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Synthesis, Characterization and Antibacterial Activity of some Cu (II), Hg (II) Complexes with a Mixture of N-(benzothiazol-2-yl) benzamide and Amines or Diphosphines Ligands

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Abstract:

Benzothiazole derivatives play vital role in some biological applications. The important coordinating sites of the Benzothiazole derivatives have participated in the preparation of many complexes. In this study, a number of Cu(II) and Hg(II) complexes of N-(benzothiazol-2-yl)benzamide**(Btba)** containing co-ligands such as Amines (2-aminopyridine, 3-aminopyridine, 4-aminopyridine, Bipy, Phen) or diphosphines (dppm, dppe) have been prepared. The prepared complexes have been characterized by Molar conductivity, magnetic susceptibility, UV-VISspectra, IR spectra, ^{31}P-NMR, ^{1}H-NMRand ^{13}C-NMR spectra. The suggestion of geometric around the metal ions can be tetrahedral form. That the **(Btba)** ligand acted like a bidentate ligand through the N atom of five member ring in benzothiazole and O atom of carbonyl group, while the amines or diphosphines ligands coordinated through the N atoms or P atoms respectively, where the dppm ligand behaves in complex $[Hg_2(Btba)_2(dppm)_2]Cl_4$ **(9)** as a bridge ligand while the dppe behaves as a bidentate ligand in complex $[Hg(Btba)(dppe)]Cl_2$ **(10)**.

The biological activity of these prepared complexes against four bacterial species was investigated in this study: *Staphylococcus Epidermidis* and *Staphylococcus aureus* (gram positive) and *E. Coli, CitrobacerFreundii* (gram negative) (gram negative). As a reference, amikacin was used. The prepared complexes were more effective than amikacin against *Staphylococcus epidermidis*. The **(9)** complex, on the other hand, was more active against *Staphylococcus aureus* than amikacin until at minimum concentration. In the minimum concentration, the **(3,5,6,8, and 10)** complexes were more active against *E. Coli*,and the **(1,3,4,5,7,8,9, and 10)** complexes were more active against *Citrobacterfreundii* than amikacin.

Keywords: Benzothiazole derivatives, Mercury complexes, diphosphines, antibacterial activity

Introduction:

Benzothiazole is one of the bicyclic ring systems that are important in organic preparations as a basic nucleus for other organic (1,2) or inorganic derivatives in the formation of complexes (3,4). Benzothiazole possesses effective N, S donor atoms and has different consistency methods and its

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importance increases as a ligand through derivatives that have donor atoms such as N, S, and O (5,6).

The benzothiazole derivatives are well known among the biologically active bicyclic ring systems containing both S and N atoms (7). Many benzothiazoles are used in medicine as anti-cancer (8), anti-inflammatory (9), anti-parasitic (10) and anti-viral agents (11).

Because of their synthetic stability and antibacterial action of their metal complexes, aminobenzothiazole derivatives are very significant (12). Mercury (II) and copper (II) complexes of 6–methyl–2–aminobezothiazole have previously been shown to have increased antibacterial activity against *Alternaria alternate*, *Aspergillusniger*, *Penicilliumfumculorusand Curvulariaplunata*(13).

The purpose of the present study is to investigate the synthesis and characterization of specific Cu(II) and Hg(II) complexes with co-ligands such as Amines or Phosphines N-(benzothiazol-2-yl)benzamide (Btba) and the biological activities of a number of the prepared complexes at (0.01, 0.001, 0.0001 mg/ml) concentrations against four *Staphylococcus epidermids* and *Staphylococcsaureus.*

Experimental Section:

The chemicals were delivered and used without being purified. Melting points were measured using a Stuart (SMP30) melting point apparatus and are provided as uncorrected values. The molar conductivity of the prepared complexes (10^{-3} M) recently dissolved DMSO solution was calculated with a (Starter 3100c) digital conductivity meter. At room temperature, the magnetic susceptibility of the prepared complexes was determined using the Sherwood magnetic susceptibility balance. An Elementarvario El III CHN elemental analyzer was used to document the CHN analysis. A Bruker 400 MHz spectrometer was used to test nuclear magnetic resonance in DMSO-d6 as a solvent. The IR spectra of complexes with KBr were measured with a Shimadzu FT-IR 8400S spectrophotometer in the 400-4000 cm-1 range. PG instruments T80 UV-Vis spectrophotometer was used to test UV-Visible spectra in the spectrum (200-900nm).

Preparation of N-(1,3-benzothiazol-2-yl)benzamide (Btba) ligand (14)

At 50–60°C, a mixture of 2-aminobenzothaiazole (0.751 g, 5.0mmol) and triethylamine (0.300 g, 5.0mmol) in dry dioxane (50 mL) was stirred for 30 minutes. By dropwise, a solution of benzoyl chloride (0.702 g, 5.0mmol) in dry dioxane (50 mL) was added. The mixture was stirred for 2 hours before being dumped onto crushed ice. The isolated solid was obtained by filtration and washed with a 1% potassium bicarbonate aqueous solution before being recrystallized in ethanol, yielding yellowish white crystals (Btba): 0.413 g (32 percent). m.p. of 186–188°C: The following values were calculated for C14H10N2OS (254.31 g mol-1): C, 66.12; H, 3.96; N, 11.02; and S, 12.61. C, 66.90 percent; H, 3.83 percent; N, 10.65 percent; S, 12.94 percent; IR (KBr): 3230 (NH), 1672 (C=O), 1598 (C=CAromatic), 1554 (C=N), 1444, 1296, 1272, 750 cm1; 1H NMR (400MHz, DMSO-d6, (ppm): 12.90 (1H, s, NH); 8.15 (2H, d (Ar-CH).

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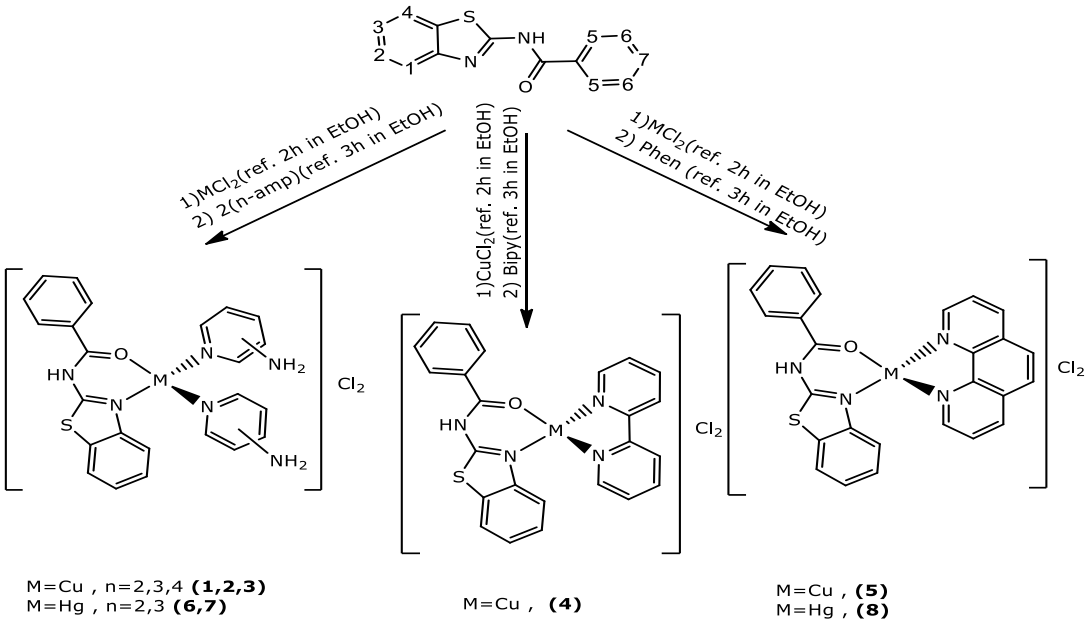

Scheme 1: The Propose Structure of (1-8) complexes.

Preparation of (1-10) complexes:

A solution of **(Btba)** (0.762, 3.0mmol) in (30ml) absolute ethanol was added to the one mole of $CuCl_2$ (0.403g, 3.0mmol), or $HgCl_2$ (0.814g, 3.0mmol) in (30ml) absolute ethanol. Then, the mixture was refluxed for two hours with stirring. Then a solution in (30ml) absolute ethanol of two moles equivalents of one of ligands (2amp, 3amp, 4amp) or one mole equivalents of one of ligands (Bipy, Phen, dppm, dppe) was added to the mixture which was refluxed for three hours with stirring, separated as a precipitate, filtered, and dried in the air.

*[Cu(Btba)(2amp)$_2$]Cl$_2$ (1)*1.324g, (76%). m.p. 209–212°C: *Anal*. Calc. for $C_{24}H_{22}Cl_2CuN_6OS$ (576.99 g mol^{-1}): C, 49.96; H, 3.84; N, 14.57; S, 5.56, Found: C, 49.57; H, 3.48; N, 14.12; S, 5.73%.; IR (KBr): 3276 (NH), 3178 (NH_2), 1672 (C=O), 1596 ($C=C_{Aromatic}$), 1554 (C=N), 1525 (C=N amine), 1442, 1296, 1272, 727 cm^{-1}.; μ(BM): 1.92.; Λ(ohm^{-1}.cm^2.mol^{-1}):72.4.

*[Cu(Btba)(3amp)$_2$]Cl$_2$(2)*1.417g, (81%). m.p. >236°C (dec.): *Anal*. Calc. for $C_{24}H_{22}Cl_2CuN_6OS$ (576.99 g mol^{-1}): C, 49.96; H, 3.84; N, 14.57; S, 5.56, Found: C, 49.63; H, 3.52; N, 14.09; S, 5.45%.; IR (KBr): 3240 (NH), 3167 (NH_2), 1671 (C=O), 1596 ($C=C_{Aromatic}$), 1552 (C=N), 1530 (C=N amine), 1444, 1295, 1274, 729 cm^{-1}.; μ(BM): 1.91.; Λ(ohm^{-1}.cm^2.mol^{-1}):69.4.

[Cu(Btba)(4amp)$_2$]Cl$_2$(3) 1.398g, (80%). m.p. 266–269°C: Anal. Calc. for $C_{24}H_{22}Cl_2CuN_6OS$ (576.99 g mol^{-1}): C, 49.96; H, 3.84; N, 14.57; S, 5.56, Found: C, 49.50; H, 3.61; N, 14.37; S, 5.49%.; IR (KBr): 3222 (NH), 3178 (NH_2), 1670 (C=O), 1598

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($C=C_{Aromatic}$), 1550 (C=N), 1518 (C=N amine), 1446, 1286, 1238, 723 cm^{-1}.; μ(BM): 1.92.; Λ($ohm^{-1}.cm^2.mol^{-1}$):83.5.

[Cu(Btba)(Bipy)]Cl_2(4) 1.267g, (77%). m.p. 214–217°C: Anal. Calc. for $C_{24}H_{18}Cl_2CuN_4OS$ (544.94 g mol^{-1}): C, 52.90; H, 3.33; N, 10.28; S, 5.88, Found: C, 52.67; H, 2.94; N, 9.81; S, 5.53%.; IR (KBr): 3325 (NH), 1679 (C=O), 1593 ($C=C_{Aromatic}$), 1541 (C=N), 1438 (C=N amine), 1296, 1284, 765, 696 cm^{-1}.; μ(BM): 1.95.; Λ($ohm^{-1}.cm^2.mol^{-1}$):77.3.

[Cu(Btba)(Phen)]Cl_2(5) 1.356g, (79%). m.p. 196–199°C: Anal. Calc. for $C_{26}H_{18}Cl_2CuN_4OS$ (568.96 g mol^{-1}): C, 54.89; H, 3.19; N, 9.85; S, 5.64, Found: C, 54.45; H, 2.77; N, 9.51; S, 5.47%.; IR (KBr): 3396 (NH), 1647 (C=O), 1606 ($C=C_{Aromatic}$), 1537 (C=N), 1423 (C=N amine), 1340, 1217, 840, 707 cm^{-1}.; μ(BM): 1.93.; Λ($ohm^{-1}.cm^2.mol^{-1}$):76.6.

*[Hg(Btba)(2amp)$_2$]Cl_2(6)*1.823g, (85%). m.p. 252–255°C: *Anal*. Calc. for $C_{24}H_{22}Cl_2HgN_6OS$ (714.03 g mol^{-1}): C, 40.37; H, 3.11; N, 11.77; S, 4.49, Found: C, 39.95; H, 2.73; N, 11.35; S, 4.51%.; IR (KBr): 3350 (NH), 3458 (NH_2), 1664 (C=O), 1618 ($C=C_{Aromatic}$), 1558 (C=N), 1539 (C=N amine), 1487, 1286, 754 cm^{-1}.^{1}H NMR (400MHz, DMSO-d6, δ(ppm): 12.76 (1*H*, s, NH); 8.27 (2*H*, d, J=7.68 Hz, *H*-C6 2amp); 8.17 (2*H*, d, J=7.45 Hz, *H*-5); 8.00 (1*H*, d, J=7.78 Hz, *H*-1); 7.81 (1*H*, d, J=7.95 Hz, *H*-4); 7.72 (2*H*, t, J=7.82 Hz, *H*-C4 2amp); 7.66 (1*H*, t, J=7.32 Hz, *H*-7); 7.57 (2*H*, t, J=7.32 Hz, *H*-6); 7.46 (1*H*, t, J=7.59 Hz, *H*-3); 7.37 (2*H*, t, J=7.99 Hz, *H*-C5 2amp); 7.30 (1*H*, t, J=7.54 Hz, *H*-2); 7.24 (1*H*, d, J=7.91 Hz, *H*-C3 2amp); 5.82 (4*H*, s, $2NH_2$);^{13}C NMR (400 MHz, DMSO-*d*6): δ 161.64 (*C*=O); 159.41 (*C*=N); 154.95 (*C2*-2amp); 149.03 (*C*-N); 144.92 (*C*-N); 137.42 (*C4*-2amp); 136.23 (*C*-CO); 131.53 (*C*-S); 130.78 (Ar-*C*H); 127.62(*C6*-2amp); 126.57 (Ar-*C*H); 124.89(*C3*-2amp); 124.48(Ar-*C*H); 121.97(*C5*-2amp); 121.64 (Ar-*C*H) 114.12 (Ar-*C*H); 109.75 (Ar-*C*H); Λ($ohm^{-1}.cm^2.mol^{-1}$):85.4.

*[Hg(Btba)(3amp)$_2$]Cl_2(7)*1.572g, (73%). m.p. 237–240°C: *Anal*. Calc. for $C_{24}H_{22}Cl_2HgN_6OS$ (714.03 g mol^{-1}): C, 40.37; H, 3.11; N, 11.77; S, 4.49, Found: C, 39.87; H, 2.96; N, 11.41; S, 4.37%.; IR (KBr): 3336 (NH), 3434 (NH_2), 1672 (C=O), 1602 ($C=C_{Aromatic}$), 1546 (C=N), 1521 (C=N amine), 1444, 1282, 748 cm^{-1}. ^{1}H NMR (400MHz, DMSO-d6, δ(ppm): 12.87 (1*H*, s, NH); 8.66 (2*H*, d, ^{4}J=5.40 Hz, *H*-C23amp); 8.34 (2*H*, d, J=9.35 Hz, *H*-5); 8.16 (2*H*, d, J=7.65 Hz, *H*-C6 3amp); 8.06 (1*H*, d, J=7.84 Hz, *H*-1); 7.82 (1*H*, d, J=8.29 Hz, *H*-4); 7.70 (2*H*, t, J=7.10 Hz, *H*-7); 7.59 (2*H*, t, J=7.21 Hz, *H*-6); 7.49 (1*H*, t, J=7.75 Hz, *H*-3); 7.37 (1*H*, t, J=7.81 Hz, *H*-2); 7.31 (2*H*, t, J=10.00 Hz, *H*-C5 3amp); 7.19 (2*H*, d, J=9.01 Hz, *H*-C43amp); 5.92 (4*H*, s, $2NH_2$); ^{13}C NMR (400 MHz, DMSO-*d*6): δ 161.55 (*C*=O); 159.84 (*C*=N); 153.13 (*C*-N); 152.43 (*C*-N); 148.12 (*C3*-3amp); 138.35 (*C6*-3amp); 133.19 (*C*-CO); 131.43 (*C*-S); 130.38 (Ar-*C*H); 129.12 (*C2*-3amp); 128.57 (Ar-*C*H); 128.29 (*C4*-3amp); 126.28 (Ar-*C*H); 123.81 (*C5*-3amp); 119.51 (Ar-*C*H) 112.20 (Ar-*C*H); 109.64 (Ar-*C*H).; Λ($ohm^{-1}.cm^2.mol^{-1}$):82.1.

[Hg(Btba)(Phen)]Cl_2(8) 1.356g, (79%). m.p. 293–295°C: Anal. Calc. for $C_{26}H_{18}Cl_2HgN_4OS$ (706.01 g mol^{-1}): C, 44.23; H, 2.57; N, 7.94; S, 4.54, Found: C, 44.45; H, 2.34; N, 7.51; S, 4.47%.; IR (KBr): 3323 (NH), 1670 (C=O), 1589 ($C=C_{Aromatic}$), 1554 (C=N), 1502 (C=N amine), 1417, 1276, 848, 736 cm^{-1}. ^{1}H NMR (400MHz, DMSO-d6, δ(ppm): 12.91 (1*H*, s, NH); 9.21 (2*H*, broad s, *H*1-

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Phen); 8.81 (2*H*, d, J=7.95 Hz, *H*3-Phen); 8.20 (2*H*, s, *H*4-Phen); 8.15 (2*H*, d, J=7.25 Hz, *H*-5); 8.07 (2*H*, m, *H*2-Phen); 8.04 (1*H*, d, J=8.22 Hz, *H*-1); 7.68 (1*H*, d, J=8.67 Hz, *H*-4); 7.68 (1*H*, t, J=7.34 Hz, *H*-7); 7.58 (2*H*, t, J=7.64 Hz, *H*-6); 7.49 (1*H*, t, J=7.99 Hz, *H*-3); 7.36 (1*H*, t, J=7.98 Hz, *H*-2); ^{13}C NMR (400 MHz, DMSO-*d*6): δ 162.42 (*C*=O); 153.32 (*C*=N); 152.61 (*C*-N); 149.72 (*C*-Phen); 145.62 (*C*-Phen); 135.78 (*C*-Phen); 133.24 (*C*-CO); 131.79 (*C*-S); 130.59 (Ar-*C*H); 129.59 (Ar-*C*H); 128.67 (Ar-*C*H); 128.41 (Ar-*C*H); 128.15 (*C*-Phen); 126.72 (Ar-*C*H); 126.08 (*C*-Phen); 123.76 (Ar-*C*H); 122.93 (*C*-Phen); 119.85 (Ar-*C*H).; Λ(ohm^{-1}.cm^2.mol^{-1}):70.6.

[Hg$_2$(Btba)$_2$(dppm)$_2$]Cl$_4$(9) 1.847g, (67%). m.p. >350°C (dec.): Anal. Calc. for $C_{78}H_{64}Cl_4Hg_2N_4O_2P_4S_2$ (1820.39 g mol^{-1}): C, 51.46; H, 3.54; N, 3.08; S, 3.52, Found: C, 50.96; H, 5.28; N, 3.07; S, 3.14%.; IR (KBr): 3247 (NH), 1674 (C=O), 1652 (C=C$_{Aromatic}$), 1552 (C=N), 1458 , 1423, 1276, 1116, 748, 692 cm^{-1}. ^{13}P{^{1}H}NMR (400MHz, DMSO-d6, δ(ppm): 27.54.; ^{1}H NMR (400MHz, DMSO-d6, δ(ppm): 12.46 (1*H*, s, NH); 8.16 (2*H*, d, J=7.67 Hz, *H*-5); 8.03 (1*H*, d, J=7.70 Hz, *H*-1); 7.80 (1*H*, d, J=7.86 Hz, *H*-4); 7.68 (1*H*, t, J=7.35 Hz, *H*-7); 7.58 (2*H*, t, J=7.49 Hz, *H*-6); 7.48 (8*H*, m, *H*-Ar); 7.35 (14*H*, m, *H*-Ar); 2.89 (2*H*, s, C*H*$_2$); Λ(ohm^{-1}.cm^2.mol^{-1}):121.7.

[Hg(Btba)(dppe)]Cl$_2$(10) 1.973g, (71%). m.p. 275–278°C: Anal. Calc. for $C_{40}H_{34}Cl_2HgN_2OP_2S$ (924.22 g mol^{-1}): C, 51.98; H, 3.71; N, 3.03; S, 3.47, Found: C, 51.57; H, 3.41; N, 2.75; S, 3.24%.; IR (KBr): 3286 (NH), 1681 (C=O), 1604 (C=C$_{Aromatic}$), 1531 (C=N), 1454 , 1431, 1242, 1101, 748, 692 cm^{-1}.; ^{13}P{^{1}H}NMR (400MHz, DMSO-d6, δ(ppm): 36.55.;^{1}H NMR (400MHz, DMSO-d6, δ(ppm): 12.89 (1*H*, s, NH); 8.15 (2*H*, d, J=5.44 Hz, *H*-5); 8.04 (1*H*, d, J=7.19 Hz, *H*-1); 7.88 (8*H*, m, *H*-Ar); 7.61 (16*H*, m, *H*-Ar); 7.36 (1*H*, t, J=7.43 Hz, *H*-3); 7.18 (1*H*, t, J=7.47 Hz, *H*-2); 2.73 (2*H*, s, C*H*$_2$); 2.67 (2*H*, s, C*H*$_2$);Λ(ohm^{-1}.cm^2.mol^{-1}):74.3.

Results and Discussion:

The methods used to make the mixed ligand complexes are assisted in their tests and have good materials with good purity. They stayed in a wind constantly. It was partially dissolve the complexes in organic solvents such as ethanol or acetone, but soluble in (DMF) or DMSO.

The molar electrical conductivity of the complexes solutions in DMSO at (10^{-3}M) recordedat (25^{o}c) showed the **(1-8,10)** complexes were ionic by 1:2 negative to positive ion. [Hg$_2$(Btba)$_2$μ(dppm)$_2$]Cl$_4$**(9)** complex showed an increase in molar conductivity which supports the current proposed formula of the complex. In addition, these results support the magnetic sensitivity values of Cu complexes as these values were between (1.91–1.96 ohm^{-1}.cm^2.mol^{-1}) these values are included within the values of the tetrahedral complexes (15,16).

UV-Vis. spectra of the prepared Cu(II) complexes have shown the charge transfer bands within the (25575-30581cm^{-1}) rangewhich are indicated in Table (1). In addition, a d-d transition bands were shown within the (16529-15275 cm^{-1}) range and they were not broad enough to explain the other transfers of $^2B_{2g}\rightarrow{}^2B_{1g}$ and $^2B_{2g}\rightarrow{}^2A_{1g}$ for octahedral complexes. So, they were interpreted as a $^2T_2\rightarrow{}^2E$ transfer of tetrahedral complexes (17).

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Table 1: Values of electronic transition of Cu (II) complexes

No.	Compounds	Transitions (nm) cm^{-1}			
		$\pi \rightarrow \pi^*$	$n \rightarrow \pi^*$	C.T.	$^2T_2 \rightarrow {}^2E$
	(Btba)	(239) 41841	(267) 37453	-	-
1	$[Cu(Btba)(2amp)_2]Cl_2$	(234) 42735	(264) 37879	(381) 26247	(604) 16556
2	$[Cu(Btba)(3amp)_2]Cl_2$	(236) 42373	(265) 37736	(387) 25840	(605) 16529
2	$[Cu(Btba)(4amp)_2]Cl_2$	(235) 42553	(263) 38023	(391) 25575	(605) 16529
4	$[Cu(Btba)(Bipy)]Cl_2$	(236) 42373	(263) 38023	(335) 29851	(640) 15625
5	$[Cu(Btba)(Phen)]Cl_2$	(235) 42553	(264) 37879	(337) 29674	(638) 15674

The spectrum of **(Btba)** ligand showed a new band of the carbonyl group υ(C=O)at (1670cm^{-1}), while the υ(NH) group showed at (3240cm^{-1}) and the υ(C=N) group displayed at (1552cm^{-1}).

The spectrum of the complexes showed a carbonyl group within the range of (1646-1681cm^{-1}). The peaks shifted to lower or higher frequency and that indicates the bonding of O atom of the carbonyl groups with the metal ion. The υ(C=N) group bands showed a range of (1531-1558cm^{-1}) and the peaks shifted to lower or higher frequency(18), this illustrates the bonding with the metal. The υ(C=N) bands of amines in **(1-8)** complexes showed a range of (1423-1539cm^{-1}), and the υ(P-Ar) bands of the **(9, 10)** complexes showed at of (1423,1431cm^{-1}), the υ(P-C) bands showed a range of (1101-1116cm^{-1}) respectively (19–21).

The ^{1}H-NMR spectra of the complexes **(6-10)** showed the signals of the ligand protons **(Btba)** and it is observe singlet of the proton of NH group within the (12.46-12.91ppm) range(22). On the other hand, integration ratio in the complexes **(6)** and **(7)** showed coordination of two (2-amp) or (3-amp) molecules against one molecule of **(Btba)** ligand. Spectrum of complex **(8)** has shown signals of phen protons at 9.21 (s, 2H), 8.81 (d, 2H, J = 7.95 Hz), 8.20 (s,2H), 8.07 (m, 2H), confirming the consistency of one phen molecule versus a **(Btba)** ligand molecule. The ^{1}H-NMR spectra of **(9,10)** complexes also showed multiple signals within the δH= (7.88-7.35ppm) range which belong to the protons of the phenyl rings in dppm and dppe ligands, the signal of CH_2 groups appeared as a singlet at (δH=2.89ppm) for **(9)** complex and two singlet at (δH=2.73, 2.67ppm) for **(10)** complex, and the integration value indicated the presence of one molecule of phosphine coordinated with the metal versus a molecule of **(Btba)** ligand. The ^{31}P-NMR spectrum has shown a single signal with a positive value at (δP=27.54ppm). This indicates the consistency of the dppm as a bridging and not as a chelating ligand. This could propose a binuclear dimer formula for complex **(9)**, while complex **(10)** showed a positive single signal at (δP=36.55ppm), where dppe is believed to behave like a chelating ligand due to its high flexibility compared with dppm(23–25). and as shown in Figure 2.

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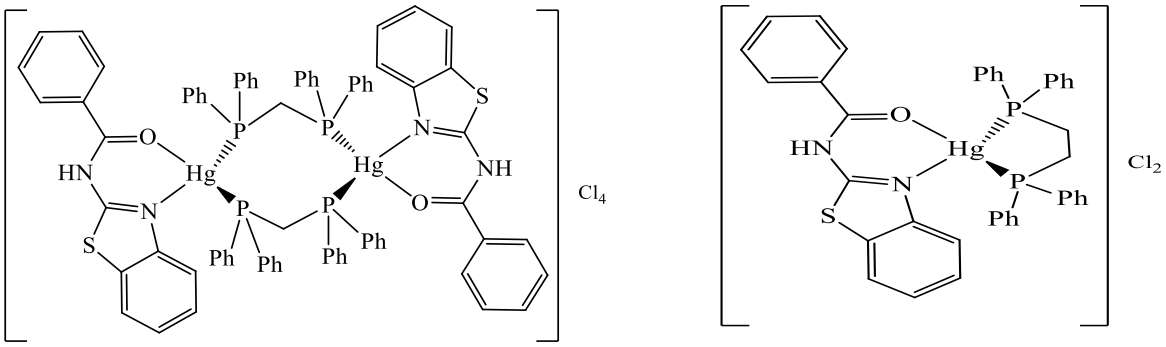


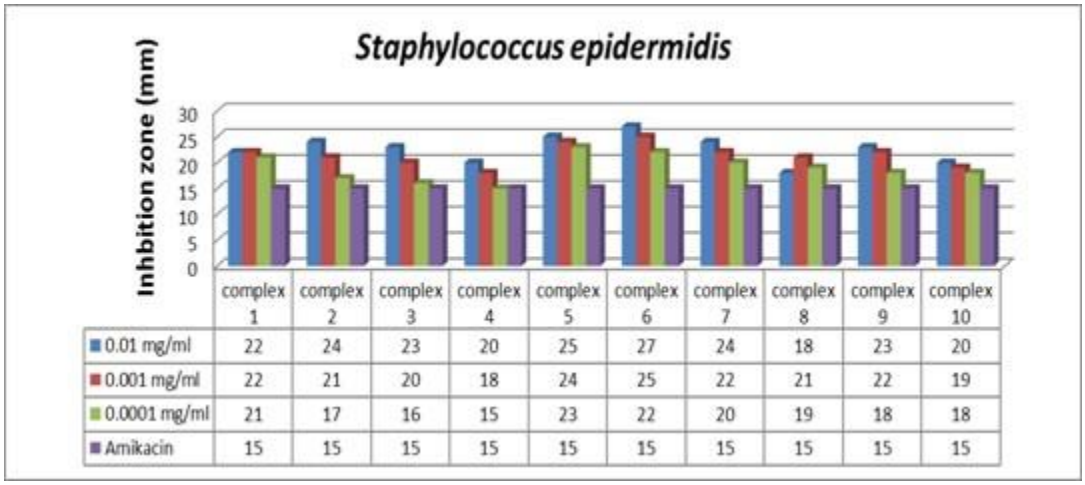
(9) **(10)**

Scheme 2: The propose structure of $[Hg_2(Btba)_2(dppm)_2]Cl_4$(9) and $[Hg(Btba)(dppe)]Cl_2$(10).

Biological activity of the prepared complexes

The biological activity of the prepared complexes counter to four bacterial species: *Staphylococcus aureus, Staphylococcus epidermidis,Citrobacerfreundii and E.coli,* was tested using the hole method with the antibiotic Amikacin as a reference material. Because of the higher toxicity of Hg(II) complexes, they displayed greater action against bacteria forms than Cu(II) complexes (26).

At the minimum inhibition concentration (MIC) all of the prepared complexes (Scheme: 3) were more effective than amikacinagainst *Staphylococcus epidermidis,*on the other side, the **(8)** complex outperformed amikacin in terms of action against *Staphylococcus aureus*, the complexes **(3,5,6,8,** and **10)** were more active against *E. Coli*and the complexes **(1,3,4,5,7,8,9,** and **10)** were more active against *Citrobacterfreundii* than amikacin.



	complex 1	complex 2	complex 3	complex 4	complex 5	complex 6	complex 7	complex 8	complex 9	complex 10
0.01 mg/ml	22	24	23	20	25	27	24	18	23	20
0.001 mg/ml	22	21	20	18	24	25	22	21	22	19
0.0001 mg/ml	21	17	16	15	23	22	20	19	18	18
Amikacin	15	15	15	15	15	15	15	15	15	15

(a)

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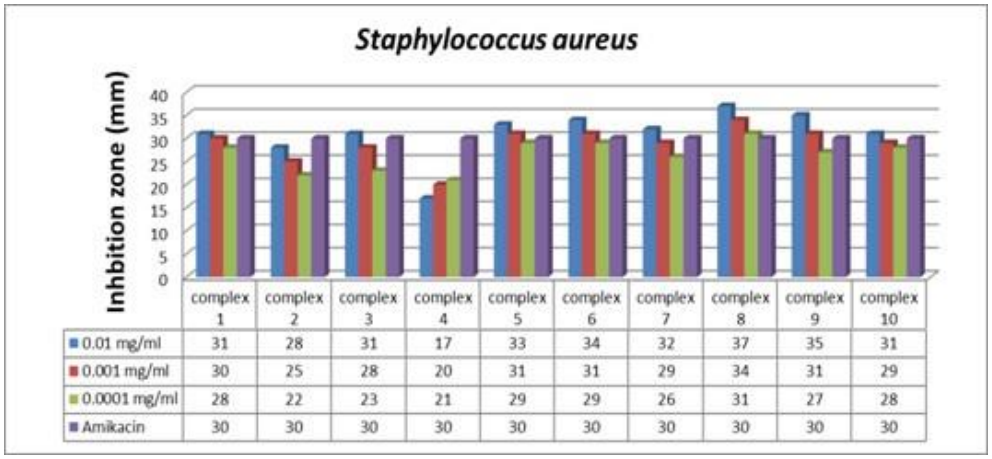
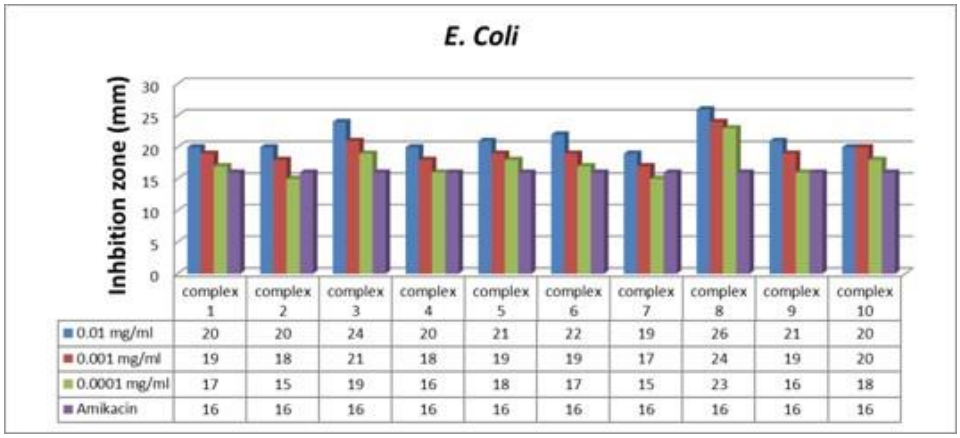


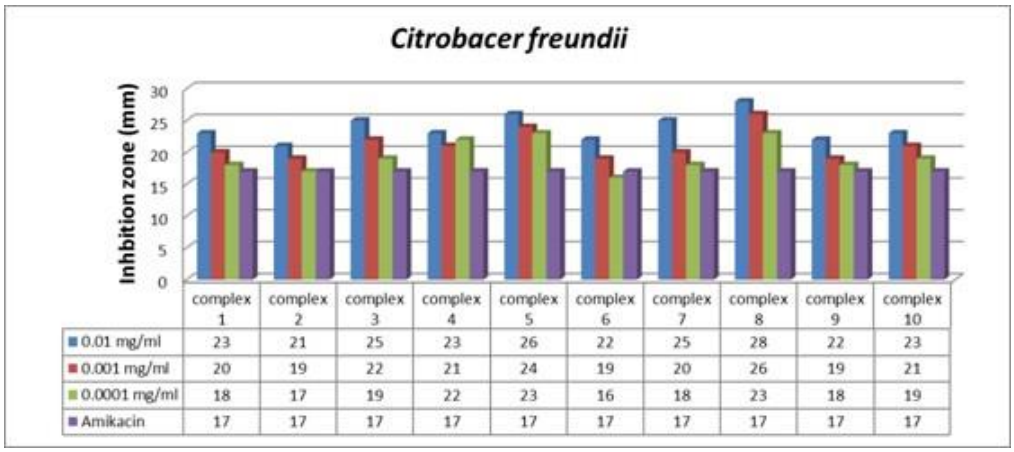
	complex 1	complex 2	complex 3	complex 4	complex 5	complex 6	complex 7	complex 8	complex 9	complex 10
0.01 mg/ml	31	28	31	17	33	34	32	37	35	31
0.001 mg/ml	30	25	28	20	31	31	29	34	31	29
0.0001 mg/ml	28	22	23	21	29	29	26	31	27	28
Amikacin	30	30	30	30	30	30	30	30	30	30

(b)



	complex 1	complex 2	complex 3	complex 4	complex 5	complex 6	complex 7	complex 8	complex 9	complex 10
0.01 mg/ml	20	20	24	20	21	22	19	26	21	20
0.001 mg/ml	19	18	21	18	19	19	17	24	19	20
0.0001 mg/ml	17	15	19	16	18	17	15	23	16	18
Amikacin	16	16	16	16	16	16	16	16	16	16

(c)



	complex 1	complex 2	complex 3	complex 4	complex 5	complex 6	complex 7	complex 8	complex 9	complex 10
0.01 mg/ml	23	21	25	23	26	22	25	28	22	23
0.001 mg/ml	20	19	22	21	24	19	20	26	19	21
0.0001 mg/ml	18	17	19	22	23	16	18	23	18	19
Amikacin	17	17	17	17	17	17	17	17	17	17

(d)

Scheme 3: The inhibitory activity of prepared complexes in the growth of a number of positive (a), (b) and negative (c), (d) bacteria.

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Conclusion:

The prepared complexes **(1-10)** were tetrahedral complexes with formula $[Cu(Btba)_2Cl_2]$ and $[M(Btba)(L)_n]Cl_2$ were M=Cu, (n=2, L=2-aminopyridine, 3-aminopyridine, 4-aminopyridine) complexes **(1-3)**, (n=1, L= Bipy, Phen) complexes **(4,5)**, or M=Hg (n=2, L=2-aminopyridine, 3-aminopyridine) complexes **(6,7)**, (n=1, L=Phen, dppe) complexes **(8,10)**. Excepting the $[Hg_2(Btba)_2(dppm)_2]Cl_4$**(9)** complex where the dppm behaves as a bridge ligand in binuclear complex. In **(1-10)** complexes the **(Btba)** ligand behaved as a bidentate through the N atom of the benzothiazole and O atom of carbonyl group.

At the minimum inhibition concentration (MIC), most of the prepared complexes appeared more effective than amikacin against *Staphylococcus epidermidis*, *E. Coli* and *Citrobacterfreundii*. The (8) complex, on the other side, showed activity against Staphylococcus aureusmore than amikacin.

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