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STUDIES ON COORDINATION AND ADDITION COMPOUNDS AND ANTI MICROBIAL ACTIVITY OF SOME MIXED LIGAND COMPLEXES OF Au (III), Mo (II), Co (II) AND Cd (II) WITH DIBASIC ACID AND HETEROCYCLIC AMINES AND ADDITION COMPOUNDS OF As (III) AND Sb (III) HALIDES WITH BENSAMIDE AND ACETOPHENON

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Abstract

Three new mixed ligand complexes of Au(III) and Mo(II) with dibasic acid e.g., homophthalic acid, oxalic acid and heterocylic amines e.g., quinonine, iso-quinonine, bipyridine, Phenylanaline and the two new addition compounds of As(III) and Sb(III) halides with N-donor ligands viz. benzamide and acetophenone and one complex $[Cd(DPH)(IQ)_2]$, where IQ = Iso-quinoline and DPH = Deprotonated phthalic acid have been prepared according to the procedure in the literature. Their conventional physical and chemical analysises have been done. Their antibacterial studies against nine gram positive and five gram negative pathogenic bacteria and antifungal activities against eight plant and three human fungi have been evaluated. Kanamycin and Nystatin have been used as a standard for carrying out experiments of antibacterial and antifungal activities, respectively. The minimum inhibitory concentration (MIC) values of these compounds, as antibiotic against two gram positive and two gram negative pathogenic bacteria, have also been carried out and in this case, Amoxacilin antibiotic has been used as a standard antibiotic.

1. Introduction

Most of the insecticides in their early stage were inorganic compounds having bad odor and were very ugly to look at [1]. The production of effective poisons in this regard began in the middle of the nineteenth century. Among them Calcium arsenate, Lead arsenate, Sulphur compounds and Paris green $\{[Cu(C_2H_3O_2)]_2.\ 3Cu(AsO_2)\}$ were remarkable.

Metal salt of phthalic acid have insecticidal [1] and fungidal [2] properties. Phthalic anhydride has biochemical importance [3]. Heterocyclic amins are well-known therapeutic agents [4-6] and their activity is generally enhanced when they are allowed to form complexes with metal ions [7]. Certain complexes of platinum exhibit potent anti-tumor activity against carcinoma and leukemia.

A Survey of the existing literature reveals that extensive studies have been done on the metal complexes of phthalic acid [8-15] but nothing significant is reported on the metal complexes of homophthalic acid. As early as 1921 Duff [16] reported a mixed ligand complex of Co (III) with homophthalic acid. Recently, Islam et al. [17] have prepared some mixed ligand complex of Ni (II), Ti (III) and oxovanadium (IV) with homophthalic acid and heterocyclic amines.

Several addition compound of tine (V) and titanium (IV) chlorides with diacetamide dipropionamide, N-N acetylpropionamide and N-methyldiacetitamide have been studied. Pellacani et al. [18] have prepared some addition compounds of antimony (III) and bismuth (III) halides with dithiomalonamide, N-N dimethyl and N-N diphenyldithiomalonamide have been characterized by IR and the mass spectroscopic technique. Andrade et al. [19] have prepared and characterized several addition compounds of tin (IV) and titanium (IV) chorides with diactamide dipropionamide, N-acetylpropionaide and N-methyldiacetaide.

In continuation of the previous work we herein report the synthesis and structural aspects of Au (III), Mo (II) ions with dibasic acids and heterocyclic bases, Co(II) and Cd (II) complexes with amino acid and heterocyclic bases and addition compounds of As(III) and Sb (III) halides with N-donor ligand viz. benzamide and acetophenone. The compounds were characterized on the basis of physiochemical methods. Their antibacterial and antifungal activities have also been carried out.

2. Experimental

2.1 Chemicals and reagents

All chemicals were of reagent grade and unless otherwise specified, were used as received. The solvents were purified using conventional methods.

2.2 Physical Measurements

Elemental analyses of all the compounds were carried out by a Perkin Elmer 2400 II organic elemental analyzer in the Department of Chemistry, University of Putra, Malaysia. Percentages of metals were estimated by weighing as the oxide produced by direct ignition method. The molar conductance of 10^{-3} M solutions of the metal complexes in DMSO was measured at room temperature using WPACM35 conductivity meter and a dip-cell with a platinised electrode. The Magnetic Susceptibility was measured with a SHERWOOD SCIENTIFIC Balance at 298K and all susceptibilities were corrected for diamagnetic contribution using Pascal's constant [14]. The melting points or decomposition temperatures of all the prepared metal complexes were observed with an electro-thermal digital melting point apparatus model no. AZ 6512. However, it was not possible to measure the melting point beyond 300^0C. Infrared spectra were recorded by using a SHIMADZU FTIR-8400 infrared spectrophotometer, from 4000-400 cm^{-1} in the Central Laboratory, Rajshahi University, Rajshahi, Bangladesh. The absorbances of the complexes were recorded by SHIMUDZU spectrophotometer (Model UV- 1200) at the Department of Biochemistry and Molecular Biology, Rajshahi University, Bangladesh. Microbial activities were evaluated at the Department of Pharmacy and the Institute of Biological Science, Rajshahi University, Bangladesh.

2.3 Metal analysis of the complexes

A known weight of the complex (0.1-0.2 g) was taken into a conical flask and treated with concentrated H_2SO_4 ($5cm^3$). The process was repeated. Concentrated HNO_3 (20 cm^3) was then added. The process was repeated two or three times. Finally $HClO_4$ (72% 20 cm^3) was added and evaporated again to dryness. Then the residue was dissolved in distilled water (250 cm^3) and the metal content was determined complexometrically [4,5].

2.4 Preparation of the compounds

Mixed ligand complexes of Au(III) and Mo(III) with dibasic acid e.g., homophthalic acid, oxalic acid and heterocyclic amines e.g., quinoline, isoqunoline, bypyridine, phenyl aniline and the two new addition compounds of As(III) and Sb(III) halides with N-donor ligands viz benzamide and acetophenone and one complex $[Cd(DPH)(IQ)_2]$, where IQ = Iso-quinoline and DPH = Deprotonated phthalic acid, have been prepared according to the procedure in the literature [10,13,22].

2.5 Antibacterial activities

The antibacterial activities of the purified metal compounds were determined at different concentrations (100 μg/disc & 30 μg/disc) against a series of Gram positive and Gram-negative pathogenic bacteria and the obtained results were compared with standard antibiotic Kanamycin (K-30μg/disc). The results are shown in Table 5 (5.1 and 5.2).

2.6 Antifungal activities

The antifungal activities of the compounds were carried out against eight plant and three human pathogenic fungi by using the disc diffusion technique. The results are illustrated in Table 6.

2.7 Maximum Inhibitory Concentration (MIC) of the antibiotics

Maximum inhibitory concentration may be defined as the lowest concentration of antimicrobial drug to inhibit the growth of the organism. The data derived from the test can be corrected with the knowledge of expected or measured antibiotic level *in vitro* to predict the efficiency of antibiotic. A Serial tube dilution technique was followed using nutrient broth medium to determine the MIC values of antibiotics against the following two gram positive and gram negative pathogenic bacteria. Generally, the more susceptible the test organism, the larger is the zone of inhibition. Antibacterial activities of the test samples are expressed by measuring the zone of inhibition in different concentrations. The results are given in Table 7 (7.1 to 7.4) and in Figure 1 (1.1 to 1.4).

3. Results and discussion

3.1 Elemental analysis and physical properties

Metal estimation, elemental analysis and physical properties of the complexes are given in Tables 1 and 2. The analytical data are in good agreement with the proposed empirical formulae of the present compounds. The molar conductance of 1.0×10^{-3} M solutions of the additional compounds (1 and 2) and mixed ligand complexes (3-6) in nitrobenzene is measured at 28^0C. The molar conductance values (Table 2) indicate that the complex 4 reveals that these are electrolytic in nature and the rest of them are non electrolytic in nature. The magnetic moments of Au(III), Mo(II) and Co(II) complexes are 2.78, 4.86 and 3.92 B.M., respectively, which indicate that these compounds are paramagnetic with two, four and three unpaired electrons, respectively and the rest of them have small values that indicate the complexes are diamagnetic in nature.

3.2 Infrared (IR) studies of the compounds

3.2.1 Infrared studies of the addition compounds

The IR spectra of the addition compounds in Table 3 (Table 3.1) have shown a sharp band in the region 3315.6 – 3010.8 cm^{-1} due to ν(N−H) mode. The bands are at a lower region compared to the free ligands which indicated that the adduct formation has taken place through nitrogen atom of NH_2 group. The bands at 1240 cm^{-1} indicate the ν(C−H) stressing mode of the compound $SbCl_3.C_6H_5COCH_3$. The bands observed at 2452.5 and at 2870.3 cm^{-1} due to ν(C−H) stressing mode of the compounds $AsBr_3.C_6H_5CONH_2$ and $SbCl_3.C_6H_5COCH_3$, respectively. The band of the compound $AsBr_3.C_6H_5CONH_2$ at 412.2 cm^{-1} is undoubtedly the ν (M−N) mode [7].

3.2.2 Infrared (IR) studies of the metal complex compounds

The infrared spectral data of the metal complexes are shown in Table 3 (Table 3.2). The strong bands obtained at about 1700 and 1400 cm^{-1} due to ν (C=O) and ν (C−O) stressing modes, respectively in the spectrum of free oxalic acid but the spectrum shifted to 1684.7 and 1390 cm^{-1} in complex 3. For the complexes 1, 2 and 4, the spectrum were found in the regions (1548.2 – 1599.1) and (1305.7 – 1359.6) cm^{-1} due to ν (C=O) and ν (C−O) stressing modes. The presence of M−O and M−N bonding is evident from the appearance of ν (M−O) modes at (476.4 to 615.5) cm^{-1} and ν (M−N) modes at (405.3 to 515.2) cm^{-1}, respectively in the spectra of all complexes [19,20].

3.3 Electronic spectra studies of the compounds

3.3.1 Electronic spectra studies of the addition compounds

The electronic spectra of the addition compounds are given in Table 4.1. The addition compound of $AsBr_3.C_6H_5CONH_2$ gave two bands at ≈ 42016 cm^{-1} and ≈ 32051 cm^{-1} and the compound of $SbCl_3.C_6H_5COCH_3$ also exhibited two bands at ≈ 40485 cm^{-1} and ≈ 31446 cm^{-1} which are caused by charged transfer only [6].

3.3.2 Electronic spectra studies of the metal complex compounds

The electronic spectral data of the complex compounds are given in Table 4.2. The complex compound of Cd (II) metal showed two bands at ≈ 43843 cm^{-1} and ≈ 39525 cm^{-1} which are caused by charged transfer only. The Au(III) complex exhibited three bands (band I, II, III) in the regions 17241-18050, 24570-25706 and 37313-38461 cm^{-1} corresponding to the transition s $^4A_{2g} \rightarrow {}^4T_{2g}$ (F), $^4A_{2g} \rightarrow 4T_{1g}$ (F) and charge transfer, respectively. These bands are typical for octahedral complex. The electronic spectra of the complex of Mo (II) complex were not shown in the table. The two intense bands at ≈ 24000 cm^{-1} and ≈ 30000 cm^{-1} were observed for Co (II) complex corresponding to the transitions of $^4A_{2g}{}^{(F)} \rightarrow {}^4T_{2g}{}^{(P)}$ (V_3) and charge transfer band, respectively. These spectra indicate the tetrahedral stereochemistry of Co (II) complex [21].

3.4 Antibacterial activities

The antibacterial activities of the compounds against fourteen pathogenic bacteria are presented in Table 5 (Tables 5.1 and 5.2). It was found that the metal complexes B, C and D were most active against all pathogenic bacteria. The zone of inhibition of the complexes was approximately the same as standard Kanamycin. But the individual activity of these three compounds can be represented sequentially B > C > D. The compounds E and L were moderately active against all pathogenic bacteria and on comparison with the results of zones of inhibition with standard Kanamycin, these activities were much lower than those of standard Kanamycin. On the other hand, the remaining

compound, such as A, was less active against all pathogenic bacteria which were compared with the results of the zone of inhibition with standard Kanamycin, the activity was approximately zero.

3.5 Anti fungal activities

The anti fungal activities of the six compounds against eleven plant and human pathogenic fungi are shown in Table 6. It was observed that the metal complexes C_1 and C_4 were highly active against all pathogenic fungi. The zones of inhibition of the complexes were approximately the same as standard Nystatin. The compound C_2 and C_3 were moderately active against all pathogenic fungi and the results were evaluated on comparison with the zone of inhibition of standard Nystatin. The rest of the compounds (C_5 and C_6) were less active against all pathogenic fungi and it was observed that the activity of these compounds were approximately zero.

3.6 Minimum Inhibition Concentration (MIC) of the antibiotics

The MIC value of six metal compounds against *Bacillus subtilis. Streptococcus-β- haemolyticus, Shigella dysenteriae and Salmonella typhi are* presented in Tables 7.1 and 7.4. The results of these values and the MIC value of standard Amoxycillin are graphically represented in Figures 1.1 to 1.4. From the data and visualization of these figures, it could be concluded that among the tested compounds, the compound B possesses substantial antimicrobial activity with a minimum inhibitory concentration. On comparison with the MIC value of standard Amoxacillin, the compound B could be inhibited these pathogenic bacteria with much lower concentration than that of standard Amoxycillin. The compounds C and D exhibited approximately the same MIC value than that of standard Amoxycillin. On the other hand, the MIC values of the remaining compounds (A, E and D) were not countable compared with standard Amoxycillin.

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Table 1: Data of the elemental analysis of the compounds

No	Compounds	Molecular weight		Metal %		Carbon %		Nitrogen %		Hydrogen %	
		Cal.	Found	Cal.	Found	Cal.	Found	Cal.	Found	Cal.	Found
1	$AsBr_3.C_6H_5CONH_2$	435.7	436.4	17.17	17.24	19.27	19.32	3.21	3.30	1.60	1.71
2	$SbCl_3.C_6H_5COCH_3$	348.27	348.32	34.78	34.84	27.54	27.19	-	-	2.29	2.32
3	$[Cd(DPH)(IQ)_2]$	534.82	534.88	21.01	21.09	58.38	58.42	5.23	5.28	3.36	3.41
4	$K[Au(HPA)_2Q_2]$	360.20	360.32	54.69	54.78	9.99	10.05	7.77	7.88	8.33	8.45
5	[Mo(Oxa)(IQ)]	315.20	315.64	32.40	30.47	41.87	41.94	4.44	4.51	2.80	2.86
6	[Co(PhA)(Bipy)]	380.22	380.28	15.49	15.53	60.01	60.09	11.04	11.12	5.00	5.09

DPH = Deprotonated Phalic acid, IQ = Iso-quinoline, HPA = Homophthalic acid,
Q = Quinoline, PhA = Phenayl aniline, Oxa = Oxalic acid and Bipy = Bipyridine

Table 2: Analytical data and physical properties of the compounds

No	Compounds	Color	Melting point or Decomposition Temperature ($\pm 5^0$C)	Molar conductance (Ohm^{-1} cm^2 mol^{-1})	μ_{eff} (B.M)
1	$AsBr_3.C_6H_5CONH_2$	White	154	10.21	Dia
2	$SbCl_3.C_6H_5COCH_3$	White	175	13.42	Dia
3	$[Cd(DPH)(IQ)_2]$	Brown	257	7.5	Dia
4	$K[Au(HPA)_2Q_2]$	Yellow	259	70.21	2.78
5	[Mo(oxa)(IQ)]	Yellow	171	11.08	4.86
6	[Co(PhA)(Bipy)]	Violet	254	9.98	3.92

Table 3: Infrared (IR) spectral data of the compounds

Table 3.1. Infrared (IR) spectral data of the addition compounds

No	Compounds	ν (N−H) (cm^{-1})	ν (C−N) (cm^{-1})	ν (C−O) (cm^{-1})	ν (C−H) (cm^{-1})	ν (M−N) (cm^{-1})
1	$AsBr_3.C_6H_5CONH_2$	-	-	477.3	2452.5	-
2	$SbCl_3.C_6H_5COCH_3$	3515.6 3010.8	1240	525.4	2870.3	412.2

Table 3.2. Infrared (IR) spectral data of the metal complex compounds

No	Compounds	ν (C=O) (cm^{-1})	ν (C−O) (cm^{-1})	ν (M−O) (cm^{-1})	ν (M−N) (cm^{-1})
1	$[Cd(DPH)(IQ)_2]$	1548.2	1358.8	501.8	405.3
2	$K[Au(HPA)_2Q_2]$	1577.0	1305.7	615.5	415.7
3	[Mo(Oxa)(IQ)]	1684.7	1390.6	476.4	409.8
4	[Co(PhA)(Bipy)]	1599.1	1359.6	530.3	515.2

Table 4: Electronic spectral data of the compounds

Table 4.1. Electronic spectral data of the addition compounds

No	Compounds	λ_{max} (cm^{-1})	
1	$AsBr_3.C_6H_5CONH_2$	42016	32051
2	$SbCl_3.C_6H_5COCH_3$	40485	31446

Table 4.2. Electronic spectral data of the metal complex compounds

No	Compounds	λ_{max} (cm^{-1})		
		Band I	Band II	Band III
1	$[Cd(DPH)(IQ)_2]$	34843	39525	-
2	$K[Au(HPA)_2Q_2]$	17241-18050	24570-25706	37313-38461
3	[Mo(Oxa)(IQ)]	-	-	-
4	[Co(PhA)(Bipy)]	24000	30000	-

Table 5: Analytical results of microbial activities of the compounds

Table 5.1
Anti bacterial activities of the metal compounds A = [Mo (Oxa)(IQ)] , B = [$SbCl_3.C_6H_5COCH_3$]
C = [$AsBr_3.C_6H_5CONH_2$] and standard Kanamycin

Test organism		[Mo(Oxa)(IQ)]		[$SbCl_3.C_6H_5COCH_3$]		[$AsBr_3.C_6H_5CONH_2$]		Standard Kanamycin
		Diameter of zone of inhibition in (mm)						
		100 µg/disc	30 µg/disc	100 µg/disc	30 µg/disc	100 µg/disc	30 µg/disc	30 µg/disc
Gram Negative bacteria								
Shigella dysenteriae	AL-35587	10	7	28	20	28	15	20
Shigella boydii	AL-17313	11	6	26	21	29	15	24
Shigella flexneri	AL-30372	8	0	22	15	17	9	28
Escherichia coli	FOFC-1407	9	0	26	19	25	12	20
Pseudomon-as aeruginosa	CRL	10	6	26	20	29	14	20
Klebsiella species	–	8	0	30	23	31	16	21
Salmonella typhi	–	7	0	30	25	29	17	19
Shigella sonnei	AJ- 8992	15	6	25	15	24	13	23
Shigella shiga	ATCC -26107	7	0	23	14	30	16	26
Gram positive bacteria								
Bacillus megaterium	QL-38	10	7	30	22	28	14	25
Sarcina lutea	QL-166	11	6	34	26	12	7	23
Streptococcus-β-haemolyticus	CRL	10	6	33	26	28	15	18
Bacilllus subtillis	QL-40	8	0	38	27	40	19	24
Staphylococcus aureus	ATCC- 25923	8	0	35	25	32	16	22

Table 5.2

Anti fungal activities of the metal compounds D = [Cd(DPH)$(IQ)_2$], E = [Co(PhA)(Bipy)], L = K[Au$(HPA)_2Q_2$] and standard Kanamycin

Test Organism		[Cd(DPH)$(IQ)_2$]		[Co(PhA)(Bipy)]		K[Au$(HPA)_2Q_2$]		Standard Kanamycin
		Diameter of zone of inhibition in (mm)						
		100 μg/disc	30 μg/disc	100 μg/disc	30 μg/disc	100 μg/disc	30 μg/disc	30 μg/disc
Gram Negative bacteria								
Shigella dysenteriae	AL-35587	21	10	12	7	14	8	20
Shigella boydii	AL-17313	22	10	10	6	15	9	24
Shigella flexneri	AL-30372	16	9	8	6	15	8	28
Escherichia coli	FOFC-1407	23	11	13	8	16	8	20
Pseudomon-as aeruginosa	CRL	15	8	9	7	18	9	20
Klebsiella species	–	16	8	14	8	14	6	21
Salmonella typhi	–	15	6	8	0	11	0	19
Shigella sonnei	AJ- 8992	18	10	10	6	16	11	23
Shigella shiga	ATCC -26107	22	14	12	8	13	7	26
Gram positive bacteria								
Bacillus megaterium	QL-38	18	10	10	9	17	11	25
Sarcina lutea	QL-166	17	9	16	11	17	8	23
Streptococcus-β-haemolyticus	CRL	22	13	8	0	15	7	18
Bacilllus subtillis	QL-40	19	10	22	15	16	9	24
Staphylococcus aureus	ATCC- 25923	16	8	12	6	20	12	22

Table 6: Analytical results of the antifungal activities of the compounds

No	Name of fungal	C_1 200 μg/disc	C_2 200 μg/disc	C_3 200 μg/disc	C_4 200 μg/disc	Control disc	Nystatine 200 μg/disc
Plant Pathogen							
1	*Trichoderma species*	9	7	8	10	0	18
2	*Fusarium species*	7	20	6	10	7	15
3	*Botarydiptoden sp.*	0	10	9	13	6	8
4	*Aspergillus flavus*	10	8	8	12	0	20
5	*Aspergillus species*	8	8	6	20	0	12
6	*Mucor species*	15	8	10	12	0	30
7	*Penicillium*	7	8	8	18	0	20
8	*Bipolaris species*	10	8	0	10	7	16
Human Pathogen							
9	*Epidermophton floccosum*	10	12	0	18	0	22
10	*Aspergillus niger*	15	10	6	19	0	30
11	*Caudida albicans*	18	9	10	13	7	20

Here $C_1 = [Cd(DPH)(IQ)_2]$, $C_2 = [Co(PhA)(Bipy)]$,

$C_3 = [AsBr_3.C_6H_5CONH_2]$ and $C_4 = [SbCl_3.C_6H_5COCH_3]$

Table 7: Results of the minimum inhibitory concentration (MIC) of antibiotics

Table 7.1
Minimum inhibitory concentration of antibiotics against *Shigella dysenteriae and Bacillus subtilis*

No.	Nutrient broth medium added (ml)	Diluted solution of antibiotics µg/ml	Inoculums added (µl) 10^7 Cells/ ml	*Shigella dysenteriae*						*Bacillus subtilis*					
				Bacterial growth of the antibiotics						Bacterial growth of the antibiotics					
				A	B	C	D	E	L	A	B	C	D	E	L
1	1	512	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	1	256	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
3	1	128	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	1	64	10	+ve	-ve	-ve	+ve	-ve	+ve	+ve	-ve	+ve	+ve	-ve	-ve
5	1	32	10	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
6	1	16	10	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
7	1	8	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
8	1	4	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
9	1	2	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
10	1	1	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
C_M	1	0	0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
C_A	1	512	0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
M	1	0	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve

Here, +ve = Growth , -ve = No growth, C_M = Medium,
C_A = Medium + Sample, and M = Medium + Inoculum

Table 7.2

Minimum inhibitory concentration of antibiotics against *solmonella typhi* and *streptococcus-β- haemolyticus*

No.	Nutrient broth medium added (ml)	Diluted solution of antibiotics (μg/ml)	Inoculums added (μl) 10^7 cells/ ml	*Solmonella typhi* Bactreial gowth of the antibiotics						*Sreptococcus-β - haemolyticus* Bactreial gowth of the antibiotics					
				A	B	C	D	E	L	A	B	C	D	E	L
1	1	512	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
2	1	256	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
3	1	128	10	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
4	1	64	10	-ve	-ve	-ve	-ve	-ve	+ve	+ve	+ve	-ve	-ve	-ve	-ve
5	1	32	10	+ve	-ve	+ve	-ve	-ve	+ve	+ve	+ve	+ve	+ve	-ve	-ve
6	1	16	10	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
7	1	8	10	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
8	1	4	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
9	1	2	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
10	1	1	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve
C_M	1	0	0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
C_A	1	512	0	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve	-ve
M	1	0	10	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve	+ve

Here, +ve = Growth , -ve = No growth, C_M = Medium,

C_A = Medium + Sample, and M = Medium + Inoculum

Table 7.3

The MIC values of metal compounds and standard amoxycillin against *solmonella typhi* and s*reptococcus-β - haemolyticus*

	Solmonella typhi			*Sreptococcus-β - haemolyticus*		
Compound code	MIC value of compound μg/ml	MIC value of Amoxycilin μg/ml	Comments	MIC value of compound μg/ml	MIC value of Amoxycilin μg/ml	Comments
A	32		Susceptible	32		More potent
B	8	16	More potent	4	63	Very much potent
C	16		Similar potent	32		More potent
D	64		Sensitive	32		More potent
E	128		Positive result	64		Similar potent
L	128		Positive result	64		Similar potent

Table 7.4

The MIC values of metal compounds and standard amoxycillin against *shigella dysenteriae* and *bacillus subtilis*

	Shigella dysenteriae			*Bacillus subtilis*		
Compound code	MIC value of compound	MIC value of Amoxycilin	Comments	MIC value of compound	MIC value of Amoxycilin	Comments
A	128		Sensitive	64		Susceptible
B	16		potent	8		More potent
C	64	32	Susceptible	64	32	Susceptible
D	128		Sensitive	32		Similar potent
E	64		Susceptible	32		Similar potent
L	128		Sensitive	128		Sensitive

Figure 1: Comparison studies of MIC values of the compounds with standard amoxycillin against four pathogenic bacteria

Figure 1.1
Comparison studies of MIC values with standard Amoxicillin against *Salmonella typhi*

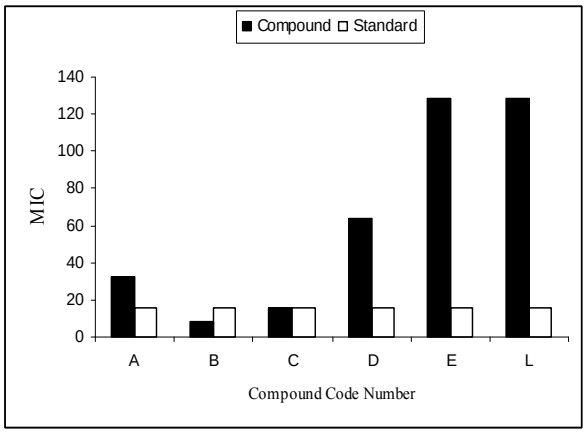

Figure 1.2
Comparison studies of MIC values with standard Amoxicillin against *Sreptococcus -β- haemolyticus*

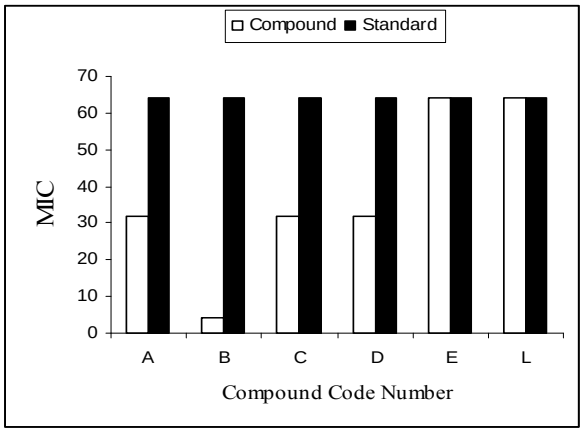

Figure 1.3
Comparison studies of MIC values with standard Amoxicillin against *Shigella dysenteraire.*

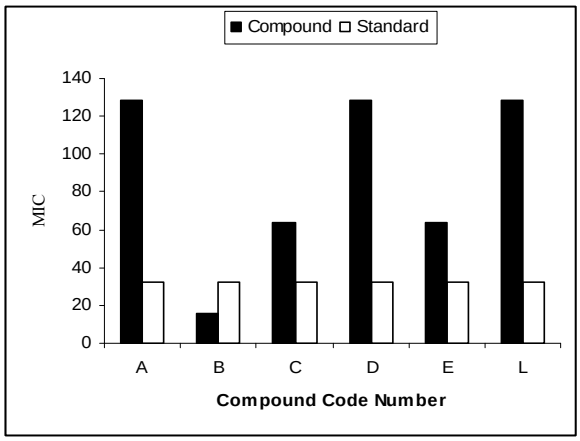

Figure 1.4
Comparison studies of MIC values with standard Amoxicillin against *Basillus subtilis*