TWO NOVEL LEAD (II) AND MERCURY (II) COMPLEXES OF 2-((7-BROMO-10-ETHYL-5-OXIDO-10H-PHENOTHIAZIN-3-YL) METHYLENE) HYDRAZINE ARBOTHIOAMIDE: SYNTHESIS, STRUCTURE AND OPTICAL ANALYSIS

● LE THI THAO UYEN - LE VAN TAN - TRAN NGUYEN MINH AN

ABSTRACT:

The two novel complexes between Lead (II) and Mercury (II) ion and ligand, 2-((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl)methylene) hydrazine carbothioamide (PTZBS), a novel thiosemicarbazone were performed from starting material, Phenothiazine, which was conducted via methylation, , forming double bond C=O (Vilsmeier - Haak - Arnol'd reaction), bromination by NBS, nucleophile addition reaction of thiosemicarbazone to C=O double bond yielding thiosemicarbazone compound. Final state made the oxidation reaction, which formed a novel thiosemicarbazone compound. The novel ligand, 2-((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl)methylene) indicated the complexes with Pb (II) and Hg (II) ion, respectively. The structure of ligand was checked IR, ^{1}H, ^{13}C, DEPT- NMR, 2D-NMR (COSY and HMBC), and HR-MS.

Keywords: complexes of lead (II) and mercury (II), phenothiazine.

1. Introduction

Chemistry of phenothiazine has been fully reported in review article[1] and new derivatives of phenothiazine, and carbazole has indicated in previous article[2]. Many applications of phenothiazine groups show as photovoltaic applications[3], solar cell performance[4], synthesis, electrochemistry, light-emitting properties[5], and phototherapeutic agents[6]. Some significant bioactivates have revealed antitubercular[7] and cancer chemo preventive effect[8-10]. The important phenothiazine derivatives have applied in biochemistry and coordinate chemistry, which were thiosemicarbazone derivatives. These thiosemicarbazone compounds have made the complexes with metal ions[11]. The bonding and structure trends of thiosemicarbazone derivatives of metals have presented in many articles[12]. Some analytical applications of the thiosemicarbazone and semi carbazones have indicated in previous article[11]. Few significant applications of metal complexes of thiosemicarbazones in imaging and therapy[13], anticancer[14-16], antibacterial of Mn(II), Co(II), Zn(II), Fe(III) and U (VI) complexes, and 2-acetylpyridine 4N-(2-pyridyl) thiosemicarbazone (HAPT), and antitumor of

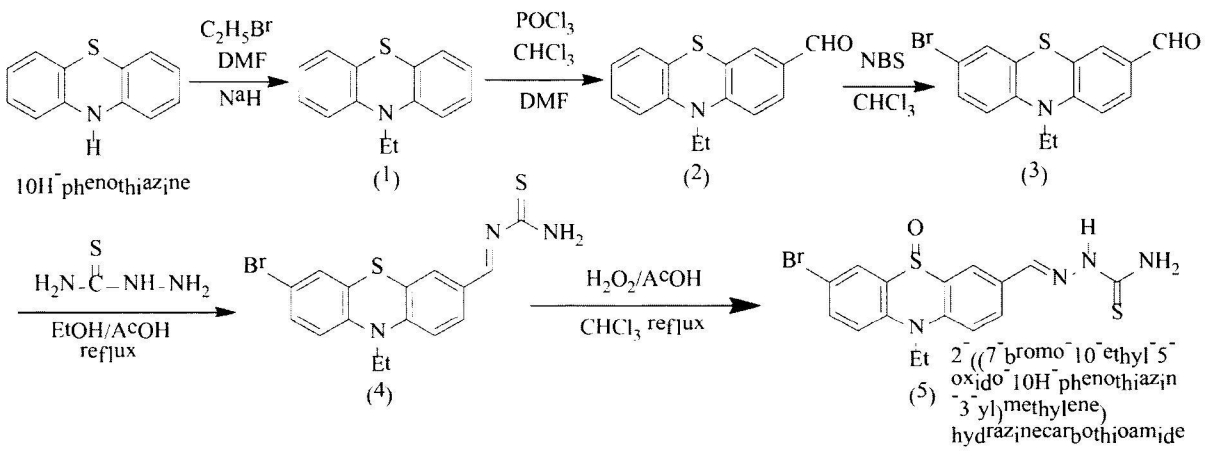
thiosemicarbazone- functionalized organ ruthenium (II)-arene, antioxidant, and antidiabetic of nickel complex of vanillin-4-Methyl-4-phenyl-3-thiosemicarbazone have mentioned, [17-18]. The complexes of thiosemicarbazone and metal ions as Cu (II), Zn(II), Ni (II), Mn(II), Fe (II), Bi (III) Co (III), Ga(III), Cd (II), Ru(II), Pd (II) and Pt (II) have studied strategy in many articles in synthesis, structure, and application in biochemistry, analytical chemistry, and optical applications[19-27]. The complexes of Hg (II) and thiosemicarbazone have reported in few article as spectroscopic studies[28], DNA[29], electrodes modified with clickable thiosemicarbazone ligands for sensitive voltametric detection of Hg(II) ions[30], and structural review[31]. The complex of Pb(II) and thiosemicarbazone derivatives have been rarely research article[32], [31]. As interesting about coordinate chemistry, analytical chemistry, the pollutions of heavy metals in wastewater, printing, and paper making, we continue to make synthesis of novel water-soluble ligand (thiosemicarbazone derivative) and conduct the complexes of Hg (II) and Pb(II) ions with ligand, respectively.

2. Materials and methods

The chemical reagents and solvents for reactions were obtained from Sigma- Aldrich, the solvents for chromatography column, ethyl acetate, n-hexane, dichloromethane, chloroform, and others were bought from Viet Nam suppliers. The TLC was received from Merk company. The synthesis compounds via ethylation (1), bromination (2), carbonylation (3), and nucleophile addition of thiosemicarbazone (4) to a derivative carbonyl were followed the scheme 1[33] except for oxidation reaction (5), which was based on article[1]. The complexes of metal ions (Hg^{2+} or Pb^{2+}) and ligand (5) and assessment of effects to form the derivative thiosemicarbazone complexes were performed based on previous article[20].

Procedure for synthesis of Ethyl phenothiazine (1): 16g (0.08 mol) of phenothiazine was dissolved in 175 mL (2.46 mol) of DMF solvent and 5 g NaH (0.08 mol), then slowly added 11.7 mL of C_2H_5Br (0,15 mol). The reaction mixer was heated and stirred for 8 hours. When the reaction was finished, it was added more water, stirred, and waited for the forming solid. The mass of solid was filtered through the vacuum filtration system to get the light purple solid. The solid was washed with MeOH solvent and heated to 50°C. After washing, the solid was filtered to yield the white solid. The yield of reaction was 86.36%. Procedure for synthesis of 10-ethyl-10H-phenothiazine-3-carbaldehyde (2): 5 g of ethyl phenothiazine (1) in 7,5 ml of CHCl3 solvent added 25 mL of DMF in a two neck round bottom flask and made the mixture in ice bath. 7,5 mL of CHCl3 solvent and 41 mL of $POCl_3$ were taken into a separating funnel. The separating funnel were slowly dropped in a two-neck flask, allowing the

Scheme 1. The synthesis of 2-((7-bromo-10-ethyl-5-oxido-10H-phenothiazin-3-yl)methylene) hydrazine carbothioamide (5), ligand from phenothiazine via intermediate (1) to (5)



mixture to run for approximately 1 hour. After one hour, the ice bath was replaced with an oil tank and started heating the system at about 70-75^{0}C. After completing of the reaction (checking TLC) was 22 hours, it was transferred the entire mixture to the separating funnel, added 10% NaOH solution, and shacked well to separate the two phases, which the water phase was above layer, and the organic phase was below layer. The organic phase was repeated the wash with amount of water until it has pH 7.0. The Na_2SO_4 was added to organic phase to dry the residual water in organic layer. The organic layer was vacuum filtration to obtain the solution. The obtained extract was evaporated in vacuum to obtain solid. The yellow solid was washed in hot hexane at 40-50^{0}C). After 2 hours of stirring, the vacuum filtration was conducted and obtained 5.25 grams of solid. The yield was obtained 93.42%. Procedure for synthesis of 7-bromo-10-ethyl-10H-phenothiazine-3-carbaldehyde (3): 2.3 grams of compound (2) (0.09 mol) added into a two neck round bottom flask, inserted the condenser system, and made exactly 9 mL of CHCl3 into it. The reaction mixer was heated and stirred. To weigh 1.61 grams (0.09 mol) of NBS added to a two neck round bottom flask. The system started to heat at 70-75^{0}C. At the end of the reaction, the entire mixture was poured to the separating funnel, added water, and shacked to separate two phases. The layer of organic was repeated to wash with water from 2-3 times. The solution was dried with Na_2SO_4 to a solution. The obtained extract was subjected to vacuum evaporation to obtain a viscous mixture. The solid was washed in warm hexane. After 2 hours of stirring and vacuum filtration, the pure solid was obtained 2.34 grams of light yellow solid. The yield was 76.47%. Procedure for synthesis of 2-((7-bromo-10-ethyl-10H-phenothiazin-3-yl) methylene) hydrazine carbothioamide (4): 2.34 gram of compound (3) and 0.808 gram of thiosemicarbazone added into a two neck round bottom flask, installed a condenser system, poured 50 mL of EtOH solvent into it, and added 0.8 mL of AcOH (ice). The mixer of reaction was started to heat to 80^{0}C and stirred continuously. After few hours of reaction, the reaction was checked TLC. After completing reaction, the solid, being formed in reaction was filtered to separate the solid. The solid was washed in warm ethanol at 55-60^{0}C. The vacuum filtration and drying yielded 2.5 gram of yellow solid. The yield was 88.23%. Procedure for synthesis of 2-((7-bromo-10-ethyl-5-oxido-10H-phenothiazin-3-yl)methylene) hydrazine carbothioamide (5): 2.5 gram of compound (4) was added a two neck round bottom flask, inserted the condenser system, and taken exactly 10 mL of $CHCl_3$ into it. When the solid was completely dissolved in $CHCl_3$ solvent, it added 1.1 mL AcOH (ice) and 0.2 mL H_2O_2. The reaction was increased temperature to 50^{0}C and stirred. When the temperature of reaction was desired, reaction time was started counting, and added 0.2 mL H_2O_2 every hour. The entire mixture was transferred to the separating funnel, added 10% of a NaOH solution, and shake well to separate into the two phases. The organic layer below was kept and repeated to wash until pH 7. The Na_2SO_4 was used to dry residual water in solution. The obtained solution was subjected to vacuum evaporation to obtain a viscous mixture. The yellow solid was washed in warm hexane at 55-60^{0}C. After completing stirring, the solid was performed the vacuum filtration and obtained 2.53 gram of yellow solid. The yield was 78.82%.

3. Results and Discussions

Results: Ethyl phenothiazine (1): FT-IR (ϑ_{max}, cm^{-1}): 2982(CH3), 2932(CH2), 2860(C-H), 1574, 1447 (C=C), 1121 C-N, 750 (substitute phenothiazine); ^{1}H-NMR (500 MHz, Acetone, d_6): δ (ppm): 1.36 (t, J =7.5, 3H; CH_3), 3.39 (q, J =7.5 Hz, 2H, CH_2), 6.90–6.93 (m, 2H, Phenothyazine–H), 6.97–6.99 (m, 2H, Phenothiazine–H), 7.10–7.12 (m, 2H, Phenothiazine–H), 7.16–7.19 (m, 2H, Phenothiazine–H); ^{13}C-NMR (125 MHz, acetone, d_6), DEPT 90, 135 and CPD: δ (ppm): 13.3 (CH3), 42.2 (CH_2), 116.2 (CH), 123.1(CH), 125.0 (quaternary carbon), 127.9 (CH), 128.2 (CH) và 145.8 (quaternary carbon); 10-ethyl-10H-phenothiazine-3-carbaldehyde (2): FT-IR (ϑ_{max}, cm^{-1}): 2976 (CH_3) 2825 (CH_2), 1667 (C=O), 1567, 1460 (C=C), 1242 (C-N), 747 (substitute phenothiazine); ^{1}H-NMR (500 MHz, Acetone, d6): δ (ppm): 1.40 (t, J =7.0 Hz, 3H; CH3), 4.09 (q, J=7.5 Hz, 2H, CH2), , 6.97–6.99 (m, 1H, Phenothiazine–H), 7.05–7.07 (m, 1H, Ar–H),

7.10–7.13 (m, 2H, Ar–H), 7.56 (d, J = 5.0 Hz, 1H, Phenothiazine–H), 7.19–7.23 (m, 1H, Phenothiazine–H), 7.69–7.71 (m, 1H, Phenothiazine–H), 9.82 (s, 1H, CH=O); ^{13}C-NMR (125 MHz, acetone, d6), DEPT 90, 135 and CPD: δ (ppm): 13.05 (CH_3), 42.90 (CH_2), 115.8 (CH), 116.8 (CH), 123.7(quaternary carbon), 124.3 (CH), 124.9 (quartenary carbon), 128.0 (CH), 128.3 (CH), 128.6 (CH), 130.9 (CH), 132.3 (quaternary carbon), 144.1(quaternary carbon), 150.9 (quaternary carbon), 190.4 (CH=O); 7-bromo-10-ethyl-10H-phenothiazine-3-carbaldehyde (3): FT-IR (ϑ_{max}, cm^{-1}): 2969 (CH_3), 2830 (CH_2), 1670 (C=O), 1463 (C=C), 1240 (C-N); 1H-NMR (500 MHz, Acetone, d6): δ (ppm): 1.38 (t, J =5.0 Hz, 3H, CH_3), 4.01(q, J = 5.0 Hz, 2H, CH_2), 6.96 (d, J =10.0 Hz,1H, Phenothiazine-H), 7.13 (d, J =10.0 Hz, 1H, Phenothiazine–H), 7.23 (d, J = 5.0 Hz,1H, Phenothiazine-H), 7.30–7.32 (m, 1H, Phenothiazine-H), 7.54 (d, J = 5.0 Hz, 1H, Phenothiazine-H), 7.70–7.71 (m, 1H, Phenothiazine-H), 9.82 (s, 1H, CH=O); ^{13}C-NMR (125 MHz, acetone, d6), DEPT 90, 135 and CPD:δ (ppm): 12.9 (CH3), 43.0 (CH2), 116.0 (CH), 118.3 (CH), 115.9 (quaternary carbon), 124.0 (quaternary carbon), 128.4 (CH), 129.9 (CH), 131.1 (CH), 131.2 (CH), 126.2 (quaternary carbon), 132.5 (quaternary carbon), 143.4 (quaternary carbon), 150.3 (quaternary carbon), 190.4 (CH=O); 2-((7-bromo-10-ethyl-10H-phenothiazin-3-yl) methylene) hydrazine carbothioamide (4): FT-IR (ϑ_{max}, cm^{-1}): 3402 (N-H of NH_2), 3345(N-H of NH_2), 2881 (CH_2), 1594 (azomethine, C=N), 1509 (C=C, Phenothiazine), 1458 (C-H, bending), 1240 (C-N), 1097 (C=S), 547 (C-Br); 1H-NMR (500 MHz, Acetone, d_6): δ (ppm): 1.22 (t, J =7.0 Hz, 3H, CH3), 3.62 (q, J =7.0 Hz, 2H, CH_2), 6.5 (s, 1H, CH=N), 6.69 (d, J = 8.5 Hz, 1H, Phenothiazine-H), 6.81(d, J = 8.5 Hz,1H, Phenothiazine-H), 7.19–7.23 (m, 3H, Phenothiazine-H), 7.32 (d, J =2.0 Hz, 1H, Phenothiazine–H), 7.34 (s, 1H, NH2), 7.69 (s, 1H, NH_2), 9.67 (s, 1H, NH); ^{13}C-NMR (125 MHz, acetone, d_6), DEPT 90, 135 and CPD:δ (ppm): 12.3 (CH_3), 41.4 (CH_2), 113.5 (CH), 113.9 (quaternary carbon), 115.2(CH), 117.1 (CH), 122.5 (C quaternary carbon), 124.7 (CH), 124.8 (quaternary carbon), 127.9 (quaternary carbon), 128.8 (CH), 130.2 (CH) and 141.0 (CH), 142.8 (quaternary carbon), 144.9 (quaternary carbon), 177.7 (quaternary carbon); 2-((7-bromo-10-ethyl-5-oxido-10H-phenothiazin-3-yl)methylene) hydrazine carbothioamide (5): FT-IR (ϑ_{max}, cm^{-1}): 3067(N-H of NH_2), 2930(CH_3), 1684, 1603 (C=N), 1492 (C=N), 1464 (C-H, bending), 1196(C=S), 1070 (S=O), 517 (C-Br); 1H-NMR (500 MHz, Acetone, d_6): δ (ppm): 1.59 (t, J = 7.25 Hz, 3H, CH_3), 4.32 (q, J = 7.25 Hz, 2H, CH_2), 7.45 (s, 1H, CH=N), 7.33 (d, J = 9.0 Hz,1H, Phenothiazin-H), 7.49 (d, J = 9.0 Hz,1H, Phenothiazine-H), 7.76 (dd, J =10.0, 2.5 Hz, 1H, Phenothiazine-H), 8.15–8.17 (m, 1H, Phenothiazine-H), 8.25 (d, J = 2.0 Hz,1H, Phenothiazine-H), 8.46 (s, 1H, NH2), 8.59 (d, J = 2.0 Hz,1H, Phenothiazine-H), 8.85 (s, 1H, NH2), 10.01 (s, 1H, NH); ^{13}C-NMR (125 MHz, acetone, d6), DEPT 90, 135 and CPD:δ (ppm): 12.61(CH_3), 43.99 (CH_2), 115.74 (quaternary carbon), 116.5 (CH), 118.1 (CH), 123.9 (quaternary carbon), 126.0 (quaternary carbon), 126.5 (CH), 128.0 (CH), 130.2 (quaternary carbon), 132.4 (CH), 138.8 (quaternary carbon), 144.1(quaternary carbon), 189 (CH=N) ,189.3 (C=S); HR-MS (ESI, MS-MS): theory value , $[M+H]+$ = 423.0103, experiment value, $[M+H]^+$ = 423.0118. Assessment of forming the complex of Hg(II), Pb(II) with ligand (5): the experiment to find the maximum absorption wavelength (λmax) of ligand: 0.0025 g of ligand was dissolved completely with pure ethanol solvent and diluted up to 250 mL to obtain a ligand solution of 10 ppm concentration. The ligand solutions between 1 ppm and 5 ppm were prepared and samples of solutions with concentrations from 1 ppm to 5 ppm was scan in the wavelength range λ = 200-600 nm. As shown in figure.4, ligand (5) obtained maximum absorption, which corresponded the value of 203 nm in maximum absorption wavelength. Effect of concentration on the forming complex: The complex PbL_2 was conducted at A_{max} of 1.7876, λ = 217 nm, the volume ratio $V_{Pb^{2+}}$: V_{ligand} = 6:4 , mol ratio, and $n_{Pb^{2+}}$: n_{ligand} : = 1: 2. The complex PbL_2 was conducted at A_{max} of 1.7876, λ = 217 nm, the volume ratio $V_{Hg^{2+}}$: V_{ligand} = 7:3 , mol ratio, and $n_{Hg^{2+}}$: n_{ligand} : = 3: 1. The complex HgL_3 was performed at A_{max} = 2.2057 , λ = 218 nm.

Figure.1. The COSY spectrum of (5) indicated H-H correlations

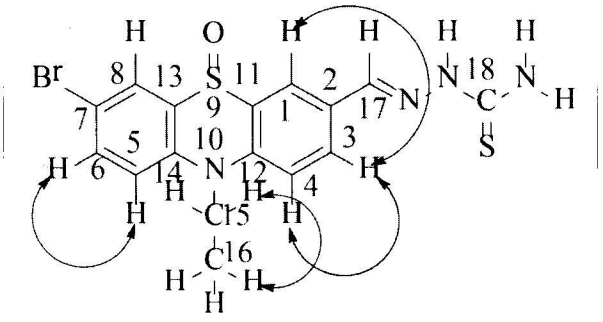


Figure. 2. HMBC of (5) showed the H-C correlations via many bonds

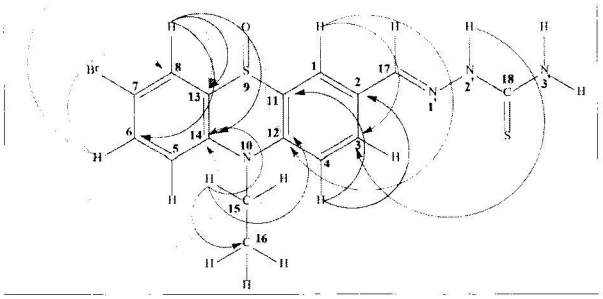


Figure.3. Structure of (5)

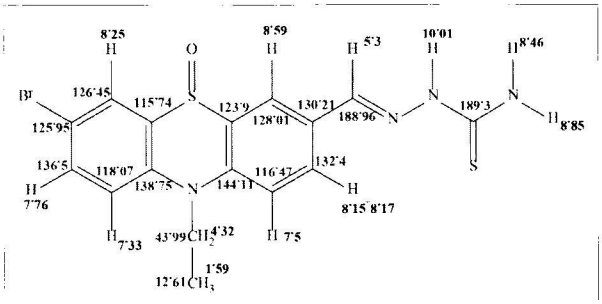


Figure 4. UV absorption spectra of ligand (5) at concentration of 1-10 ppm

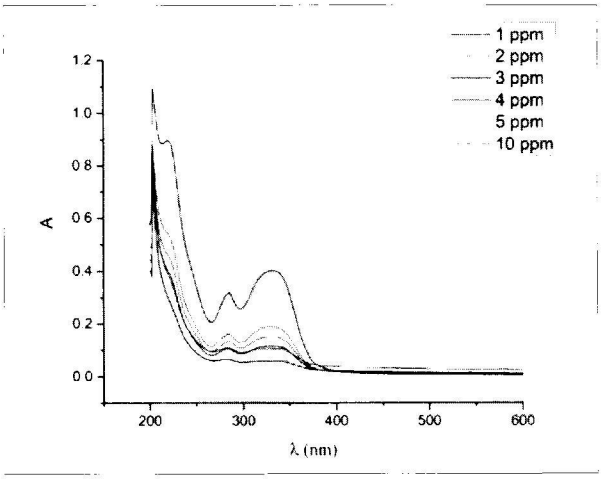


Figure.5. A complex was formed between ligand (5) and Pb^{2+}, which was given the best optical absorption, A_{max} of 1.7876, at λ = 217 nm, the volume ratio $V_{Pb^{2+}} : V_{ligand}$ = 6:4, mol ratio, $n_{Pb^{2+}} : n_{ligand}$ = 1.91 : 1.

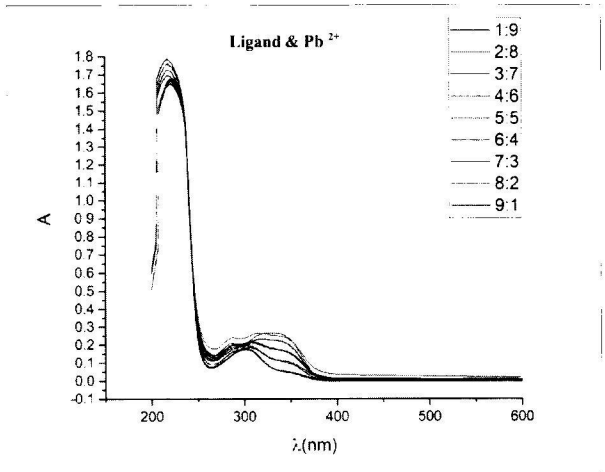
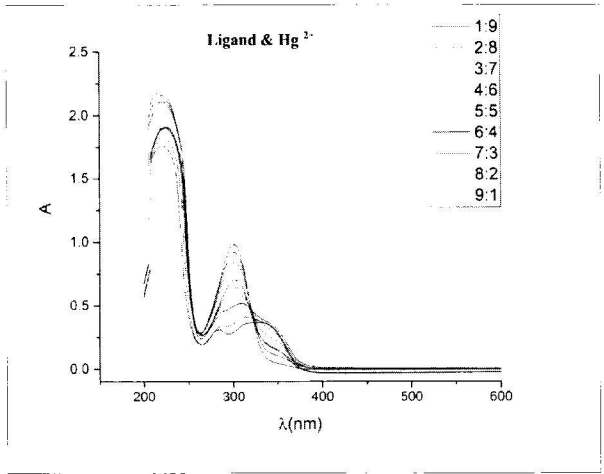


Figure.6. A complex was formed between ligand (5) and Hg^{2+}, which was given the best optical absorption, A_{max} of 2.2057, at λ = 218 nm, the volume ratio $V_{Hg^{2+}} : V_{ligand}$ = 7:3, mol ratio, $n_{Pb^{2+}} : n_{ligand}$ = 3.04 : 1.



Discussions: COSY(H,H) was 2D spectrum as shown in Figure.1, H-15 and H-16 indicated a correlation via 3 bonds, which matched the signal on the spectrum map at 1.59 ppm (t) with 4.32 ppm (q).

The H-3 and H-4 showed the correlation via 3 bonds, which were consistent with the signal on the spectrum at 8.15-8.17 ppm (m) with 7.5 ppm (d, $J = 9$ Hz), orto coupling. The correlation via 4 bonds between H-1 and H-3 was matched with the signal on the spectrum at 8.59 ppm (d, $J = 2$ Hz), meta coupling with 8.15-8.17 ppm (m). The correlation via 3 bonds made the resonance between H-5 and H-6, which was consistent with the signal on the spectrum at 7.33 ppm (d, $J = 9,0$ Hz) with 7.76 ppm (dd, $J = 9.0$, 2.5 Hz), orto coupling. The coupling correlation of 4 bonds was formed between H-6 and H-8 that was consistent the resonance signals at 7.76 ppm (dd, $J =$ 9.0, 2.5 Hz) with 8.25 ppm (d, $J = 2.5$ Hz), meta-coupling. The HMBC spectrum was 2D spectrum as showed in Figure.2. it presented the H-C correlations via many bonds. Based on ^{1}H, ^{13}C, DEPT, COSY, HMBC, and HR-MS, the structure of compound (5) was determined in Figure.3.

4. Conclusions

The compound (5), 2-((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl)methylene) hydrazine carbothioamide(PTZBS) was synthesized via 5 reactions and checked physical chemistry. The two novel complexes between Lead (II) and Mercury (II) and ligand, 2-((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl)methylene) hydrazine carbothioamide were performed ■

REFERENCES

[1] S. P. Massie. (1954). The chemistry of phenothiazine, *Chem. Rev.*, 54(5),797–833.

[2] M. Lu, Y. Zhu, K. Ma, L. Cao, K. Wang. (2012). Facile synthesis and photo-physical properties of cyano-substituted styryl derivatives based on carbazole/phenothiazine. Spectrochim. Acta - Part A Mol. *Biomol. Spectrosc.*, 95, 128-134.

[3] Y. Li. (2009). Energy level and molecular structure engineering of conjugated donor-acceptor copolymers for photovoltaic applications. *Macromolecules*, 42(13), 4491-4499.

[4] Y. Hua. (2013). Significant improvement of dye-sensitized solar cell performance using simple phenothiazine-based dyes. *Chem. Mater.*, 25(10), 2146-2153.

[5] X. Kong, A. P. Kulkarni, S. A. Jenekhe. (2003). Phenothiazine-Based Conjugated Polymers: Synthesis, Electrochemistry, and Light-Emitting Properties. *Macromolecules*, 36(24), 8992-8999.

[6] R. Rajagopalan, T. Lin, A. S. Karwa, A. R. Poreddy, B. Asmelash,R. B. Dorshow. (2012). Studies of Tricyclic Diarylamines. *Med. Chem. Lett.*, 3, 284-288.

[7] D. Addla, A. Jallapally, D. Gurram, P. Yogeeswari, D. Sriram, S. Kantevari. (2014). Rational design, synthesis and antitubercular evaluation of novel 2-(trifluoromethyl)phenothiazine-[1,2,3]triazole hybrids. *Bioorganic Med. Chem. Lett.*, 24(1), 233-236.

[8] M. A. Azuine. (2004). Cancer chemopreventive effect of phenothiazines and related tri-heterocyclic analogues in the 12-O-tetradecanoylphorbol-13-acetate promoted Epstein-Barr virus early antigen activation and the mouse skin two-stage carcinogenesis models. *Pharmacol. Res.*, 49, (2), 161-169.

[9] C. M. Abuhaie. (2013). Synthesis and anticancer activity of analogues of phenstatin, with a phenothiazine A-ring, as a new class of microtubule-targeting agents. *Bioorganic Med. Chem. Lett.*, 23(1), 147-152.

[10] A. Bisi, M. Meli, S. Gobbi, A. Rampa, M. Tolomeo, L. Dusonchet, Multidrug resistance reverting activity and antitumor profile of new phenothiazine derivatives, Bioorganic Med. Chem., Vol. 16, No. 13, 6474-6482, 2008.

[11] B. S. Garg, V. K. Jain. (1988). Analytical applications of thiosemicarbazones and semicarbazones. *Microchem. J.*, 38(2), 144-169.

[12] T. S. Lobana, R. Sharma, G. Bawa, S. Khanna. (2009). Bonding and structure trends of thiosemicarbazone derivatives of metals-An overview. *Coord. Chem. Rev.*, 253(7-8), 977-1055.

[13] J. R. Dilworth, R. Hueting. (2012). Metal complexes of thiosemicarbazones for imaging and therapy. *Inorganica Chim. Acta*, 389, 3-15.

[14] J. Qi. (2018). Synthesis, antiproliferative activity and mechanism of gallium(III)-thiosemicarbazone complexes as potential anti-breast cancer agents. *Eur. J. Med. Chem.*, 154, 91-100.

[15] J. Deng. (2018). Designing anticancer copper (II) complexes by optimizing 2-pyridine-thiosemicarbazone ligands, *Eur. J. Med. Chem.*, 158, 442-452.

[16] N. K. Singh, A. A. Kumbhar, Y. R. Pokharel, P. N. Yadav. (2020). Anticancer potency of copper(II) complexes of thiosemicarbazones. *J. Inorg. Biochem.*, 210, 111134.

[17] L. V Kumar, S. Sunitha, G. Rathika Nath. (2020). Antioxidant, antidiabetic and anticancer studies of nickel complex of Vanillin-4-Methyl-4-Phenyl-3-Thiosemicarbazone. *Mater. Today,* Proceeding.

[18] T. Bal-Demirci, Ş. Güveli, S. Yeşilyurt, N. Özdemir, and B. Ülküseven. (2020). Thiosemicarbazone ligand, nickel(II) and ruthenium(II) complexes based on vitamin B6 vitamer: The synthesis, different coordination behaviors and antioxidant activities. *Inorganica Chim. Acta,* 502, 119335.

[19] J. Haribabu. (2021). N-substitution in isatin thiosemicarbazones decides nuclearity of Cu(II) complexes – Spectroscopic, molecular docking and cytotoxic studies. Spectrochim. Acta - Part A Mol. *Biomol. Spectrosc.*, 246, 118963.

[20] A. A. El-Asmy, O. A. El-Gammal, H. S. Saleh. (2008). Spectral, thermal, electrochemical and analytical studies on Cd(II) and Hg(II) thiosemicarbazone complexes. Spectrochim. Acta - Part A Mol. *Biomol. Spectrosc.*, 71(1), 39-44.

[21] F. A. Beckford and K. R. Webb. (2017). Copper complexes containing thiosemicarbazones derived from 6-nitropiperonal: Antimicrobial and biophysical properties. Spectrochim. Acta - Part A Mol. *Biomol. Spectrosc.*, 183, 158-171.

[22] S. Eïlence-Bakýr. (2020). Palladium (II) complexes with thione and thioalkylated thiosemicarbazones: Electrochemical, antimicrobial and thermogravimetric investigations. Spectrochim. Acta - Part A Mol. *Biomol. Spectrosc.*, 237.

[23] S. Kumar. (2017). Co(II), Ni(II), Cu(II) and Zn(II) complexes of acenaphthoquinone 3-(4-benzylpiperidyl) thiosemicarbazone: Synthesis, structural, electrochemical and antibacterial studies. *Polyhedron,* 134, 11-21.

[24] S. J. Sardroud, S. A. Hosseini-Yazdi, M. Mahdavi, M. Poupon, E. Skorepova. (2020). Synthesis, characterization and in vitro evaluation of anticancer activity of a new water-soluble thiosemicarbazone ligand and its complexes. *Polyhedron,* 175, 114218.

[25] S. Huang, H. Luo, Y. Liu, W. Su, Q. Xiao. (2020). Comparable investigation of binding interactions between three arene ruthenium (II) thiosemicarbazone complexes and calf thymus DNA. *Polyhedron,* 192, 114864.

[26] A. M. Palve, P. V. Joshi, V. Puranik, S. S. Garje. (2013). Synthesis and X-ray single crystal structure of a cadmium (II) acetophenone thiosemicarbazone complex and its use as a single-source precursor for the preparation of CdS nanocrystallites and thin films. *Polyhedron,* 61, 195–201.

[27] B. Amritha, O. Manaf, M. Nethaji, A. Sujith, M. R. Prathapachandra Kurup, S. Vasudevan. (2020). Mn(II) complex of a di-2-pyridyl ketone-N(4)-substituted thiosemicarbazone: Versatile biological properties and naked-eye detection of Fe^{2+} and Ru^{3+} ions'. *Polyhedron,* 178, 114333.

[28] A. Basu, G. Das. (2011). Zn(II) and Hg(II) complexes of naphthalene based thiosemicarbazone: Structure and spectroscopic studies. *Inorganica Chim. Acta,* 372(1), 394-399.

[29] T. A. Yousef, G. M. Abu El-Reash, R. M. El Morshedy. (2013). Structural, spectral analysis and DNA studies of heterocyclic thiosemicarbazone ligand and its Cr(III), Fe(III), Co(II) Hg(II), and U(VI) complexes. *J. Mol. Struct.*, 1045, 145-159.

[30] M. D. Raicopol. (2000). Electrodes modified with clickable thiosemicarbazone ligands for sensitive voltammetric detection of Hg (II) ions, Sensors Actuators. *B Chem.*, 313(April), 128030.

[31] J. S. Casas, M. S. García-Tasende, J. Sordo. (2000). Main group metal complexes of semicarbazones and thiosemicarbazones. A structural review. *Coord. Chem. Rev.*, 209(1), 197-261.

[32] N. M. Quang, T. X. Mau, N. T. Ai Nhung, T. N. Minh An, P. Van Tat. (2019). Novel QSPR modeling of stability constants of metal-thiosemicarbazone complexes by hybrid multivariate technique: GA-MLR, GA-SVR and GA-ANN. *J. Mol. Struct.*, 1195, 95-109.

[33] T. N. M. An. (2019). Synthesis, Docking Study, Cytotoxicity, Antioxidant, and Anti-microbial Activities of Novel 2,4-Disubstituted Thiazoles Based on Phenothiazine. *Curr. Org. Synth.*, 17(2), 151-159.

Received date: January 2, 2021
Reviewed date: January 15, 2021
Accepted date: January 30, 2021

Authors' information:
1. Eng. LE THI THAO UYEN
2. Prof. Ph.D LE VAN TAN
3. Assoc.Prof. Ph.D TRAN NGUYEN MINH AN
Industrial University of Ho Chi Minh City, Ho Chi Minh City, Viet Nam

CÁC PHỨC MỚI CỦA CHÌ (II), THỦY NGÂN (II) VÀ LIGAND, 2-((7-BROMO-10-ETHYL-5-OXIDO-10H-PHENOTHIAZIN-3-YL) METHYLENE) HYDRAZINE CARBOTHIOAMIDE: TỔNG HỢP VÀ ỨNG DỤNG TRONG PHÂN TÍCH QUANG TRẮC

● KS. **LÊ THỊ THẢO UYÊN**
● GS.TS. **LÊ VĂN TÁN**
● PGS.TS. **TRẦN NGUYỄN MINH ÂN**
Đại học Công nghiệp Thành phố Hồ Chí Minh,
Thành phố Hồ Chí Minh, Việt Nam

TÓM TẮT:

Hai phức chất mới giữa ion Chì (II) và Thủy ngân (II) với phối tử, 2-((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl) methylene) hydrazine carbothioamide (PTZBS), được tổng hợp từ nguyên liệu ban đầu, Phenothiazine, ngang qua ethyl hóa, hình thành liên kết C=O (phản ứng Vilsmeier - Haak- Arnol'd), brom hóa bởi NBS, phản ứng cộng nucleophile với thiosemicarbazone để tạo ra liên kết đôi, C=O tạo hợp chất thiosemicarbazone. Cuối cùng thực hiện phản ứng oxy hóa, tạo thành hợp chất thiosemicarbazone mới. Ligand, 2 - ((7-bromo-10-ethyl-5-oxido-10h-phenothiazin-3-yl) methylene) được tạo phức với hai ion Pb (II) và Hg (II). Các cấu trúc của ligand đã được xác định bằng các phương pháp hóa lý hiện đại: IR, ^{1}H, ^{13}C, DEPT, NMR và kỹ thuật NMR 2 chiều: 2D, COSY và HMBC) và HR-MS.

Từ khóa: phức chất giữa ion Chì (II) và Thuỷ ngân (II), Phenothiazine.