Synthesis and Properties of Mixed Ligand Complexes of Diorganotin (IV): Part (VI): Synthesis and Characterisation of Antibacterial Benzoylacetato Diorganotin (IV)-O-Alkyl Trithiophosphates

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ABSTRACT

The reaction of diorganotin dichloride with benzoyl acetone and O-alkyl trithiophosphate have been carried out in 1:1:1 molar ratio in refluxing benzene. The newly synthesized complexes $R_2Sn[PhCOCHCOMe][SSH(S)POR']$ are found to be non volatile, light yellow coloured crystalline solids, monomeric in nature and highly sensitive towards atmospheric moisture. These complexes were characterized by elemental analysis (S,Sn), molecular weight measurements, IR and NMR (1H , ^{31}P , ^{119}Sn) spectral data. On the basis of spectral studies, the bidentate nature of benzoyl acetate and O-alkyl trithiophosphate moieties and the hexacoordinated nature of tin atom was established. All these newly synthesized compounds were tested for their antibacterial activity against gram positive and gram negative bacteria. All compounds showed good activity against bacteria.

Key words: Diorganotin dichloride, benzoyl acetone, O-alkyl trithiophosphates.

INTRODUCTION

In continuation of our earlier investigations on mixed ligand complexes of diorganotin(IV) /1-4/, the work has been extended to investigate the effect of O-alkyl trithiophosphates on the bonding modes of β -diketonate moiety towards the central tin atom. O-alkyl trithiophosphates contribute an important series of ligands which show an interesting versatility in their chemical bonding modes (e.g. bidentate, chelating / bridging) towards different metals /5/.

The chemistry of metal β -diketonate has been extensively reported in the literature /6,7/. The mixed derivatives of β -diketonate with alkoxides /8/, chlorides /9/, acetates /10/ and alkylxanthates /11/ have been reported in the literature. The mixed derivatives of the type $R_2Sn[OCOCH_3][S_2P(OR)_2]$ have been reported from our laboratory /4/ in which monofunctional bidentate behaviour of the ligand has been established. In

general, β -diketonates show facile reactivity towards metal alkoxide, in which alkoxy group of metal alkoxide is easily replaced by the enolate form of β -diketonate. Diisopropyltin(IV) trithiophosphate and their adducts with nitrogen donor bases have also been reported in the literature /12/. O-alkyl, O-cycloalkyl and O-aryl trithiophosphato derivatives of trimethyl- and tributyl tin(IV) chloride have also been synthesized and characterized by various spectral studies /13/.

The mixed derivatives of diorganotin (IV) with β -diketonates and alkyl trithiophosphates have not been studied so far. In view of the above, it was considered of interest to synthesize and study the chemical bonding modes in these new derivatives. These newly synthesized derivatives showed higher anti-bacterial activity at 500 $\mu\text{g/mL}$ concentration against gram-negative and gram-positive bacteria.

In the present communication, we report the synthesis and spectroscopic properties of mixed ligand complexes of the type $\text{R}_2\text{Sn}[\text{SSH}(\text{S})\text{POR}'][\text{C}_6\text{H}_5\text{COCHCOCH}_3]$.

MATERIALS AND METHODS

Owing to the hygroscopic nature of the mixed ligand complexes, stringent precautions were taken to exclude moisture. Sulphur and tin were estimated gravimetrically as barium sulphate (Messenger's method /14/) and tin oxide, respectively. A Knauer vapour pressure osmometer in chloroform was used for molecular weight determination. FTIR spectra were recorded on a Shimadzu 8201 PC spectrophotometer in the range of $4000\text{--}200\text{ cm}^{-1}$ using CsI cells. ^1H NMR spectra (in CDCl_3) and ^{31}P and ^{119}Sn NMR spectra (in benzene) were recorded on Bruker DRX-300 spectrophotometer using TMS (for ^1H), H_3PO_4 (for ^{31}P) and Me_4Sn (for ^{119}Sn) as external references.

Synthesis of $\text{Me}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POPh}]$

A mixture of dimethyltin dichloride (1.08 g; 4.91 mmole), benzoyl acetone (0.79 g; 4.88 mmole), O-phenyl trithiophosphate (1.46 g; 4.90 mmole) are taken in dry benzene ($\sim 35\text{ mL}$). The reaction mixture is then refluxed for about 10 hours, Precipitate of KCl formed during the course of the reaction, is removed by filtration in anhydrous condition and excess of solvent (benzene) is removed under reduced pressure. A light yellow coloured crystalline solid $\text{Me}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POPh}]$ is obtained, 2.46g yield; 95.35%. Calcd. for $\text{Me}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POPh}]$, S = 18.08%, Sn = 22.41% ; Found: S = 17.95%, Sn = 21.26%.

Details of similar derivatives are also summarized in Table-I.

RESULTS AND DISCUSSION

Diorganotin dichloride, benzoyl acetone and dipotassium salt of O-alkyl trithiophosphate are mixed in stoichiometric ratio and refluxed in dry benzene for ~ 10 hours. Benzoylacetonato diorganotin(IV)-O-alkyl trithiophosphate is formed. The KCl formed is being removed by alkoxy funnel in anhydrous condition.

The complexes thus formed are light-yellow coloured crystalline solids, soluble in common organic solvents, monomeric in nature and are extremely sensitive towards atmospheric moisture.

SPECTRAL STUDIES

IR Spectra :

IR spectra of these complexes have been recorded in the region 4000 – 200 cm⁻¹ (Table-II). A comparison of the IR spectra of these complexes [benzoylacetato diorganotin(IV)-O-alkyl trithiophosphates] with those of the starting materials is as follows:

- (1) A new absorption band in the region 365.8 – 392.4 cm⁻¹ has been assigned to ν_{Sn-S} linkage.
- (2) Appearance of a new sharp band at 442.5 – 458.3 cm⁻¹, assigned to ν_{Sn-O} linkage.
- (3) The strong absorption bands in the region between 1428.3-1474.5 cm⁻¹ and 1567.6-1598.7 cm⁻¹ have been assigned to coordinated $\nu_{C=O}$ and $\nu_{C=C}$ stretching vibrations, respectively.
- (4) A new broad absorption band is observed in the region 2351.2-2382.5 cm⁻¹. This band indicates the presence of a S-H bond in the complexes.
- (5) No absorption band is observed at 1100-1200 cm⁻¹, which indicates that P=O linkage is absent in these newly synthesized compounds and also indicates that the O-alkyl trithiophosphate moiety, in these newly synthesized compounds is present in thiono form, not in thiolo form.
- (6) In these complexes, ν_{P-S} absorption band is shifted towards lower frequency, which indicates that this group is strongly chelated with the central tin atom.

NMR Spectra

¹H :

The PMR spectra of these complexes show characteristic resonance signals for benzoylacetato moiety, alkyl and aryl protons present on tin atom and O-alkyl protons present on phosphorus atom (Table-III). A singlet at δ 2.6 ppm is observed which is due to O-methoxy protons of O-alkyl trithiophosphate moiety in these complexes.

Table I
Synthesis and Characterisation of Benzoylacetone Diorgano in -O- Alkyl Triphenyl phosphates

S No.	R ₂ SnCl ₂ --g. --m mole	R'OPSiK ₂ --g. --m mole	C ₆ H ₅ COCH ₂ COCH ₃ --g. --m mole	R ₂ Sn[SSH(S)POR][PhCOCHCOMe] --g. --% yield	Analysis Sn% found-- (Calc.--) (Calc.--)	Molecular weight found-- (Calc.--)
1	R = Me 0.98 4.45	R' = Me 1.05 4.45	0.72 4.45	Me ₂ Sn[SSH(S)POMe] [PhCOCHCOMe] 2.02 96.65	25.21 20.43 (25.37) (20.47)	—
2	R = Me 1.05 4.77	R' = Et 1.20 4.80	0.78 4.81	Me ₂ Sn[SSH(S)POEt] [PhCOCHCOMe] 2.19 95.22	24.42 19.81 (24.63) (19.87)	463 (483)
3	R = Me 1.13 5.14	R' = Pr ⁱ 1.36 5.15	0.83 5.13	Me ₂ Sn[SSH(S)POPr ⁱ] [PhCOCHCOMe] 2.47 96.86	23.84 19.27 (23.94) (19.31)	471 (497)
4	R = Me 0.98 4.45	R' = Bu ⁱ 1.25 4.49	0.73 4.51	Me ₂ Sn[SSH(S)POBu ⁱ] [PhCOCHCOMe] 2.12 92.98	23.11 18.70 (23.28) (18.79)	—
5	R = Me 1.08 4.91	R' = Pr ⁿ 1.46 4.90	0.79 4.88	Me ₂ Sn[SSH(S)POPh] [PhCOCHCOMe] 2.46 95.35	21.26 17.95 (22.41) (18.08)	—
6	R = Bu 1.02 3.35	R' = Me 0.80 3.38	0.54 3.33	Bu ₂ Sn[SSH(S)POMe] [PhCOCHCOMe] 1.79 96.76	21.41 17.21 (21.51) (17.36)	541 (553)
7	R = Bu 1.08 3.55	R' = Et 0.89 3.56	0.58 3.58	Bu ₂ Sn[SSH(S)POEt] [PhCOCHCOMe] 1.97 98.01	20.87 16.81 (20.99) (16.93)	—

8	R = Bu 1.05 3.45	R' = Pr ⁱ 0.92 3.48	0.56	3.46	Bu ₂ Sn[SSH(S)POPri][PhCOCHCOMe] 1.95 97.01	20.40 (20.48)	16.12 (16.52)	542 (581)
9	R = Bu 1.03 3.39	R' = Bu ⁱ 0.95 3.42	0.55	3.39	Bu ₂ Sn[SSH(S)POBu ⁱ][PhCOCHCOMe] 1.98 98.50	19.86 (20.00)	15.95 (16.13)	—
10	R = Bu 1.10 3.62	R' = Ph 1.09 3.65	0.59	3.64	Bu ₂ Sn[SSH(S)POPh][PhCOCHCOMe] 2.15 96.85	19.21 (19.35)	15.38 (15.61)	—
11	R = Ph 1.13 3.28	R' = Me 0.79 3.35	0.54	3.33	Ph ₂ Sn[SSH(S)POMe][PhCOCHCOMe] 1.55 79.49	19.85 (20.06)	16.01 (16.19)	—
12	R = Ph 1.06 3.08	R' = Et 0.78 3.12	0.50	3.08	Ph ₂ Sn[SSH(S)POEt][PhCOCHCOMe] 1.71 91.44	19.48 (19.60)	15.45 (15.81)	564 (607)
13	R = Ph 1.01 2.94	R' = Pr ⁱ 0.77 2.92	0.48	2.96	Ph ₂ Sn[SSH(S)POPri][PhCOCHCOMe] 1.56 85.71	19.02 (19.16)	15.32 (15.46)	—
14	R = Ph 1.15 3.34	R' = Bu ⁱ 0.93 3.34	0.55	3.39	Ph ₂ Sn[SSH(S)POBu ⁱ][PhCOCHCOMe] 1.96 92.45	18.54 (18.74)	14.93 (15.12)	—
15	R = Ph 1.21 3.52	R' = Ph 1.05 3.52	0.57	3.52	Ph ₂ Sn[SSH(S)POPh][PhCOCHCOMe] 2.25 97.83	17.95 (18.17)	14.41 (14.66)	612 (655)

Table II
I.R. Spectral Data of Benzoylacetonato Diorganotin (IV)-O-Alkyl Trithiophosphates

Compound	ν S-H	ν C=C	ν C=O	ν (P)-O-C	ν P-O-(C)	ν P=S	ν P-S	ν Sn-C	ν Sn-O	ν Sn-S
$R_2Sn[SSH(S)P(OR)]$ [MeCOCHCOPh]										
R=Me; R'=Me	2369.1s	1570.2s	1430.2s	985.5m	865.5m	751.5s	531.5vs	645.2s	448.3s	368.4w
R=Me; R'=Et	2351.2s	1572.4vs	1442.5s	992.9m	870.2br	764.3s	525.4s	662.5vs	445.8s	372.5w
R=Me; R'=Pr	2382.5s	1585.1s	1453.4s	997.7br	881.5m	757.3vs	527.8s	654.2s	443.9vs	377.7w
R=Me; R'=Bu ⁱ	2374.2s	1568.0vs	1435.7vs	1015.5m	868.3m	775.4s	520.5vs	655.2s	449.3s	365.8w
R=Me; R'=Ph	2355.7s	1581.3s	1428.3s	1002.8m	885.5br	768.7s	522.7s	630.8s	458.3vs	368.5w
R=Bu; R'=Me	2363.1s	1595.9s	1438.5s	1004.7m	861.8m	758.3s	532.5s	642.8vs	443.8s	385.4w
R=Bu; R'=Et	2374.3s	1592.4s	1445.6s	1012.5br	878.4m	762.5s	521.4vs	667.7s	453.4vs	390.2w
R=Bu; R'=Pr ⁱ	2368.6s	1578.3vs	1454.8vs	1021.3m	872.5m	774.8vs	535.4s	647.8s	443.4s	366.1w
R=Bu; R'=Bu ⁱ	2361.5s	1574.1s	1435.4s	1018.8br	877.2br	778.3vs	527.3s	641.7vs	457.4s	371.7w
R=Bu; R'=Ph	2378.7s	1583.5s	1474.5vs	1007.3br	882.5m	781.5s	539.2vs	630.4s	450.5vs	382.5w
R=Ph; R'=Me	2371.4s	1596.4vs	1462.3s	1016.9m	889.1br	785.3s	523.8s	633.6vs	446.3s	388.8w
R=Ph; R'=Et	2359.8s	1567.6s	1438.4s	1024.8m	874.4m	772.7s	531.3s	638.5s	456.5s	392.4w
R=Ph; R'=Pr ⁱ	2379.8s	1570.1s	1431.4s	998.3m	867.6m	787.8vs	536.6s	644.5s	451.3s	390.4w
R=Ph; R'=Bu ⁱ	2365.4s	1593.4s	1471.3vs	1021.1br	873.8m	755.1s	537.4vs	651.3s	442.3vs	391.8w
R=Ph; R'=Ph	2371.0s	1598.7vs	1473.5s	1019.5m	884.7br	764.6s	529.0s	656.5vs	446.4s	368.5w

Table III

PMR Spectral Data of Benzoylacetato Diorganotin(IV)-O-Alkyl Trithiophosphates

S.N	Compound	Chemical Shift (δ ppm)
1.	Me ₂ Sn[SSH(S)POMe] [C ₆ H ₅ COCHCOCH ₃]	1.53,s,6H(Sn-CH ₃);2.05,s,3H(CH ₃);2.45,s,3H(OCH ₃); 3.42,s,1H(SH);5.22,s,1H(CH);7.25-7.38,m,5H(C ₆ H ₅)
2	Me ₂ Sn[SSH(S)POEt] [C ₆ H ₅ COCHCOCH ₃]	1.64,s,6H(Sn-CH ₃);2.11,s,3H(CH ₃);2.24-2.38,t, 3H(CH ₃);2.52-2.67, q, 2H(OCH ₂);3.51,s,1H(SH); 5.24,s,1H(CH); 7.28-7.41, m,5H(C ₆ H ₅)
3	Me ₂ Sn[SSH(S)POPr ⁱ] [C ₆ H ₅ COCHCOCH ₃]	2.02,s,9H(Sn-CH ₃ ,CH ₃);2.25-2.32,d,6H(CH ₃ -Pr ⁱ); 2.65-2.81, m, 1H(OCH); 3.38,s,1H(SH);5.13,s,1H(CH); 7.34-7.47, m,5H(C ₆ H ₅)
4	Me ₂ Sn[SSH(S)POBu ⁱ] [C ₆ H ₅ COCHCOCH ₃]	2.01,s,6H(Sn-CH ₃);2.25,s, 3H(CH ₃);2.54-2.61,d, 6H (CH ₃ -Bu ⁱ); 3.15, s, 1H(SH); 3.84-3.95,d,2H(OCH ₂); 4.61-4.78,m, 1H(CH- Bu ⁱ); 5.22, s, 1H(CH);7.21-7.42, m,5H(C ₆ H ₅)
5	Me ₂ Sn[SSH(S)POPh] [C ₆ H ₅ COCHCOCH ₃]	2.24,s,9H(Sn-CH ₃ ,CH ₃);3.51, s, 1H(SH);5.45, s, 1H(CH); 7.12-7.30, m, 5H(C ₆ H ₅); 7.51-7.68,m,5H(OC ₆ H ₅)
6	Bu ₂ Sn[SSH(S)POMe] [C ₆ H ₅ COCHCOCH ₃]	0.82-0.96,t,6H(CH ₃);1.56-1.68,m,12H(Sn-(CH ₂) ₃); 1.98,s,3H(CH ₃);2.35,s, 3H(OCH ₃);3.51,s,1H(SH); 5.12,s,1H(CH);7.18-7.32,m,5H(C ₆ H ₅)
7	Bu ₂ Sn[SSH(S)POEt] [C ₆ H ₅ COCHCOCH ₃]	0.85-0.96,t,6H(CH ₃);1.45-1.57,m,12H(Sn-(CH ₂) ₃);2.02,s,3H(CH ₃); 2.32- 2.43,t, 3H(CH ₃);2.81-2.97,q, 2H(OCH ₂); 3.41, s,1H(SH); 5.23,s, 1H(CH); 7.31-7.45,m,5H(C ₆ H ₅)
8	Bu ₂ Sn[SSH(S)POPr ⁱ] [C ₆ H ₅ COCHCOCH ₃]	0.81-0.89,t,6H(CH ₃);1.52-1.63,m,12H(Sn-(CH ₂) ₃);1.95,s,3H(CH ₃);2.14- 2.21,d,6H(CH ₃ -Pr ⁱ); 3.35,s,1H(SH);3.61-3.77, m,1H(OCH-Pr ⁱ); 5.42, s, 1H(CH);7.24-7.38 ,m,5H(C ₆ H ₅)
9	Bu ₂ Sn[SSH(S)POBu ⁱ] [C ₆ H ₅ COCHCOCH ₃]	0.84-0.97,t,6H(CH ₃);1.49-1.62,m,12H(Sn-(CH ₂) ₃);1.98,s,3H(CH ₃);2.28- 2.39,d,6H(CH ₃ -Bu ⁱ); 3.26,s,1H(SH);3.81-3.92,d,2H(OCH ₂); 4.72-4.91, m, 1H(CH- Bu ⁱ); 5.32,s,1H(CH);7.34-7.47,m,5H(C ₆ H ₅)
10	Bu ₂ Sn[SSH(S)POPh] [C ₆ H ₅ COCHCOCH ₃]	0.85-1.02,t,6H(CH ₃);1.64-1.78,m,12H(Sn-(CH ₂) ₃) ; 1.87, s, 3H(CH ₃); 3.52, s, 1H(SH); 5.39,s,1H(CH); 7.31-7.44,m,5H (C ₆ H ₅); 7.84-7.97, m, 5H(OC ₆ H ₅)
11	Ph ₂ Sn[SSH(S)POMe] [C ₆ H ₅ COCHCOCH ₃]	2.22,s,3H(CH ₃);3.11,s,3H(OCH ₃);3.34,s,1H(SH); 5.28,s,1H(CH);7.38- 7.52,m,15H(C ₆ H ₅)
12	Ph ₂ Sn[SSH(S)POEt] [C ₆ H ₅ COCHCOCH ₃]	2.33,s,3H(CH ₃);2.51,t,3H(CH ₃);2.72-2.84,q,2H(OCH ₂);3.47,s,1H(SH); 5.41, s, 1H(CH);7.42-7.58,m,15H(C ₆ H ₅)
13	Ph ₂ Sn[SSH(S)POPr ⁱ] [C ₆ H ₅ COCHCOCH ₃]	2.13,s,3H(CH ₃);2.24-2.32,d,6H(CH ₃ -Pr ⁱ);2.91-3.03, m, 1H(OCH); 3.48, s, 1H(SH); 5.27,s,1H(CH);7.37-7.52,m,15H(C ₆ H ₅)
14	Ph ₂ Sn[SSH(S)POBu ⁱ] [C ₆ H ₅ COCHCOCH ₃]	2.18,s,3H(CH ₃);2.24-2.46,d,6H(CH ₃ -Bu ⁱ);3.27,s,1H(SH);4.21-4.45, m, 1H(CH-Bu ⁱ);5.22-5.31,d,2H(OCH ₂);5.64,s,1H(CH);7.24-7.43,m,15H(C ₆ H ₅)
15	Ph ₂ Sn[SSH(S)POPh] [C ₆ H ₅ COCHCOCH ₃]	2.24,s,3H(CH ₃);3.45,s,1H(SH); 5.52,s,1H(CH);7.28-7.46, m, 15H(C ₆ H ₅); 7.91-8.13,m,5H(OC ₆ H ₅)

A singlet at $\sim\delta$ 5.4 ppm is due to the CH proton of benzoylacetato moiety. Methyl tin protons give a singlet at $\sim\delta$ 1.62-1.85 ppm and phenyl tin protons give a multiplet at $\sim\delta$ 7.4-7.8 ppm. An overlapping of the multiplets has been observed due to tin –methyl protons with the resonance signals of benzoylacetato moiety.

^{31}P : Only one resonance signal in the region at δ 94.53 to 98.82 ppm is observed in the ^{31}P chemical shift values for these complexes (Table IV). On comparing these values with the parent compound, a downfield shift is observed. This unexpected downfield shift indicates that there is an isomerisation of S-alkyl trithiophosphate to O-alkyl trithiophosphate in these complexes and also indicates that Sn-S-P bond is formed in these complexes.

^{119}Sn : ^1H and ^{31}P NMR spectral results of these complexes show the presence of single species, but ^{119}Sn NMR spectral results for these complexes [benzoylacetato diorganotin(IV)-O-alkyl trithiophosphates] show the presence of three species (Table-IV). A comparison of these values with those of corresponding $\text{R}_2\text{Sn}[\text{PhCOCHCOMe}]_2$ and $\text{R}_2\text{Sn}[\text{SSH}(\text{S})\text{POR}']_2$ compounds indicates that these complexes are also formed with mixed derivative, $\text{R}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POR}']$.

Table IV

^{31}P and ^{119}Sn NMR Spectral Data of Benzoylacetato Diorganotin (IV)-O- Alkyl Trithiophosphate

S.N.	Compound	^{31}P NMR	^{119}Sn NMR		
			I	II	III
1.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	94.53	-173.1	-249.1	-374.8
2.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	94.73	-168.2	-239.3	-367.1
3.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^i][\text{PhCOCHCOMe}]$	95.21	-157.5	-235.4	-361.4
4.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^i][\text{PhCOCHCOMe}]$	96.44	-175.1	-251.7	-370.0
5.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	97.32	-182.4	-280.8	-399.2
6.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	94.78	-176.1	-251.3	-377.1
7.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	95.22	-170.3	-242.2	-368.5
8.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^i][\text{PhCOCHCOMe}]$	95.85	-161.2	-233.4	-364.1
9.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^i][\text{PhCOCHCOMe}]$	96.74	-178.7	-254.2	-372.2
10.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	97.48	-184.4	-282.7	-390.6
11.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	95.94	-177.2	-252.1	-378.2
12.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	96.17	-171.3	-244.5	-370.4
13.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^i][\text{PhCOCHCOMe}]$	96.66	-164.1	-236.6	-367.1
14.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^i][\text{PhCOCHCOMe}]$	97.25	-179.3	-258.3	-375.3
15.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	98.82	-182.5	-284.4	-395.8

❖ The I and III resonance peaks correspond to $\text{R}_2\text{Sn}[\text{SSH}(\text{S})\text{POR}']_2$ and $\text{R}_2\text{Sn}[\text{PhCOCHCOMe}]_2$, respectively.

These spectral results indicate that as a result of disproportionation, the following equilibrium is obtained between these derivatives.

These results also indicate the hexacoordinated nature of tin atom in these complexes. On the basis of spectroscopic studies, following structure can be suggested for benzoylacetono diorganotin(IV)-O-alkyl trithiophosphates.

ANTIBACTERIAL ACTIVITY

All the newly synthesized compounds were screened for their antibacterial activity against gram-negative and gram-positive bacteria (Table-V). The activity was carried out by using the paper disc method. The zone of inhibition was measured in mm. DMF was used as a solvent. The compounds were tested at 500 µg/mL concentration. The observation shows that compounds 10, 13, 14 are more effective against gram-negative bacteria and compounds 5, 11, 12 are more effective against gram-positive bacteria.

$\text{Ph}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POPr}]$
effective against gram negative bacteria

$\text{Bu}_2\text{Sn}[\text{PhCOCHCOMe}][\text{SSH}(\text{S})\text{POPh}]$
effective against gram positive bacteria

Table V
Antibacterial Activity of Benzoylacetono Diorganotin (IV)-O-Alkyl Trithiophosphates
[Zone Of Inhibition Measured In Mm]

S.No.	Compounds	Gram positive bacteria	Gram negative bacteria
1.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	8	28
2.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	10	31
3.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^1][\text{PhCOCHCOMe}]$	15	27
4.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^1][\text{PhCOCHCOMe}]$	12	33
5.	$\text{Me}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	27	29
6.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	11	32
7.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	20	29
8.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^1][\text{PhCOCHCOMe}]$	23	37
9.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^1][\text{PhCOCHCOMe}]$	18	40
10.	$\text{Bu}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	22	43
11.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POMe}][\text{PhCOCHCOMe}]$	29	35
12.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POEt}][\text{PhCOCHCOMe}]$	28	38
13.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POPr}^1][\text{PhCOCHCOMe}]$	25	46
14.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POBu}^1][\text{PhCOCHCOMe}]$	15	41
15.	$\text{Ph}_2\text{Sn}[\text{SSH}(\text{S})\text{POPh}][\text{PhCOCHCOMe}]$	11	32

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