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Synthesis, Characterization And Evaluation Antibacterial Activity For Mixed-Ligand Complexes Of Saccharine and Acetylacetonato

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ABSTRACT— Saccharine and its complexes have critical importance with biological and pharmacological properties. The main objective of this study was to synthesize the mixed ligand complexes from the complexes [M $(Sac)_2$ $(H_2O)_2$] [M: Zn(II), Cd(II), Hg(II), Fe(III), Ni(II) and Cu (II) with a second ligand (acac), The structures of the complexes were characterized by elemental analysis, FT-IR, magnetic susceptibility, UV-VIS., molar conductivity, According to the experimental results, it was determined that saccharin complexes coordinated with four molecules of H_2O and two molecules of saccharin, second step include established four molecules of H_2O to the second ligand (acac) it was coordinated to the metal ions via oxygen atom of carbonyl group in saccharin and acetylacetonato, In antibacterial activity, study was determined to occur significant inhibition zones, It is obtained that the complexes exhibited the highest inhibition zone in compared with the free two ligands.

KEYWORDS: Saccharine, Acetylacetonato, Mixed-Ligand, Antibacterial Activity.

1. INTRODUCTION

Inorganic compounds have become the subject of extensive research due to their potential application in different areas of chemistry notably in coordination chemistry, geochemistry, solid-state chemistry and in the current arena of nanotechnology. Coordination chemistry, or the chemistry of metal complexes, plays a vital role in industry, technology and in several biological processes [1], [2]. Saccharin (o-sulfobenzimide; 1,2-benzothiazole-3(2H)-one 1,1-dioxide; Hsac is one of the best known and most widely used artificial sweetening agents. The imino hydrogen is acidic and, thus, the molecule can be easily converted into the corresponding nitranion. It has been shown that the coordination chemistry of this anion is very interesting and versatile, taking into account that it offers different coordination sites to metallic centers, i.e., one N, one O (carbonylic) and two O (sulfonic) atoms. Using these donor atoms the anion can generate either N- or O-monodentate or bidentate (N, O) coordination, and also more complex polymeric species with the participation of all possible donor atoms [3- 5]. The isomorphous coordination of saccharinato complexes is produced by the reaction of the first row divalent transition metals in aqueous solution and has been extended to the various late transition metal complexes [6], [7]. The imino hydrogen of sac H is acidic and thus in solutions, the molecule can be easily converted into the corresponding nitranion, saccharinate (sac). Although metal complexes of molecular saccharin are not known, the coordination chemistry of its anion is very intriguing. Sac has different coordination sites, such as one negatively charged imino nitrogen, one carbonyl and two sulfonyl oxygen atoms [8], [9]. The most common coordination mode of sac is ligation through the negatively charged nitrogen atom, usually observed in the aqua bis(saccharinate) complexes of first-row transition metals [10]. Both saccharin and saccharinate complexes have critical importance with biological, biochemical and pharmacological properties. On the other hand, researchers has synthesized a lot of mixed ligand saccharinate complexes with the ligands such as acetyl acetone, For the synthesis of mixed-ligand saccharinate complexes, [M(sac), (H_2O),] H_2O, are used as a starting metal saccharin-aqua complex. Since the aqua ligands in these metal complexes are labile and readily displaced by neutral ligands, new complexes are simply prepared by the direct reaction of a neutral ligand with the starting aqua-saccharinate complex in solution. The addition of the ligands to the solutions of the complexes usually results in substitution of all four aqua ligands, thereby forming stable new mixed-ligand complexes [9]. The recent study investigation the syntheses, characterization, and biological activity of mixed-ligand Complexes of saccharine and Acetylacetonato.

2. Experimental

2.1 Materials and measurements

All reagents were commercially available and used without further purification. Elemental analyses (C, H, N and S) were carried out on an Elementar Eager 300 elemental analyzer. The FT-IR spectra were recorded from KBr pellets in the range 400 – 4000 cm^{-1} [65 FT-IR Perkin Elmer Spectrophotometer]. Magnetic susceptibility data were measured from powder samples of solid material in the temperature range of 2-300 K by using a SQUIT susceptometer MPMS-7, Quantum Design with a field of 1.0T. The experimental data were corrected for underlying diamagnetism by the use of tabulated Pascal's constants.

2.2 Synthesis of metal complexes of Saccharin

The starting complexes [M (sac)2(H2O)4]··2H2O, was prepared according to the literature methods reported by [11], [12], respectively.

2.3 Synthesis of mixed ligand complexes

This complex was synthesized in molar ratio (1:2), (metal saccharin complex: Acetyl acetone ligand) using the following procedure: A solution of Acetyl acetone ligand (0.47g, 0.002mol) in ethanol was added to a solution of metal saccharin complex(0.56g, 0.001mol) in ethanol, the mixture was reflexed for (3h), the solution formed was left for evaporation at room temperature. The solid product was wished in methanol and dried in oven at 100 C^0.

$$[M (sac)2(H2O)4] .2H2O + 2 (acac) \rightarrow [M (sac)2(acac)2]$$

M: [M: Zn(II), Cd(II), Hg(II), Fe(III), Ni(II) and Cu (II)

Tab. 1 Some physical properties of prepared complexes

Symb.	Complexes	Molecular Weight	Melting point	Color	yield
A_1	[Zn $(sac)_2$ $(H_2O)_4$]Cl_2	589.74	>300	Wight	78%
A_2	[Cd $(sac)_2$ $(H_2O)_4$]Cl_2	636.77	>300	Wight	74%
A_3	[Hg $(sac)_2$ $(H_2O)_4$]Cl_2	724.95	>300	Wight	81%
A_4	[Fe $(sac)_2$ $(H_2O)_4$]Cl	527.70	>300	yellow	85.7%
A_5	[Ni $(sac)_2$ $(H_2O)_4$]	497.12	>300	green	80%
A_6	[Cu $(sac)_2$ $(H_2O)_4$]	501.97	>300	blue	89.4%
N_1	[Zn $(sac)_2$ $(acac)_2$]	631.98	>300	Wight	72%
N_2	[Cd $(sac)_2$ $(acac)_2$]	679.01	>300	Wight	79.4%
N_3	[Hg $(sac)_2$ $(acac)_2$]	767.19	>300	Wight	76.8%

N$_4$	[Fe (sac)$_2$ (acac)$_2$]Cl	655.88	>300	red	83.5%
N$_5$	[Ni (sac)$_2$ (acac)$_2$]	625.29	>300	green	82%
N$_6$	[Cu (sac)$_2$ (acac)$_2$]	630.14	>300	purple	88.6%

3. Results and Discussion

3.1 Elemental micro analysis

Elemental analysis (C.H.N.S) content were found to be in agreement with calculated values Table (1) show the values:

Table (2) Elemental micro analysis (%)for prepared compounds (calculated)

Symb.	**Complexes**	**C**	**H**	**N**	**S**
A$_1$	**[Zn (sac)$_2$ (H$_2$O)$_4$]Cl$_2$**	30.08 **(30.55)**	3.17 **(3.59)**	5.02 **(4.75)**	10.34 **(10.87)**
A$_2$	**[Cd (sac)$_2$ (H$_2$O)$_4$]Cl$_2$**	28.07 **(28.29)**	3.46 **(3.32)**	4.18 **(4.40)**	10.26 **(10.07)**
A$_3$	**[Hg (sac)$_2$ (H$_2$O)$_4$]Cl$_2$**	24.73 **(24.85)**	2.84 **(2.92)**	3.65 **(3.86)**	8.59 **(8.84)**
A$_4$	**[Fe (sac)$_2$ (H$_2$O)$_4$]Cl**	31.11 **(31.87)**	2.54 **(3.06)**	5.05 **(5.31)**	12.54 **(12.15)**
A$_5$	**[Ni (sac)$_2$ (H$_2$O)$_4$]**	33.61 **(33.83)**	3.71 **(3.65)**	5. 23 **(5.64)**	12.68 **(12.9)**
A$_6$	**[Cu (sac)$_2$ (H$_2$O)$_4$]**	33.14 **(33.5)**	3.22 **(3.61)**	5.36 **(5.58)**	12.42 **(12.77)**
N$_1$	**[Zn (sac)$_2$ (acac)$_2$]**	45.78 **(45.61)**	3.53 **(4.15)**	4.88 **(4.43)**	10.48 **(10.15)**
N$_2$	**[Cd (sac)$_2$ (acac)$_2$]**	42.35 **(42.45)**	4.08 **(3.86)**	4.43 **(4.13)**	9.82 **(9.44)**
N$_3$	**[Hg (sac)$_2$ (acac)$_2$]**	37.46 **(37.57)**	3.57 **(3.42)**	3.91 **(3.65)**	8.53 **(8.36)**
N$_4$	**[Fe (sac)$_2$ (acac)$_2$]Cl**	43.49 **(43.95)**	3.35 **(3.69)**	4.67 **(4.27)**	9.69 **(9.78)**
N$_5$	**[Ni (sac)$_2$ (acac)$_2$]**	46.32 **(46.10)**	3.93 **(4.19)**	4.76 **(4.48)**	9.95 **(10.25)**
N$_6$	**[Cu (sac)$_2$ (acac)$_2$]**	45.53 **(45.75)**	4.05 **(4.16)**	4.62 **(4.45)**	10.25 **(10.18)**

3.2 FTIR Spectroscopy studying

The most important IR spectral bands of the saccharin and its metal complexes are listed in table 3. The Ʋ(C=O) band at 1647.2 cm^{-1} of the ligand was shifts to higher and lower frequencies in complexes indicating weakening of the carbonyl bond due to coordination to the metal, The IR spectrum of the mixed ligand complexes listed in table 4 The Ʋ(C=O) band at 1643 cm^{-1} of the (acac) was shifts to higher and lower frequencies in complexes indicating weakening of the carbonyl bond due to coordination to the metal which is consistent with the literature [13- 17].

Table (3) FT-IR absorptions of the metal complexes of saccharin in cm^{-1}

No.	compounds	(O-H) υ	(N-H) υ	(C-H)Ar. υ	(C=O) υ	(C=C) υ	(SO_2) asym.υ	(SO_2) sym.υ	(C-N) υ	(M-O) υ
A	Saccharin	-----	3352.2	3105.3	1647.2	1591.2	1255.6	1147.6	1051.2	------
A_1	$[Zn(sac)_2(H_2O)_4]Cl_2$	3468	3352	3099.6	1687.7	1622.1	1292.3	1159.2	1056.9	540
A_2	$[Cd(sac)_2(H_2O)_4]Cl_2$	3455	3352	3070.6	1665.9	1581	1274	1145.7	1053	543.9
A_3	$[Hg(sac)_2(H_2O)_4]Cl_2$	------	3352	3088	1693.5	1635.6	1247.9	1145.7	1053	526
A_4	$[Fe(sac)_2(H_2O)_4]Cl$	3400	3352	3101.5	1722.4	1587	1250	1178.5	1116.7	516
A_5	$[Ni(sac)_2(H_2O)_4]$	3459	3352	3155.6	1622.1	1581	1296	1157.2	1055	538.1
A_6	$[Cu(sac)_2(H_2O)_4]$	3448	3352	3064.8	1659	1579	1267	1151	1055	541.9

Table (4) FT-IR absorptions of mixed ligand complexes in cm^{-1}

No.	compounds	(N-H) υ	(C-H)Ar. υ	(C-H)Aleph. υ	(C=O) υ	(C=C) υ	(SO_2) asym.υ	(SO_2) sym.υ	(C-N) υ	(M-O) υ
N	acac	-------	-------	2914	1643	-------	--------	-------	-------	-------
N_1	$[Zn(sac)_2(acac)_2]$	3352	3111	2854	1620	1579	1292	1155	1056	594
N_2	$[Cd(sac)_2(acac)_2]$	-------	3084	-------	1627	1585	1261	1149.5	1055	594
N_3	$[Hg(sac)_2(acac)_2]$	3354	3089	-------	1695	1630	1246	1147	1053	596
N_4	$[Fe(sac)_2(acac)_2]Cl$	3353	3099	2959	1720	1566	1271	1178	1016	596
N_5	$[Ni(sac)_2(acac)_2]$	3354.9	3111		1714	1618	1292	1157	1056	592
N_6	$[Cu(sac)_2(acac)_2]$	3355	3091	2951.9	1722.4	1583	1294	1180.4	1020	594

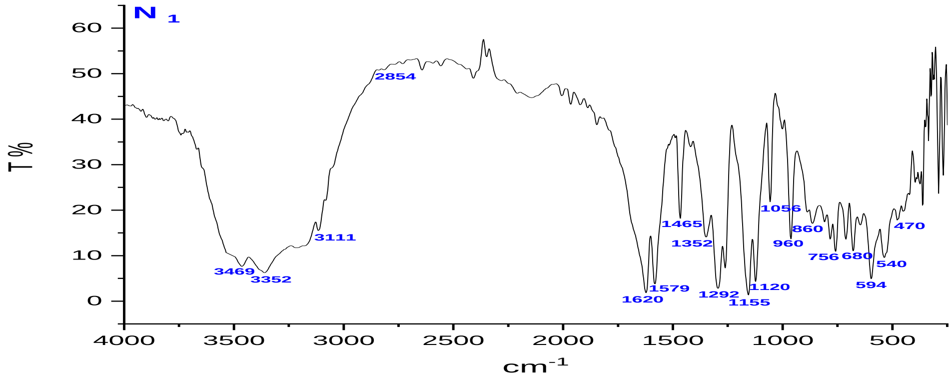

Figure (1): FT-IR spectrum of (N_1)

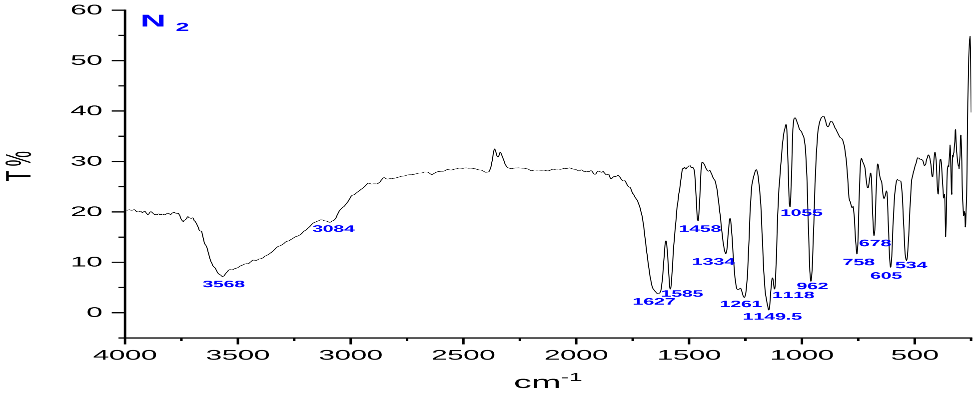

Figure (2): FT-IR spectrum of (N_2)

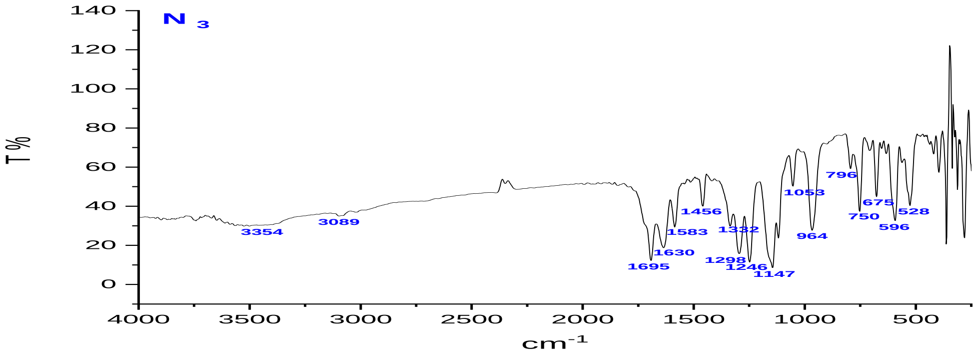

Figure (3): FT-IR spectrum of (N_3)

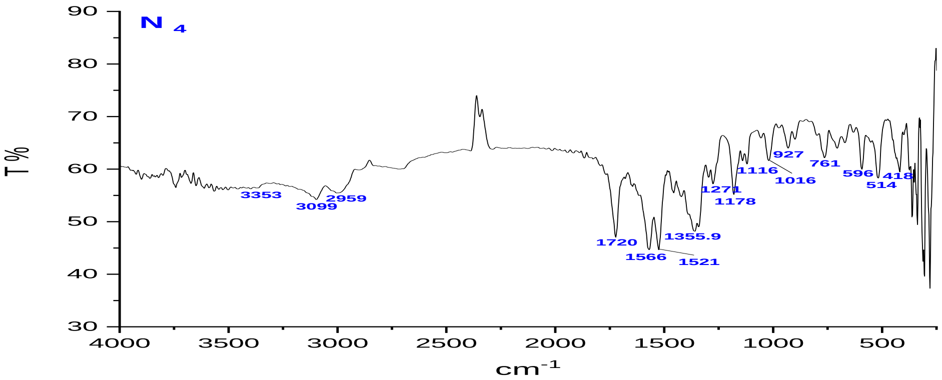

Figure (4): FT-IR spectrum of (N_4)

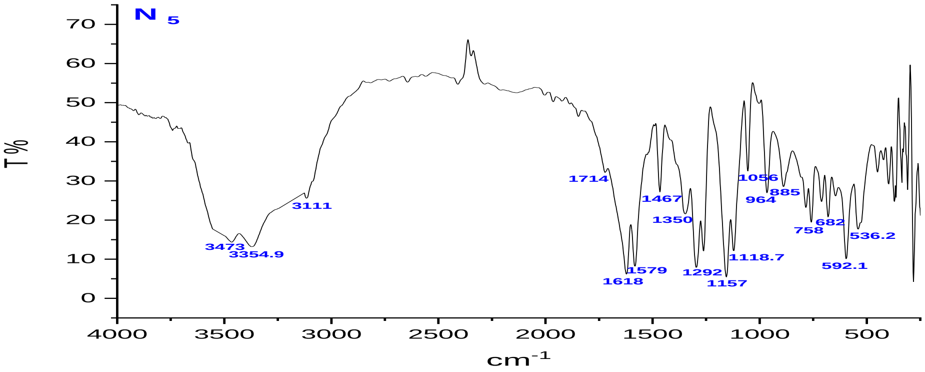

Figure (5): FT-IR spectrum of (N_5)

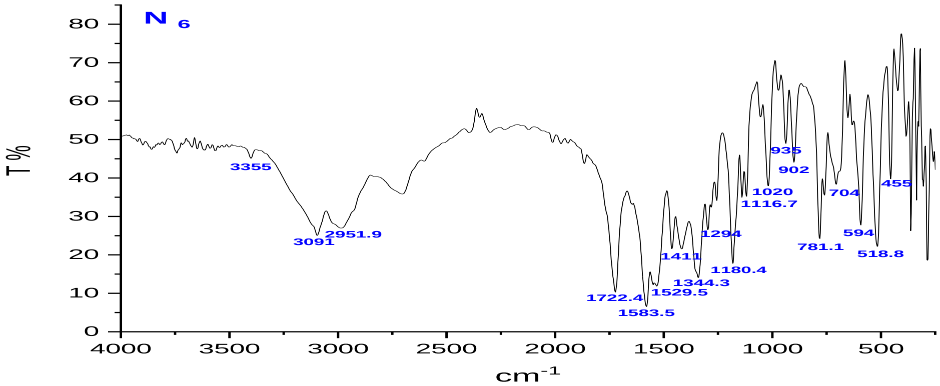

Figure (6): FT-IR spectrum of (N_6)

3.3 Electronic Spectra and Magnetic Moment

The values of band positions (λmax nm)cm^{-1} and magnetic moment values were calculated from the measured magnetic susceptibilities after employing diamagnetic corrections together with the proposed assignments transition and suggested geometries . are listed in Table (5,6). The electronic spectra of d^{10}[Zn(II), Hg (II)and Cd (II)] complexes do show the charge transfer, and the magnetic susceptibility shows that all complexes have diamagnetic moments, because d-d transitions are not possible hence electronic spectra did not give any fruitful information. in fact this result is a good agreement with previous work of octahedral geometry [18], [19]. The (U.V- Vis) spectrum region of Fe(III), Ni(II) and Cu (II) are ascribed to an intra-ligand transition and d-d transition [20], [21].

Table (5) Electronic spectra and magnetic moments of saccharine complexes

Symb.	**Complexes**	**Λm (ohm^{-1}.cm^{2}.mol^{-1}) Solvent(DMSO)**	**ύ cm-1**	**Tentative assignment**	**µ (B.M.)**
	Sac.	----------	36496.35 34364.26	π→ π* n→ π*	
A_1	[Zn (sac)$_2$ (H$_2$O)$_4$]Cl$_2$	73	35714.28 33898.3	π→ π* n→ π*	--------
A_2	[Cd (sac)$_2$ (H$_2$O)$_4$]Cl$_2$	78	35971.22 34722.22	π→ π* n→ π*	--------
A_3	[Hg (sac)$_2$ (H$_2$O)$_4$]Cl$_2$	77	35971.22 34965.03	π→ π* n→ π*	--------
A_4	[Fe (sac)$_2$ (H$_2$O)$_4$]Cl	34	23809	$^{6}A_{1}g \rightarrow {}^{2}T_{2}g$	1.77
A_5	[Ni (sac)$_2$ (H$_2$O)$_4$]	7	10554 16129 25310	$^{3}A_{2}g\ F \rightarrow {}^{3}T_{2}g\ F$ $^{3}A_{2}g\ F \rightarrow {}^{3}T_{1}g\ F$ $^{3}A_{2}g\ F \rightarrow {}^{3}T_{1}g\ P$	2.66
A_6	[Cu (sac)$_2$ (H$_2$O)$_4$]	18	15728	$^{2}B_{1}g \rightarrow {}^{2}A_{1}g$ $^{2}B_{1}g \rightarrow {}^{2}A_{2}g$ $^{2}B_{1}g \rightarrow {}^{2}Eg$	1.83

Table (5) Electronic spectra and magnetic moments of mixed-ligand complexes

Symb.	**Complexes**	**Λm (ohm^{-1}.cm^{2}.mol^{-1}) Solvent(DMSO)**	**ύ cm-1**	**Tentative assignment**	**µ (B.M.)**
	acac	----------	37313.43 34722.22	π→ π* n→ π*	
N_1	[Zn (sac)$_2$ (acac)$_2$]	15	36764.7 32362.45	π→ π* n→ π*	--------
N_2	[Cd (sac)$_2$ (acac)$_2$]	24.3	34722.22 30864.19	π→ π* n→ π*	--------
N_3	[Hg (sac)$_2$ (acac)$_2$]	13.1	34965.03 31948.88	π→ π* n→ π*	--------
N_4	[Fe (sac)$_2$ (acac)$_2$]Cl	39.5	19047.6	$^{6}A_{1}g \rightarrow {}^{2}T_{2}g$	1.85
N_5	[Ni (sac)$_2$ (acac)$_2$]	13.7	10240 15384 23224	$^{3}A_{2}g\ F \rightarrow {}^{3}T_{2}g\ F$ $^{3}A_{2}g\ F \rightarrow {}^{3}T_{1}g\ F$ $^{3}A_{2}g\ F \rightarrow {}^{3}T_{1}g\ P$	2.31
N_6	[Cu (sac)$_2$ (acac)$_2$]	19.1	16393.4	$^{2}B_{1}g \rightarrow {}^{2}A_{1}g$	1.65

				$^2B_1g \rightarrow {}^2A_2g$ $^2B_1g \rightarrow {}^2Eg$	

3.4 antibacterial activity studying

The antibacterial Gram negative species (-ve) and Gram positive species (+Ve) of the ligands and their metal complexes were tested by using agar diffusion method. The antibacterial activities of the prepared compounds against bacteria, staphylococcus aureus, staphylococcus epidermidis, Escherichia coli, Klebsiella spp and Candida albicans, The higher inhibitionzone of metal complexes than those of the ligand can be explained on the basis of Overtone's concept and Chelation theory. On chelation, the polarity of the metal ion will be reduced to a greater extent due to the overlap of the ligand orbital and partial sharing of the positive charge of the metal ion with donor groups. Further, it increases the delocalization of p-electrons over the whole chelating ring and enhances the penetration of the complexes into lipid membranes and blocking of the metal binding sites in the enzymes of microorganisms. There are other factors which also increase the activity is solubility, conductivity and bond length between the metal and ligand [22- 26].

Table (4) biological activity of ligands and complexes zone inhibition (mm)

No.	**staphylococcus aureus**	**staphylococcus epidermidis**	**Escherichia coli**	**Klebsiella spp**	**Candida albicans**
N_1	14	16	14	12	15
N_2	21	26	25	24	26
N_3	31	29	28	29	23
N_4	15	19	13	12	12
N_5	14	14	14	15	15
N_6	15	15	13	12	14


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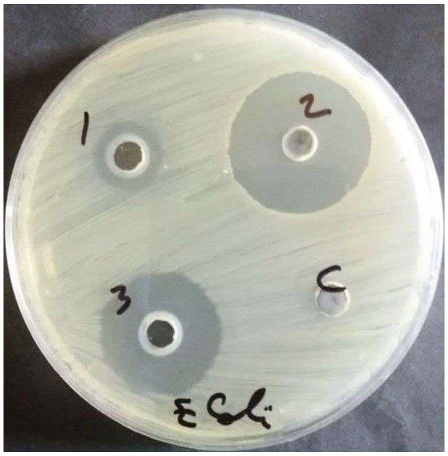
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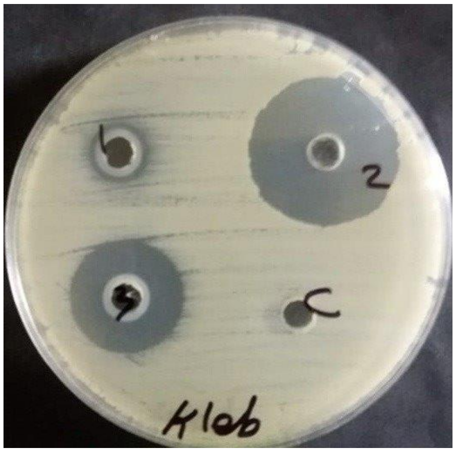
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Figure (7): antibacterial activity studying of mixed-ligand complexes

4. Conclusions

In conclusion, the Zn(II), Cd (II), Hg (II), Fe(II), Ni(II), and Cu(II), complexes of mixed saccharin and acetylacetonato were prepared and characterized by melting point, conductivity measurement, UV-Vis and FTIR spectroscopy, according to the results obtained from elemental analyses and spectral studies, it is obtained that all complexes were octahedral. Investigation of antibacterial activities was carried out against the staphylococcus aureus, staphylococcus epidermidis, Escherichia coli, Klebsiella spp and Candida albicans.

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