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## ULTRASONIC SPEED AND ACOUSTICAL PARAMETERS OF SOME SYNTHESIZED 3D METAL COMPLEXES IN SOLUTION AT 301K

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### ABSTRACT

Ultrasonic propagation parameters yield valuable information regarding the behavior of liquid systems, because intramolecular association, dipolar interactions, complex formation and related structural changes effect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity. Some metal complexes of Co (II), Ni(II) and Cu(II) derived from 2-acetonaphthone with 2-amino-4-methylbenzothiazole (AABT), 2-amino-4-chlorophenol (AACP) and 2-aminothiazole (ACAT) have been synthesized and their ultrasonic velocity and density have been measured in non- aqueous solution methanol at 301.15K. The value of apparent molar volume, acoustic impedance, adiabatic compressibility, inter molecular free length, molar sound velocity (Rao's constant), free volume, internal pressure and cohesive forces have been calculated from density and ultrasonic velocity data. The results have been discussed in the light of solvent interaction and structure effecting metal complexes.

**Keywords-** Ultrasonic velocity, Density, Acoustical parameters and Metal complexes.

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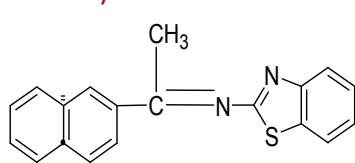
### I. INTRODUCTION

Schiff bases are used as fine chemicals, medical substrates and ligands for metal complexes. They find their industrial importance as antifungal and biological application. They are known to be important due to their various applications such as preparation of dyes, liquid crystals and powerful corrosion inhibitor<sup>1-6</sup>. Ultrasonic speeds and related acoustical properties of organic liquids and non aqueous electrolytic solutions are extensively useful especially in process industry<sup>7-13</sup>. Ultrasonic velocity of a solution is an important property from which some structural features of liquid or solutions are reflected, eg intermolecular interactions and distances. Velocity and absorption of ultrasonic waves play an important role in the interaction and other thermodynamic studies of liquid and liquid mixtures<sup>14-20</sup>. The knowledge of experimental values of these parameters serves as a versatile tool for investigating physic chemical behavior and structure of liquid<sup>21-24</sup>.

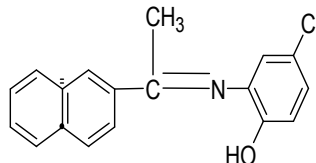
However, due to the complexities of biological compounds, direct experimental studies are not feasible and hence several parameters viz. apparent molar volume, adiabatic compressibility, Rao's constant, (molar sound velocity), acoustic impedance, free volume, internal pressure and cohesive forces studied through density and ultrasonic velocity measurement, indirectly may be used to investigate the chemical behavior/molecular interaction in such systems. The successful application of acoustic methods to physico-chemical investigation of solution becomes possible after the development of adequate theoretical approaches and methods for precise ultrasound velocity measurements in small volumes of liquids. In the present studies, the ultrasonic velocity and density of solutions of twelve new Schiff bases and their metal complexes of Co(II), Ni(II) and Cu(II) have been measured and various acoustical parameters have been calculated in non-aqueous medium.

### II. EXPERIMENTAL

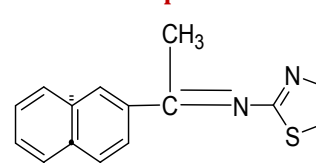
All the used chemicals were of Anal R grade. All the reagents used for the preparation of the Schiff bases were obtained from Sigma Aldrich. Metal salts were obtained from Loba Chemie. All solutions were prepared in fresh (by weight) double distilled water, degassed by boiling, having conductance less  $0.6 \times 10^{-6}$  S  $\text{cm}^{-1}$ . The density measurements were performed with a precalibrated bicapillary pycnometer. The complexes 2-Acetonaphthone with 2-amino-4-methylbenzothiazole, 2-amino thiazole and 2-amino-4-chlorophenol in Co(II), Ni(II) and Cu(II) were studied. The solutions of varying concentration of metal complexes were prepared on molarity basis. The ultrasonic velocity of the solution was measured by using M-84 (Mittal Enterprises, New Delhi) instrument of a frequency of 2MHz with an accuracy of 0.03% at constant temperature.



(AABT)



(AACP)



(AACT)

### III. THEORY

The ultrasonic velocity and density data described many parameters for understanding solvent interaction and structural effect. The parameters have been computed using the following relation.

The apparent molar volume ( $\phi_v$ ) can be calculated by using following relation

$$\phi_v = \frac{M_2}{d_1} - \frac{d_2 - d_0}{C \times d_1} \dots\dots\dots (1)$$

Molar sound velocity or (Rao' constant) (R) is evaluated using the relation

$$R = V \times U^{\frac{1}{3}} \dots\dots\dots (2)$$

Adiabatic compressibility ( $\beta_s$ ) is evaluated using the formula

$$\beta_s = \frac{1}{U^2 \times d_0} \dots\dots\dots (3)$$

Acoustic impedance (Z) is calculated by the relation

$$Z = U \times d_0 \dots\dots\dots (4)$$

Intermolecular free length ( $L_f$ ) is obtained using the relation

$$L_f = K \times \beta_s^{\frac{1}{2}} \dots\dots\dots (5)$$

Free volume  $v_f$  is the effective volume accessible to the centre of amolecule in a liquid an is represented as;

$$V_f = v_m^{-b} \dots\dots\dots (6)$$

Internal pressure is represented by

$$\Pi_i = 2RT / (V_f v_m^2)^{1/3} \dots\dots\dots (7)$$

### IV. RESULTS AND DISCUSSION

Acoustical parameters offer a convenient method for the study of various properties of liquid mixtures not easily obtained by other means. Complex compounds have characteristics that are favorable for the study of solute-solvent interactions, by a suitable selection of ligands and/or metal ions, the effect of factors such as the size, structures and electric charge and its distribution can be studied systematically. The results may be used to establish the nature of the ion-solvent/solute-solvent interactions. These metal complexes may act as structure-promoters/structure maker or

breaker. The density, ultrasonic velocity, acoustic impedance, molar sound velocity (Rao's constant), molar compressibility, intermolecular free length, free volume, internal pressure and cohesive forces of ligands (Schiff bases), metal ions and metal complexes are presented in Table (1-2)

The values of above parameters for solutions of complexes, ligands (Schiff base) and metal chlorides (Methanol as solvent) have been found to vary up to a considerable extent. This reflects molecular interactions between solute and solvent. This further indicates the interactions between metal ion and ligand using methanol as medium (solvent). The values of apparent molar volume for Ni (II) -complexes in all the cases decrease in the order: Ni(II)-ACAT>AABT>AAP. In the Co (II) complex, this order comes to be Co(II)- ACAT> AABT>AAP, while in the copper (II) complex values of apparent molar volume are in order Cu(II) -AAP> ACAT> AABT.

Variation in apparent molar volume may be accounted to the size and geometrical arrangement of metal complexes in solution. Apparent molar volume decreases with decrease in concentration of solute indicating the decrease in stacking interaction between solute and solvent molecules. Fig-1 show a plot of ultrasonic velocity against the concentration of solution while studying the values of ultrasonic velocity of ligands, it comes comparatively higher for the metal, (M = CoII/NiII/CuII) complexes of 2- acetonephthone-2-amino-4-chlorophenol (AAP) ligand. The values of ultrasonic velocity of various Schiff base (ligand) systems at three different concentrations follow the order: AAP>AABT>ACAT. In general, on comparing the metal ion systems, this order comes to be Cu(II)>Ni(II)>Co(II), almost for all the three concentrations.

On complexation the value and order of ultrasonic velocity changes. This reflects about the impact of nature and extent of interaction of both ligand and metal ions on the solute-solvent interaction. Ultrasonic velocity and density decrease on lowering the concentration. With increase in concentration of solution, the ultrasonic velocity (U), acoustic impedance (Z) and molar sound velocity (R) increase, while compressibility ( $\beta_s$ ), and inter molecular free length ( $L_f$ ) decreases. The increase in ultrasonic velocity also indicates about the association among the molecules and greater solute-solvent interaction. Molar sound velocity (Rao's constant)<sup>1</sup> increases with increase in concentration of solute. This parameter also indicates solute-solvent interactions.

Eyring and Kincaid's model for sound propagation suggests that inter molecular free length ( $L_f$ ) is a predominant factor in determining the variation of ultrasonic velocity in solution. Increase or decrease in ultrasonic velocity depends on free length among the molecules.

The intermolecular free length shows an inverse relation to ultrasonic velocity. Ultrasonic velocity decreases with increase in intermolecular free length as given in Fig1-2 .Intermolecular free length is a predominant factor in determining the variation of ultrasonic velocity in solution. In the present investigation, the relative intermolecular free length among ligand (Schiff base), metal ions and metal ligand complexes (solvent methanol) have been found to decrease with concentration of all the metal-chelates, metal ions and schiff bases. The greater interaction between complex species and solvent molecule may be accounted to the size of ligand. This indicates significant interaction between solute and solvent molecules because of strong intermolecular force of attraction, which brings the molecules close to each other. This has also been reported for thermo acoustic parameters of some binary liquid mixtures. It shows that the ion-solvent interaction increases with concentration of solvent.

Extent of compressibility gives the information of ion-solvent molecular attraction and the resultant compactness. It is a measure of an ion capacity to attract solvent molecules. The increase and decrease of  $\beta_s$  values may be ascribed to two effects. (1) The decrease in compressibility caused by the introduction of in-compressible molecules of ions and (2) the addition of solute affects the structure of solvent which results in an increase in compressibility. The adiabatic compressibility values are comparatively lower in ligand- metal complexes (ACAT-Cu), in comparison to other metal chelates. The (ACAT-Cu(II)) metal complexes are in more compressed state than others.

The difference in  $\beta_s$  may be accounted to the nature of ligand (relatively weak or strong field), solvation behavior, stereo-arrangement of ligand around the metal ion, non-spherical 3d-ions radii and change in co-ordination number. In other words, the bulky chelate ring of the ligand makes the metal complexes hard to compress. The change in trend may be attributed to the activation energy of solvation, influence of size and distorted geometry of metal ion-polyhedron. The decrease in  $\beta_s$  values with increasing concentration of solute might be due to aggregation of solvent molecules around the solute molecules.

The above order of  $\beta_s$  follows that  $\beta_s$  depend upon the solvation layer formed around the metal complexes. A tight or dense solvation layer (Primary and Secondary) around an ion leads to decrease in  $\beta_s$ . The lowering of  $\beta_s$  varies with the effective size of entering ligands in the metal complexes as the metal ion remains the same.

The solvation number is useful in understanding the structure making and structure breaking tendency of solute in a solvent. On comparing the values of solvation number of metal ion, ligand and corresponding metal complex, it has been found that the metal complex is more solvated than the ligand and their metal ions. The value of solvation number for the ligand has been found more than metal ions. This may tentatively be accounted to the placement of solvent molecules in the interstitial spaces, occurring in the metal chelate. Solvation number decreases in the order Cu(II)-ACAT>Cu(II)-AACP>Co(II)-ACAT>Cu(II)-AABT>Ni(II)-AABT>Ni(II)-ACAT>Ni(II)-AACP>Co(II)-AACP>Co(II)-AABT.

On comparing the values of solvation number of different metal ions with same ligand, it has been found that the ligand AACP and AABT, show similar behavior i.e. Cu(II)>Ni(II)>Co(II) but in the case of ACAT ligand, this order changes i.e. Cu(II)>Ni(II)>Co(II). This different behaviour of ligand may be attributed to effect of LFSE, solvation energies and constitutional and structural changes in symmetry. As observed the solvation number decreases with increase in concentration of solution, this may be due to increased solute molecules and also to electrostriction effect.

Higher values of ultrasonic velocity and acoustic impedance and lower value of adiabatic compressibility for ligand-complexes may be due to ligand's structural effect. In present studies Cu(II)-ACAT complex has been found maximum compact while Cu(II)-AABT metal complex stands minimum.

The computed other parameters like free volume and internal pressure are given in Table-2. The free volume is found to decrease with lowering in concentration. The free volume is the space available for the molecule to move in an imaginary unit cell. This reduces internal pressure. The internal pressure is found to increase with lowering in concentration. An inverse trend as expected has been seen in free volume changes. Free volume decreases in order Ni(II)-ACAT>Co(II)-ACAT>Cu(II)-ACAT>Ni(II)-ACAP>Cu(II)-AACP>Co(II)-AABT>Ni(II)-AABT>Cu(II)-AABT.

On comparing the values of free volume of different metal ion with same ligand, it has been found that the ligand AACP and ACAT show similar behaviour i.e. Ni(II)>Co(II)>Cu(II), but in the case of AABT ligand this order changes i.e. Cu(II)>Co(II)>Ni(II). This may be due to hydrogen bonding and size of the molecules, which in turn depend on the concentration and the size of solvated solute and structure of the solvent methanol. As the concentration of solvent methanol decreases, the extent of amount of hydrogen bonding also decreases. Therefore, the amount of solvent molecules occupying the volume decreases and hence a decrease in free volume has been observed.

The internal pressure is a sensitive parameter of solute and solvent interaction, and gives both the attractive and repulsive molecular interactions. The internal pressure of the solutions increases with lowering in concentration. Internal pressure provides a very important remark for the study of structure and nature of molecular interactions in liquids. The results are reported in table A comparative account of values of internal pressure among various complexes is as follows: Cu(II)-AABT>Co(II)-AABT>Ni(II)-AABT>Cu(II)-AACP>Co(II)-AACP>Ni(II)-AACP>Cu(II)-ACAT>Co(II)-ACAT>Ni(II)-ACAT.

On comparing the value of internal pressure of different metal ions with same ligand, it has been found that the ligand show similar behaviour of AABT, AACP and ACAT ligands this order is as Cu>Co>Ni.

Further the decrease in free volume and increase in internal pressure with rise in concentration of metal complexes in all the systems clearly show the increasing magnitude of molecular interactions. In order to understand the nature of molecular interactions between the solute and solvents, it is of interest to discuss the same in terms of excess parameters rather than actual values. Non-ideal liquid mixtures show considerable deviation from linearity in their physical behaviour with respect to concentration and these have been interpreted as arising from the presence of strong or weak interactions. The effect of deviation depends upon the nature of the constituent and composition of the mixtures.

The internal pressure is a cohesive force, which is the result of attractive and repulsive forces between the molecules. The attractive forces mainly consist of hydrogen bonding, dipole-dipole, and dispersion interactions. Repulsive forces acting over very small intermolecular distances; play a minor role in the cohesion forces under normal circumstances.

Most of the biological and pharmacological process and reactions are accompanied in aqueous/semi- aqueous/non-aqueous media. There occur a state of ligand competition among various ligands and metal ions. Many enzymatic processes are completed or mediated by metal ions. During transportation within the body of system, hydrophilic/hydrophobic interaction occurs. A background knowledge of phenomenon of chelation and interaction in solutions helps in understanding the stabilization, of drug and its mechanistic path for targeted drug delivery and drug toxicity.

## V. CONCLUSIONS

In the present investigation, density and ultrasonic velocity have been measured in non-aqueous solution of synthesized 3d metal complexes viz AACP, ACAT, and AABT with Co(II), Ni(II), Cu(II) at 301.15 K. The results were used to test the applicability of simple equation for the ultrasonic velocity and density of electrolytic solutions, and their acoustical parameters have been used to study the interaction in solution. The results show that equation can yield good prediction for the densities and ultrasonic velocity of electrolytic solutions. From the behavior of acoustical parameters, it can be concluded that solute-solvent interaction gets weakened with lowering concentration of 301.15 K.

Such biomimetic and bio-synergistic studies of metal chelates in solution may be useful in understanding the interaction of metal chelated biomolecules in the body system. The studies on these lines may govern and guide for the subjects and problems, viz pharmacokinetics and bio- molecular dynamics in animal physiology vis-à-vis inorganic medicinal chemistry.

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**Table : 1 Value of density ( $d_0$ ), ultrasonic velocity( $U$ ), apparent molar volume ( $\phi_v$ ), acoustic impedance ( $Z$ ), adiabatic compressibility ( $\beta_s$ ), Rao's Constant ( $R$ ) and intermolecular free length ( $L_f$ ) for ligands AACP, AABT and AACT, metal ( $Co^{II}/Ni^{II}/Cu^{II}$ ) chlorides and their metal complexes at 301.15K.**

Molar Conc. $dm^{-3}$	$d_0 \times 10^{-3}$ ( $kgm^{-3}$ )	$U$ ( $ms^{-1}$ )	$\phi_v \times 10^5$ ( $m^3mol^{-1}$ )	$Z \times 10^{-3}$ ( $kgm^{-2}s^{-1}$ )	$\beta_s \times 10^{11}$ ( $m^2N^{-1}$ )	( $R \times 10^6$ )	Sn
<b>AACP (Ligand) (<math>C_{18}H_{14}ClNO</math>)</b>							
0.01	0.8150	1145	490	933.17	81.50	2556.0	164.59
0.005	0.8148	1142	594	930.50	81.52	2553.13	320.69
0.0025	0.8143	1140	703	928.30	81.58	2550.08	594.71
<b>Co(II) – AACP (<math>C_{36}H_{32}Cl_2CoN_2O_5</math>)</b>							
0.01	0.8158	1175	544	958.56	81.67	5978.28	168.73
0.005	0.8153	1172	824	955.53	81.69	5969.50	332.60
0.0025	0.8151	1171	1010	954.48	81.74	59.66.32	630.86
<b>Ni(II) – AACP (<math>C_{36}H_{28}Cl_2N_2NiO_3</math>)</b>							
0.01	0.8160	1178	532	961.24	81.64	5981.99	170.36
0.005	0.8158	1176	780	959.38	81.68	5977.12	335.37
0.0025	0.8154	1172	1015	955.64	81.72	5970.14	635.67
<b>Cu(II) - AACP (<math>C_{36}H_{28}Cl_2CuN_2O_5</math>)</b>							
0.01	0.8162	1180	520	963.11	81.60	6028.80	173.47
0.005	0.8160	1172	820	956.35	81.64	6013.67	338.46
0.0025	0.8154	1170	971	954.01	81.69	6005.82	640.73
<b>AABT (Ligand) (<math>C_{20}H_{16}N_2S</math>)</b>							
0.01	0.8148	1144	484	932.13	81.48	2696.55	163.65
0.005	0.8147	1142	630	930.38	81.50	2694.66	317.46
0.0025	0.8145	1140	810	928.53	81.53	2692.46	430.65
<b>Co(II) – AABT (<math>C_{40}H_{36}Cl_2CoN_4O_2S_2</math>)</b>							
0.01	0.8159	1173	545	957.05	81.60	6246.98	168.74



0.005	0.8156	1171	690	955.0	81.63	6241.11	325.63
0.0025	0.8153	1169	998	953.0	81.64	6235.24	436.52
<b>Ni(II) – AABT (C<sub>40</sub>H<sub>36</sub>Cl<sub>2</sub>N<sub>4</sub>NiO<sub>2</sub>S<sub>2</sub>)</b>							
0.01	0.8159	1175	535	958.68	81.59	6250.53	171.63
0.005	0.8158	1173	780	956.93	81.64	6246.24	330.32
0.0025	0.8158	1170	994	954.48	81.68	6240.91	450.63
<b>Cu(II) – AABT (C<sub>40</sub>H<sub>36</sub>Cl<sub>2</sub>CuN<sub>4</sub>O<sub>2</sub>S<sub>2</sub>)</b>							
0.01	0.8160	1178	510	916.24	81.60	6255.10	172.56
0.005	0.8158	1176	817	959.38	81.61	6251.56	338.68
0.0025	0.8156	1173	998	956.69	81.65	6244.66	458.32
<b>ACAT (Ligand) (C<sub>15</sub>H<sub>12</sub>N<sub>2</sub>S)</b>							
0.01	0.8149	1143	480	931.40	81.49	2148.83	167.31
0.005	0.8147	1141	615	929.50	81.50	2147.05	328.42
0.0025	0.8146	1139	720	927.80	81.52	2145.59	512.35
<b>Co(II) – ACAT (C<sub>30</sub>H<sub>32</sub>CoN<sub>4</sub>O<sub>4</sub>S<sub>2</sub>)</b>							
0.01	0.8173	1172	555	957.80	81.73	5464.56	171.31
0.005	0.8170	1171	620	957.60	81.75	5460.49	332.32
0.0025	0.8169	1168	994	954.10	81.78	5455.83	521.64
<b>Ni(II) – ACAT (C<sub>30</sub>H<sub>32</sub>N<sub>4</sub>NiO<sub>4</sub>S<sub>2</sub>)</b>							
0.01	0.8178	1174	542	960.10	81.78	5472.64	173.43
0.005	0.8177	1172	680	958.30	81.79	5468.80	338.61
0.0025	0.8173	1171	1012	957.05	81.83	5464.61	528.32
<b>Cu(II) – ACAT (C<sub>30</sub>H<sub>32</sub>CuN<sub>4</sub>O<sub>4</sub>S<sub>2</sub>)</b>							
0.01	0.8181	1176	515	962.0	81.81	5517.55	175.32
0.005	0.8178	1174	705	960.0	81.83	5512.41	341.63
0.0025	0.8177	1171	820	957.5	81.86	5501.71	535.45

<b>CoCl<sub>2</sub>- 6H<sub>2</sub>O</b>							
0.01	0.8189	1135	225.67	929.45	82.60	2553.99	155.21
0.005	0.8185	1130	280.68	924.90	82.40	2923.50	304.21
0.0025	0.8180	1125	640.46	920.25	82.00	6661.05	606.56
<b>NiCl<sub>2</sub> - 6H<sub>2</sub>O</b>							
0.01	0.8187	1138	230.68	929.45	82.20	2408.37	154.22
0.005	0.8184	1135	294.74	924.90	82.00	3074.47	298.43
0.0025	0.8184	1132	880.69	920.25	82.00	9178.50	601.23
<b>CuCl<sub>2</sub> 2H<sub>2</sub>O</b>							
0.01	0.8190	1140	235.67	933.66	82.10	2461.91	154.24
0.005	0.8178	1136	340.46	933.02	81.90	3552.43	303.21
0.0025	0.8168	1134	990.45	929.25	81.80	10328.49	610.36

**Table– 2 Value of molar volume ( $V_m$ ), free volume ( $V_f$ ) internal pressure ( $\pi_i$ ), cohesive forces ( $H$ ) and intermolecular free length ( $L_f$ ) for ligands AACP, AABT and AACT, metal ( $Co^{II}/Ni^{II}/Cu^{II}$ ) chlorides and their metal complexes at 301.15K.**

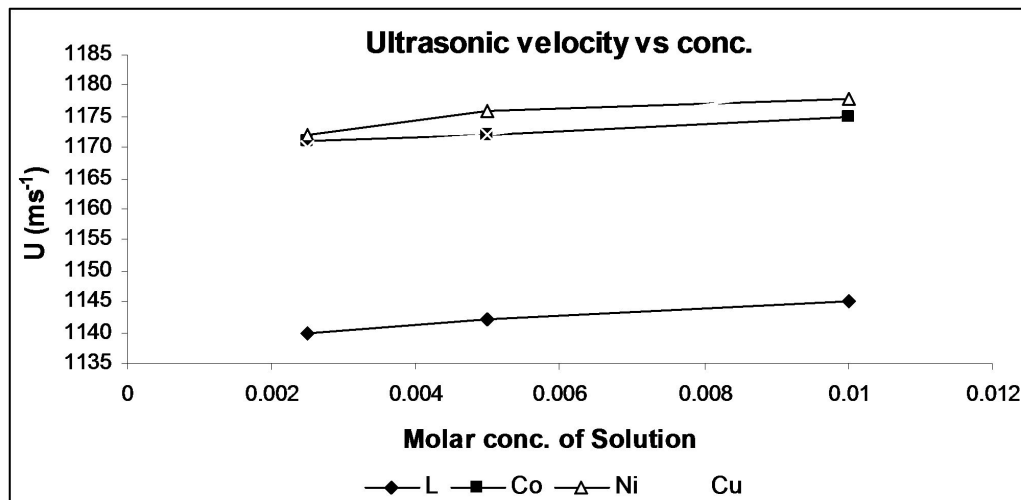
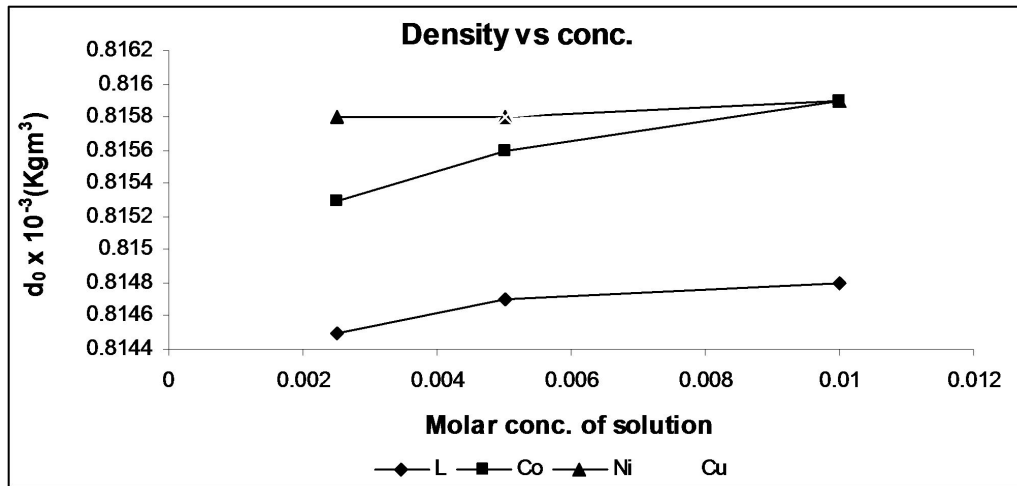
molar Conc. dm <sup>-3</sup>	$V_m \times 10^3$	$V_f \times 10^7$	$\pi_i \times 10^{-8}$	$H \times 10^{-3}$	$L_f \times 10^{-10}$
<b>AACP (Ligand) (C<sub>18</sub>H<sub>14</sub>CINO)</b>					
0.01	367.820	0.7393	1.018	37.444	0.5689
0.005	367.918	0.7384	1.019	37.490	0.5690
0.0025	368.390	0.7368	1.024	37.723	0.5692
<b>Co(II) - AACP (C<sub>36</sub>H<sub>32</sub>Cl<sub>2</sub>CoN<sub>2</sub>O<sub>5</sub>)</b>					
0.01	851.262	1.379	2.923	24.882	0.5690
0.005	851.784	1.378	2.927	24.931	0.5692
0.0025	851.588	1.378	2.929	24.943	0.5693
<b>Ni(II) - AACP (C<sub>36</sub>H<sub>28</sub>Cl<sub>2</sub>N<sub>2</sub>NiO<sub>3</sub>)</b>					
0.01	850.649	1.381	2.915	24.796	0.5691

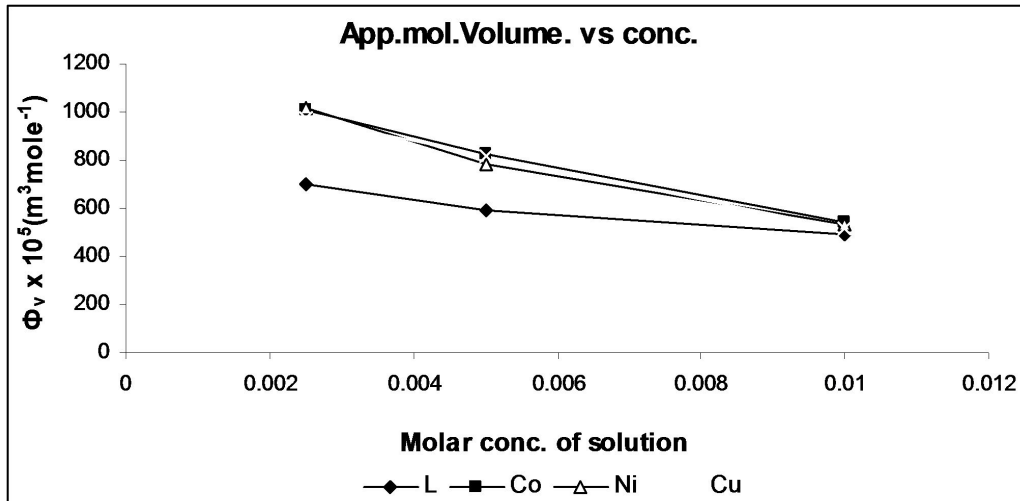


0.005	850.858	1.380	2.918	24.828	0.5693
0.0025	851.875	1.377	2.931	24.968	0.5695
<b>Cu (II) - AACP (C<sub>36</sub>H<sub>28</sub>Cl<sub>2</sub>CuN<sub>2</sub>O<sub>5</sub>)</b>					
0.01	856.407	1.363	2.993	25.632	0.5690
0.005	856.617	1.362	2.997	25.672	0.5693
0.0025	857.247	1.360	3.006	25.768	0.5695
<b>AABT (Ligand) (C<sub>20</sub>H<sub>16</sub>N<sub>2</sub>S)</b>					
0.01	388.365	0.6630	1.264	49.089	0.5689
0.005	388.412	0.6628	1.266	49.172	0.5690
0.0025	388.508	0.6625	1.267	49.223	0.5690
<b>Co(II) - AABT (C<sub>40</sub>H<sub>36</sub>Cl<sub>2</sub>CoN<sub>4</sub>O<sub>2</sub>S<sub>2</sub>)</b>					
0.01	889.914	1.262	3.491	31.066	0.5691
0.005	890.142	1.261	3.495	31.110	0.5693
0.0025	890.469	1.260	3.496	31.130	0.5694
<b>Ni(II) – AABT (C<sub>40</sub>H<sub>36</sub>Cl<sub>2</sub>N<sub>4</sub>NiO<sub>2</sub>S<sub>2</sub>)</b>					
0.01	889.814	1.262	3.490	31.054	0.5690
0.005	889.924	1.260	3.496	31.111	0.5691
0.0025	889.925	1.259	3.499	31.138	0.5693
<b>Cu(II) – AABT (C<sub>40</sub>H<sub>36</sub>Cl<sub>2</sub>CuN<sub>4</sub>O<sub>2</sub>S<sub>2</sub>)</b>					
0.01	893.382	1.252	3.546	30.875	0.5689
0.005	893.601	1.251	3.511	31.374	0.5690
0.0025	893.820	1.250	3.555	31.775	0.5692
<b>ACAT (Ligand) (C<sub>15</sub>H<sub>12</sub>N<sub>2</sub>S)</b>					
0.01	309.375	0.1044	5.100	15.778	0.5690
0.005	309.451	0.1043	5.107	15.803	0.5691

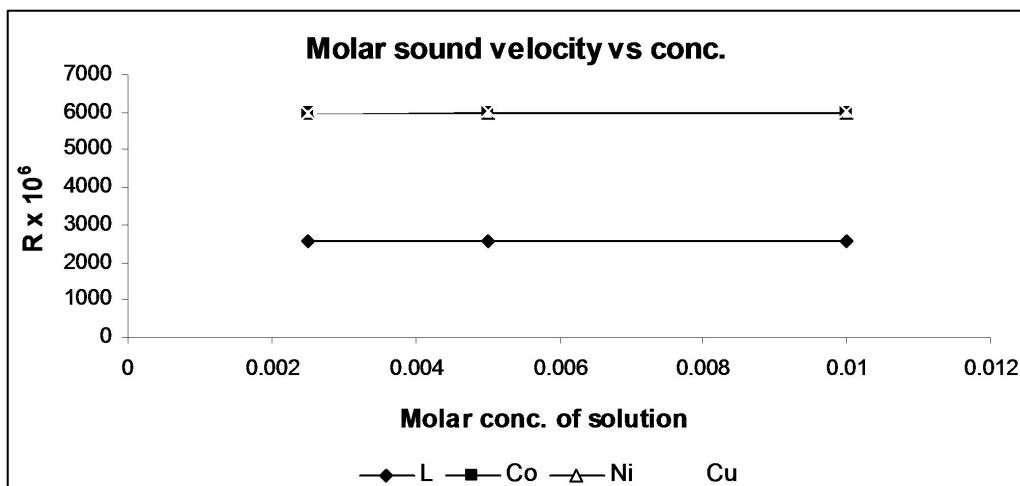
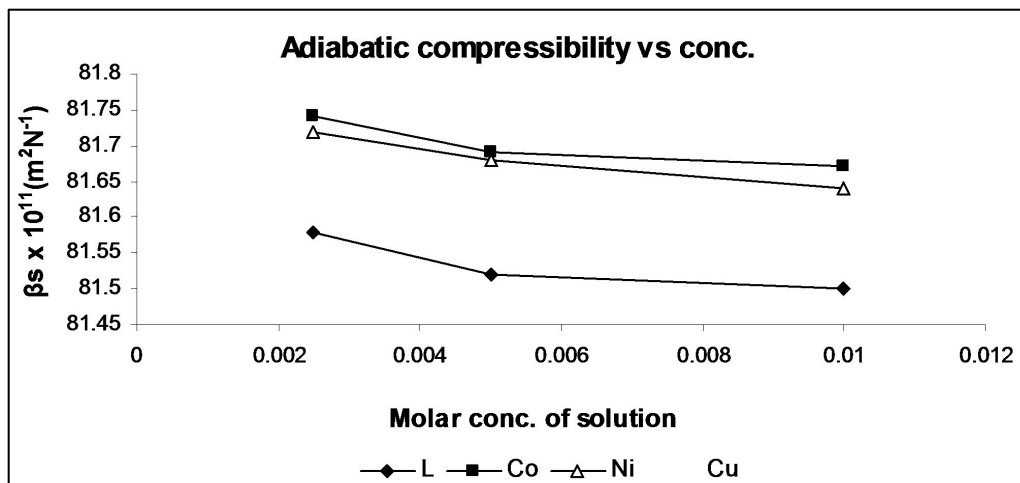
0.0025	309.612	0.1041	5.122	15.858	0.5692
<b>Co (II) - ACAT (C<sub>30</sub>H<sub>32</sub>CoN<sub>4</sub>O<sub>4</sub>S<sub>2</sub>)</b>					
0.01	776.153	1.663	2.015	15.639	0.5692
0.005	776.144	1.660	2.018	15.662	0.5693
0.0025	776.533	1.658	2.023	15.709	0.5693
<b>Ni (II) - ACAT (C<sub>30</sub>H<sub>32</sub>N<sub>4</sub>NiO<sub>4</sub>S<sub>2</sub>)</b>					
0.01	775.385	1.663	2.011	15.592	0.5691
0.005	775.480	1.662	2.013	15.610	0.5693
0.0025	775.859	1.661	2.015	15.633	0.5694
<b>Cu (II) - ACAT (C<sub>30</sub>H<sub>32</sub>CuN<sub>4</sub>O<sub>4</sub>S<sub>2</sub>)</b>					
0.01	781.029	1.639	2.070	15.753	0.5690
0.005	781.315	1.638	2.073	16.196	0.5692
0.0025	781.411	1.637	2.074	16.206	0.5693
<b>CoCl<sub>2</sub> .6H<sub>2</sub>O</b>					
0.01	290.279	0.01186	39.525	11.473	0.8751
0.005	290.421	0.01185	39.575	11.493	0.8849
0.0025	290.599	0.01184	39.602	11.513	0.8932
<b>NiCl<sub>2</sub> .6H<sub>2</sub>O</b>					
0.01	290.350	0.01186	39.545	11.516	0.8722
0.005	290.456	0.01185	39.625	11.720	0.8789
0.0025	290.456	0.001185	39.624	11.863	0.8888
<b>CuCl<sub>2</sub> .2H<sub>2</sub>O</b>					
0.01	208.156	0.02307	10.448	21.790	0.8620
0.005	208.730	0.02295	10.561	21.805	0.8703
0.0025	208.998	0.2289	10.572	21.903	0.8810

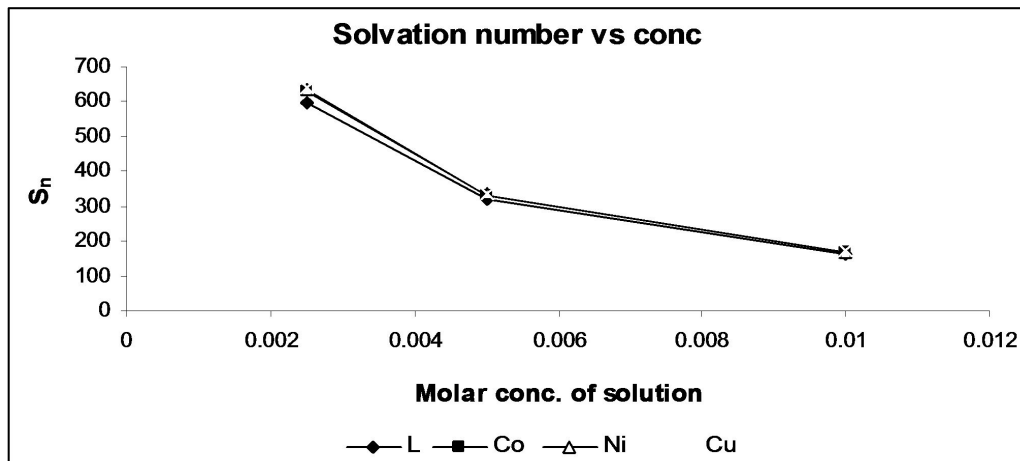
Fig: (1-9) M(II) - AACP Complexes





M(II) - AACP Complexes





M(II) - AACP Complexes

