

# A Review On Organotin(IV) Thiosemicarbazone Complexes, Synthesis, Characterization And Biological Activity

Rawnaq B. Jimaa<sup>1</sup>, Jinan Mohammed Mahmood Al-Zinkee<sup>1</sup>

<sup>1</sup>University of Diyala, College of Sciences, Chemistry Department, Diyala, Iraq



## ARTICLE INFO

Received: 8 / 11 / 2021  
Accepted: 18 / 11 / 2021  
Available online: 21 / 12 / 2020

## DOI:

<http://dx.doi.org/10.37652/JUAPS.2021.15.2.10>

## Keywords:

Organotin(IV),  
thiosemicarbazones,  
Antitumor,  
Stabilizers,  
Diorganotin(IV),  
Triorganotin(IV)

## ABSTRACT

Organotin(IV) complexes recently have been receiving great attention due to their stability with a unique structure, physical and chemical properties. There are many applications, the organotin(IV) can be used as catalysts, antifouling agents, UV- and heat stabilizers, anticorrosion, anticancer and antimicrobial activities. This review summarizes the synthesis methods, characterization and biological activities of organotin(IV) thiosemicarbazones derivatives with their activities as anticancer and antimicrobial agents.

## 1. INTRODUCTION

Initially, chemistry of thiosemicarbazone derivatives was discovered in the 1960s and show an important class of NNS containing donor ligands with formula ( $R^1R^2C^2=N^3-N^2(H)-C^1(=S)N^1R^3R^4$ ). These heterocyclic compounds are able to bind readily with transition and non-transition metals. This leads to different structural binding which contribute in the development of the coordination chemistry. Last decades, thiosemicarbazones and their organotin(IV) complexes play a role in the pharmacological industry as antiviral, antimicrobial, antitumor, antioxidant, and also show interest in agricultural applications[1-5].

### Synthesis of Organotin(IV) Thiosemicarbazone

#### Complexes:

Organotin(IV) complexes can obtain using organotin halides in non-aqueous medium such as methanol, ethanol, acetone, benzene, and n-hexane due to these compounds have a hydrolysable nature in aqueous solutions[6].

Affan *et al.* (2011) synthesized three organotin(VI) complexes of the type  $MeSnCl_2$ ,  $PhSnCl_2$  and  $Ph_2SnCl$  with ligand 2-benzoylpyridine-*N*(4)-cyclohexylthiosemicarbazone (HBPCT). The prepared ligand and its complexes were characterized using  $^1H$  NMR, UV-Vis, FTIR, XRD, CHN analyses and molar conductivity. These characterizations

approved that the ligand coordinated through thiolate-S, azomethine-N and pyridine ring-N to the Sn(VI) to form octahedral geometry Figure 1 [7].

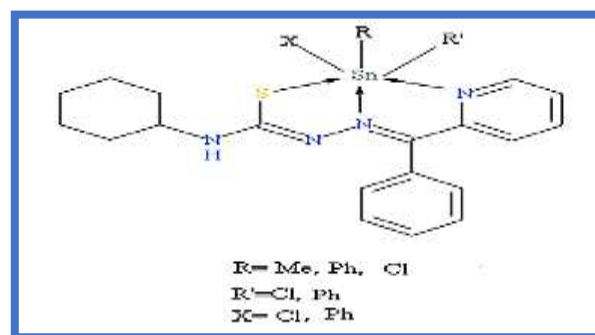


Fig. 1: Diorganotin(IV)chloride with 2-benzoylpyridine-*N*(4)-cyclohexylthiosemicarbazone (HBPCT) complexes

Also, Salam *et al.* (2012) studied the preparation of 2-hydroxyacetophenone-2-methylphenylthiosemicarbazone ( $H_2dampt$ ) from the reaction between 2-methylphenylisothiocyanate with hydrazine hydrate and 2-hydroxyacetophenone in absolute methanol. FTIR spectroscopy, molar conductivity and ( $^1H$ ,  $^{13}C$ , and  $^{119}Sn$ ) NMR suggested that  $H_2dampt$  connected to the tin(IV) in dinegative tridentate to form a five-member ring chelate [8].

\*Corresponding Author: Rawnaq B. Jimaa Orcid ID: 0000-0002-3706-2227.

E-mail: [rawnaq@sciences.uodiyala.edu.iq](mailto:rawnaq@sciences.uodiyala.edu.iq)

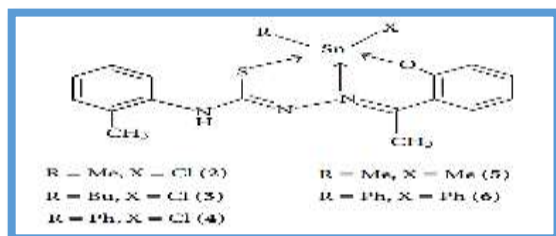


Fig.2: Organotin (IV)-2-2-hydroxyacetophenone-2-methylphenylthiosemicarbazone complexes

Six organotin(IV) complexes were prepared of the type  $R\text{SnCl}(L_1)$ ,  $R\text{SnCl}(L_2)$  (when R= alkyl or phenyl) of new thiosemicarbazone derivatives.

Ligands have been formed by reaction both 2,3-dihydroxybenzaldehyde and 2-hydroxy-5-methylbenzaldehyde separately with 4-methylthiosemicarbazide in ethanol to produce 2,3-dihydroxybenzaldehyde -N(4)-methylthiosemicarbazone ( $H_2DDTM$ ) and 2-hydroxy-5-methylbenzaldehyde-N(4)-methyl thiosemicarbazone ( $H_2DMMT$ ) respectively. Spectroscopy studies, elemental analysis and X-ray crystallography assumed that these ligands connected to tin(IV) as dinegative tridentate chelating ligands ONS, thus, the coordination number of tin(IV) is five as shown in Figure 3 [9].

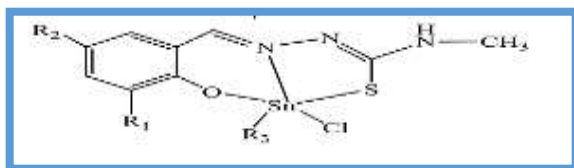


Fig.3: Organotin (IV)- 2,3-dihydroxybenzaldehyde-N(4)-methylthiosemicarbazone and 2-hydroxy-5-methylbenzaldehyde -N(4)- methylthiosemicarbazone complexes

Organotin(IV) thiosemicarbazone complexes can be synthesized by the condensation reaction between pyruvic acid thiosemicarbazide  $H_2pt$  and  $R_2\text{SnCl}_2$ , where R= Me, Ph. The structural formula of these compounds was confirmed by X-ray analysis, NMR, elemental analysis and IR. These characterizations suggested that the tridentate and octahedral geometry were for the prepared complexes Figure 4 [10].

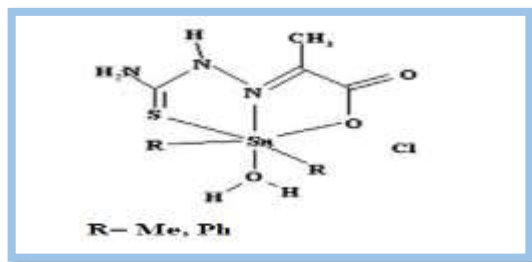


Fig. 4: Diorganotin(IV) pyruvic acid thiosemicarbazone complexes

On 2015 Rosenani *et al.* synthesized 5-bromo-2-hydroxybenzaldehyde-4,4-dimethylthiosemicarbazone ( $H_2L$ )

by reaction of 5-bromo-2-hydroxybenzaldehyde with 4,4-dimethylthiosemicarbazide in an ethanolic solution. A new mono-organotin(IV) compounds have been formed with the ligand  $H_2L$  and characterized by CHN-analysis, UV-Vis., FTIR, and ( $^1\text{H}$ ,  $^{13}\text{C}$ ,  $^{119}\text{Sn}$ ) NMR spectroscopic studies. The ligand is coordinated to tin(IV) *via* ONS-donor atoms and NMR studies confirmed pentadentate coordination in all complexes as shown in Figure 5 [11].

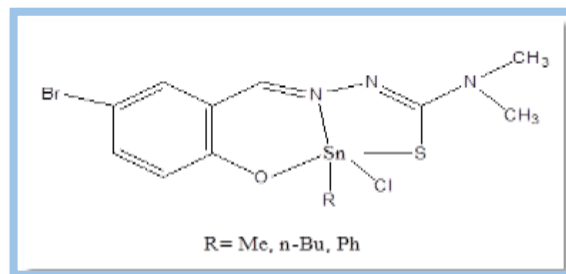


Fig. 5: Mono-organotin(IV)- 5-bromo-2-hydroxybenzaldehyde-4,4- dimethylthiosemicarbazone complexes

Huedo *et al.* (2018) reported a new structural form of diorganotin(IV) compounds by preparing new complexes of ligand diacetyl-2-thiosemicarbazone-3-(3-hydroxy-2-naphthohydrazide). The ligand was synthesized by the condensation of diacetyl-2-thiosemicarbazone and 3-hydroxy-2-naphthohydrazide in absolute ethanol with drops of concentrated HCl. Tetradentate ligand, octahedral geometry was suggested of the prepared compounds Figure 6.[12]

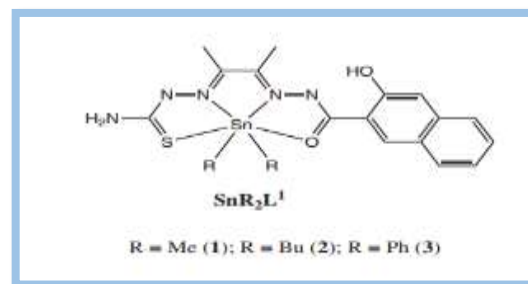


Fig. 6: Diorganotin(IV) complexes of diacetyl-2-thiosemicarbazone-3-(3-hydroxy-2-naphthohydrazide)

Another diorganotin (IV) complexes were synthesized by Singh *et al.* (2016) by the condensation of (2-hydroxyphenyl)(pyrrolidine-1-yl)methanone with phenylthiosemicarbazide in ethanol solution as a reaction medium. The prepared ligand 2-hydroxyphenyl (pyrrolidine-1-yl)methanone phenylthiosemicarbazone and its diorganotin(IV) complexes were characterized by elemental analysis, molar conductivity, molecular weight determination and spectral studies. These may assume that the ligand connected through-OSN leading to the formation of a penta-coordination around Sn(IV) in these complexes Figure 7.[13]

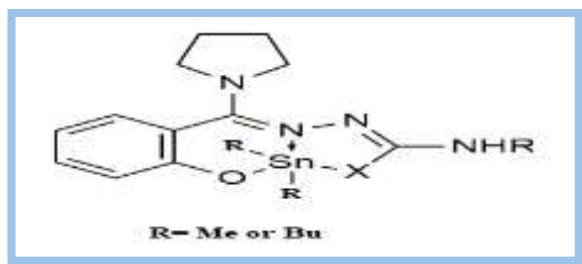


Fig. 7: Diorganotin(IV)-2-hydroxyphenyl(pyrrolidine-1-yl)methanone phenylthiosemicarbazone complexes

Mendes *et al.* (2008) reported the synthesis, characterization, antimicrobial and cytotoxic activity of *n*-butyltin(IV) trichloride with 2-pyridineformamide-derived thiosemicarbazones. Octahedral geometry was proposed for the prepared complexes Figure 8. [14]

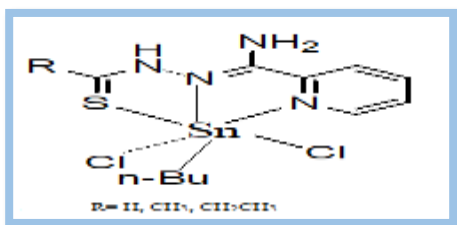


Fig. 8: *n*-Butyltin(IV) trichloride-2-pyridineformamide-derived thiosemicarbazone complexes

While, Singh *et al.* prepared tridentate ligand ONS 2-hydroxyacetophenone thiosemicarbazone to form a 5-coordinated complexes with diorgano tin(IV) chloride in a trigonal bipyramidal geometry Figure 9.[15] There is no meaning of this sentence, the authors need to re-write this sentence to be more consistent.

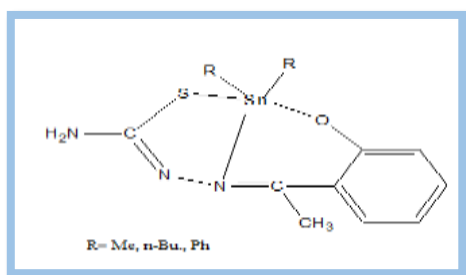


Fig.9: Diorganotin(IV) 2-hydroxyacetophenone thiosemicarbazone complexes

Khan *et al.* (2016) have been formed a new ligand (5-bromo-2-hydroxybenzaldehyde-N(4)-methylthiosemicarbazide) using the condensation of 5-bromo-2-hydroxybenzaldehyde and 4-methyl-3-thiosemicarbazide in ethanolic solution. Elemental analysis, FTIR, electronic and  $^1\text{H}$ ,  $^{13}\text{C}$  NMR spectroscopy showed that the newly synthesized ligand connected through ONS to Sn(IV) to form pentacoordinated geometry Figure 10. [16] Anti-tumor results

showed that these compounds could be promising and active against A549, MCF-7 and HCT-116 cancer cell lines.

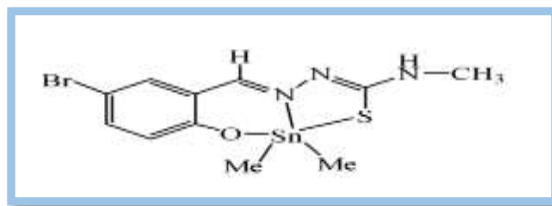


Fig. 10: Dimethyltin(IV)-5-bromo-2-hydroxybenzaldehyde-N(4)-methylthiosemicarbazone complex

### Anticancer Activity:

The extraordinary achievements of cisplatin and carboplatin (Figure 11) *in vitro* proliferative activity and *in vivo* experiments have been encouraging the researchers to investigate a new non-platinum complexes. This is to use as anticancer therapies with optimistic results, and with low or no side effects [6,17]. The feature of the metal ion and the organic ligand are versatile and the ability of the metal ions to lose electrons to be cationic in the biological systems are preferred. These positively charged species interact and coordinate with the opposite charged molecules and rich of electrons e.g. DNA and proteins to become soluble in the biological systems. [18-20]

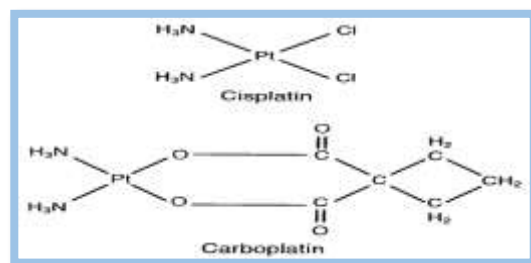


Fig.11: Structure of cisplatin and carboplatin complexes

Among these non-platinum compounds, organotin complexes have taken a significant attention as an active antitumor against different types of human cancer cell lines [21]. For this researchers have been synthesized organotin(IV) complexes and study their anticancer activity as drugs[ 22-28].

The biological activity of organotin(IV) compounds was discovered in 1929 [29]. I could not actually understand this sentence, what the authors want to say here? I kindly ask the authors to re-write this sentence to be understandable.

Thiosemicarbazones and their tin(IV) complexes the subject of this review attracted attentions due to their significant flexibility as a multi-dentate donor molecules through the sulfur as well as azomethane nitrogen atoms. Due to the ability of thiosemicarbazones to behave as N,S-multidentate ligands and the opportunity to modify the binding properties through the insertion of other atoms/molecules in the backbone structure *i.e.* (phenolic or pyridyl halves). This is characterized them as versatile ligands with the excellent

bending ability with most transition and non-transition elements such as Sn. These ligands are also have the flexibility and ability to bind either in neutral or in deprotonated forms [30, 31]

The higher activity of organotin(IV) complexes may be due to the number and type of R- groups [R= alkyl or aryl] that attached to the Sn(IV) core. Many studies show that tri-organotin complexes have higher activities compared with di and mono-organotin and this can increase their ability to bind with the DNA of tumors and damage them. [32-34]. Also, the high cytotoxic activity can be assigned to the bulky aryl groups attached to Sn-center compared to alkyl groups [27]. These bulky groups increase the lipophilicity nature of the complexes by catalyzes  $\pi$ - $\pi$  interaction between the metal ions and the lipid membrane that surrounds the cancer cells.[35] Literatures describe the mechanism of apoptotic (programmed cell death) using organotin(IV) complexes. This is happened by the interaction between organotin(IV) moieties to cellular proteins and bind with DNA, leading to the death of pathogenic cells. The intracellular metabolism of the phospholipids of the endoplasmic reticulum is modified by tin(IV) complexes when they bind to the phosphodiester of DNA. [36]

Gielen in 1996 and 2003 reported the influence of R-groups of various organotin(IV) complexes as a metallodrugs against colon and breast cancer cell lines [37,38]

The structure of organotin(IV) compounds to be potent as antitumor drugs is distinguished by: (i) the availability of coordination positions around tin atom, (ii) the relative stability of Sn-S thione and (iii) slow hydrolytic decomposition of Sn-S bond besides lipophilic and hydrophilic properties of the complexes. [39,40]

Devi *et al.* reviewed different types of organotin(IV) complexes which they have therapeutic activities against different tumor cell lines depends on the reduction potential of these complexes. The review summarized that the number and type of R-groups attached to the tin, the type of ligands, geometry of the prepared complexes and the presence of heteroatom (OH, X, NH, ...etc.) in the backbone of the complexes. This leads to assist to modulate the lipophilicity character to increase the absorption of the compounds. Also, preventing cell recognition and adhesion process and interfering in carbohydrate-protein interaction and helps in transport at the molecular levels all these are crucial in cancer growth. [41, 42].

### Biological Activities:

Organotin(IV) have been investigated due to their structural features and potent biological activity [43]. Inorganic tin(IV) compounds can be considered non-poisonous or with very little toxicity towards mammals and organisms while organotin(IV) compounds reveal varying

biological activities [44,45]. Antibiological drugs work by preventing bacteria from multiplying or killing them without harming the host.

The complexes of organotin(IV) with thiosemicarbazones derivatives are more efficient against all organisms than semicarbazones complexes, so as a result sulfur is more active as antimicrobial drugs than oxygen, as suggested by Tandon [46-47].

Currently, the inhibition activity of organotin(IV) thiosemicarbazones is studied and found that the geometry has no impact role on their biological activity. It has been observed whether the ligands coordinated around Sn(IV) in trigonal bipyramidal or octahedral geometry have good antimicrobial activity and degrade DNA[47-49].

The free ligands found to be inactive or lower activity than their complexes against the tested bacteria and fungi, which indicates that metalation increases the antimicrobial activity [30,39,44]. Also, studies show that the highest inhibition activity of complexes attributed to the type and size of R-groups attached to the Sn atom. The screening results showed that the activity of R-groups can be arranged from the higher to the lower activity on the microorganisms as follows: Ph > Bu > Me.

It can be noted that the complexes with bulkier phenyl groups exhibited greater effectiveness compared to other alkyl groups against the tested microorganisms, due to the rise of lipophilicity character of the complexes. The increases in the lipophilicity nature of the coordinated metal ion resulting from reducing the polarity character of it in which enable them to penetrate through the lipid layers of the microorganisms' membranes[13, 51-54].

Antimicrobial activity of some of organotin(IV) thiosemicarbazones complexes showed promising results as drugs and also found to be competing with reference drug such as ampicillin and miconazole that used for treatment of bacteria and fungi respectively.[51]

More than 3.8 billion years microscopic organisms have survived on the earth and characterized with the extreme variety in genetic and metabolic. They are consist about 50% of the living biomass, one component of the ecosphere in which play an essential role in the maintenance and sustainability of environments. These microorganisms adapt with various environmental challenges such as pressure. The disease-causing microorganisms are particularly vulnerable to man's selfishness for survival, who has sought to deprive them of their habitat by using antimicrobial agents. But these disease-causing microorganisms develop resistance against antimicrobial agents which consider a serious threat to infectious disease management globally [55-58]

Mechanism action of antimicrobial agents can be classified depends on the structure of microorganisms or on the function that they are affect, *i.e.* inhibition the synthesis of cellular wall, of ribosome function, of nucleic acid synthesis,

of folic acid metabolism or of cell membrane function. Thus, the mechanisms of inhibition depend on which pathways are inhibited by the antimicrobial drugs and whether the organisms can change those mechanisms. Resistance of antimicrobial drugs by microorganisms can be either intrinsic or acquired immunity. Because of the chemical nature of the drugs or the structure of the microbial membranes, microorganisms with intrinsic or natural resistance either do not have functional sites for drugs or have low penetrability to them. While, microorganisms with acquired resistance in which naturally susceptible gains ways of being not affected by various means [59-61].

### Conclusion:

In conclusion, thiosemicarbazone derivatives are well known as Schiff base ligands exist either in neutral or anionic forms also characterized with bidentate, tridentate and polydentate ligands due to the presence of sulfur, nitrogen or even oxygen in some cases as donor atoms. Organotin(IV) thiosemicarbazone complexes are synthesized in different molar ratio by refluxing the calculated amount of the prepared thiosemicarbazone derivatives and organotin(IV) compounds in a suitable solvent.

Spectroscopic results show that the coordination of thiosemicarbazone derivatives through azomethine-N, thiolate-S, and O-in some cases forming either hexa- or penta-coordinate Sn(IV). Various applications of organotin(IV) complexes have been noted because of their ability to be diverse in coordination behaviors. The presence of R-groups on tin(IV) atom affects the anticancer and antimicrobial activities of the complexes. It has been noted that the existence of aryl group in the complexes plays a role in the biological activity owing to its ability to increase lipophilic character of Sn(IV) complexes and form stable structures with the biological molecules. There are several complexes containing thiosemicarbazones as ligands which can be effective and even better than traditional antitumor and antimicrobial drugs.

### References:

1. Lobana T., Sharma R., Bawa G., Khanna S.(2009). Bonding and structure trends of thiosemicarbazone derivatives of metals—An overview. *Coordination Chemistry Review*, 253:977-1055.
2. Momeni Z., Shahbazi, S., Khavasi, R.(2010). *Polyhedron*, 29: 1393.
3. Wiecek, J.; Dokorou, V.; Zbigniew, C.; KovalaDemertzi, D.(200) *Polyhedron*, 28: 3298.
4. Suni, V., Prathapachandra R., Nethaji M. (2007). *Polyhedron*, 26: 5203.
5. Gazieva G. Thiosemicarbazides in the synthesis of five- and six-membered heterocyclic compounds.(2012). *Russian Chemical Reviews*, 81(6):494-523.

6. Hadi A., Jawad Kh., Ahmed D., Yousif E.(2019). Synthesis and Biological Activities of Organotin (IV) Carboxylates: A Review. *Sys Rev Pharm*, 10(1):26-31.
7. Affan M., Salam M., Ahmed F., Ismail J., Shamsuddin M., Ali H.(2011). Synthesis and spectroscopic characterization of organotin(IV) complexes with 2-benzoylpyridine-N(4)-cyclohexylthiosemicarbazone (HBPCT): X-ray crystal structure of [PhSnCl<sub>2</sub>(BPCT)]. *Inorganica Chimica Acta*, 366:227-232.
8. Affan M., Salam M., Saha R., Ahmed F., Sam N.(2012). Synthesis, Characterization and In Vitro Antibacterial Studies of Organotin(IV) Complexes with 2-Hydroxyacetophenone-2-methylphenylthiosemicarbazone (H<sub>2</sub>damp). *Bioinorganic Chemistry and Applications*, 698491.
9. Haque R., Salam M., Arafath MD.(2015) New organotin(IV) complexes with N(4)-methylthiosemicarbazone derivatives prepared from 2,3-dihydroxybenzaldehyde and 2-hydroxy-5-methylbenzaldehyde: synthesis, characterization, and cytotoxic activity. *Journal of Coordination Chemistry*, 68(16): 2953-2967.
10. Wiecek J., Dokorou V., Ciunik Z., Kovala-Demertzi D.(2009). Organotin complexes of pyruvic acid thiosemicarbazone: Synthesis, crystal structures and antiproliferative activity of neutral and cationic diorganotin complexes. *Polyhedron*, 28: 3298–3304.
11. Haque R., Salam M.(2015). Synthesis, spectroscopic properties and biological activity of new mono organotin(IV) complexes with 5-bromo-2-hydroxybenzaldehyde-4,4-dimethylthiosemicarbazone. *Cogent Chemistry*, 1:1045212.
12. Huedo C., Zania F., Mendiola A., Pradhan S., Sinha Ch., Lopez-Torres E.(2018). Synthesis, antimicrobial activity and molecular docking of di- and triorganotin (IV) complexes with thiosemicarbazide derivatives. *Appl Organometal Chem*,:e4700.
13. Singh H., Singh J., Bhanuka S.(2016). Synthesis, spectroscopic characterization, biological screening, and theoretical studies of organotin(IV) complexes of semicarbazone and thiosemicarbazones derived from (2-hydroxyphenyl) (pyrrolidin-1-yl)methanone. *Research on Chemical Intermediates*, 42:997-1015.
14. Mendes I., Moreira J., Ardisson J., Santos R., O. da Silva P., Garcia I., Castineiras A., Beraldo H.(2008). Organotin(IV) complexes of 2-pyridineformamide-derived thiosemicarbazones: Antimicrobial and cytotoxic effects. *European Journal of Medicinal Chemistry*, 43:1454-1461.
15. Singh M., Singh P.(2003). Highly Versatile Synthesis of Some Organotin(IV) Complexes of 2-ydroxyacetophenone Semicarbazone and Thiosemicarbazone. *Synthesis and*

- reactivity in inorganic and metal organic chemistry, 33(10): 1895–1909.
16. Khan Md., Salam Md., Haque R., Abdul Majid A., Bin Abdul Majid A., Asif M., Basheer M., and Tabana Y.(2016). Synthesis, cytotoxicity, and long-term single dose anti-cancer pharmacological evaluation of dimethyltin(IV) complex of N(4)-methylthiosemicarbazone (having ONS donor ligand). *Cogent Biology*, 2, 1154282.
  17. Go R., Adjei A.(1999). Review of the Comparative Pharmacology and Clinical Activity of Cisplatin and Carboplatin. *Journal of Clinical Oncology*, 17(1), 409-422.
  18. Zhang C., Lippard S.(2003). New metal complexes as potential therapeutics. *Curr. Opin. Chem. Biol.*, 7:481-489.
  19. Zeglis B.M., Pierre V.C., Barton J.K..(2007). Metallo-intercalators and metallo-insertors, *Chem. Commun*, 4565-4579.
  20. Adeyemi J., Onwudiwe D.(2018). Organotin(IV) Dithiocarbamate Complexes: Chemistry and Biological Activity. *Molecules*, 23: 2571.
  21. Khandani M., Sedaghat T., Erfani N., Haghshenas M., Khavasi H.(2013). Synthesis, spectroscopic characterization, structural studies and antibacterial and antitumor activities of diorganotin complexes with 3-methoxysalicylaldehyde thiosemicarbazone. *Journal of Molecular Structure*, 1037, 136–143.
  22. Ullah H., Previtali V., Mihigo H., Twamley B., Rauf M., Javed F., Waseem A.(2019). BakerR., Rozas I. Structure-activity relationships of new Organotin(IV) anticancer agents and their cytotoxicity profile on HL-60, MCF-7 and HeLa human cancer cell lines. *European Journal of Medicinal Chemistry*, 181, 111544.
  23. Kamaludin N., Awang N., Baba I. Hamid A., Meng Ch.(2013). Synthesis, Characterization and Crystal Structure of Organotin(IV) N-Butyl-N-phenyldithiocarbamate Compounds and their Cytotoxicity in Human Lukemia Cell Lines. *Pakistan Journal of Biological Sciences*, 16(1), 12-21.
  24. Ahmad M., Hussain M., Hanif M., Ali S., Mirza B.(2007). Synthesis, Chemical Characterization and Biological Screening for Cytotoxicity and Antitumor Activity of Organotin (IV) Derivatives of 3,4-Methylenedioxy 6-nitrophenylpropenoic Acid. *Molecules*, 12, 2348-2363.
  25. Rocamora-Reverte L., Carrasco-Garca E., Ceballos-Torres J., Prashar S., Kalud'erovic' G., Ferragut J., Gomez-Ruiz S.(2012). Study of the Anticancer Properties of Tin(IV) Carboxylate Complexes on a Panel of Human Tumor Cell Lines. *ChemMedChem.*, 7, 301 – 310.
  26. Awang N., Baba I., Yamin B., Othman M., Kamaludin N.(2011). Synthesis, Characterization and Biological Activities of Organotin (IV) Methylcyclohexyldithiocarbamate Compounds. *American Journal of Applied Sciences*, 8(4): 310-317.
  27. Salam M., Hussein M., Ramli I., Saiful-Islam Md.(2016). Organomet J. Synthesis, structural characterization, and evaluation of biological activity of organotin(IV) complexes with 2-hydroxy-5-methoxybenzaldehyde-N(4)-methylthiosemicarbazone. *Chem*, 813, 71–77.
  28. Khandani M., Sedaghat T., Erfani N., Haghshenas M., Khavasi H.(2013). *J. Mol. Struct.*, 1037, 136–143.
  29. Narayanan, V.L.; in Reinhoudt, D.N.; Connors, T.A.; Pinedo, H.M.; van de Poll, K.W.(1983).(Eds.). Structure-activity relationship of anti-tumour agents, *Martinus Nijhoff. The Hague*, 5.
  30. Affan M., Salam M., Saha R., Ahmed F., White F., Ali H.(2012). Organotin(IV) complexes of 2-hydroxyacetophenone-N(4)-cyclohexylthiosemicarbazone (H2dact): Synthesis, spectral characterization, crystal structure and biological studies. *Inorganica Chimica Acta.*, 387, 219–225.
  31. Bonaccorso C., Marzo T., Mendola D.(2020). Biological Applications of Thiocarbohydrazones and Their Metal Complexes: A Perspective Review. *Pharmaceuticals*, 13(4).
  32. Iftikhar S., Gilani S., Taj M., Raheel A., Din I., Termizi S., Al-Shakban M., Ali H.(2018). Design, synthesis and biological evaluation of organotin(IV) complexes of flumequine and cetirizine. *Journal of the Serbian Chemical Society*. 2018, 8 (4), 425–437.
  33. Hadjikakou S.K., Hadjiliadis N.(2009). *Coord. Chem. Rev.*, 253: 235.
  34. Pettinari C., Marchetti F., Pettinari R., Cingolani A., Drozdov A., Troyanov S.(2002). *Dalton Trans*, 188–194.
  35. Prasad K., Kumar L., Shekar S., Prasad M., Revanasiddappa H.(2001). *Chem. Sci. J.*, 12 , 1-10.
  36. Arjmand F., Parveen S., Tabassum S., Pettinari C.(2014). Organotin antitumor compounds: Their present status in drug development and future perspectives. *Inorganica Chimica Acta.*, 423(B), 26-37.
  37. Gielen M., *Coord. Chem. Rev.* 1996;151: 41.
  38. Gielen M., *J. Braz. Chem. Soc.* 2003;14: 870.
  39. Devi J., Yadaf. (2018). *J. Recent Advancements in Organotin(IV) Complexes as Potential Anticancer Agents. Anti-Cancer Agents in Medicinal Chemistry*, 18, 335-353.
  40. Saxena A.(1989). Organotin(IV) compounds and cancer chemotherapy. *Coordination Chemistry Reviews*, 95, 109-123.
  41. Storr, T.; Thompson, K.H.; Orvig, C.(2006). Design of targeting ligands in medicinal inorganic chemistry. *Chem. Soc. Rev.*, 35(6), 534- 544.

42. Keppler, B.K.(2008). Carbohydrate-metal complexes and their potential as anticancer agents. *Curr. Med. Chem.*, 15(25), 2574–2591.
43. Cortes L., Okio C., Brandao P.(2011). Tin(IV) Complexes of 1,5-phenylthiosemicarbazone and thiosemicarbazide: Synthesis, X-ray Characterization and Biological Activity. *Phosphorus, Sulfur, and Silicon*, 186, 1356–1360.
44. Van der K, Luijten JGA.(1954). Investigations on organotin compounds. III. The biocidal properties of organotin compounds. *J App Chem.*, 4(6), 314-9.
45. Van der KGJM, Luijten JGA.(1956). Investigations on organotin compounds. V The preparation and antifungal properties of unsymmetrical tri-n-alkyltin acetates. *J. App Chem.*, 6(2), 56-60.
46. Saxena A., Tandon J.P.(1983). *Polyhedron.*, 2, 443–446.
47. Singh H., Singh J., Sharma K.(2012). Synthetic, structural, and antimicrobial studies of organotin(IV) complexes of semicarbazone, thiosemicarbazone derived from 4-hydroxy-3-methoxybenzaldehyde. *Res Chem Intermed.*, 38, 53–65.
48. Zafarian H., a, Sedaghat T., Motamedi H., Rudbari H.(2016). A multiprotic ditopic thiocarbohydrazone ligand in the formation of mono-and di-nuclear organotin(IV) complexes: Crystal structure, antibacterial activity and DNA cleavage. *Journal of Organometallic Chemistry.*, 825-826, 25-32.
49. Salam M., Affan M., Arafat Md., Saha R., Nasrin R.(2013). Synthesis, Characterization, and Antibacterial Activities of Organotin(IV) Complexes with 2-Acetylpyridine-N(4) cyclohexylthiosemicarbazone (HAPCT). *Heteroatom Chemistry.*, 24(1).
50. Siang-Guan Teoh S.,\*<sup>a</sup>, Show-Hing Ang,<sup>a</sup> Soon-Beng Teo,<sup>a</sup> Hoong-Kun Fun,<sup>b</sup> Khing-Ling Khew c., Chi-Wi Ong.(1997). Synthesis, crystal structure and biological activity of bis(acetone thiosemicarbazone-S)dichlorodiphenyltin(IV). *J. Chem. Soc., Dalton Trans*, 465–468.
51. López-Torres E., Zani F., Mendiola M.(2011). Antimicrobial activity of organotin(IV) complexes with the ligand benzil bis(benzoylhydrazone) and 4,4'-bipyridyl as coligand. *Journal of Inorganic Biochemistry*, 105, 600–608.
52. Singh H., Varshney A.(2006). Synthetic, Structural, and Biochemical Studies of Organotin(IV) With Schiff Bases Having Nitrogen and Sulphur Donor Ligands. *Bioinorganic Chemistry and Applications.*, Article ID 23245: 1–7.
53. Singh H., Gupta M., Varshney A.(2001). Organotin(IV) complexes of Schiff bases derived by condensation of heterocyclic ketones and sulfa drugs. *Res. Chem. Intermed.*, 27(6), 605–614.
54. Awang N., Zakri N., Zain N.(2016). Antimicrobial activity of organotin(IV) alkylisopropildithiocarbamate compounds. *J. Chem. Pharm. Res.*, 8(3), 862-866.
55. Zhang X., Yan H., Song Q., Liu X., Tang L.(2007). Synthesis, structure and biological activity of organotin derivatives with pyridylmethylthiobenzoic acid, *Polyhedron*, 26, 3743–3749.
56. Rehman W., Badshah A., Khan S., Tuyet L.(2009). Synthesis, characterization, antimicrobial and antitumor screening of some diorganotin(IV) complexes of 2-[(9H-purin-6-ylimino)]-phenol, *Eur. J. Med. Chem.*, 44, 3981–3985.
57. Rehman W., Baloch M., Badshah A., Ali S.(2006) Synthesis, characterization and biological study of diorganotin(IV) complexes of monomethyl phthalate, *Spectrochim. Acta A.*, 65, 689–694.
58. Rehman W., Baloch M., Badshah A.(2008). Synthesis, spectral characterization and bio-analysis of some organotin(IV) complexes, *Eur. J. Med. Chem.*, 43, 2380–2385
59. Yeaman R., Yount N.(2003). Mechanisms of antimicrobial peptide action and resistance, *Pharmacol. Rev.*, 55, 27–55.
60. Tenover F.(2006). Mechanisms of antimicrobial resistance in bacteria, *Am. J. Med.*, 119, 62–70.
61. Hawkey P., Lewis D.(1994). *Medical Bacteriology—A Practical Approach*, Oxford University Press, Oxford.

## إستعراض عن تحضير وتشخيص والفعالية البيولوجية لمعدّات القصدير العضوي (IV) لمشتقات الثايوسمي كاربازون

رونق بهمان جمعه ، جنان محمد محمود الزنكي

قسم الكيمياء، كلية العلوم، جامعة ديالى/ ديالى - العراق

الخلاصة:

حظيت معدّات القصدير العضوي (IV) في السنوات الأخيرة بأهتمام كبير نظرا لأستقرارها ببنية فريدة وخصائص كيميائية وفيزيائية. بعض الأمثلة لها تطبيقات واسعة ومختلفة مثل العوامل المحفزة والمضادة للأشعة فوق البنفسجية ومثبتات الحرارة ومقاومة التآكل وفعاليتها كعوامل مضادة للأمراض السرطانية والفعالية البيولوجية وغيرها من المجالات. هذا الملخص يستعرض طرق التحضير والتشخيص والفعالية البيولوجية لمعدّات القصدير العضوي (IV) مع مشتقات الثايوسمي كاربازون ودراسة نشاطها البيولوجي.

**الكلمات المفتاحية:** القصدير العضوي (IV)، الثايوسمي كاربازون، مضاد للسرطان، مثبتات، ثنائي القصدير العضوي (IV)، ثلاثي القصدير العضوي (IV).