



Original Article

Synthesis, Structure, and *in vitro* Cytotoxic Activity of Two Organotin Complexes of 2-[(2, 3-Dimethylphenyl) Amino] Benzoic Acid

Eman H. Al-Rikabi¹, Rana A. K. Al-Refai¹, Sadiq J. Baqir¹, Angham G. Hadi^{1,*}, Ahmed Kareem Al-Qayyim²

¹Department of Chemistry, College of Science, University of Babylon, Babylon 51002, Iraq

²Medical Laboratories Techniques Department, Al-Mustaqbal University College, Babylon, Iraq

ARTICLE INFO

Article history

Receive: 2022-07-14

Received in revised: 2022-08-16

Accepted: 2022-09-25

Manuscript ID: JMCS-2206-1542

Checked for Plagiarism: Yes

Language Editor:

Dr. Fatimah Ramezani

Editor who approved publication:

Dr. Ali Delpisheh

DOI:10.26655/JMCHMSCI.2023.6.3

KEYWORDS

Antitumor

Cytotoxic activity

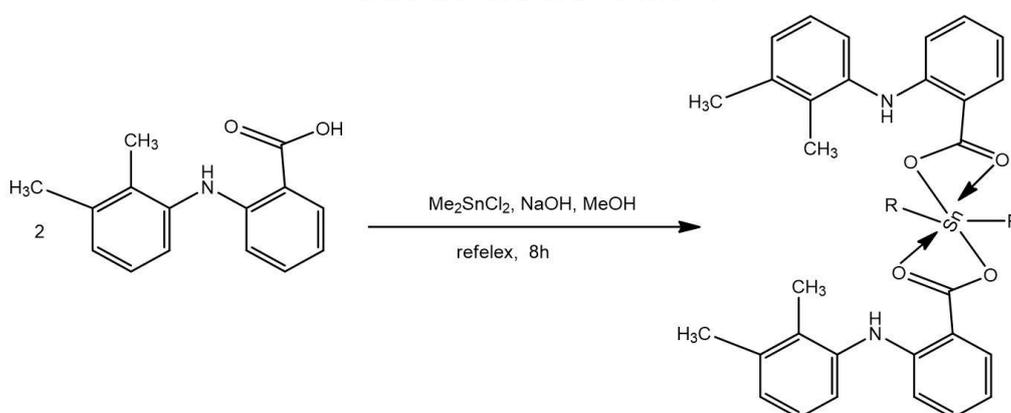
Ligand

Triorganotin carboxylate

ABSTRACT

Organotin carboxylates have gotten a lot of attention in recent years because of their structural intrigue and several uses. The production and characterization of organotin carboxylates, as well as their action against cancers, fungi, bacteria, and other microbes have been described by a number of researchers. Some di- and triorganotin carboxylates have been found to have the potential as anticancer drugs. The amount and kind of organic groups bound to the tin core and carboxylate ligand appear to have a significant impact on their anticancer efficacy. Two new organotin complexes of di and triorganotin carboxylate were successfully synthesized by refluxing reaction of 2-[(2,3-dimethylphenyl) amino] benzoic acid (ligand) with tri phenyl tin chloride and dimethyl tin dichloride salts to give the corresponding substituted tin complexes with high yields. The chemical structures of the complexes were confirmed by different techniques included elemental analysis, proton, carbon and Sn¹¹⁹-NMR, and FT-IR-spectra. The activity of each complex has been examined against the target cell line A-172 compared with the ligand alone. It was found that the complex **1** and **2** have higher cellular cytotoxicity than ligand.

GRAPHICAL ABSTRACT



* Corresponding author: Angham G. Hadi

✉ E-mail: Email: sci.angam.ganem@uobabylon.edu.iq

© 2023 by SPC (Sami Publishing Company)

Introduction

Cisplatin has been widely used in cancer treatment, and it was the first inorganic compound used since 1978. Cisplatin had a great effect in the treatment of cancer of the bladder, ovary, esophagus, breast, stomach, and others [1-3]. After that, unfortunately, it was found that the cisplatin use is not safe because of the appearance of side effects and several defects such as neurotoxicity, nephrotoxicity, and ototoxicity for patients who received treatment [4, 5]. Subsequently, platinum derivatives such as carboplatin and oxaliplatin were used. Until the present time, platinum and its derivatives are as an antitumor treatment. Despite the emergence of metal compounds derived from the elements tin, gold, palladium, and copper where these compounds showed cytotoxic properties [6-8]. Tin derivatives have shown significant efficacy when used as a drug for cancer treatment, especially organotin compounds, as the use of their low doses has better or similar potential to the approved and used drugs [9, 10].

The effectiveness of using organic tin compounds depends on the type of bond, the type, and number of organic groups associated with the central atom of tin [11,12]. The genetic changes and the accumulation of mutations led to the formation of a malignant tumor, and this led to attracting many to search for antitumor drugs that are metallic and non-platinum based, such as binary and triple derivatives of organic tin, which showed the strong effects against the proliferation of cancer cells [13-19].

Dicarboxylate and organotin tricarboxylates showed anticancer activity in solid and solution phase [20, 21]. Studies have demonstrated that

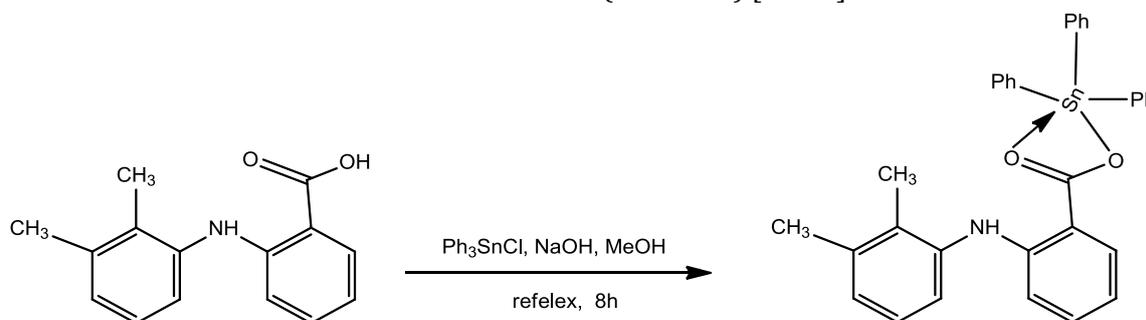
tertiary organotin compounds are more biologically active than their mono- and binary counterparts due to their ability to bind with proteins depending on the number of coordination and the nature of the groups attached to the tin atom [22-24]. In general, the coordination structure of organotin compounds is of great importance for the antitumor activity [25-30]. The subsequent studies reported that the compounds of di-organotin carboxylate have more antitumor activity *in vivo* than cis platinum [31, 32]. Likewise, alkyl or aryl tin derivatives are more active when R is phenyl also, the di-butyltin derivatives are more active than their tri-butyltin counterparts [33].

In this study, by refluxing the reaction of 2-[(2,3-dimethylphenyl) amino] benzoic acid (ligand) with tri phenyl tin chloride and dimethyl tin dichloride salts, it was possible to successfully synthesize two new organotin complexes of di- and triorganotin carboxylate, which led to the high yields of the corresponding substituted tin complexes.

Materials and Methods

Synthesis of triphenyltin Tin carboxylate complex 1

A reaction of a 1:1 mixture (M: L) was obtained by dissolving of (0.48 g, 2 mmol) 2-[(2,3-dimethylphenyl) amino] benzoic acid in 20 ml methanol, and then the equivalent moles of NaOH (0.08, 2 mmol) was added with stirring for 30 min. A (0.84 g, 2 mmol) triphenyltin chloride in boiling (20 mL MeOH) was added to the first solution and it was allowed to reflux for 8 hours, left to evaporate, washed with diethyl ether, and collected to provide complex 1 with 75% yield (Scheme 1) [34-37].

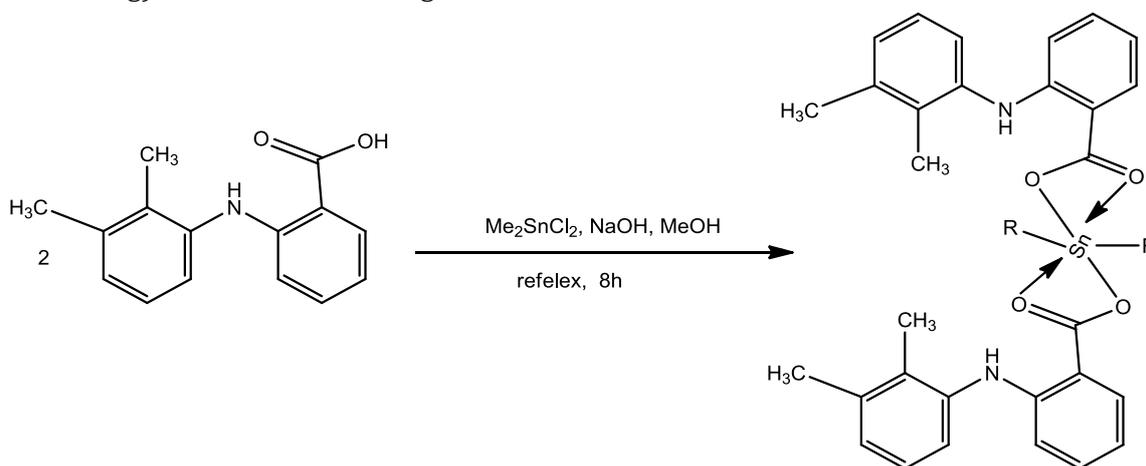


Scheme 1: Synthesis of triphenyltin tin carboxylate

Synthesis of dimethyl Tin complex 2

Synthesis of dimethyl tin complex **2** is carried out according to Kovala and Demertzi *et al.* [38]. (0.96 g, 6 mmol) of 2-[(2,3-dimethylphenyl) amino] benzoic acid in methanol (30 mL) and (6 mmol) NaOH were stirred for 30 minutes at room temperature. A solution of dimethyl tin dichloride (3 mmol, 0.66 g) with 20 ml of boiling methanol

was added to the first mixture. The mixture was allowed to reflux for 8 hours while being constantly stirred. The white precipitated was evaporated under vacuum. The product was washed with diethyl ether and collected to provide complex **2** with 70% yield (Scheme 2) [39].



Scheme 2: Synthesis of dimethyl tin

Results and Discussion

The physical properties of 2-[(2,3-dimethylphenyl) amino] benzoic acid and the prepared complexes were listed in Table 1.

FT-IR spectroscopy of complexes 1 and 2

The FT-IR spectroscopy is able to grasp the vibrations of carbonyl groups in the range where stretching vibration modes appear 3500–1400 cm^{-1} . In complexes **1** and **2**, a new peak was appeared in 520-535 cm^{-1} and 440-450 cm^{-1} region related to tin-carbon and tin-oxygen groups. Carbonyl group vibrations were appeared clearly at (1685-1697 cm^{-1}). Likewise, the broad peak of hydroxyl of carboxyl group was disappeared due to the complexation. Figure 1

and Table 2 indicate the important FT-IR spectrum numbers of complexes **1** and **2**.

NMR spectroscopy of complexes 1 and 2

The $^1\text{H-NMR}$ spectra showed a singlet signal at the 9.45–9.77 ppm region that was related to the NH proton (Figure 2 and Table 3). The aromatic protons were appeared with multiple signals at 7.90–6.67 ppm region. The protons of methyl-tin atom of complex **2** were appeared as a singlet in 0.78 ppm of a high field due to the shielding effect. Also, multiple signals are visible in the $^{13}\text{C-NMR}$ spectra of **1** and **2** inside the aromatic area (Figure 3 and Table 4).

Table 1: The elemental analysis and physical properties of 2- [(2,3-dimethylphenyl) amino] benzoic acid and complexes 1-2

Sn (IV) Complex	R	Color	Yield (%)	Melting point	Calcd. (Found) (%)		
					C	H	N
L	-	White	-	230-231	74.67(73.83)	6.27(6.07)	5.81(6.21)
1	Ph	White	75	123-125	67.14(66.85)	4.95(5.32)	2.37(3.11)
2	Me	White	70	213-215	61.07(62.14)	5.45(6.35)	4.45(5.02)

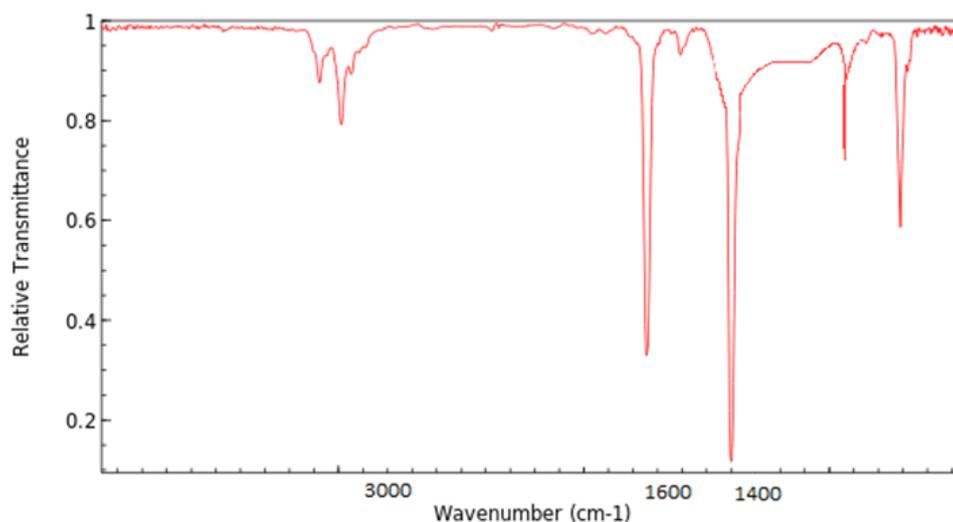


Figure 1: FT-IR-spectra of complexes

Table 2: FT-IR spectral data of ligand (L) and complexes **1** and **2**

Sn (IV) Complex	FTIR (ν , cm^{-1})				
	N-H	C=O	C=C	Sn-C	Sn-O
1	3313	1651	1452	522	449
2	3309	1660	1450	520	445
Ligand (L)	3310	1673	1486	526	451

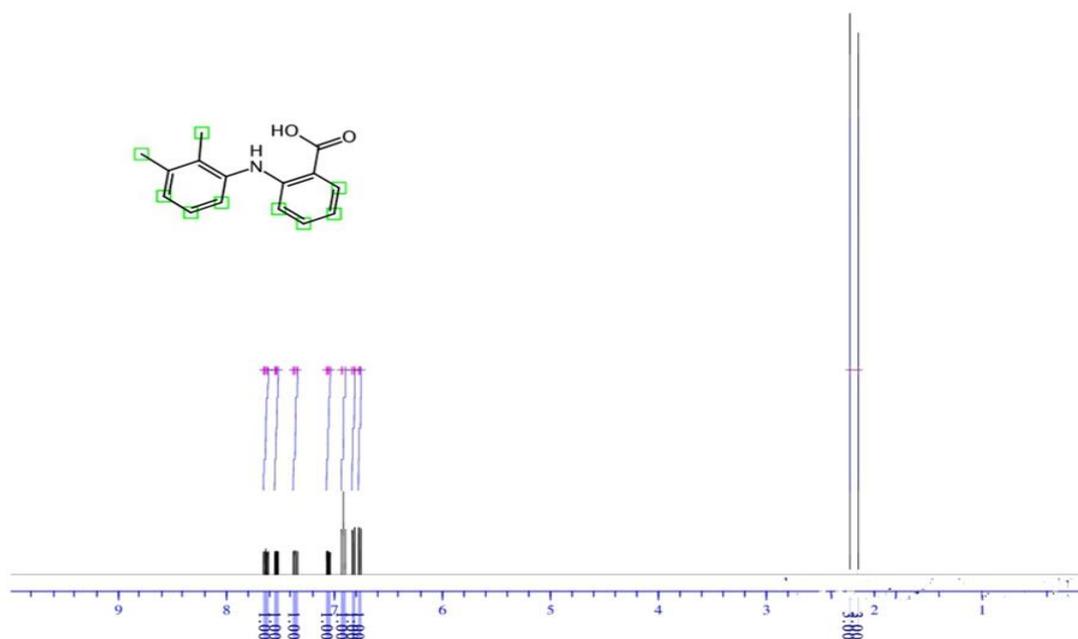


Figure 2: $^1\text{H-NMR}$ spectrum of 2-[(2,3-dimethylphenyl) amino] benzoic acid

Table 3: $^1\text{H-NMR}$ spectral data of 2-[(2,3-dimethylphenyl) amino] benzoic acid and complexes **1-2 1-4**

Sn (IV) Complex	$^1\text{H-NMR}$
L	13.005 (s, 1H, OH), 9.48 (s, H, NH), 6.65-7.89 (m, 6H, Ar), 2.501 (s, 3H, CH_3), and 2.08 (s, 3H, CH_3).
1	2.09 (s, 3H, Me), 2.50 (s, 3H, Me), 7.13-6.67 (m, 4H, Ar), 7.33-7.29 (m, 9H, Ar), 7.44-7.41 (m, 6H, Ar), 7.90-7.84 (m, 3H, Ar), and 9.46 (s, 1H, NH).
2	0.78 (s, 6H, 2Me), 2.08 (s, 6H, 2Me), 2.50 (s, 6H, 2Me), 7.32-6.98 (m, 8H, Ar), 7.89-7.84 (m, 6H, Ar), and 9.45 (s, 2H, 2NH).

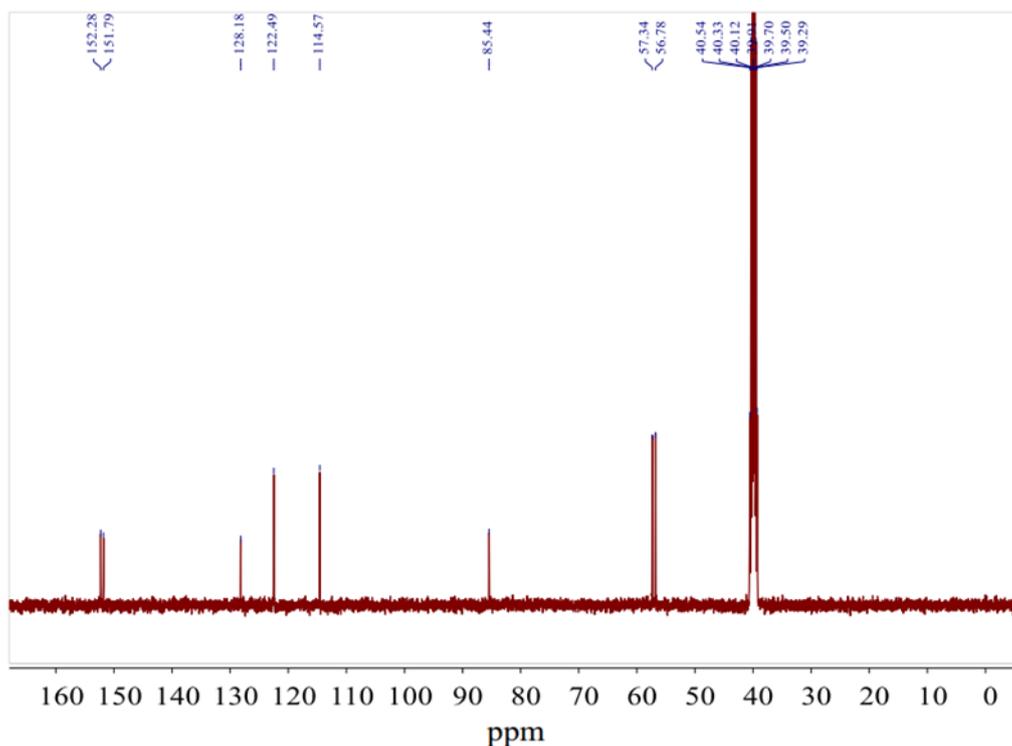


Figure 3: ^{13}C -NMR spectral data of **1** and **2** inside the aromatic area

Table 4: ^{13}C -NMR spectral data of complexes 1-2

Sn (IV) Complex	^{13}C -NMR
L	172.7 (C=O), 149.2 (C-NH), 138.3 (C-NH), 134.3 (C-CH ₃), 132.5, 126.8, 126.4, 122.6, 116.6, 113.5, 20.6, and 14.0.
1	170.2 (C=O), 149.6 (C-NH), 136.2 (C-NH), 136.2 (C-CH ₃), 129.5, 129.4, 129.1, 128.9, 128.8, 128.8, 128.7, 128.5, 111.7, 14.1, and 20.5 CH ₃ .
2	171.2 (C=O), 149.6 (C-NH), 138.3 (C-NH), 138.3 (C-CH ₃), 134.6, 132.2, 131.7, 126.8, 126.4, 122.6, 116.7, 113.5, 111.7, 14.1, and 20.6.

Cytotoxic activity

To demonstrate the binding efficiencies of each complex, the activity of each one was examined against the target cell line A-172, as compared

with the ligand alone. It was found that the complexes **1** and **2** have a higher cellular cytotoxicity than unconjugated ligand as follow (Figure 4).

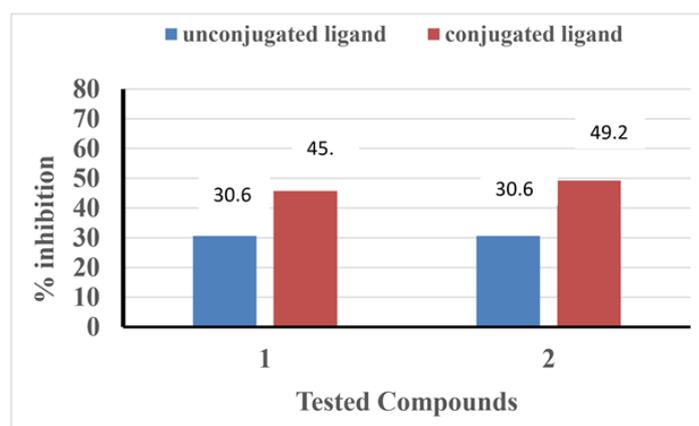


Figure 4: Effects of conjugated and unconjugated ligand A-172 cells viability

The data obtained that the prepared complexes **1** and **2** caused more inhibition on growth of target cells A-172 (45.7 %), (49.2 %) than ligand (30.6 %) (Figure 5). In addition, (IC₅₀) was calculated for complexes and unconjugated ligand to be 8.1µM for ligand alone and 3.1µM and 2.8 µM for complexes **1** and **2**, respectively. Thus, it indicated the important role for each compound to improve the activity of ligand as anticancer agent. Complex **2** shows a high activity than complex **1**, this may be related to the existence of methyl groups besides a high symmetry in complex **2** and the high contents of tin as compared with complex **1** containing tri phenyl group.

Conclusion

Cisplatin or cis-amino dichloroplatinium (II) (CDDP) is a platinum-based chemotherapy drug. Cisplatin is used to treat different cancers, including sarcomas, some carcinomas (such as small cell lung cancer and ovarian cancer), lymphomas, and germ cells. Cisplatin is an anti-neoplastic (anti-cancer) drug from the class of alkylating agents and is used to treat various types of cancers. The reason for naming alkylating agents is because of their ability to add alkyl groups to many electronegative groups in cells. They stop tumour growth by directly attacking the DNA and creating a cross-link between the guanine bases in the double-stranded DNA strand. This prevents the chains from being able to separate from each other, which is essential in the transcription process, so the cells cannot be divided and multiplied. In this study, we found that the anticancer activity depends on the geometrical structure of the prepared complexes and type of substituted organotin groups. The two prepared complexes show a higher antitumor activity than the ligand derived from.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

Conflict of Interest

The author declared that they have no conflict of interest.

References

- [1]. Boztepe T., Castro G.R., Leon I.E., Lipid, polymeric, inorganic-based drug delivery applications for platinum-based anticancer drugs, *International Journal of Pharmaceutics*, 2021, **605**:120788 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [2]. Shah A.S., Surnar B., Kolishetti N., Dhar S., Intersection of Inorganic Chemistry and Nanotechnology for the Creation of New Cancer Therapies, *Accounts of Materials Research*, 2022, **3**:283 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [3]. Dasari S., Njiki S., Mbemi A., Yedjou C.G., Tchounwou P.B., Pharmacological effects of cisplatin combination with natural products in cancer chemotherapy, *International Journal of Molecular Sciences*, 2022, **23**:1532 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [4]. Stankovic J.S.K., Selakovic D., Mihailovic V., Rosic G., Antioxidant supplementation in the treatment of neurotoxicity induced by platinum-based chemotherapeutics—a review, *International Journal of Molecular Sciences*, 2020, **21**:7753 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [5]. Wang W., Shanmugam M.K., Xiang P., Yam T.Y.A., Kumar V., Chew W.S., Chang J.K., Ali M.Z.B., Reolo M.J.Y., Peh Y.X., Abdul Karim S.N.B., Tan A.Y.Y., Sanda T., Sethi G., Herr D.R., Sphingosine 1-phosphate receptor 2 induces otoprotective responses to cisplatin treatment, *Cancers*, 2020, **12**:211 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [6]. Zhang C., Xu C., Gao X., Yao Q., Platinum-based drugs for cancer therapy and anti-tumor strategies, *Theranostics*, 2022, **12**:2115 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [7]. Cai L., Yu C., Ba L., Liu Q., Qian Y., Yang B., Gao C., Anticancer platinum-based complexes with non-classical structures, *Applied Organometallic Chemistry*, 2018, **32**:e4228 [[Crossref](#)], [[Google Scholar](#)]

[Scholar](#)], [[Publisher](#)]

[8]. Rébé C., Demontoux L., Pilot T., Ghiringhelli F., Platinum derivatives effects on anticancer immune response, *Biomolecules*, 2020, **10**:13 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[9]. Choudante P.C., Nethi S.K., Díaz-García D., Prashar S., Misra S., Gómez-Ruiz S., Patra C.R., Tin-loaded mesoporous silica nanoparticles: Antineoplastic properties and genotoxicity assessment, *Biomaterials Advances*, 2022, **137**:212819 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[10]. Banerjee K., Choudhuri S.K., A novel tin based hydroxamic acid complex induces apoptosis through redox imbalance and targets Stat3/JNK1/MMP axis to overcome drug resistance in cancer, *Free Radical Research*, 2021, **55**:1018 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[11]. Marzorati S., Verotta L., Trasatti S.P., Green corrosion inhibitors from natural sources and biomass wastes, *Molecules*, 2019, **24**:48 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[12]. Moradi M., Vasseghian Y., Khataee A., Kobya M., Arabzade H., Dragoi E.N., Service life and stability of electrodes applied in electrochemical advanced oxidation processes: a comprehensive review, *Journal of Industrial and Engineering Chemistry*, 2020, **87**:18 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[13]. Contel M., Unconventional anticancer metallodrugs and strategies to improve their pharmacological profile, *Inorganics*, 2019, **7**:88 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[14]. Malik M.A., Raza M.K., Mohammed A., Wani M.Y., Al-Bogami A.S., Hashmi A.A., Unravelling the anticancer potential of a square planar copper complex: toward non-platinum chemotherapy, *RSC Advances*, 2021, **11**:39349 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[15]. Wani M.Y., Malik M.A., Non-platinum Anticancer Agents, In *Gold and its Complexes in Anticancer Chemotherapy*, 2021, 51 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[16]. Ferraro M.G., Piccolo M., Misso G., Santamaria R., Irace C., Bioactivity and Development of Small Non-Platinum Metal-Based Chemotherapeutics, *Pharmaceutics*, 2022, **14**:954 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[17]. Yadav S., Potential of Metal Complexes for the Treatment of Cancer: Current Update and Future Prospective, *Chemistry of Biologically Potent Natural Products and Synthetic Compounds*, 2021, 183 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[18]. Zare A., Mirzaei M., Rostami M., Jafari E., Photosensitization of phthalocyanine for singlet oxygen generation in photodynamic therapy applications, *Journal of Medicinal and Chemical Sciences*, 2020, **3**:55 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[19]. Fazal-ur-Rehman M., Qayyum I., Biomedical scope of gold nanoparticles in medical sciences; an advancement in cancer therapy, *Journal of Medicinal and Chemical Sciences*, 2020, **3**:399 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[20]. Kaur N., Ahlawat N., Grewal P., Bhardwaj P., Verma Y., Organo or metal complex catalyzed synthesis of five-membered oxygen heterocycles, *Current Organic Chemistry*, 2019, **23**:2822 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[21]. Ma P., Hu F., Wang J., Niu J., Carboxylate covalently modified polyoxometalates: From synthesis, structural diversity to applications, *Coordination Chemistry Reviews*, 2019, **378**:281 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[22]. Dahmani M., Ettouhami A., Bali B.E., Yahyi A., Wilson C., Ullah K., Rehan I., Ullah S., Sheeba W., Arshad F., Elmsellem H., Organotin (IV) derivative of Piperic acid and Phenylthioacetic acid: Synthesis, Crystal structure, Spectroscopic characterizations and Biological activities, *Moroccan Journal of Chemistry*, 2020, **8**:8 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[23]. Wu X., Kang W., Zhu D., Zhu C., Liu S., Synthesis, crystal structure and biological activities of two novel organotin (IV) complexes constructed from 12-(4-methylbenzoyl)-9, 10-dihydro-9, 10-ethanoanthracene-11-carboxylic acid, *Journal of Organometallic Chemistry*, 2009, **694**:2981 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

[24]. Xiao X., Li Y., Dong Y., Li W., Xu K., Shi N., Liu X., Xie J., Liu P., "S" shaped organotin (IV) carboxylates based on amide carboxylic acids: syntheses, crystal structures and antitumor activities, *Journal of Molecular Structure*, 2017,

- 1130:901 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [25]. Rosenberg B., Vancamp L., Trosko J.E., Mansour V.H., Platinum compounds: a new class of potent antitumor agents, *Nature*, 1969, **222**:385 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [26]. Shang X., Cui J., Wu J., Pombeiro A.J.L., Li Q., Polynuclear diorganotin (IV) complexes with arylhydroxamates: syntheses, structures and in vitro cytotoxic activities, *Journal of Inorganic Biochemistry*, 2008, **102**:901 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [27]. Arora R., Issar U., Kakkar R., Theoretical investigation of organotin (IV) complexes of substituted benzohydroxamic acids, *Computational and Theoretical Chemistry*, 2018, **1138**:57 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [28]. Shang X., Wu J., Pombeiro A.J.L., Li Q., Mononuclear diorganotin (IV) complexes with arylhydroxamates: syntheses, structures and assessment of in vitro cytotoxicity, *Applied Organometallic Chemistry*, 2007, **21**:919 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [29]. Li Q., Yang P., Wang H., Guo M., Diorganotin (IV) antitumor agent. (C₂H₅)₂SnCl₂ (phen)/nucleotides aqueous and solid-state coordination chemistry and its DNA binding studies, *Journal of Inorganic Biochemistry*, 1996, **64**:181 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [30]. Li Q., Guedes da Silva M.F.C., Pombeiro A.J., Diorganotin (IV) derivatives of substituted benzohydroxamic acids with high antitumor activity, *Chemistry—A European Journal*, 2004, **10**:1456 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [31]. Banti C.N., Hadjikakou S.K., Sismanoglu T., Hadjiliadis N., Anti-proliferative and antitumor activity of organotin (IV) compounds. An overview of the last decade and future perspectives, *Journal of Inorganic Biochemistry*, 2019, **194**:114 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [32]. Hadjikakou S.K., Hadjiliadis N., Antiproliferative and anti-tumor activity of organotin compounds, *Coordination Chemistry Reviews*, 2009, **253**:235 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [33]. Singh R., Chaudhary P., Kaushik N.K., A Review: Organotin compounds in corrosion inhibition, *Reviews in Inorganic Chemistry*, 2010, **30**:275 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [34]. Mohammadnejad M., Moeinipour A., Rapid determination of mefenamic acid by ion mobility spectrometry after ultrasound-assisted extraction by HKUST-1 metal-organic framework: a simple strategy for food safety control, *International Journal for Ion Mobility Spectrometry*, 2020, **23**:105 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [35]. Zapała L., Kosińska M., Woźnicka E., Byczyński Ł., Zapała W., Synthesis, spectral and thermal study of La (III), Nd (III), Sm (III), Eu (III), Gd (III) and Tb (III) complexes with mefenamic acid, *Journal of Thermal Analysis and Calorimetry*, 2016, **124**:363 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [36]. Batool S.S., Gilani S.R., Zainab S.S., Tahir M.N., Harrison W.T.A., Syed Q., Mazhar S., Synthesis and Structural Characterization of a Monomeric Mixed Ligand Copper (II) Complex Involving N, N, N', N'-Tetramethylethylenediamine and Mefenamate, *Journal of Structural Chemistry*, 2019, **60**:1156 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [37]. Basu Baul T.S., Das P., Eng G., Linden A., Synthesis and Characterization of Some Triphenyltin (IV) Complexes from Sterically Crowded [(E)-1-{2-Hydroxy-5-[(E)-2-(aryl)-1-diazenyl] phenyl} methylidene) amino] acetate Ligands and Crystal Structure Analysis of a Tetrameric Triphenyltin (IV) Compound, *Journal of Inorganic and Organometallic Polymers and Materials*, 2010, **20**:134 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [38]. Kovala-Demertzi D., Dokorou V., Ciunik Z., Kourkoumelis N., Demertzis M.A., Organotin mefenamic complexes—preparations, spectroscopic studies and crystal structure of a triphenyltin ester of mefenamic acid: novel anti-tuberculosis agents, *Applied Organometallic Chemistry*, 2002, **16**:360 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]
- [39]. Sakakura T., Choi J.C., Saito Y., Sako T., Synthesis of dimethyl carbonate from carbon dioxide: catalysis and mechanism, *Polyhedron*, 2000, **19**:573 [[Crossref](#)], [[Google Scholar](#)], [[Publisher](#)]

HOW TO CITE THIS ARTICLE

Eman H. Al-Rikabi, Rana A. K. Al-Refai, Sadiq J. Baqir, Angham G. Hadi, Ahmed Kareem Al-Qayyim. Synthesis, structure, and *in vitro* cytotoxic activity of two organotin complexes of 2- [(2, 3-dimethylphenyl) amino] benzoic acid. *J. Med. Chem. Sci.*, 2023, 6(6) 1230-1238

<https://doi.org/10.26655/JMCHMSCI.2023.6.3>

URL: http://www.jmchemsci.com/article_160313.html