF_6$	162	65	Off-white	Pet.Ether
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	$C_{16}F_{10}H_6O_4Sn$	176	80	Off-white	Pet.Ether
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	$C_{16}F_{10}H_4O_4Sn\ Cl_2$	166	55	Off-white	Pet.Ether
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	$C_{16}F_{10}H_2O_4Sn\ Cl_4$	162	60	Off-white	Pet.Ether
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	$C_{16}F_{10}O_4Sn\ Cl_6$	160	62	Off-white	Pet.Ether
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	$C_{16}F_{16}O_4Sn$	158	65	Off-white	Pet.Ether
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	$C_{16}H_{14}F_2O_4Sn$	182	70	Off-white	Pet.Ether
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	$C_{16}H_{12}F_2O_4SnCl_2$	172	75	Off-white	Pet.Ether
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	$C_{16}H_{10}F_2O_4SnCl_4$	177	65	Off-white	Pet.Ether
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	$C_{16}H_8F_2O_4SnCl_6$	166	82	Off-white	Pet.Ether
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	$C_{16}H_8F_8O_4Sn$	163	65	Off-white	Pet.Ether

Table-2 Analytical data of diorganotin(IV)dicarboxylates

S.N.	Compounds	Formula	Formula Wieght	Elemental Analysis	
				C(%)	H(%)
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	$C_{16}H_{16}O_4Sn$	391	49.10	4.09
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	$C_{16}H_{14}O_4SnCl_2$	460	41.73	3.04
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	$C_{16}H_{12}O_4SnCl_4$	529	36.29	2.26
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	$C_{16}H_{16}O_4SnCl_6$	598	32.10	1.67
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	$C_{16}H_{16}O_4SnF_6$	499	38.47	2.00
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	$C_{16}F_{10}H_6O_4Sn$	571	33.62	1.05
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	$C_{16}F_{10}H_4O_4Sn\ Cl_2$	640	30.00	0.62
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	$C_{16}F_{10}H_2O_4Sn\ Cl_4$	709	27.08	0.28
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	$C_{16}F_{10}O_4Sn\ Cl_6$	778	24.67	-
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	$C_{16}F_{16}O_4Sn$	679	28.27	-
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	$C_{16}H_{14}F_2O_4Sn$	427	44.96	3.27
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	$C_{16}H_{12}F_2O_4SnCl_2$	496	38.70	2.41
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	$C_{16}H_{10}F_2O_4SnCl_4$	565	33.98	1.76
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	$C_{16}H_8F_2O_4SnCl_6$	634	30.28	1.26
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	$C_{16}H_8F_8O_4Sn$	535	35.88	1.49

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Section–B: Biological and Insecticidal Studies

The spectrum of the biomedicinal aspects of organotin compounds has been expanded as they have found their place among a class of potential biologically active compounds [1-4] exhibiting antimicrobial activity against different kinds of microbial strains [5-14]. They also show anti-inflammatory and cardiovascular activity [15], trypanosomal activity [16, 17] along with anti-herpes [18] and anti-tubercular activity [19]. We deal here the biological and insecticidal screening of newly synthesized diorganotin (IV) dicarboxylate. Fluorine based compounds were synthesized because of their higher biological efficacy due to higher water and lipid solubility.

EXPERIMENTAL

The biomedicinal screening of the entire newly synthesized 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 [20]. 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 [21] 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 [22], 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.

Contact Toxicity against Insect

The contact toxicity of these compounds was carried out by topical application method [23] 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 larvae. 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 morality. 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 [24]. 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 [24] 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 [24]. 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 petriplate. 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 diorganotin (IV) dicarboxylate was studied against the human breast cancer (MCF-7) and mammary cancer cell lines (EVSA-7). The 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 antibacterial activity of these compounds was tested against three human pathogenic bacteria: *Pseudomonas auruginosa, Staphylococcus aureus* and *Klebsiela pneumoniae* using 10 μg/ml concentration of the test compound. It was found that compound shows high activity against *pseudomonas auruginosa*, *Klebsiela pneumoniae* and against *Staphylococcus aureus*. The variability in the bacterial activity is due to presence of different kinds of carboxylate group as ligand. The chloride

containing carboxylate ligands are more effective than the simple carboxylate ligands.

Antifungal Activity

The antifungal activity of these compounds was tested against two fungal strains: *Aspergillus flavus* and *Aspergillus niger* at 50 μg/ml and 100 μg/ml respectively of the test compounds. It was so amazing that these compounds show high efficacy against the fungal strains. Again the activity is due to presence of different kinds of carboxylate which shows higher activity against different fungal strains. The presence of chloride group in carboxylate molecule enhances the activity. At 100 μg/ml concentration, all the compounds show high activity against *Aspergillus flavus* and *Aspergillus niger*. The carboxylate ligand definitely plays an important role in controlling the fungal infections.

Contact Toxicity against Insects

The contact activity of diorganotin (IV) dicarboxylate was also tested against the larvae of *Spodoptera litura* insect 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 show low value of LC_{50}. It was found that compounds having chlorine and fluorine based ligands show higher activity against insects.

Stomach Toxicity against Insects

The stomach toxicity of these compounds was also 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 compounds show good activity against the larvae of insect and are much effective. The variation in activity was due to presence of different kinds of carboxylate group in the molecule. The presence of chlorine group in carboxylate ligand increases the activity.

Antifeedant Activity against Insects

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 high antifeedant activity and the compound having acetate, dichloroacetate; trichloroacetate moieties are more effective against the insects.

Acaricidal Activity against Mites

Acaricidal activity of thse 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 carboxylate group as ligand in compounds enhances the activity.

Table-1 Antitumor activity of diorganotin (IV) dicarboxylate

S. No.	Compounds	MCF-7 Cell No. x 10^4	EVSA-7 Cell No. x 10^4	Activity
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	11.69 ± 1.04	11.82 ± 1.06	Negative
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	9.17 ± 0.90	8.6 7 ± 0.69	Positive
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	8.79 ± 0.52	8.42 ± 0.46	Positive
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	12.31±1.02	12.39±1.03	Negative
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	8.95±0.67	8.55±0.62	Positive
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	11.59±1.06	11.29±1.02	Negative
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	9.29±0.88	9.89±0.92	Positive
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	12.79±1.20	12.69±1.16	Negative
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	11.52±1.02	11.82±1.06	Negative
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	9.19±0.92	9.29±0.88	Positive
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	9.17 ± 0.90	8.6 7 ± 0.69	Positive
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	8.95±0.67	8.55±0.62	Positive
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	8.79 ± 0.52	8.42 ± 0.46	Positive
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	11.52±1.02	11.82±1.06	Negative
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	9.19±0.92	9.29±0.88	Positive
16	Negative control	10.21±1.01	10.22±1.01	–
17	Positive control	40.26±3.23	41.23±3.28	–

Table-2: Antibacterial Activity of diorganotin (IV) dicarboxylate

S. N.	Compounds	Control	*Pseudomonas aeruginosa*	*Staphylococcus aureus*	*Klebsiela pneumoniae*
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	–	+++	++	++
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	–	++	+	++
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	–	++	+	++
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	–	++	++	++
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	–	+	++	+
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	–	+++	+	++
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	–	++	+	++
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	–	++	+	+++
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	–	+	+++	++
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	–	+++	++	++
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	–	++	+	++
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	–	++	++	++
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	–	+	++	+
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	–	+++	+	++
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	–	++	+	++

+ = 6-10 mm; ++ = 10-14 mm; +++= >14 mm; – = Inactive

Table-3: Antifungal Activity of diorganotin (IV) dicarboxylate at 50 µg/ml conc.

S. N.	Compounds	*Aspergillus flavus* Col. Dia. (mm)	% Inhibition	*Aspergillus niger* Col. Dia. (mm)	% Inhibition
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	0.7	76.6	0.5	75.0
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	0.5	83.3	0.4	80.0
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.5	83.3	0.4	80.0
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.6	80.0	0.7	65.0
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.7	76.63	0.6	70.0
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	0.8	73.3	0.8	60.0
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.7	76.6	0.7	65.0
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	0.2	93.3	0.7	65.0
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	0.2	93.3	0.7	65.0
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.4	86.7	0.6	70.0
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	0.7	76.63	0.6	70.0
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.8	73.3	0.8	60.0
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	0.7	76.6	0.7	65.0
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.2	93.3	0.7	65.0
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	0.2	93.3	0.7	65.0
16	Control	3.0	–	2.0	–

Table-4: Antifungal Activity of diorganotin (IV) dicarboxylate at 100 µg/ml conc.

S. N.	Compounds	*Aspergillus flavus* Col. Dia. (mm)	% Inhibition	*Aspergillus niger* Col. Dia. (mm)	% Inhibition
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	0.1	96.7	0.2	90.0
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	0.2	93.3	0.1	95.0
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.1	96.7	0.1	95.0
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.4	86.7	0.2	90.0
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.2	93.3	0.2	90.0
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	0.1	96.7	0.4	80.0
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.2	93.3	0.3	75.0
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	0.1	96.7	0.3	75.0
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	0.1	96.7	0.2	90.0
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.2	93.3	0.3	85.0
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	0.1	96.7	0.4	80.0
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.2	93.3	0.3	75.0
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	0.1	96.7	0.3	75.0
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.1	96.7	0.1	95.0
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	0.2	93.3	0.3	85.0
16	Control	3.0	–	2.0	–

Table-5: Contact Toxicity of diorganotin (IV) dicarboxylate

S. N.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	1.87-12.07	1.09±0.19	1.62 (3)	3.53
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	1.57-9.32	1.07±0.17	0.72 (3)	2.83
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.28-0.40	1.96±0.16	4.39 (3)	0.33
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.39-0.59	1.67±0.15	5.62 (3)	0.46
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.43-0.75	1.63±0.6	2.94 (3)	0.58
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	1.87-12.07	1.09±0.19	1.63 (3)	3.52
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.56-1.05	1.32±0.15	0.63 (3)	0.73
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	1.42-3.89	1.32±0.16	2.37 (3)	2.12
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	1.61-9.30	1.07±0.17	0.67 (3)	2.83
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.72-1.46	1.71±0.18	3.32 (3)	0.97
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	1.87-12.07	1.09±0.19	1.63 (3)	3.52
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.56-1.05	1.32±0.15	0.63 (3)	0.73
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	1.42-3.89	1.32±0.16	2.37 (3)	2.12
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.72-1.46	1.71±0.18	3.32 (3)	0.97
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	1.87-12.07	1.09±0.19	1.63 (3)	3.52

Table-6: Stomach Toxicity of diorganotin (IV) dicarboxylate

S. N.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	1.61-9.55	1.45±0.17	0.68 (3)	2.97
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	0.86-1.99	1.28±0.16	0.80 (3)	1.20
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.49-0.76	1.57±0.16	2.78 (3)	0.60
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.55-0.90	1.48±0.16	3.37 (3)	0.67
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.56-0.97	1.33±0.15	0.63 (3)	0.75
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	0.85-1.82	1.22±0.16	0.72 (3)	1.12
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.55-0.97	1.32±0.15	0.69 (3)	0.73
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	1.33-3.99	1.42±0.20	2.38 (3)	2.01
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	1.62-9.39	1.01±0.17	0.69 (3)	2.93
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.74-1.32	1.62±0.18	3.24 (3)	0.94
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	0.85-1.82	1.22±0.16	0.72 (3)	1.12
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.55-0.97	1.32±0.15	0.69 (3)	0.73
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	1.33-3.99	1.42±0.20	2.38 (3)	2.01
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.55-0.90	1.48±0.16	3.37 (3)	0.67
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	0.56-0.97	1.33±0.15	0.63 (3)	0.75

Table-7: Antifeedant Toxicity of diorganotin (IV) dicarboxylate

S. N.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	0.82-3.41	1.81±0.14	0.43 (3)	1.35
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	0.68-1.72	1.03±0.14	0.66 (3)	0.98
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.43-0.87	1.03±0.14	0.34 (3)	0.58
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.62-1.42	1.06±0.14	1.07 (3)	0.86
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.83-2.33	1.08±0.15	0.79 (3)	1.24
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	0.72-2.41	0.93±0.14	0.22 (3)	1.13
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.30-0.47	1.28±0.14	3.42 (3)	0.39
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	0.33-0.61	1.00±0.13	0.68 (3)	0.43
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	0.45-1.09	0.87±0.13	1.71 (3)	0.64
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.49-0.76	1.52±0.16	2.59 (3)	0.58
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	0.72-2.41	0.93±0.14	0.22 (3)	1.13
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.30-0.47	1.28±0.14	3.42 (3)	0.39
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	0.33-0.61	1.00±0.13	0.68 (3)	0.43
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.83-2.33	1.08±0.15	0.79 (3)	1.24
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	0.33-0.61	1.00±0.13	0.68 (3)	0.43

Table-8: Acaricidal Toxicity of diorganotin (IV) dicarboxylate

S. N.	Compounds	Fiducial limits	Slop ± S.E.	Chi. Square	LC_{50}/LD_{50} at 24 hrs.
1	$(C_6H_5)_2Sn(OOC.CH_3)_2$	0.12-0.30	0.78±0.08	1.70 (3)	0.18
2	$(C_6H_5)_2Sn(OOC.CH_2Cl)_2$	0.14-0.31	0.96±0.09	7.52 (3)	0.20
3	$(C_6H_5)_2Sn(OOC.CHCl_2)_2$	0.05-0.10	0.93±0.08	13.22 (3)	0.06
4	$(C_6H_5)_2Sn(OOC.CCl_3)_2$	0.04-0.09	0.69±0.06	4.64 (3)	0.05
5	$(C_6H_5)_2Sn(OOC.CF_3)_2$	0.05-0.09	0.16±0.09	12.67 (3)	0.07
6	$(C_6F_5)_2Sn(OOC.CH_3)_2$	0.07-0.22	0.76±0.06	5.63 (3)	0.14
7	$(C_6F_5)_2Sn(OOC.CH_2Cl)_2$	0.05-0.10	0.78±.0.06	4.64 (3)	0.06
8	$(C_6F_5)_2Sn(OOC.CHCl_2)_2$	0.10-0.23	0.88±0.08	2.14 (3)	0.15
9	$(C_6F_5)_2Sn(OOC.CCl_3)_2$	0.08-0.23	0.65±0.07	6.12 (3)	0.13
10	$(C_6F_5)_2Sn(OOC.CF_3)_2$	0.05-0.10	0.97±0.07	13.23 (3)	0.07
11	$(FC_6H_4)_2Sn(OOC.CH_3)_2$	0.07-0.22	0.76±0.06	5.63 (3)	0.14
12	$(FC_6H_4)_2Sn(OOC.CH_2Cl)_2$	0.05-0.10	0.78±.0.06	4.64 (3)	0.06
13	$(FC_6H_4)_2Sn(OOC.CHCl_2)_2$	0.10-0.23	0.88±0.08	2.14 (3)	0.15
14	$(FC_6H_4)_2Sn(OOC.CCl_3)_2$	0.05-0.09	0.16±0.09	12.67 (3)	0.07
15	$(FC_6H_4)_2Sn(OOC.CF_3)_2$	0.14-0.31	0.96±0.09	7.52 (3)	0.20

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