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New macrocyclic compounds using organotin complexes as intermediates: synthesis and characterization

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Abstract

Background & Aim:A new series of macrocyclic compounds 1-4 have been synthesized using tin as templates. **Method:**Tin templates are formed by refluxing the solution of dibutyltin (IV) oxide with orthophenylenediamine (L1H), 4-chlorocatechol (L2H), butane dithiol (L3H) and 3-carboxypropyldisulphide (L4H). **Results:**The reaction is visualized by cleavage X-Sn-X (X= oxygen/ nitrogen/ sulphur atom) bond of tin template when treated with adipoyldichloride. **Conclusion:**The compounds 1-4 are characterized with the aid of elemental analyses, IR and NMR (1H, 13C) studies which confirmed their proposed framework.

Keywords: dibutyltin (IV) oxide, orthophenylenediammine (L1H), 4-chlorocatechol (L2H), butane dithiol (L3H), 3-carboxypropyldisulphide (L4H).

1. Introduction

Now days, macrocyclic chemistry is a growing area of research in inorganic and bioinorganic chemistry in view of its biological significance. Macrocyclic complexes are considered to mimic the synthetic models of metalloporphyrin and metallocorrins due to their intrinsic structural properties[1,2]. A large number of macrocyclic derivatives have been used in analytical, industrial and medical field3,4. Macrocyclic metal chelating agents are useful for detecting tumor lesions5. Macrocyclic complexes have also received special attention because of their mixed soft-hard donor character and versatile coordination behavior and their pharmacological properties [6,7,8,9,10,11].

Tin template is important by virtue of supramolecular chemistry12. Organotin (IV) derivatives containing reactive Sn-O bonds have been used in number of organic transformations13. The difficulty in direct condensation reactions to provide the ring products in preference to the polymeric materials represents the major barrier towards the efficient synthesis of macrocyclic structures. To overcome the barrier, an alternative method to synthesize macrocyclic compounds is one in which metalloid derivatives serve as a covalent template for the construction of cyclic compounds from cyclic precursors[14,15]. Already some macrocyclic compounds using organotin (IV) dicarboxylates as covalent templates have successfully been synthesized and characterized[16]. The development of efficient and novel synthetic route to new macrocycles is a worthy endeavor that will aid the design of a vast variety of new macrocyclic compounds17.In the present paper, we are reporting new macrocyclic compounds having different hetero atoms via ring-opening condensation of new tin templates bearing labile tin-hetero atom bond.

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2. Experimental Methodology

2.1 Materials

Dibutyltin oxide and ligands (L^1H, L^2H, L^3H and L^4H) were purchased from Sigma and were used as such. All the reactions were carried out under anhydrous conditions. The solvents used were dried before use according to the literature method[18,19].

2.2 Instruments and Measurements

Melting points were determined in a capillary tube on an electro-thermal melting point apparatus. IR spectra for the complexes 1-4 were recorded on a Perkin Elmer FTIR spectrophotometer at 4000-200cm^{-1}. The 1H NMR and 13C NMR were recorded on a Bruker Avance II 400 NMR Spectrometer. All chemical shift values were reported with respect to TMS as internal solvent. CHN analysis of the samples was performed on the Perkin Elmer model 2400 C H N analyzer.

2.3 Preparation and characterization

2.3.1 STEP I: Formation of Tin Templates (A-D)

Tin templates (A-D) were prepared by refluxing the

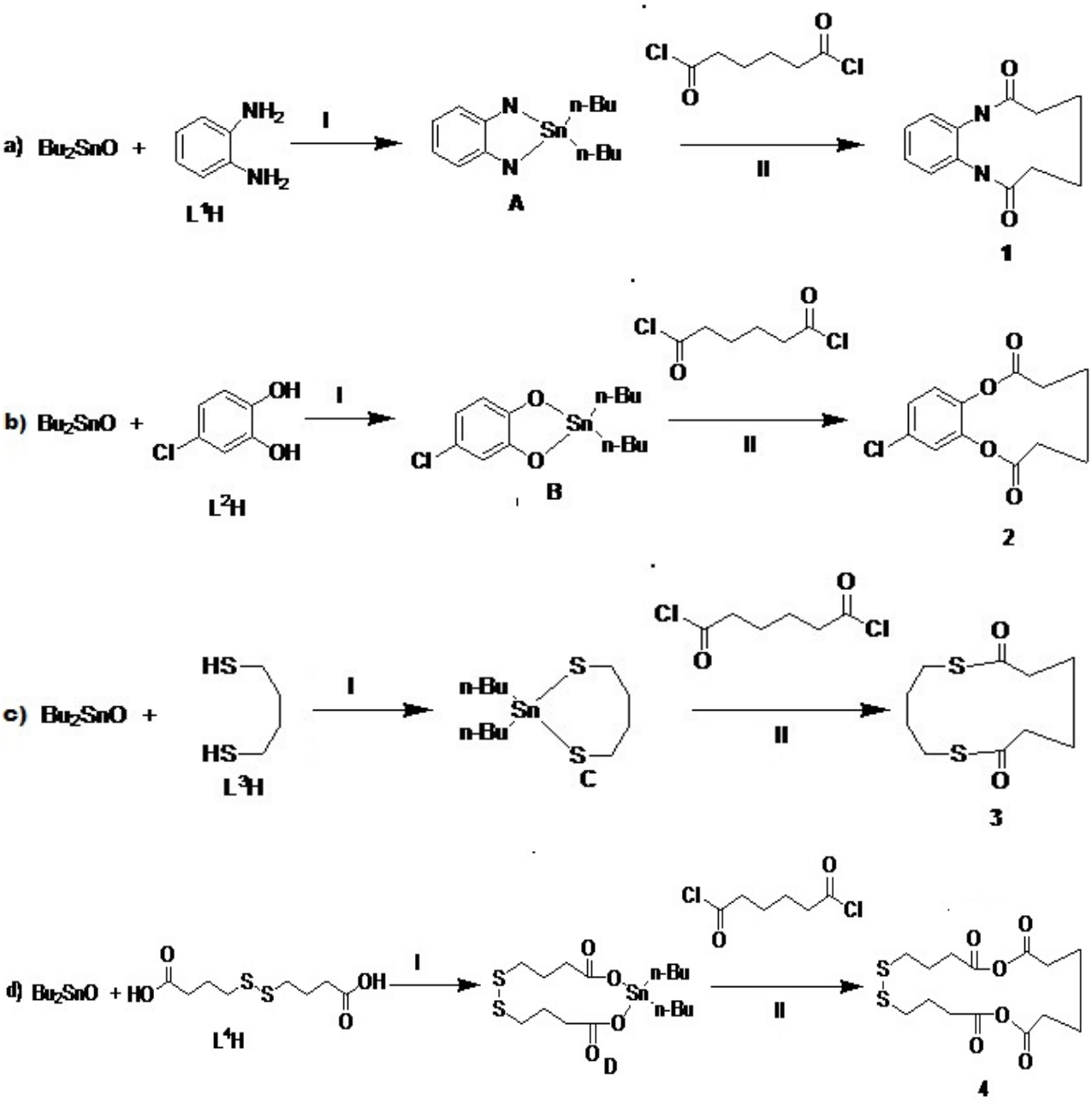
solution of dibutyltin (IV) oxide [1 mmol] and the ligands (L1H, L2H, L3H and L4H) [1mmol], which were dissolved in a mixture of dry benzene (30 ml) and methanol (10 ml). The reaction mixture was then heated at reflux and the water removed by azeotropic distillation. The dibutyltin (IV) oxide dissolved within 10 -15 minutes to give a clear solution. Refluxing was further continued for 3-4 hours and the contents were filtered and then cooled. Excess of solvent was removed by distillation to leave behind a solid complex. All the solid complexes were recrystallized from the mixture of methanol and hexane (5:1) and dried in vacuo at 40-50ºC for 2-3 h. Purity of the complexes was checked by TLC using silica gel G as adsorbent.

2.3.2 STEP II: Formation of Macrocyclic compound

Adipoyl dichloride (0.001mol) was then added to the solution of dibutyltin (IV) ligands (L^1H, L^2H, L^3H and L4H) in dry carbon tetrachloride (50 cm^3) under dry conditions and the mixture was refluxed (80ºC) for 5-6 hours. After removal of excess of solvent by distillation under reduced pressure, the reaction mixture was cooled. A white solid product separated which was filtered off and the filtrate was evaporated to yield white crystals of Bu_2SnCl_2. The white product (macrocyclic compound) was washed with petroleum ether (B.P 60-80ºC) to remove the last traces of Bu_2SnCl_2 and was then re-crystallized from dry carbon tetrachloride.

3. Results and discussion

The interaction of Bu_2SnO with *ortho*-phenylenediamine (L^1H), 4-chlorocatechol (L^2H), butane dithiol (L^3H) and 3-carboxypropyldisulphide (L4H) in 1:1 (Metal: Ligand) molar ratio lead to the formation of macrocyclic compounds 1-4, via tin template with an azeotropic removal of water (Scheme I). All the compounds 1-4 were obtained in a good yield of 62-68% and are soluble



Scheme 1:Formation of Macrocyclic Compounds 1-4

in chloroform with one drop of dimethyl sulfoxide. These were stable towards air, moisture and identified by elemental analysis (Table I).

diacyldichloride. The methylene protons of diacyl moiety which have been incorporated in the macrocycles have been identified. All the protons in the complexes 1-4

Table I. Elemental analysis and some physical properties of macrocyclic compounds.

Sr. No.	Compound No.	Physical State	Melting Point (°C)	Yield (%)	Molecular Formula	Molecular Weight	Contents (calcd/found),%	
							C	H
1.	**1**	White solid	125	62	$C_{12}H_{12}N_2O_2$	216.21	66.65/66.64	5.59/5.58
2.	**2**	Light brown solid	143	68	$C_{12}H_{11}ClO_4$	254.64	56.59/56.60	4.35/4.33
3.	**3**	White viscous solid	135	65	$C_{10}H_{16}O_2S_2$	232.34	51.69/51.67	6.93/6.95
4.	**4**	White solid	178	63	$C_{14}H_{20}S_2O_6$	348.40	48.26/48.28	5.78/5.77

3.1 Spectroscopic data

3.1.1. Infrared spectra

Characteristic IR frequencies (in cm^{-1}) for 1-4 are presented in table II. The data reveal that the peaks due

TableII: Characteristic IR frequencies (in cm^{-1}) of macrocyclic compounds

Serial No.	Compound no.	ν (C=O)	ν(C-O)	V(C-O-C)
1.	**1**	**1602**	**1268**	
2.	**2**	**1700**	**1278**	**1084**
3.	**3**	**1657**	**1375**	
4.	**4**	**1705**	**1412**	**1021**

to C=O and C-O in the spectra of 1-4 are observed in the 1705-1602 $cm^{-1}$and 1268-1412 cm^{-1} regions. The presence of ν(C-O-C) values for 4 at 1021 cm-1 shows the asymmetric nature of the anhydride linkages. The absence of ν (Sn-O), ν (Sn-N), ν (Sn-S) and ν (Sn-C) bands at 475, 426, 350 and 500 cm^{-1} respectively, confirms the formation of 1-4[4,21]. A band due to OH stretching in 3345-3334 cm-1, N-H stretching in 3340-3400 cm^{-1} and S-H stretching in 2500-2600 cm^{-1} regions present in free ligands is absent in 1-4.

3.1.2 Multinuclear (1H and 13C) NMR Spectra

3.1.2.1 ^{1}H NMR spectra

^{1}H NMR spectral data of organotin (IV) complexes is presented in Table III. The proton NMR of 1-4, show the absence of signals due to dibutyltin group and the presence of signal due to the methylene protons in the range of δ 0.90-4.54 ppm, confirms the incorporation of

Table III: ^{1}H NMR chemical shifts (δ, ppm) of macrocyclic compounds.

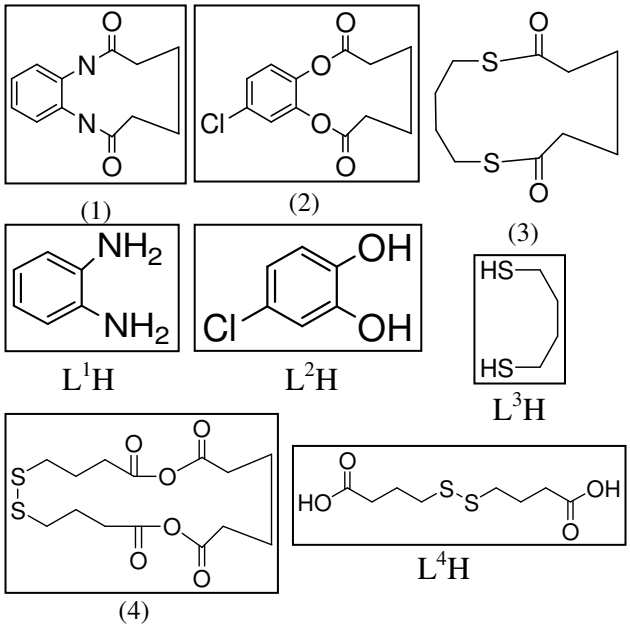
Serial No.	Compound no.	Phenyl protons	Aliphatic protons
1.	**1**	6.90-7.43	1.07-4.54
2.	**2**	6.37-7.43	1.19-3.66
3.	**3**	-	1.51-3.05
4.	**4**	-	0.90-3.14

diacyl moiety and expulsion of dibutyltin groups as dibutyltin dichloride. The proton signals in all the macrocyclic compounds suffer slight downfield shift compared with the dibutyltin templates, which may be due to the two or more carbonyl groups from

have been identified and total numbers of protons calculated from the integration curves are in agreement to those calculated by incremental method19.

3.1.2.2 ^{13}C NMR Spectra

^{13}C NMR spectral data along with the assignment of



characteristic peaks of all the synthesized organotin (IV) complexes are presented in table IV. In the spectra of 1-4, the number of signal found corresponds with the magnetically non equivalent heterotropic carbon atoms. The disappearance of butyl carbon signals and the appearance of methylene carbon signals in the range of δ 13.0-50.6 ppm confirm the formation of macrocyclic compounds. All magnetically non-equivalent carbons of alkyl or phenyl groups attached to the tin have been identified and their chemical shifts are in close

Table IV. ^{13}C NMR spectral data of organotin(IV) complexes

Serial No.	Compound no.	C=O	Ph-C	Aliphatic Carbon
1.	**1**	173.2	126.1-108.4	24.2-50.6
2.	**2**	169.7	120.9-112.8	13.0-39.9
3.	**3**	161.6	-	14.6-35.7
4.	**4**	174.0	-	23.8-40.3

agreement with the reported values[20,21].

Conclusion

The yield of macrocyclic compounds 1-4 ranged from 62 -68%. We have prepared organotin templates; which are used as intermediate for making titled macrocyclic compounds 1-4, as well as variety of other compounds that could be used for soft metal complexation. The formation of macrocyclic compounds 1-4 is well supported by above studies.

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References

1. Mruthyunjayaswamy BHM, Ijare OB & Jadegoud Y, Synthesis, Characterization and Biological Activity of Symmetric Dinuclear Complexes Derived from a Novel Macrocyclic Compartmental Ligand. *J Braz Chem Soc*, **16** (2005) 783-789.
2. Shankar K, Ashok M, Reddy P, Muralidhar R, & Ravinder V, Spectroscopic characterization and antibacterial activities of Mn(III) complexes containing the tetradentate aza Schiff base ligands. *Int J Chem Tech Res*, **1**(2009) 777-783.
3. Singh D P, Kumar R, Malik V & Tyaqi P, Template synthesis, spectroscopic studies and biological activities of macrocyclic complexes derived from thiocarbohydrazide and glyoxal. *J Enzyme Inhib Med Chem,* **22**(2007) 177-182.
4. Singh RV, Chaudhary P, Chauhan S, Swami M, Microwave-assisted synthesis, characterization and biological activities of organotin (IV) complexes with some thio Schiff bases. *Spectrochim Acta-Part A*, **72** (2009) 260–268.
5. Singh DP, Kumar R, Malik V & Tyagi P, Synthesis and characterization of complexes of Co (II), Ni(II), Cu(II), Zn(II), and Cd(II) with macrocycle 3,4,11,12-tetraoxo-1,2,5,6,9,10,13,14-octaaza-cyclohexadeca-6,8,14,16-tetraene and their biological screening. *Transition Met Chem,* **32** (2007) 1051-1055.
6. Chandra S, Gupta R, Gupta N & Bawa SS. Biologically Relevant Macrocyclic Complexes of Copper Spectral, Magnetic, Thermal and Antibacterial Approach. *Transition Met Chem*, **31** (2006) 147-151.
7. Chandra S, Jain D, Sharma AK & Sharma P, Coordination Modes of a Schiff Base Pentadentate Derivative of 4-Aminoantipyrine with Cobalt(II), Nickel(II) and Copper(II) Metal Ions: Synthesis, Spectroscopic and Antimicrobial Studies. *Molecules*, **14** (2009) 174-190.
8. Kosmos C, Snook D, Gooden CS, Courtenay-Luck NS, McCall NS, Meares CF & Epenetos AA, Development of humoral immune responses against a macrocyclic chelating agent (DOTA) in cancer patients receiving radioimmunoconjugates for imaging and therapy. *Cancer Res,* **52** (1992) 904-911.
9. Collen SAJ, Everaerts FM & Huf FA, Characterization of 60Co γ-Radiation Induced Radical Products of Antipyrine by Means of High-Performance Liquid Chromatography, Mass Spectrometry, Capillary Zone Electrophoresis, Micellar Electrokinetic Capillary Chromatography and Nuclear Magnetic Resonance Spectrometry. *J Chromatogr A,* **788** (1997) 95-103.
10. Rosu T, Pasculescu S, Lazar V, Chifiriuc C, Cernat R, Copper(II) Complexes with Ligands Derived from 4-Amino-2,3-dimethyl-1-phenyl-3-pyrazoline-5-one. *Molecules,* **11** (2006) 904-914.
11. Filho VC, Corréa R, Vez Z, Calixto JB, Nunes RJ & Pinheiro T R, Andricopulo AD, Yunes RA, Further Studies on Analgesic Activity of Cyclic Imides. *Farmaco*, **53** (1998) 55-57.
12. Turhan ZG, Sivaci M, Kilic FS & Erol K, Synthesis of Some Triazolyl-antipyrine Derivatives and Investigation of Analgesic Activity. *Eur J Med Chem*, **36** (2001) 685-689.
13. Qvchinnikov YA & Ivanov, VT. The Protiens, 3rd edition, Vol. 5, Academic Press, New York, 1979.
14. Lehn JM, Design of organic complexing agents. Strategies towards properties. *Struct Bonding,* **16** (1973) 1-69.
15. Anchi C, Corda L, Maccioni A & Podda A, Studies on the synthesis of heterocyclic compounds. VII. Action of acyl halides on heterocyclic compounds containing the O-M-O (M P, As, Sb) bond in the ring. *J Hetrocycl Chem,* **19** (1982), 141-144.
16. Shanzer A, Libman J, Total synthesis of enterobactin via an organotin template. *J Chem Soc Chem Commun,* (1983) 846-847.
17. Puri JK, Kaur H, Synthesis of Macrocyclic compounds using Diorganotin (IV) dicarboxylate as covalent templates. *Orient J Chem*, **21**(2005) 207-212.
18. Vujasinovic I, Veljkovic J, Majerski KM, New Tin Templates for the Synthesis of Macrocyclic Polythiaether–Polythiaester Ligands. *J Org Chem,* **69** (2004) 8550-8553.
19. Armarego WLF & Chai CLL, Purification of Laboratory Chemicals, 5th Ed., Butterworth Heinemann, London, 2003.
20. Danish M, Ali S, Mazhar M, Badshah A & Tieknik, ERT, Crystal and molecular structures of Bis[3-(2-furanyl)-2-propenoato)Di-n-butyltin] oxide and Triphenyltin 3-(2-furanyl)-2-propenoate. *Main Group Met Chem,* **18** (1995) 697-706.
21. Szorcsik A, Nagy L, Scopelliti M, Deak A, Pellerito L & Hegetschweiler K, Preparation and structural characterization of organotin(IV) complexes with ligands containing a hetero {N} atom and a hydroxy group or hydroxy and carboxyl groups. *J Organomet Chem*, **690** (2005) 2243–2253.