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Organotin (IV) Derivatives of 1-Ethyl-1,4-Dihydro-7-Methyl-4-Oxo-1,8-Naphthyridine-3-Carboxylic Acid (Nalidixic Acid): Synthesis, Structural Elucidation and Biological Activities

Sajjad AHMED, Moazzam Hussain BHATTI, Saqib ALI*, Fiaz AHMED
Department of Chemistry, Quaid-i-Azam University, 45320, Islamabad-PAKISTAN
e-mail: drsa54@yahoo.com

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Organotin carboxylates of the general formulae $R_2SnL_2$and R_3SnL, where R = CH_3, n-C_4H_9, C_6H_5, $CH_2C_6H_5$ and L = 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid), have been prepared. These compounds were characterized by FT-IR, mass and multinuclear NMR (^{1}H, ^{13}C and ^{119}Sn) spectroscopy. The geometry around the tin atom is compared both in solution and in solid state. These compounds were also screened for their antifungal and antibacterial activities.

Key Words: Organotin(IV) complexes, 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8- naphthyridine-3-carboxylic acid (nalidixic acid), Spectroscopic characterization, Biological Activity.

Introduction

The synthesis, characterization (solution and solid) and biological activities of organotin compounds is a continuing field of interest as reflected in recent reviews[1−4]. In fact, the greater use of organometallic compounds of tin than any other element reflects the broad spectrum use of organotin in both biological and non-biological applications.

These applications include potential agricultural biocides, pharmaceutical agents, wood preservatives, polymer chemistry, antifouling paints etc[5].

Several report are available in the literature regarding various therapeutic effects on tumor cells of the organotin compounds[4]. In addition to biological and non-biological applications, rich structural possibilities are opened to both tri- and diorganotin compounds[4,6]. The present investigation is an extension of our previous work on the synthesis, structural characterization and biological activities of organotin(IV) carboxylates[7−12]. The carboxylic acid used in the present work is 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid) (Figure 1).

*Corresponding author

We report here the synthesis and spectral characterization of 8 organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

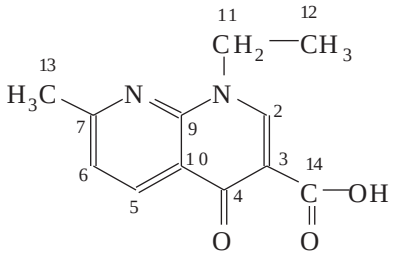


Figure 1. Numbering scheme and structure of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Results and Discussion

Organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid) were prepared by the reaction of the silver salt of the ligand acid with the corresponding organotin(IV) chlorides in 1:2 and 1:1 molar ratios in anhydrous chloroform as given in Equations 1 and 2.

$$R_2SnCl_2 + 2AgL \longrightarrow R_2SnL_2 + 2AgCl \quad (1)$$

R = Me (**1**), n-Bu (**2**), Ph (**3**), Bz (**4**)

$$R_3SnCl + AgL \longrightarrow R_3SnL + AgCl \quad (2)$$

R = Me (**5**), n-Bu (**6**), Ph (**7**), Bz (**8**)

All these complexes are white solids and stable in air. These complexes are soluble in common organic solvents. The synthesized complexes were characterized by elemental analysis (Table 1), infrared, ^{1}H, ^{13}C, ^{119}Sn NMR spectroscopy and mass spectrometry. Bioassay tests against Gram-positive and Gram-negative bacteria and different fungi were carried out to investigate their biological significance.

Table 1. Physical data for organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl- 4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid)[a].

Comp. No.	Compounds	Empirical Formula	M. p. (^{o}C)	Yield %	% C Calc./Found	% H Calc./Found	% N Calc./Found
(1)	Me_2SnL_2	$C_{26}H_{28}O_6N_4Sn$	180-2	54	50.98/51.3	4.58/4.59	9.15/9.12
(2)	Bu_2SnL_2	$C_{32}H_{40}O_6N_4Sn$	207-9	92	55.17/55.1	5.75/5.68	8.06/7.92
(3)	Ph_2SnL_2	$C_{36}H_{32}O_6N_4Sn$	98-100	81	58.69/58.3	4.34/4.41	7.61/7.51
(4)	Bz_2SnL_2	$C_{38}H_{36}O_6N_4Sn$	173-5	35	59.68/59.9	4.71/4.74	7.33/7.37
(5)	Me_3SnL	$C_{15}H_{20}O_3N_2Sn$	82-4	87	45.45/45.4	5.05/5.12	7.07/7.29
(6)	Bu_3SnL	$C_{24}H_{38}O_3N_2Sn$	219-21	30	55.17/55.3	7.28/7.29	5.36/5.41
(7)	Ph_3SnL	$C_{30}H_{26}O_3N_2Sn$	98-100	60	61.86/61.0	4.47/4.49	4.81/4.79
(8))	Bz_3SnL	$C_{33}H_{32}O_3N_2Sn$	120-2	23	63.46/63.5	5.13/5.19	4.49/4.54

[a]Me = CH_3, Bu = n-C_4H_9, Ph = C_6H_5, Bz = $CH_2C_6H_5$

Infrared spectroscopy

The infrared spectra of the synthesized complexes **(1)-(8)** were recorded in the range 4000-400 cm^{-1} using KBr and CsI optics. Important absorption bands are listed in Table 2. Characteristic absorption bands have been identified by comparison with various reported analogue compounds[13].

In the spectra of the complexes, the absence of a broad band in the range 2900-2500 cm^{-1} and the presence of the bands in the range 486-448 cm^{-1} and 574-523 cm^{-1} indicates the deprotonation of the –COOH group and the formation of new Sn-O and Sn-C bonds, respectively[13]. The coordination number of tin affects the absorption vibration frequency of the carboxyl group. The $\Delta\nu$ [$\Delta\nu = \nu(COO)_{as}$-$\nu(COO)_s$] value, which is useful in drawing structural influences in the case of metal carboxylate, is used to determine the nature of bonding of the carboxylate group to tin atoms[14]. According to earlier reports, if this value is comparable to that of the silver salt of the ligand acid, then the carboxylate ion is acting as a bidentate chelate group. It is, therefore, proposed that the carboxylate group in these compounds is acting as a bidentate ligand. Therefore, we suggest a distorted octahedral geometry for diorganotin derivatives in solid state[15] and trigonal bipyramidal structure for triorganotin compounds.

Table 2. Infrared data (cm^{-1}) for organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7- methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

	ν (COO)				
Comp. No.	Asym	Sym	$\Delta\nu$	ν_{Sn-C}	ν_{Sn-O}
AgL	1605	1405	200	-	-
Ligand	1630	1384	266	-	-
(1)	1612	1407	205	574	486
(2)	1611	1410	201	560	462
(3)	1618	1420	198	543	450
(4)	1603	1410	193	562	455
(5)	1600	1400	200	543	479
(6)	1610	1409	201	523	461
(7)	1620	1425	195	539	448
(8)	1617	1415	202	563	486

Multinuclear NMR spectroscopy

The multinuclear NMR data (^1H, ^{13}C and ^{119}Sn) are presented in Tables 3 and 4. In the ^1H NMR spectra, all the protons in the compounds were identified by intensity and multiplicity patterns and the total number of protons calculated form the integration curve are in agreement with the expected molecular composition.

In all compounds signals of the ligand protons were observed within the expected range. In the case of diphenyltin and triphenyltin derivatives a complex pattern is observed in the range δ 7.18–7.89 due to the aromatic protons of phenyl groups of organotin moiety.

The butyl protons also show a complex pattern due to $-CH_2-CH_2-CH_2-$ in the range δ 1.25–1.63 and a clear triplet due to the terminal methyl group around δ 0.88 with (^1H – ^1H) coupling of 8.3 Hz. In di- and tribenzyltin derivatives the methylene protons show singlets at δ 2.53 and 2.59, respectively. In the ^1H NMR spectra of dimethyltin and trimethyltin compounds well resolved [$^2J(^{119}Sn,^1H)$] have been observed at 76 and 61 Hz, respectively. ^{13}C NMR data reveal that there is no apparent change for carbon signals

of the ligand and complexes except the position of the carboxylate carbon, which has been moved to lower field in all complexes, indicating the participation of the carboxylic group in coordination to tin(IV)[16]. The complete assignment of alkyl/phenyl/benzyl carbons attached to tin in all complexes confirms complexation. The coupling constant [$^1J(^{119/117}Sn,^{13}C)$] has been observed for trimethyltin derivative, which supports the tetrahedral geometry around the tin atom in solution[17]. It is reported that trialkyltin compounds of amino acids and peptides give sharp signals at 125 ± 25 ppm in ^{119}Sn NMR spectra (in $CDCl_3$), indicating typical quasi tetrahedral arrangement of the central tin atom[1]. The value of δ ^{119}Sn for compound **(5)** corresponds well to the above mentioned reported values. The δ ^{119}Sn for compounds **(1)** and **(3)** are in good agreement with the earlier reported analogous compounds suggesting a coordination number greater than 5 for tin[18]. The value of δ ^{119}Sn for compound **(7)** show pseudo tetrahedral configuration of the Ph_3SnO group and is well supported by the δ ^{119}Sn value of –93.1 ppm for Ph_3SnL (L = 2',4'-difluoro-4-hydroxo-[1,1']-biphenyl-3-carboxylate)[18].

Table 3. ^{1}H NMR data for organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid)[a–c].

Proton no.	Ligand	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
2	8.70 s	8.87 s	8.82 s	8.84 s	8.84 s	8.77 s	8.89 s	8.83 s	8.84 s
5	8.57 d (8.3)	8.63 d (8.0)	8.71 d (7.9)	8.60 d (8.1)	8.58 d (7.8)	8.63 d (8.0)	8.75 d (8.0)	8.64 d (7.8)	8.56 d (8.2)
6	7.33 d (7.7)	7.36 d (8.0)	7.35 d (8.0)	7.34 d (8.0)	7.10 d (7.7)	7.27 d (8.1)	7.29 d (8.0)	7.23 d (7.7)	7.35 d (8.1)
11	4.40 q (7.0)	4.58 q (7.1)	4.60 q (7.2)	4.53 q (7.1)	4.58 q (7.0)	4.48 q (7.0)	4.57 q (7.0)	4.48 q (7.0)	4.44 q (7.0)
12	1.40 t (7.1)	1.50 t (7.1)	1.49 t (7.1)	1.46 t (7.1)	1.47 t (7.1)	1.48 t (7.0)	1.58 t (7.0)	1.47 t (7.1)	1.41 t (7.1)
13	2.71 s	2.73 s	2.74 s	2.74 s	2.68 s	2.65 s	2.74 s	2.67 s	2.70 s

[a]Compound **(1)**: Sn-CH_3, 1.0 s ^2J[76].
Compound **(2)**: Sn-$CH_2CH_2CH_2CH_3$, 1.27-1.55 m, 0.89 t (8.3).
Compound **(3)**: Sn-C_6H_5, 7.18-7.30 m, 7.48-7.89 m.
Compound **(4)**: Sn-$CH_2C_6H_5$, 2.59 s, 7.17-7.47 m.
Compound **(5)**: Sn-CH_3, 0.60 s ^2J[57,61].
Compound **(6)**: Sn-$CH_2CH_2CH_2CH_3$, 1.25-1.63 m, 0.88 t (8.2).
Compound **(7)**: Sn-C_6H_5, 7.48-7.89 m.
Compound **(8)**: Sn-$CH_2C_6H_5$, 2.53 s, 6.80-7.30 m.
[b]Chemical shifts (δ) in ppm, proton-proton coupling constants are listed in parentheses $^nJ(^1H\text{-}^1H)$ and tin-proton coupling constants are listed in square brackets $^nJ[^{119}/^{117}Sn\text{-}^1H]$ in Hz.
[c]Multiplicity is given as: s, singlet; d, doublet; t, triplet; q, quartet.

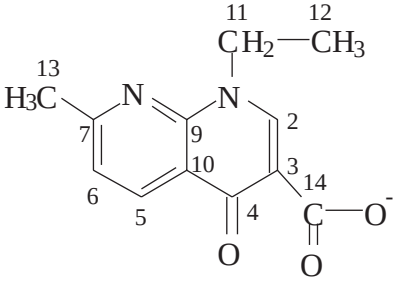
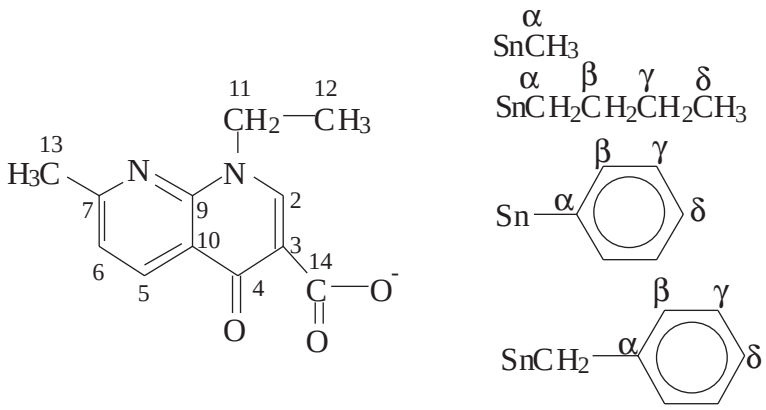


Table 4. ^{13}C and ^{119}Sn NMR data for organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid)[a].

Carbon no.	Ligand	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
2	145.2	148.2	150.0	148.1	148.2	148.9	150.8	148.2	148.2
3	119.3	122.3	122.1	122.2	122.3	121.7	123.1	122.0	122.3
4	164.6	166.6	167.3	166.6	166.6	169.2	166.7	168.2	166.6
5	109.7	109.7	109.8	109.4	109.4	112.6	110.6	109.3	109.4
6	120.3	120.3	120.0	119.0	118.9	121.1	120.0	118.9	119.0
7	148.6	148.6	148.6	148.1	148.5	148.7	148.4	148.5	148.5
9	164.8	164.8	164.3	164.8	164.8	163.6	164.5	164.7	164.8
10	136.5	136.5	136.5	136.2	136.2	136.9	136.4	136.0	136.9
11	47.4	47.4	47.3	47.4	47.4	47.1	47.5	47.0	47.4
12	15.2	15.2	15.3	15.2	15.2	15.1	15.1	15.2	15.2
13	25.3	25.3	25.3	25.3	25.3	25.5	25.4	25.1	25.2
14	172.0	178.0	175.5	178.5	178.5	176.3	175.0	175.2	178.5
CH_2	-	-	-	-	29.1	-	-	-	25.4
α	-	1.5	25.0	136.5	126.4	-0.28 ^1J[394,412]	16.5	137.7	137.2
β	-	-	26.4	135.8	128.5	-	27.8	135.6	136.9
γ	-	-	26.9	129.7	127.4	-	27.6	129.5	128.9
δ	-	-	13.3	128.4	124.8	-	13.6	128.9	130.1
^{119}Sn	-	-158.5	-	-54.8	-	128.0	-	-83.4	-

[a] CH_2 of benzyl group, Chemical shifts (δ) are in ppm. Tin-carbon coupling constants are listed in square brackets, $^nJ[^{119}/^{117}Sn\text{-}^{13}C]$ in Hz.



Mass spectrometry

A very low intensity molecular ion peak was observed in triorganotin carboxylates while it was absent in diorganotin(IV) dicarboxylates. The mass spectral data are presented in Tables 5 and 6.

The base peak for diorganotin(IV) and triorganotin(IV) complexes is observed due to the $[C_{11}H_{12}N_2O]^+$ and $[R_2SnC_{12}H_{11}N_2O_3]^+$ fragments, respectively.

Table 5. Mass spectral data for diorganotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Mass Fragment	**(1)** m/z	Int. (%)	**(2)** m/z	Int. (%)	**(3)** m/z	Int. (%)	**(4)** m/z	Int. (%)
$[R_2SnC_{24}H_{22}N_4O_6]^+$	612	n.o.	696	n.o.	736	n.o.	764	n.o.
$[R_2SnC_{22}H_{22}N_4O_2]^+$	524	1	608	10	648	1	676	2
$[SnC_{22}H_{22}N_4O_2]^+$	494	1	494	2	494	5	494	3
$[C_{12}H_{12}N_2O_3]^+$	232	4	232	5	232	3	232	16
$[C_{11}H_{12}N_2O]^+$	188	100	188	100	188	100	188	100
$[C_{10}H_{12}N_2]^+$	160	50	160	12	160	10	160	57
$[R_2SnC_{12}H_{11}N_2O_3]^+$	381	10	465	35	505	15	533	8
$[SnC_{12}H_{11}N_2O_3]^+$	351	10	351	10	351	14	351	21
$[R_2Sn]^+$	150	35	234	50	274	55	302	37
$[RSn]^+$	135	15	177	21	191	17	211	14
$[Sn/SnH]^+$	120/121	8/6	120/121	9/5	120/121	8/7	120/121	5/4

n.o.: not observed

Table 6. Mass spectral data for triorganotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Mass Fragment	**(5)** m/z	Int. (%)	**(6)** m/z	Int. (%)	**(7)** m/z	Int. (%)	**(8)** m/z	Int. (%)
$[R_3SnC_{12}H_{11}N_2O_3]^+$	396	7	522	2	582	1	624	1
$[R_2SnC_{12}H_{11}N_2O_3]^+$	381	100	465	100	505	100	533	100
$[R_2SnC_{11}H_{11}N_2O]^+$	337	60	421	41	461	40	489	45
$[SnC_{12}H_{11}N_2O_3]^+$	351	7	351	9	351	7	351	9
$[C_{12}H_{12}N_2O_3]^+$	232	8	232	12	232	13	232	4
$[C_{11}H_{12}N_2O]^+$	188	22	188	71	188	66	188	56
$[R_3Sn]^+$	165	59	291	45	352	73	393	43
$[R_2Sn]^+$	150	36	234	32	275	43	302	32
$[RSn]^+$	135	24	177	21	197	15	211	21
$[Sn/SnH]^+$	120/121	10-11	120/121	5/6	120/121	11-14	120/121	5/9

Biological activity

Antifungal activity

The synthesized compounds were tested for antifungal activity against various pathogens listed in Table 7 by tube diffusion test[19]. Generally all derivatives show markedly higher antifungal activity than the parent ligand with few exceptions. It has been reported that within a given series the triorganotin(IV) derivatives are more active against fungi. Our screening tests are quite consistent with the earlier reports[17,19,20]. The fungal growth inhibition due to compound **(7)** is highest in all fungi tested. The rest of the compounds show good fungal inhibition activity except for a few fungi for which their activity is nil.

Antibacterial activity

All the synthesized compounds were subjected to screening of their antibacterial activity using the agar well diffusion method[19]. The data are listed in Table 8. It is concluded that organotin(IV) derivatives

of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid) show marginally higher activity than the ligand acid but considerably lower activity than the reference drug.

Table 7. Antifungal activity of organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Name of Fungus	Percent Inhibition									Standard Drug	MIC μg/mL
	Ligand	(**1**)	(**2**)	(**3**)	(**4**)	(**5**)	(**6**)	(**7**)	(**8**)		
Trichoehyton longiformis	100	100	0	95	85	100	0	100	89.4	Miconazole Ketoconazole	70
Candida albicans	0	0	0	95	0	0	0	100	0	Miconazole Ketoconazole	110.8
Aspergillus flavis	0	0	0	95	0	100	0	100	57.8	Amphotericin. B Flucytosine	20
Microsporum canis	94	100	0	95	100	100	0	100	94.7	Miconazole Ketoconazole	98.4
Fusarium solani	0	0	0	95	0	100	0	85	10.5	Benlate Naban	73.25
Fusarium moniliformis	0	21.1	0	95	0	100	0	89	0	Benlate Naban	110.8

Table 8. Antibacterial Activity of organotin(IV) derivatives of 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Name of Fungus	Percent Inhibition									*Reference Drug
	Ligand	(**1**)	(**2**)	(**3**)	(**4**)	(**5**)	(**6**)	(**7**)	(**8**)	
Corynebacterium diphtheriae	-	20	0	28	20	18	25	30	17	34
Bacillus subtilis	26	23	0	28	26	26	27	27	24	30
Streptococcus pyogenes	28	21	0	29	18	17	29	28	17	30
Staphylococcus aureus	27	26	0	18	19	25	25	26	20	30
Pseudomonas aeruginosa	19	22	0	18	17	20	19	18	17	26
Salmonella typhi	32	30	0	31	31	29	29	26	29	38

*Tetracycline

Cytotoxic study

The reported compounds were screened for cytotoxic study by brine-shrimp assay[21] and the results are given in Table 9. Compound **(2)** does not show any toxicity, while compound **(7)** is found to be most toxic compared to the ligand. Compound **(4)** is the least toxic compared to the other reported compounds.

Table 9. Cytotoxicity data of organotin derivatives of 1-ethyl- 1,4-dihydro-7-methyl-4-oxo-1,8-naphthyridine-3-carboxylic acid (nalidixic acid).

Comp.	Toxicity		
	Upper Toxic Conc.	$_{50}(\mu g/mL)$	Lower Toxic Conc.
Ligand	0.41	0.23	0.13
(**1**)	127.47	54.87	30.3692
(**2**)	0	0	0
(**3**)	0.0021	0.18	0.16
(**4**)	974.72	143.63	64.27
(**5**)	643.29	139.82	75.46
(**6**)	15.17	9.41	5.91
(**7**)	0.08	0.05	0.0
(**8**)	40.75	20.38	11.29

Experimental

All the chemicals including di- and triorganotin compounds except benzyl were procured from Aldrich or Fluka, while di- and tribenzyltin chlorides were prepared by the reported method[22]. All the solvents were dried before use by the literature methods.

Instrumentation

Melting points were determined in capillary tubes using a MP-D Mitamura Riken Kogyo (Japan) electrothermal melting point apparatus and are uncorrected. Infrared absorption spectra were recorded as KBr/CsI pellets on a Perkin Elmer Spectrum 1000 FT-IR spectrometer. ^{1}H, ^{13}C and ^{119}Sn NMR spectra were recorded on a Brucker AM 250 spectrometer (Germany), using $CDCl_3$ as an internal reference [$\delta\ ^{1}H(CDCl_3)$ = 7.25] and [$\delta^{13}C(CDCl_3)$ = 77.0]. ^{119}Sn NMR spectra were obtained with Me_4Sn as external reference [Ξ (Sn) = 37.290665]. Mass spetral data were measured on a MAT 8500 Finnigan 70 eV mass spectrometer (Germany).

Synthesis

To a suspension of the silver salt of the 1-ethyl-1,4-dihydro-7-methyl-4-oxo-1,8- naphthyridine-3-carboxylic acid (nalidixic acid) in dry chloroform (25 mL) contained in a 250 mL 2-necked round bottom flask equipped with a water condenser and magnetic stirring bar, diorganotin dichloride (0.05 mol) or triorganotin chloride (0.01 mol) in dry chloroform (25 mL) was added dropwise with constant stirring. The reaction was refluxed for 7-8 h, under inert atmosphere, and was allowed to stand overnight at room temperature. Silver chloride that had formed was filtered off and the solvent was removed under reduced pressure. The residual solid mass was recrystallized from a chloroform/*n*-hexane mixture (1:1).

Antifungal activity

The antifungal activities of the synthesized compounds were tested against various pathogens namely *Trichophyton longiformis, Candida albicans, Aspergillus flavis, Microsporum canis, Fusarium solani* and

Fusarium moniliformis by tube diffusion test[19]. The Micoanazole (75 μg/mL), Ketoconazole (75 μg/mL), Amphotericin B (75 μg/mL), Flucytosine (75 μg/mL), Benlate (50 μg/mL) and Nabam (50 μg/mL) were used as standards drugs. Stock solutions of pure compounds (12 μg/mL) were prepared in sterile DMSO. Sabouraud dextrose agar was prepared by mixing Sabouraud (32.5 g), glucose agar (4%) and agar-agar (4 g) in 500 mL of distilled water followed by steamed dissolution, 4 mL of media being dispensed into screw-capped tubes and autoclaved at 121 ^{o}C for 15 min. Test compound (66.6 μg/mL) was added from the stock solution to nonsolidified Sabouraud agar media (50 ^{o}C). Tubes were allowed to solidify at room temperature and inoculated with 4-mm-diameter portions of inocula derived from a-7 days-old respective fungal culture. For nonmycelial growth, an agar surface streak was employed. The tubes were incubated at 27-29 ^{o}C for 7-10 days and the growth in the compound containing media was determined by measuring the linear growth (mm) and growth inhibition with the respective control. The results of the antifungal activity are shown in Table 7.

Antibacterial activity

The antibacterial activities of the reported organotin compounds against *Corynebacterium diptheriae, Bacillus subtilis, Streptococcus pyogenes, Staphylococcus aureus, Pseudomonas aeroginosa* and *Salmonella typhi* bacterial strains were screened using the agar well diffusion method[19]. Tetracycline was used as the standard drug. The wells were dug in the media with the help of a sterile metallic borer with centers at least 24 mm apart. Then 2-8 h old bacteria inocula containing approximately 10^4–10^6 colony forming units (CFU)/mL were spread on the surface of a nutrient agar with the help of sterile cotton swabs. The recommended concentration of the test sample (2 mg/mL in DMSO) was introduced into the respective wells. Other wells were supplemented with DMSO and reference antibacterial drugs serving as negative and positive controls, respectively. The plates were incubated immediately at 37 ^{o}C for 20 h. The activity was determined by measuring the diameter of zones showing complete inhibition (mm). Growth inhibition was calculated with reference to the positive control and the results are collected in Table 8.

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