Synthesis and Properties of Mixed Ligand Complexes of Diorganotin(IV): Part(VII) – Synthesis and Characterisation of Some Antibacterial Dibenzoylmethane Diorganotin(IV)-O-alkyl Trithiophosphates

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A series of some new mixed ligand complexes have been synthesized with an objective for evaluation as antimicrobials. Reactions of diorganotin(IV) dichloride with dibenzoyl methane and O-alkyl trithiophosphates in a 1:1:1 molar ratio in refluxing benzene yield products of the type [PhCOCHCOPh]R₂Sn-[SSH(S)POR'] [where R = Me, Bu, Ph; R' = Me, Et, Pr^i , Buⁱ, Ph]. The newly synthesized complexes are light yellow colored crystalline solids, non-volatile, soluble in common organic solvents, monomeric in nature and highly sensitive towards atmospheric moisture. These complexes are characterized by elemental analysis, IR and multinuclear NMR (¹H, ³¹P and ¹¹⁹Sn) spectral studies. Spectral studies of these complexes indicate that dibenzoyl methane and O-alkyl trithiophosphate moieties are bidentate and the central tin atom is hexacoordinated in nature. A few of these compounds were tested for their antibacterial activity using standard drugs.

Keywords: Diorganotin(IV); O-Alkyl trithiophosphate and dibenzoyl methane.

INTRODUCTION

In recent years, considerable interest has been evinced in the field of chemistry of metallic moieties bonded with sulfur ligands such as dithiolates,¹ thio- β -diketonates,² dithiocarbamates³ and O,O'-dialkyl and alkylene dithiophosphates.^{4,5}

Organic trithiophosphate esters have been used as defoliants,⁶ insecticides,^{7,8} nematodicials⁸ and inhibitors⁸ of steel corrosion. The persual of the literature revealed only a few publications of metallic esters of trithiophosphoric acids.⁹⁻¹¹ Trithiophosphates of the element tin have received very little attention to the best of our knowledge.^{12,13} The β -diketonates in general depict a facile reactivity towards metal alkoxides in which the alkoxy group undergoes facile replacement by the enolate form of β -diketonates.^{14,15}

This is a continuation of our earlier investigations on mixed ligand complexes of diorganotin(IV) with O,O'-dialkyl and alkylene dithiophosphates,^{16,17} acetates¹⁸ and Oalkyl trithiophosphates,¹⁹ in addition to β -diketonate moiety. The proposed work has been extended to investigate the effect of the bonding modes of O-alkyl trithiophosphate and dibenzoyl methane moieties towards the central tin atom.

RESULTS AND DISCUSSION

Synthesis of dibenzoyl methane diorganotin(IV)-Oalkyl trithiophosphates have been successfully carried out by the reactions of dialkyltin dichloride with dibenzoyl methane and O-alkyl trithiophosphates in a 1:1:1 molar ratio in dry benzene. The KCl formed during the reaction is removed by filtration in an alkoxy funnel in anhydrous conditions.

$$R_{2}SnCl_{2} + R'OP(S)S_{2}K_{2} + PhCOCH_{2}COPh$$

$$\xrightarrow{dry \ benzene} [PhCOCHCOPh]R_{2}Sn[SSH(S)POR']$$
(where R = Me, Bu, Ph; R' = Me, Et, Prⁱ, Buⁱ, Ph)

The complexes formed are a light yellow colored crystalline solid, soluble in common organic solvents, non-volatile, monomeric in nature and sensitive towards atmospheric moisture.

SPECTRAL ANALYSIS

IR SPECTRA

The tentative assignments of some of the important

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Table 1.	Synthetic and anal	lytical data of dil	benzoyl met	hane diorganoti	in(IV)-O-alkyl trithiophosphat	tes					
	ان میں م	7 900/0			Product			Anal	ysis		Molecular
S.	K25nU12	K UP3h2	LINC	UCH2CUFn	[PhCOCHCOPh]R ₂ Sn[SS	SH(S)POR']	Fou	nd	(Cal	cd.)	weight
NO.	g mmole	g mmo	le g	mmole	90	% yield	%Н	C %	S %	Sn%	round (Calcd.)
	R = Me	R' = Me			[PhCOCHCOPh]Me ₂ Sn[SS	SH(S)POMe]	3.87	40.59	17.88	22.21	
	1.01 4.59	1.08 4.55	9 1.03	4.60	2.28	93.82	(3.95)	(40.68)	(18.08)	(22.41)	
2	R = Me	R' = Et			[PhCOCHCOPh]Me ₂ Sn[St	SH(S)POEt]	4.17	41.72	17.33	21.68	5.30
	1.05 4.77	1.20 4.8() 1.07	4.78	2.45	94.23	(4.22)	(41.83)	(17.61)	(21.83)	(545)
3	$\mathbf{R} = \mathbf{M}\mathbf{e}$	$R' = Pr^{i}$			[PhCOCHCOPh]Me ₂ Sn[S:	SH(S)PoPi ⁱ j	4.41	42.84	16.97	21.06	
	1.12 5.09	1.35 5.11	1.15	5.13	2.67	94.01	(4.47)	(42.93)	(17.17)	(21.29)	
4	R = Me	$R' = Bu^{i}$			[PhCOCHCOPh]Me ₂ Sn[SS	SH(S)POBu ⁱ]	4.64	43.85	16.48	20.54	555
	1.08 4.90	1.36 4.89) 1.10	4.91	2.65	94.31	(4.71)	(43.98)	(16.75)	(20.77)	(573)
5	R = Me	R' = Ph			[PhCOCHCOPh]Me ₂ Sn[S5	[HOPPh]	3.82	46.42	15.98	19.91	
	1.02 4.64	1.38 4.65	3 1.04	4.64	2.63	96.34	(3.88)	(46.54)	(16.19)	(20.07)	
9	R = Bu	R' = Me			[PhCOCHCOPh]Bu ₂ Sn[SS	SH(S)POMe]	5.33	46.70	15.53	19.22	601
	1.12 3.68	0.87 3.69) 0.83	3.70	2.19	96.90	(5.36)	(46.83)	(15.61)	(19.35)	(615)
7	R = Bu	R' = Et			[PhCOCHCOPh]Bu ₂ Sn[SS	SH(S)POEt]	5.51	47.53	14.97	18.67	
	1.18 3.88	0.97 3.85	3 0.87	3.88	2.38	95.90	(5.56)	(47.69)	(15.26)	(18.92)	
8	R = Bu	$R' = Pr^{i}$			[PhCOCHCOPh]Bu ₂ Sn[SS	SH(S)POPr ⁱ]	5.71	48.36	14.68	18.34	615
	1.24 4.08	1.08 4.05	0.91	4.06	1.86	70.92	(5.75)	(48.52)	(14.93)	(18.51)	(643)
9	R = Bu	$R' = Bu^{I}$			[PhCOCHCOPh]Bu ₂ Sn[SS	SH(S)POBu ⁱ]	5.89	49.18	14.52	17.89	638
	1.16 3.81	1.07 3.85	5 0.86	3.84	2.38	94.82	(5.94)	(49.31)	(14.61)	(18.11)	(657)
10	R = Bu	R' = Ph			[PhCOCHCOPh]Bu ₂ Sn[SS	[HOPh]	5.13	51.27	14.02	17.34	
	1.13 3.71	1.11 3.72	2 0.84	3.75	2.40	95.24	(5.17)	(51.40)	(14.18)	(17.58)	
11	$\mathbf{R} = \mathbf{Ph}$	R' = Me			[PhCOCHCOPh]Ph ₂ Sn[SS	SH(S)POMe]	3.80	51.28	14.57	17.99	
	1.01 2.94	0.70 2.96	60.66	2.95	1.86	96.87	(3.82)	(51.30)	(14.66)	(18.17)	
12	$\mathbf{R} = \mathbf{Ph}$	$\mathbf{R'} = \mathbf{Et}$			[PhCOCHCOPh]Ph ₂ Sn[SS	SH(S)POEt]	4.00	51.79	14.17	17.65	651
	1.05 3.05	0.77 3.08	89.0 8	3.08	1.98	97.06	(4.03)	(52.02)	(14.35)	(17.79)	(699)
13	$\mathbf{R} = \mathbf{Ph}$	$R' = Pr^{i}$			[PhCOCHCOPh]Ph ₂ Sn[SS	SH(S)POPr ⁱ]	4.19	52.57	13.94	17.23	662
	1.03 2.99	0.80 3.05	3 0.68	3.03	1.97	96.57	(4.24)	(52.71)	(14.05)	(17.42)	(683)
14	$\mathbf{R} = \mathbf{Ph}$	$R' = Bu^{i}$			[PhCOCHCOPh]Ph ₂ Sn[SS	SH(S)POBu ⁱ]	4.40	53.18	13.58	16.84	
	1.09 3.17	0.88 3.17	7 0.71	3.17	2.15	97.28	(4.45)	(53.37)	(13.77)	(17.07)	
15	$\mathbf{R} = \mathbf{Ph}$	R' = Ph			[PhCOCHCOPh]Ph ₂ Sn[SS	[HOPPh]	3.71	55.11	13.28	16.41	
	1.03 2.99	0.90 3.02	2 0.67	2.99	2.09	97.66	(3.76)	(55.23)	(13.39)	(16.60)	

bands have been made and are recorded in Table 2.

1. Presence of a new sharp absorption band in the region 2379.6-2351.2 cm⁻¹ indicates the formation of an S-H bond which was absent in the parent ligand moiety.

2. The bands present in the region between 1594.9-1568.5 cm⁻¹ and 1471.1-1428.5 cm⁻¹ have been attributed to coordinated vC=C and vC=O stretching vibrations, respectively.

3. Absence of the band in the region $1200-1100 \text{ cm}^{-1}$ indicates that a P=O linkage is absent in these complexes and also indicates that O-alkyl trithiophosphate moiety is present in thiono form, not in thiolo form.

4. Due to strong chelation of the P-S group with the central tin atom, its absorption band shifted towards a lower frequency $(30-40 \text{ cm}^{-1})$.

5. The appearance of one new sharp and one weak intensity band in the regions of 459.8-441.3 cm⁻¹ and 396.3-361.3 cm⁻¹, respectively, indicates the formation of Sn-O and Sn-S bonds, respectively.

NMR SPECTRA

¹H: Characteristic signals in the ¹H NMR spectra of these complexes are summarised in Table 3; PMR spectra of these complexes show characteristic resonance signals due to dibenzoyl methane moiety, alkyl and aryl protons present on tin atom and alkoxy protons present on phosphorus atom. A singlet at δ 2.53 ppm may be assigned to the methoxy protons of O-alkyl trithiophosphate moiety. A singlet at δ 1.57-1.78 ppm and a multiplet at $\sim \delta$ 7.15-7.40 ppm are observed due to tin-methyl and tin-phenyl protons, respectively. The dibenzoyl methane moiety shows a methine (CH) singlet at δ 5.13-5.54 ppm, a multiplet for phenyl protons at δ 7.15-7.40 ppm. The SH proton shows a singlet at $\sim \delta$ 3.17-3.37 ppm.

³¹P: ³¹P NMR spectra shows the presence of a single resonance signal for these complexes in the region of 93.12-98.93 ppm. There is a marked shifting of signal towards downfield by 15-20 ppm from its position in the corresponding parent compounds. This is probably due to the dative bonding $P = S \rightarrow M$ indicative of formation of a strong metal-sulfur bond and also suggests that there is an isomerisation of S-alkyl trithiophosphate to O-alkyl trithiophosphate in these derivatives.

¹¹⁹Sn: In contrast to ¹H and ³¹P NMR spectra which show the presence of a single species, the ¹¹⁹Sn NMR spectra of dibenzoyl methane diorganotin-O-alkyl trithiophosphates show three resonance signals (Table 4). A comparison of

Table 2. I.R. spectral data of dibenzoyl me	thane diorgan	otin(IV)-O-al	kyl trithiophe	sphates						
Compound	vS-H	vC=C	vC=O	v(P)-O-C	vP-O-(C)	vP=S	vP-S	vSn-C	vSn-O	vSn-S
[PhCOCHCOPh]Me ₂ Sn[SSH(S)POMe]	2352.5s	1575.48s	1429.1s	984.8m	871.4m	765.1s	521.4s	644.2s	442.1s	368.1w
[PhCOCHCOPh]Me2Sn[SSH(S)POEt]	2361.2s	1568.5vs	1453.9s	1002.5m	865.2m	754.3s	534.1s	652.5s	453.6vs	375.7w
[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPr ¹]	2354.7vs	1582.8s	1434.5s	1013.2m	882.5m	778.4vs	528.1s	633.5vs	445.3s	385.3w
[PhCOCHCOPh]Me ₂ Sn[SSH(S)POBu ⁱ]	2375.3s	1591.3s	1445.2vs	992.3br	861.3m	773.7s	535.5s	661.3s	447.1s	365.7w
[PhCOCHCOPh]Me2Sn[SSH(S)POPh]	2364.5vs	1584.4s	1462.6s	987.4br	877.8m	768.3s	520.3s	642.4s	458.1s	387.8w
[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POMe]	2351.2s	1569.4vs	1432.2s	995.8m	884.2m	757.8s	538.3s	634.7s	446.4s	376.2w
[PhCOCHCOPh]Bu2Sn[SSH(S)POEt]	2367.7s	1578.1s	1471.1vs	1029.7m	864.8m	764.2vs	539.8s	637.2s	457.2s	393.3w
[PhCOCHCOPh]Bu2Sn[SSH(S)POPr ⁱ]	2371.1s	1572.7s	1453.3s	1013.1m	887.7m	788.3s	524.5vs	648.9vs	450.7s	385.4w
[PhCOCHCOPh]Bu2Sn[SSH(S)POBu ⁱ]	2378.2vs	1582.1vs	1466.4s	1018.8m	871.3m	771.0vs	533.8s	655.3s	443.3s	369.2w
[PhCOCHCOPh]Bu2Sn[SSH(S)POPh]	2357.8s	1594.9s	1458.5s	1007.0m	867.2m	762.6s	536.6s	664.3s	459.2s	392.5w
[PhCOCHCOPh]Ph2Sn[SSH(S)POMe]	2363.3s	1569.6s	1437.7s	1014.4m	876.8m	779.4s	523.3s	639.1s	441.3s	372.6w
[PhCOCHCOPh]Ph ₂ Sn[SSH(S)POEt]	2372.4s	1592.6s	1428.5vs	$998.3 \mathrm{m}$	865.5m	783.8s	528.4s	656.6s	451.6s	387.4w
[PhCOCHCOPh]Ph ₂ Sn[SSH(S)POPr ¹]	2379.6s	1588.7s	1441.0s	1025.8m	882.8m	758.1vs	531.7s	661.7s	459.8s	396.3w
[PhCOCHCOPh]Ph2Sn[SSH(S)POBu ⁱ]	2376.7vs	1573.3s	1470.3s	1016.4m	889.1m	775.7s	537.3s	648.3s	448.3s	377.2w
[PhCOCHCOPh]Ph2Sn[SSH(S)POPh]	2358.8s	1594.5s	1467.4s	1027.9m	873.3m	767.2s	526.6s	651.8s	458.7vs	361.3w

S.No.	Compound	Chemical Shift (δ ppm)
1	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POMe]	1.57, s, 6H (Sn-CH ₃); 2.52, s, 3H (OCH ₃); 3.46, s, H (SH); 5.42, s, 1H (CH); 7.21-7.33, m, 10H (C ₆ H ₅)
2	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POEt]	1.73, s, 6H (Sn-CH ₃); 2.12-2.24, t, 3H (CH ₃); 2.65-2.79, q, 2H(OCH ₂); 3.38, s, 1H (SH); 5.27, s, 1H (CH); 7.24-7.38, m 10H (CH)
3	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPr ⁱ]	ni, 1011 (C ₆ /15) 1.67, s, 6H (Sn-CH ₃); 2.15-2.19, d, 6H (CH ₃); 2.71-2.83, m, 1H (CH-Pr ⁱ); 3.51, s, 1H (SH); 5.54, s, 1H (CH); 7.21-
4	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POBu ⁱ]	 7.37, m, 10H (C₆H₅) 1.78, s, 6H (Sn-CH₃); 2.54-2.58, d, 6H (CH₃); 3.37, s, 1H (SH); 4.37-2.42, m, 1H (CH); 5.12-5.17, d, 2H (OCH₂); 5.54, s,1H (CH); 7.25-7.38, m, 10H (C₆H₅)
5	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPh]	1.69, s, 6H (Sn-CH ₃); 3.21, s, 1H (SH); 5.13, s, 1H (CH); 7.22-7.34, m, 10H (C ₆ H ₅); 7.60-7.75, m, 5H (OC ₆ H ₅)
6	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POMe]	0.71-0.82, t, 6H (CH ₃); 1.65-1.78, m, 12H (Sn-(CH ₂) ₃); 2.53, s, 3H (OCH ₃); 3.41, s, 1H (SH); 5.14, s, 1H (CH); 7.13-7.25, m, 10H (C ₆ H ₅)
7	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POEt]	0.75-0.87, t, 6H (CH ₃); 1.51-1.63, m, 12H (Sn-(CH ₂) ₃); 2.15-2.24, t, (CH ₃); 2.65-2.79, q, 2H (OCH ₂); 3.27, s, 1H (SH): 5.31, s, 1H (CH): 7.29-7.91, m, 10H (C ₂ H ₂)
8	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POPr ⁱ]	(S11, 513, 5, 6, 111 (CH3), 1.22 + 1.54, m, 1011 (C6n3)); 0.81-0.87, t, 6H (CH ₃); 1.72-1.84, m, 12H (Sn-(CH ₂) ₃); 2.21-2.27, d, 6H (CH ₃ -Pr ⁱ); 2.71-2.83, m, 1H (OCH); 3.17, s, 1H (SH); 5.36, s, 1H (CH); 7.24-7.35, m, 10H (C ₆ H ₃)
9	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POBu ⁱ]	0.72-0.78 ,t, 6H (CH ₃); 1.84-1.92, m, 12H (Sn(CH ₂) ₃); 2.12-2.23, t, 6H (CH ₃ -Bu ⁱ); 2.42-2.55, m, 1H (CH-Bu ⁱ); 2.91-2.96, d, 2H (OCH ₂); 3.35, s, 1H (SH); 5.32, s, 1H
10	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POPh]	(CH); 7.21-7.33, m, 10H (C ₆ H ₅) 0.85-0.92, t, 6H (CH ₃); 1.75-1.82, m, 12H (Sn-(CH ₂) ₃); 3.35, s, 1H (SH); 5.42, s, 1H (CH); 7.24-7.36, m, 10H
11	[PhCOCHCOPh]Ph ₂ Sn[SSH(S)POMe]	(C_6H_5) , 7.51-7.67, iii, 5H (OC_6H_5) 2.72, s, 3H (OCH_3) ; 3.31, s, 1H (SH) ; 5.23, s, 1H (CH) ; 7.21-7.33 m 20H (C_2H_5)
12	[PhCOCHCOPh]Ph ₂ Sn[SSH(S)POEt]	2.25-2.31, t, 3H (CH ₃); 2.82-2.91, q, 2H (OCH ₂); 3.13, s, 1H (SH): 5 34 s 1H (CH): 7 24-7 37 m 20H (C ₄ H ₂)
13	[PhCOCHCOPh]Ph ₂ Sn[SSH(S)POPr ⁱ]	2.33-2.40, d, 6H (CH ₃); 2.71-2.83, m, 1H (CH-Pr ⁱ); 3.24, s. 1H (SH); 5.36, s. 1H (CH): 7.15-7.32, m. 20H (C-H ₂)
14	[PhCOCHCOPh] Ph ₂ Sn[SSH(S)POBu ⁱ]	2.31-2.38, d, 6H (CH ₃); 2.45-2.53, m, 1H, (CH); 2.85- 2.92, d, 2H (OCH ₂); 3.31, s, 1H (SH); 5.42, s, 1H (CH); 7.21-7.37, m, 20H (C ₆ H ₅)
15	[PhCOCHCOPh]Ph2Sn[SSH(S)POPh]	3.34, s, 1H (SH); 5.25, s, 1H (CH); 7.25-7.40, m, 20H (C_6H_5) ; 7.62-7.71, m, 5H (OC_6H_5)

Table 3. PMR spectral data of dibenzoyl methane diorganotin(IV)-O-alkyl trithiophosphates

the chemical shift values with those of the corresponding $R_2Sn[C_6H_5COCHCOC_6H_5]_2$ and $R_2Sn[SSH(S)POR']_2$ compounds obtained under similar conditions, indicates the presence of those species with the mixed derivative $R_2Sn[C_6H_5COCHCOC_6H_5][SSH(S)POR']$. The above results indicate that an equilibrium as a result of disproportionation of the following type exists in these derivatives.





ANTIBACTERIAL ACTIVITY

A few synthesized compounds were screened for their antibacterial activity against *E. Coli, Enterococci* and *Klebsiella* using Muller Hinten Agar Media (Hi Media). The activity was carried out using the paper disc method. DMF was used as a solvent. *Imipenem* and *Linezolid* were used as standard drugs for comparison. The compounds were tested at a 1000 μ g/mL concentration. Complex-10 shows maximum activity against *E. coli* while complex-13 exhibits a minimum against it. Against *Enterococci*, maximum activity is exhibited by complex-4 and minimum by complex-10 while against *Klebsiella*, antibacterial action of complex-10 is maximum.

EXPERIMENTAL

Moisture was carefully excluded throughout the experimental manipulation. All the chemicals used during these investigations were of analytical reagent grade. O-alkyl trithiophosphate and their potassium salt were prepared by a method reported earlier. Carbon and hydrogen were estimated by Coleman C, H, N analyzer. Sulfur and tin were estimated gravimetrically as barium sulphate (Messenger's method)¹⁹ and tin oxide, respectively. Molecular weights were determined by Knauer vapour pressure osmometer in chloroform. FTIR spectra were recorded on a Shimadzu 8201 PC spectrophotometer in the range of 4000-400 cm⁻¹ using CsI cells. ¹H NMR spectra (in CDCl₃) and

Table 4. ³¹P and ¹¹⁹Sn NMR spectral data of dibenzoyl methane diorganotin(IV)-O-alkyl trithiophosphates

	Compounds	Chemical Shift (δ ppm)				
S.No		³¹ D NIMD	¹¹⁹ Sn NMR			
_		PINMK	Ι	II	III	
1	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POMe]	93.12	-174.1	-249.3	-371.3	
2	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POEt]	94.23	-166.2	-241.7	-365.1	
3	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPr ⁱ]	96.71	-154.8	-237.8	-360.8	
4	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POBu ⁱ]	97.17	-171.3	-252.6	-368.5	
5	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPh]	98.29	-184.2	-284.9	-395.8	
6	[PhCOCHCOPh]Bu ₂ Sn[SSH(S)POMe]	93.85	-173.5	-253.5	-376.1	
7	[PhCOCHCOPh]Bu2Sn[SSH(S)POEt]	94.73	-168.4	-243.2	-366.3	
8	[PhCOCHCOPh]Bu2Sn[SSH(S)POPr ⁱ]	95.87	-161.9	-239.3	-359.7	
9	[PhCOCHCOPh]Bu2Sn[SSH(S)POBu ⁱ]	96.67	-179.0	-256.5	-369.5	
10	[PhCOCHCOPh]Bu2Sn[SSH(S)POPh]	98.51	186.7	-285.1	-396.5	
11	[PhCOCHCOPh]Ph2Sn[SSH(S)POMe]	94.27	-174.0	-255.2	-378.0	
12	[PhCOCHCOPh]Ph2Sn[SSH(S)POEt]	95.38	-169.3	-247.7	-371.6	
13	[PhCOCHCOPh]Ph2Sn[SSH(S)POPr ⁱ]	96.64	-161.1	-240.3	-356.8	
14	[PhCOCHCOPh]Ph2Sn[SSH(S)POBu ⁱ]	97.71	-176.5	-258.8	-373.1	
15	[PhCOCHCOPh]Ph2Sn[SSH(S)POPh]	98.93	-188.3	-287.9	-398.5	

I and III resonance peaks corresponds to the $R_2Sn[C_6H_5COCHCOC_6H_5]_2$ and $R_2Sn[SSH(S)POR']_2$, respectively.

Table 5. Antibacterial activity of a few dibenzoyl methane diorganotin(IV)-O-alkyl trithiophosphates (zone of inhibition measured in mm)

Comp. No.	Compound	E. coli	Enterococci	Klebsiella
3	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPr ⁱ]	24	18	18
4	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POBu ⁱ]	20	28	15
5	[PhCOCHCOPh]Me ₂ Sn[SSH(S)POPh ⁱ]	20	17	14
9	[PhCOCHCOPh]Bu2Sn[SSH(S)POBui]	18	20	12
10	[PhCOCHCOPh]Bu2Sn[SSH(S)POPh]	28	12	20
12	[PhCOCHCOPh]Ph2Sn[SSH(S)POEt]	19	22	17
13	[PhCOCHCOPh]Ph2Sn[SSH(S)POPr ⁱ]	14	18	10
А	Imipenem	30	12	22
В	Linezolid	10	18	11

 31 P and 119 Sn NMR spectra (in benzene) were recorded on Bruker DRX – 300 spectrophotometer using TMS (for ¹H), H₃PO₄ (for ³¹P) and Me₄Sn (for ¹¹⁹Sn) as external references.

Synthesis of [PhCOCHCOPh]Me₂Sn[SSH(S)POPh]

Dimethyltin dichloride (1.04 g; 4.64 mmole), dibenzoyl methane (1.04 g; 4.64 mmole) and dipotassium salt of O-phenyl trithiophosphate (1.38 g; 4.63 mmole) were mixed in 30 mL benzene. After stirring and refluxing for about 10 hours, precipitate of KCl is formed, is being removed by filtration in alkoxy funnel in anhydrous condition. After removal of excess of benzene in vacuo, the residue was first washed with acetone to give the desired product. Products were recrystallized from acetone/benzene results in the formation of light yellow coloured crystalline solid (2.63 g; 96.34%). (Calcd. for [PhCOCHCOPh]Me₂Sn-[SSH(S)POPh]: C = 46.54%; H = 3.88%; S = 16.19%; Sn = 20.07%; Found: C = 46.42%; H = 3.82; S = 15.98% and Sn = 19.91%).

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