Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2017, 4(11): 828-835

Research Article ISSN: 2394 - 658X

Conductometric, Potentiometric and Antimicrobial Investigations on Cu (II)-ThiosemicarbazoneSystems

Uma Rathore, Garima Prajapat, Rama Gupta and N Bhojak

PG Department of Chemistry, Govt Dungar College (NAAC 'A' Grade), MGS University, Bikaner, Rajasthan, India
drbhojak@rediffmail.com

ABSTRACT

This paper describes the conductometric, potentiometric and antimicrobial investigations on few Cu(II)- thiosemicarbazone complexes. Solution studies on the complexes have also been carried out in different micellar systems at 25℃ and data have been compared with ethanol- water mixture. Stability constants have been determined in 60% ethanol by pH metric study. The conductometric studies have been carried out in doubly distilled water, Triton X-100 and Brij-35 mediums. Proton ligand stability constant and metal-ligand stability have been determined by pH data. Association constants and formation constants have been computed and different types of stoichiometry [M: L] have been observed for metal-ligand complexes as; 1: 2, 1: 3, 1: 4 etc.

Keywords: Cu (II)-Thiosemicarbazone, biological, formation constants, Brij-35 and Triton X-100

INTRODUCTION

In most of the cases it has been found that, thiosemicarbazones behave as bidentated ligand and possess carcinostatic potency. This has been exhibited *in vitro* activity against various human tumour lines [1-4]. Various drugs containing thiosemicarbazone moiety like Triapine has paid important role in the treatment of solid tumors and hematological malignancies. It has also exhibited property of radiosensitizer [5-7] and has also shown lesser antitumor activity and selectivity than di-2-pyridylketone thiosemicarbazone [8-9]. Cu metal complexes of di-2-pyridylketone-4, 4-dimethyl-3-thiosemicarbazone have been found redox active and provided appreciable cytotoxicity [10]. Interaction of these compounds with target lysosomes and importance in metal metabolismhas been studied [11-12].

In this paper we are reporting the stability constant, association constant, Gibbs Free energies and antimicrobial activity of Cu (II) complexes with thiosemicarbazide based ligand: 2, 6-Dihydroxyacetophenone thiosemicarbazone (2, 6-DHAT).

MATERIALS AND METHODS

All the chemicals used were of AR grade and procured from Himedia. Metal salt were purchased from E. Merck and were used as received. All solvent used were of standard/spectroscopic grade. Ligand 2, 6-DHAT was synthesized by condensation reaction of thiosemicarbazide with acetophenone in presence of methanol according to the literature [13]. Metal-ligand complexes were formed by conductometrically and potentiometrically. All biological activities have been carried out by disc diffusion method under horizontal laminar.Conductivity TDS Meter 307 is employed in present study for conductometric investigations.The Digital pH meter 335 is used to observe the pH values of various solutions in present study.

PROCEDURE

Potentiometric Study

Potentiometric study has been conducted in non-micellar (Alcohol, Alcohol and water) and in micellar medium (CTAB, SDS and TX-100). Three sets of titrations were prepared for comparison.Volume of all the system was made up to 25 ml using 60% ethanol. Titration of the three sets of mixtures has been carried out against a standard alkali given by Irving and Rossotti method [14].

Conductometric Study

The conductometric titration of the ligand ($1x10^{-3}$) mole/L in doubly distilled water, TX-100 and Brij-35medium against the $CuCl_2$ ($1x10^{-4}$) mole/L was performed with definite amount of metal ($CuCl_2$) solution [15-18]. The cell was calibrated with standard KCl solution [19].

Biological Study

Biological investigation has been carried out by disc diffusion method. The agar was prepared in plate and microorganisms were cultivated on to the surface of the agar plate. Broth was applied on agar plate then filter paper discs impregnated with different types of sample, were placed on the agar. After incubation of the plates the diameter of the zone of inhibition (ZI) of microorganism growth around each disc was measured [20-21].

RESULTS AND DISCUSSION

Potentiometric Study

Proton-ligand Stability Constants (pK):

The proton–ligand formation curves were estimated by plotting graphs between the values ($\overline{n}_A$) Vs pH readings. This curve indicates average number of hydrozen ions **($\overline{n}_A$)** attached to a ligand. The value of pH where $\overline{n}_A$ = 1.5 and $\overline{n}_A$ = 0.5 corresponds to the values of pK_1 and pK_2, respectively. The proton-ligand formation numbers ($\overline{n}_A$) were calculated by Irving and Rossotti method [14].

$$\overline{n}_A = Y - \frac{(V_1 - V_2)(N^o + E^o)}{(V^o + V_1)T_{CL^o}} \quad (1)$$

Where, V^0 = Initial volume of solution (25 ml), E^0 = Initial concentration of free acid (HNO_3), Y= Number of dissociable protons from ligand, T_{CL}^0 is concentration of ligand in solution, (V_1–V_2) = Volume of alkali (KOH) consumed by acid and ligand on the same pH [22].

Metal ligand Stability Constant (logK):

Metal ligand stability constant (log K) were determined by metal complex formation curve and this curve indicated average number of ligand ($\overline{n}$) attached to metal ion. Metal ligand stability constant (logK) were determine by the half integral method by plotting $\overline{n}$ vs. pL.

$$\overline{n} = \frac{(V_3 - V_2)(N^o + E^o)}{(V^o + V_1)(\overline{n}_A)T_{CM^o}} \quad (2)$$

$$pL = \log_{10} \frac{\sum_{n=0}^{n} \beta_n^H \cdot \frac{1}{(anti\log pH)^n}}{T_{CL^o} - \overline{n}T_{CM^o}} \times \frac{V^o + V_3}{V^o} \quad (3)$$

V_3 is the volume of KOH added in the metal ions titration to attain the given pH reading and T_{CM}^0 total concentration of metal present in solution. log K_1 and logK_2 were calculated from the formation curve by the known value of pL at which ($\overline{n}$) = 0.5 and ($\overline{n}$) = 1.5 corresponding to the values of logK_1 and logK_2, respectively [23].

The values of $\overline{n}_A$ and pH of ligand in non-micellar medium and micellar medium have been reported in table-1. The $\overline{n}$ and pL values of ligand 2,6-DHAT with Cu (II) metal in non-micellar and micellar medium have been reported in table-2.

Conductometric Study

The values of molar conductance (/\m) for $CuCl_2$ were calculated [24] in water, Brij-35and TX-100 medium at 298.15 K temperature.

$$/\backslash m = (Ks - Ksolv.)Kcell \times 1000/C \quad (4)$$

Here,

Ks = specific conductance of the solution, Ksolv = specific conductance of the solvent

Kcell = cell constant

C = molar concentration of the metal ion solution.

The stoichiometric of complexes were decided by association and formation constants. The association constants of complexes were calculated by using equation (5) [25, 26] in water, TX-100 and Brij-35 medium.

$$K_A = [/\backslash_0^2 (/\backslash_0 - /\backslash_m)] / [4C_m^2 + /\backslash^3 S(z)] \quad (5)$$

K_A = association constants

/\m =molar conductance

$/\backslash_0$ = limiting molar conductance of metal ion solution

$\gamma\pm$ = activity coefficient

S(Z) = Fuoss-Shedlovsky factor [27]

The calculated association constants are shown in Table -3.

Table -1 The $\bar{n}_A$ and pH Values of Ligand 2,6-DHAT in Non Micellar Medium and Micellar Medium

Sr. No.	pH	Non Micellar		Micellar Medium		
		Alcohol	Alc.+water	CTAB	SDS	TX-100
		$\bar{n}_A$	$\bar{n}_A$	$\bar{n}_A$	$\bar{n}_A$	$\bar{n}_A$
1	4.15					1.18569
2	4.4	1.09502	1.25055	1.11662	1.09504	1.15537
3	4.65	1.0561	1.263457	1.09498	1.09501	1.1467
4	4.9	1.09928	1.267712	1.08632	1.0993	1.1294
5	5.15	1.09063	1.26333	1.06905	1.07337	1.14233
6	5.4	1.07767	1.271942	1.0604	1.02157	1.138
7	5.65	1.07334	1.271921	1.05176	1.01294	1.1423
8	5.9	1.0647	1.267583	1.04313	1.01725	1.1466
9	6.15	1.06901	1.271888	1.03881	1.01725	1.15522
10	6.4	1.07331	1.293443	1.05175	1.01725	1.15521
11	6.65	1.07331	1.319322	1.05174	1.02156	1.15951
12	6.9	1.06899	1.332255	1.05605	1.02156	1.16381
13	7.15	1.06899	1.358116	1.06036	1.03018	1.16379
14	7.4	1.06899	1.366731	1.05173	1.02156	1.16378
15	7.65	1.06467	1.379659	1.05604	1.03018	1.17239
16	7.9	1.06466	1.379613	1.05604	1.03449	1.17669
17	8.15	1.06466	1.392539	1.06035	1.03449	1.17667
18	8.4	1.06035	1.396837	1.06034	1.0388	1.18529
19	8.65	1.06034	1.409744	1.06034	1.0388	1.18526
20	8.9	1.06034	1.405383	1.06033	1.04742	1.18525
21	9.15	1.06033	1.40963	1.06033	1.05173	1.19386
22	9.4	1.05602	1.435449	1.05601	1.05604	1.19815
23	9.65	1.0474	1.465573	1.07324	1.05603	1.21967
24	9.9	1.0517	1.478429	1.09047	1.06896	1.25841
25	10.15	1.04308	1.495611	1.10337	1.06896	1.3273
26	10.4	1.06461	1.517035	1.15075	1.07758	1.4177
27	10.65	1.09045	1.555658	1.1938	1.06032	1.88666
28	10.9	1.1292	1.667517	1.42204	1.0603	
29	11.15	1.18085	1.813292		1.0732	
30	11.4	1.198	1.859154		1.14204	
31	11.65	1.34422	1.883243		1.43462	
32	11.9	1.39989				
33	12.15	1.50251				

Table -2 The $\bar{n}$ and pLValues of Ligand 2,6-DHAT with Cu (II) in Non-Micellar and Micellar Medium

		Alcohol		Alc.+water		CTAB		SDS		TX-100	
Sr. No.	pH	pL	$\bar{n}$	pL	$\bar{n}$	pL	$\bar{n}$	pL	$\bar{n}$	pL	$\bar{n}$
1	4.15									4.33556	0.127707
2	4.4	4.4984015	0.2682152	4.33029	0.17963	4.37997	0.23982	4.32467	0.06312	4.07535	0.104964
3	4.65	4.2090924	0.1879682	4.11324	0.24612	4.12463	0.22868	4.06779	0.04733	3.84568	0.148289
4	4.9	3.948184	0.1649215	3.87678	0.27249	3.87958	0.23839	3.80745	0.02356	3.59273	0.141765
5	5.15	3.6950846	0.1582881	3.63436	0.28703	3.64364	0.26642	3.55424	0.01608	3.34677	0.150087
6	5.4	3.4384716	0.1441388	3.39048	0.29864	3.39894	0.27667	3.31213	0.03378	3.09657	0.149452
7	5.65	3.1812729	0.1286193	3.14404	0.30541	3.15016	0.27889	3.06992	0.0511	2.84638	0.148823
8	5.9	2.9280602	0.1215349	2.91241	0.34048	2.90137	0.28115	2.81612	0.0424	2.6001	0.156432
9	6.15	2.6704358	0.1048975	2.66907	0.35289	2.66049	0.2989	2.57758	0.06783	2.35377	0.163984
10	6.4	2.41294	0.0883961	2.4162	0.34698	2.40875	0.29522	2.3315	0.07631	2.12362	0.204965
11	6.65	2.1666668	0.0964286	2.16287	0.34016	2.16303	0.30339	2.08525	0.08443	1.89438	0.246951
12	6.9	1.9168755	0.0968103	1.9147	0.34332	1.91246	0.30214	1.8588	0.13507	1.66102	0.279867
13	7.15	1.6632331	0.0887362	1.65486	0.32405	1.66609	0.30904	1.63225	0.18417	1.43296	0.322314
14	7.4	1.4132663	0.0887329	1.41053	0.33462	1.43459	0.34433	1.42472	0.27013	1.21007	0.373415
15	7.65	1.1671846	0.0971842	1.16563	0.34398	1.19258	0.35924	1.20817	0.33483	0.98731	0.423188
16	7.9	0.9135273	0.0890788	0.92237	0.35646	0.94701	0.36737	0.97968	0.3751	0.75129	0.448047
17	8.15	0.7452413	0.2591287	0.69417	0.3965	0.70944	0.39026	0.76638	0.44177	0.5359	0.508196
18	8.4	0.6870146	0.601626	0.4745	0.45085	0.48188	0.43088	0.54381	0.48972	0.31437	0.555846
19	8.65	0.3780447	0.5040461	0.23628	0.47116	0.29781	0.54465	0.37435	0.62248	0.10879	0.627348
20	8.9			0.00495	0.50325						

Table -3 Association Constant (K_A) of $CuCl_2$ with 2, 6-DHAT in Different Medium

		K_A	K_A	K_A	Δ GA	Δ GA	Δ GA
$C_{[ligand]}$	$C_{m[CuCl_2]}$	Water	TX-100	Brij-35	Water	TX-100	Brij-35
0.000992	7.94E-07	6.55E+09	1.17E+10	9.63E+10	-56.0086	-57.4386	-62.6705
0.000984	1.57E-06	1.45E+09	2.96E+09	2.45E+10	-52.2784	-54.0426	-59.2744
0.000977	2.34E-06	5.71E+08	1.22E+09	9.81E+09	-49.9645	-51.8384	-57.0121
0.000969	3.1E-06	2.83E+08	6.95E+08	5.61E+09	-48.2228	-50.4512	-55.6249
0.000962	3.85E-06	1.84E+08	4.11E+08	3.25E+09	-47.1552	-49.1485	-54.2716
0.000954	4.58E-06	1.12E+08	2.9E+08	2.29E+09	-45.921	-48.2829	-53.406
0.000947	5.3E-06	71308119	1.96E+08	1.53E+09	-44.8088	-47.3196	-52.3995
0.00094	6.02E-06	55425613	1.39E+08	1.19E+09	-44.1844	-46.4558	-51.7751
0.000933	6.72E-06	37709439	1.01E+08	8.51E+08	-43.2301	-45.6669	-50.9533
0.000926	7.41E-06	26005270	82882645	6.27E+08	-42.3092	-45.1816	-50.1974
0.000909	9.09E-06	17265502	49831591	3.74E+08	-41.2942	-43.9208	-48.916
0.000893	1.07E-05	12429893	29264307	2.18E+08	-40.48	-42.6018	-47.58
0.000877	1.23E-05	7821546	20052215	1.35E+08	-39.3321	-41.665	-46.3943
0.000862	1.38E-05	5027137	11386976	87607433	-38.2367	-40.2628	-45.3189
0.000847	1.53E-05	4110207	8264145	64829928	-37.7377	-39.4685	-44.5728
0.000833	1.67E-05	3443081	5363751	44558743	-37.2988	-38.3973	-43.6437
0.00082	1.8E-05	2321237	3989701	34496209	-36.3218	-37.664	-43.0094
0.000806	1.94E-05	2014958	2987423	27143044	-35.9712	-36.9471	-42.4153
0.000794	2.06E-05	1344887	2628271	21646353	-34.9694	-36.6297	-41.8546
0.000781	2.19E-05	1196728	1993724	17457996	-34.6801	-35.9449	-41.3217
0.000769	2.31E-05	1075315	1791452	14213931	-34.415	-35.6798	-40.8123
0.000758	2.42E-05	694160.3	1623338	11665520	-33.3305	-35.4357	-40.3227
0.000746	2.54E-05	633670.7	1244306	9638794	-33.1046	-34.7767	-39.8498
0.000735	2.65E-05	582216.7	1143269	8009439	-32.8947	-34.5669	-39.3909
0.000725	2.75E-05	341576.4	869553.6	6033707	-31.5732	-33.8887	-38.689
0.000714	2.86E-05	317272.9	807683.9	5049115	-31.3903	-33.7058	-38.2475
0.000704	2.96E-05	142020.7	603473.3	980304.9	-29.3985	-32.9836	-34.1858
0.000694	3.06E-05	133074	565457	754423.6	-29.2373	-32.8223	-33.5368
0.000685	3.15E-05	125159.5	409090.8	567037.7	-29.0854	-32.0202	-32.8292
0.000676	3.24E-05	2202.149	386074	410925.2	-19.0738	-31.8767	-32.0313
0.000667	3.33E-05	2084.722	365487.2	280397.5	-18.938	-31.7409	-31.0842
0.000658	3.42E-05	1979.184	250438.4	82906.79	-18.8093	-30.8042	-28.0647
0.000649	3.51E-05	1883.908	238382.5	1487.087	-18.687	-30.6819	-18.1009
0.000641	3.59E-05	1797.541	227454	1418.912	-18.5707	-30.5656	-17.9846
0.000633	3.67E-05		139732.2	1356.878		-29.3583	-17.8738
0.000625	3.75E-05		133898.5	1300.229		-29.2526	-17.7681
0.000617	3.83E-05		62164.22	1248.329		-27.3512	-17.6672

The Gibbs free energies were obtained by employing equation (6) [28]

$$\Delta G_A = - R T \ln K_A \quad (6)$$

here

R = gas constant (8.314 J)

T = absolute temperature

The result of Gibbs free energies were presented in Table (3).

$$K_f = [\Lambda_M - \Lambda_{obs}]/[(\Lambda_{obs} - \Lambda_{ML})[L]] \quad (7)$$

The formation constants (K_f) [29-30] of complexes were calculated by applying above eq.

here,

Λ_M = molar conductance of the metal ion solution alone

Λ_{obs} = observed molar conductance of solution

Λ_{ML} = molar conductance of the complex

The calculated values (K_f) for complexes are presented in Tables (4-9).

Also the Gibbs free energies of complex formation constant were obtained using equation (8) and exhibited in tables (4-9).

$$\Delta G_f = - RT \ln K_f \quad (8)$$

Table -4 Formation Constants and Gibbs free Energies of Formation for 1:9 (M/L) Complexes in Water Medium

/\obs	[L]	($/\_M$-$/\_{obs}$)	(/\obs-$/\_{ML}$)[L]	K_f	ΔG_f (k J/mol)
54	0.000675676	25	0.001317568	18974.35897	-24.3819541
54	0.000666667	25	0.0013	19230.76923	-24.4151776
54	0.000657895	25	0.001282895	19487.17949	-24.447961
55	0.000649351	24	0.001915584	12528.81356	-23.3546398
55	0.000641026	24	0.001891026	12691.52542	-23.3865772
56	0.000632911	23	0.0025	9200	-22.5902566
56	0.000625	23	0.00246875	9316.455696	-22.6213905
56	0.000617284	23	0.002438272	9432.911392	-22.6521376
57	0.000609756	22	0.003018293	7288.888889	-22.0139206
57	0.00060241	22	0.002981928	7377.777778	-22.0439223
57	0.000595238	22	0.002946429	7466.666667	-22.0735648
58	0.000588235	21	0.0035	6000	-21.5322842
58	0.000581395	21	0.003459302	6070.588235	-21.5612332
59	0.000574713	20	0.003994253	5007.194245	-21.0845765
59	0.000568182	20	0.003948864	5064.748201	-21.1128638
59	0.000561798	20	0.003904494	5122.302158	-21.1408315
60	0.000555556	19	0.004416667	4301.886792	-20.7087998
60	0.000549451	19	0.004368132	4349.685535	-20.7361494
60	0.000543478	19	0.004320652	4397.484277	-20.7632001
60	0.000537634	19	0.004274194	4445.283019	-20.7899583
60	0.000531915	19	0.004228723	4493.081761	-20.8164304

$/\_{ML}$ = **52.05 $cm^2 ohm^{-1} mol^{-1}$**

Table -5 Formation Constants and Gibbs Free Energies of Formation for 1:3 (M/L) Complexes in Brij-35 Medium

/\obs	[L]	($/\_M$-$/\_{obs}$)	(/\obs-$/\_{ML}$)[L]	K_f	ΔG_f (k J/mol)
71	0.000685	6	0.001335616	4492.308	-20.8160039
72	0.000676	5	0.001993243	2508.475	-19.373776
73	0.000667	4	0.002633333	1518.987	-18.1321826
75	0.000658	2	0.003914474	510.9244	-15.4353546
76	0.000649	1	0.004512987	221.5827	-13.3675818
76	0.000641	1	0.004455128	224.4604	-13.3995192
76	0.000633	1	0.004398734	227.3381	-13.4310497
76	0.000625	1	0.00434375	230.2158	-13.4621837
76	0.000617	1	0.004290123	233.0935	-13.4929308

$/\_{ML}$ = **69.05 $cm^2 ohm^{-1} mol^{-1}$**

Table -6 Formation Constants and Gibbs Free Energies of Formation for 1:3 (M/L) Complexes in TX-100 Medium

/\Obs	[L]	($/\_M$-$/\_{Obs}$)	(/\Obs-$/\_{ML}$)[L]	K_f	ΔG_f (K J/Mol)
77	0.000657895	4	0.001177632	3396.648045	-23.357255
77	0.000649351	4	0.001162338	3441.340782	-21.528295
77	0.000641026	4	0.001147436	3486.03352	-21.567898
78	0.000632911	3	0.001765823	1698.924731	-20.370584
78	0.000625	3	0.00174375	1720.430108	-20.408959
79	0.000617284	2	0.002339506	854.8812665	-20.446747
79	0.000609756	2	0.002310976	865.4353562	-19.494545
79	0.00060241	2	0.002283133	875.9894459	-19.531214
79	0.000595238	2	0.002255952	886.5435356	-18.693065
79	0.000588235	2	0.002229412	897.0976253	-18.728679
80	0.000581395	1	0.002784884	359.0814196	-17.936683
80	0.000574713	1	0.002752874	363.256785	-17.9713
80	0.000568182	1	0.002721591	367.4321503	-17.176715
80	0.000561798	1	0.002691011	371.6075157	-17.21039
80	0.000555556	1	0.002661111	375.782881	-17.24361359
80	0.000549451	1	0.002631868	379.9582463	2.6319E-06

$/\_{ML}$ = **75.21 $cm^2 ohm^{-1} mol^{-1}$**

Table -7 Formation Constants and Gibbs Free Energies of Formation for 1:3 (M/L) Complexes in Brij-35 Medium

/\obs	[L]	($/\_M$-$/\_{obs}$)	(/\obs-$/\_{ML}$)[L]	K_f	Δ G_f (k J/mol)
70	0.000694	7	0.008798611	795.5801	-16.5314585

$/\_{ML}$ = **55.33 $cm^2ohm^{-1}mol^{-1}$**

Table -8 Formation Constants and Gibbs Free Energies of Formation for 1:6 (M/L) Complexes in TX-100 Medium

/\obs	[L]	($/\_M$-$/\_{obs}$)	(/\obs-$/\_{ML}$)[L]	K_f	Δ G_f (k J/mol)
70	0.000819672	11	0.000877049	12542.05607	-20.124018
71	0.000806452	10	0.001669355	5990.338164	-20.156373
71	0.000793651	10	0.001642857	6086.956522	-20.18831
72	0.00078125	9	0.002398437	3752.442997	-18.409276
72	0.000769231	9	0.002361538	3811.074919	-18.44041
72	0.000757576	9	0.002325758	3869.70684	-16.709397
73	0.000746269	8	0.003037313	2633.906634	-16.739767
73	0.000735294	8	0.002992647	2673.218673	-16.769769
74	0.000724638	7	0.003673913	1905.325444	-16.799411
74	0.000714286	7	0.003621429	1932.938856	-16.828703
75	0.000704225	6	0.004274648	1403.624382	-14.56245
75	0.000694444	6	0.004215278	1423.39374	-14.591065
76	0.000684932	5	0.004842466	1032.531825	-14.619352
76	0.000675676	5	0.004777027	1046.676096	-14.64732
76	0.000666667	5	0.004713333	1060.820368	-14.674975

$/\_{ML}$ = **68.93 $cm^2ohm^{-1}mol^{-1}$**

Table -9 Formation Constants and Gibbs Free Energies of Formation for 1:9 (M/L) Complexes in TX-100 Medium

/\obs	[L]	($/\_M$-$/\_{obs}$)	(/\obs-$/\_{ML}$)[L]	K_f	Δ G_f (k J/mol)
66	0.000862069	15	0.002594828	5780.730897	-21.440137
67	0.000847458	14	0.003398305	4119.700748	-20.601694
69	0.000833333	12	0.005008333	2396.006656	-19.260239

$/\_{ML}$ = **62.99 $cm^2ohm^{-1}mol^{-1}$**

Biological Investigations

Study of ligand and metal complexes has been carried out against E. *coli, S. aureus, B. substilis* bacterial strain. By applying disc diffusion method following results have been found [31].

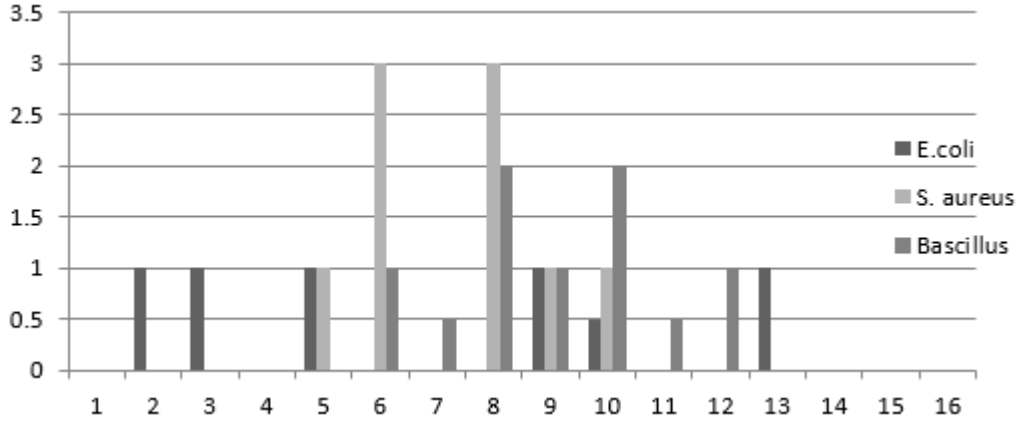

Fig. 1 Biological activity of thiosemicarbazone ligand and metal complexes

CONCLUSION

The values of log K are found greater than zero which indicates the formation of complex between metal ion and ligand by potentiometrically. The negative values of ΔG show the ability of the studied ligand to form stable complexes by conductometrically. Highest antibacterial activity has been screened by ligand in alcohol: water medium against *S. aureus*.

Acknowledgements
The author, Uma Rathore gratefully thanks the University Grant Commission (UGC) CRO Bhopal for awarding Minor Research Project (MRP) to carry out the research work. The author also thanks BIFR, Bikaner for the evaluation of the biological activities of the compounds.

REFERENCES

[1] KSO Ferraz, L Ferandes, D Carrilho, MCX Pinto, MF Leite, FEM Souza, NL Speziali, IC Mendes and H Beraldo, 2-Benzoylpyridine-*N* (4)-Tolyl Thiosemicarbazones and their Palladium(II) Complexes: Cytotoxicity against Leukemia Cell, *Bioorganic & Medicinal Chemistry,* **2009**, 17, 7138-7144.
[2] NC Saha, RJ Butcher, S Chaudhuri and N Saha, Synthesis and Spectroscopic Characterisation of Cobalt(III) and Nickel(II) Complexes with 5-Methyl-3-Formylpyrazole-*N*(4)-Dibutyl Thiosemicarbazone ($HMPzNBu_2$): X-ray Crystallography of $[Co(MPzNBu_2)_2]NO_3{\cdot}H_2O$(I) and $[Ni(HMPzNBu_2)_2](ClO_4)_2$ (II), *Polyhedron,* **2003**, 22, 383-390.
[3] KK Verma, P Soni Gupta, K Solanki and N Bhojak, Microwave Assisted Synthesis, Characterisation and Antimicrobial Activities of few Cobalt (II) Thiosemicarbazones Complexes, *World Journal of Pharmacy Pharmaceutical Sciences,* **2015**, 4 (11), 1673-1683.
[4] KK Verma, R Ram, K Sharma and N Bhojak, Microwave Assisted Synthesis, Characterisation and Anti-Microbial Activities of few Nickel (II)-Thiosemicarbazones Complexes**,** *World Journal of Pharmacy Pharmaceutical Sciences,* **2016**, 5 (4),1307-1318.
[5] ES Ratner, YL Zhu, PG Penketh, J Berenblum, ME Whicker, PH Huang, Y Lee, K Ishiguro, R Zhu, AC Sartorelli and Z Lin, Triapine Potentiates Platinum-Based Combination Therapy by Disruption of Homologous Recombination Repair, *British Journal of Cancer,* **2016**, 114, 777-786.
[6] CM Nutting, CMLH Van and AB Miah, Phase II Study of 3-AP Triapine in Patients with Recurrent or Metastatic Head and Neck Squamous Cell Carcinoma, *Annals of Oncology,* **2009**, 20, 1275-1279.
[7] B Ma, BC Goh and EH Tan, A Multicenter Phase II Trial of 3- Aminopyridine-2-Carboxaldehyde Thiosemicarbazone (3-AP, Triapine) and Gemcitabine in Advanced Non-Small-Cell Lung Cancer with Pharmacokinetic Evaluation using Peripheral Blood Mononuclear Cells, *Invest New Drugs,* **2008**, 26, 169-73.
[8] J Yuan, DB Lovejoy and DR Richardson, Novel Di-2-Pyridyl-Derived Iron Chelators with Marked and Selective Antitumor Activity: In-vitro and In-vivo Assessment, *Blood*, **2004**, 104, 1450–1458.
[9] Whitnall, J Howard, P Ponka and DR Richardson, A Class of Iron Chelators with a Wide Spectrum of Potent Antitumor Activity that Overcomes Resistance to Chemotherapeutics, *Proceeding of National Academy of Sciences,* **2006**, 103, 14901–14906.
[10] PJ Jansson, PV Bernhardt and DR Richardson, Novel Thiosemicarbazones of the ApT and DpT Series and Their Copper Complexes: Identification of Pronounced Redox Activity and Characterization of their Antitumor Activity, *Journal of Medicinal Chemistry,* **2010**, 53, 5759–69.
[11] BPV Van den, DE Folmer, HEE Malingr, BE Van, A Klomp and BVD Sluis, Human Copper Transporter 2 is Localized in Late Endosomes and Lysosomes and Facilitates Cellular Copper Uptake, *Biochemical Journal,* **2007**, 407, 49–59.
[12] T Kurz, A Terman, B Gustafsson, UT Brunk, Lysosomes in Iron Metabolism, Ageing and Apoptosis, *Histochemistry and Cell Biology,* **2008**, 129, 389–406.
[13] TS Lobana, A Sanchez and JS Casas, Synthesis, Characterization, and in vitro Cytotoxic Activities of Benzaldehyde Thiosemicarbazone Derivatives and Their Palladium (II) and Platinum (II) Complexes Against Various Human Tumor Cell Lines, *Journal of the Chemical Society,***1997**, 22, 4289-4300.
[14] HM Irving and HS Rosstti, The Calculation of Formation Curves in Mixed Solvents, *Journal of the Chemical Society* **2009**, 2904-2910.
[15] U Rathore, R Gupta, M Soni, N Bhojak**,** Conductometric and pH Metric Investigationson Thiosemicarbazone Co(II) Systems, *International Journal of New Technologies in Science and Engineering,* **2016,** 3 (3), 1-10.
[16] EA Gomaa and BMA Jahdali, Association of $Cu(NO_3)_2$ With Kryptofix-221 in Mixed (MeOH-DMF) Solvents at Different Temperatures, *American Journal of Fluid Dynamics,* **2011**, 1 (1), 4-8.
[17] NE Shishtawi, MA Hamada and EA Gomaa, Influence of Permanent Magnet on the Association Constants of $FeCl_3$+10% PVA(Polyvinylalcohol) in 50% Ethanol-Water Solutions Conductometrically at 298.25K Using New Equation for 1:3 Asymmetric Electrolytes, *Physical Chemistry,* **2011**, 1 (1), 14-16.
[18] EA Gomaa, Solvation Parameters of Lead Acetate in Mixed N, N-Dimethylformamide-Water Mixtures at 298.15K, *Analele Universitatii din Bucuresti-Chimie,***2010**, 19, 45-48.
[19] R Biswas and D Brahman, Thermodynamics of the Complexation between Salicylaldehyde Thiosemicarbazone with Cu(II) Ions in Methanol–1,4-Dioxane Binary Solutions, *Indian Journal of Chemistry,* **2009**, A 48, 1145.
[20] T Mohammadzadeh, SM Sadjjadi, P Habibi andB Sarkari,Comparison of Agar Dilution, Broth Dilution, Cylinder Plate and Disk Diffusion Methods for Evaluation of Anti-Leishmanial Drugs on *Leishmania* Promastigotes, *Iranian Journal of Parasitology,***2012**, 7 (3), 43–47.

[21] BK Singh, P Mishra, A Prakash and N Bhojak, Spectroscopic, Electrochemical and Biological Studies of the Metal Complexes of the Schiff Base Derived from Pyrrole-2-Carbaldehyde and Ethylenediamine, *Arabian Journal of Chemistry*, **2012**, 10, S472-S483.
[22] DA Pund, RA Bhagwatkar, DT Tavade and DB Rathod, Studies on Interaction between La (ii), and Nd (iii) Metal Ions and 1-(4-Hydroxy-6-methyl pyrimidino)-3-Substituted Thicarbamide at 0.1 m Ionic Strength pH Metrically, *Rasayan Journal of Chemistry*,**2009**, 2 (3), 246-249.
[23] DM Janrao, J Pathan, DD Kayande and JJ Mulla, An Over View of Potentiometric Determination of Stability Constants of Metal Complexes, *Scientific Reviews & Chemical Communications*,**2014**, 4 (1), 11-24.
[24] W Gryzybkowski, M Pilarczyk, Electrical Conductance and Apparent Molar Volumes of $Al(ClO_4)_2$, $Be(ClO_4)_2$ and $Cu(ClO_4)_2$ in N, N-Dimethylformamide Solutions at 25^{o}C, *Electrochimica Acta*, **1989**, 32, 1601-1605.
[25] NAE Shishtawi, MA Hamada and EAGomaa, Influence of Permanent Magnet on the Association Constants of $FeCl_3$ in 50% Ethanol-H_2O Solutions (conductometrically) at 298.15 K Using a new Equation for 1:3 Asymmetric Electrolytes, *Journal Chemical Engineering Data*, **2010**, 55, 5422-5424.
[26] MA Hamada, NAE Shishtawiand and EA Gomaa, Conductometric Evaluation of Association Constants for Aqueous Solutions of $CoCl_2$ in the Absence and Presence of a Magnetic Field, *Southern Brazilian Journal of Chemistry*, **2009**, 17, 33-40.
[27] EA Gomaa, Solute-Solvent Interactions of Some Univalent-Univalent Salts with Various Organic Solvents at 25^{o}C, *Thermochimica Acta*, **1987**, 120, 183-189.
[28] EA Gomaa, Theoretical Contribution of Solvation of AgBr in Some Organic Solvents at 25^o. *Thermochimica Acta*, **1988**, 128, 99-120.
[29] FIE Dossoki, Electric Conductance and Semi-Emperical Studies on Two Thiophene Derivatives/Metal Cation Complexation, *Journal of Molecular Liquids*, **2008**, 142, 53-56.
[30] MR Nasrabadi, F Ahmedi, SMP Tazari, MP Ganjal and K Alizadeh, Conductometric Study of Complex Formation between Some Substituted Pyrimidines and Some Metal Ions in Acetonitrile and the Determination of Thermodynamic Parameters, *Journal of Molecular Liquids*, **2009,** 144, 97-101.
[31] N Gakkhar, A Bhatia and N Bhojak, Comparative Study on Physiochemical Properties of Various Milk Samples, *International Journal of Recent Scientific Research*, **2015**, 6 (6), 4436-4439.