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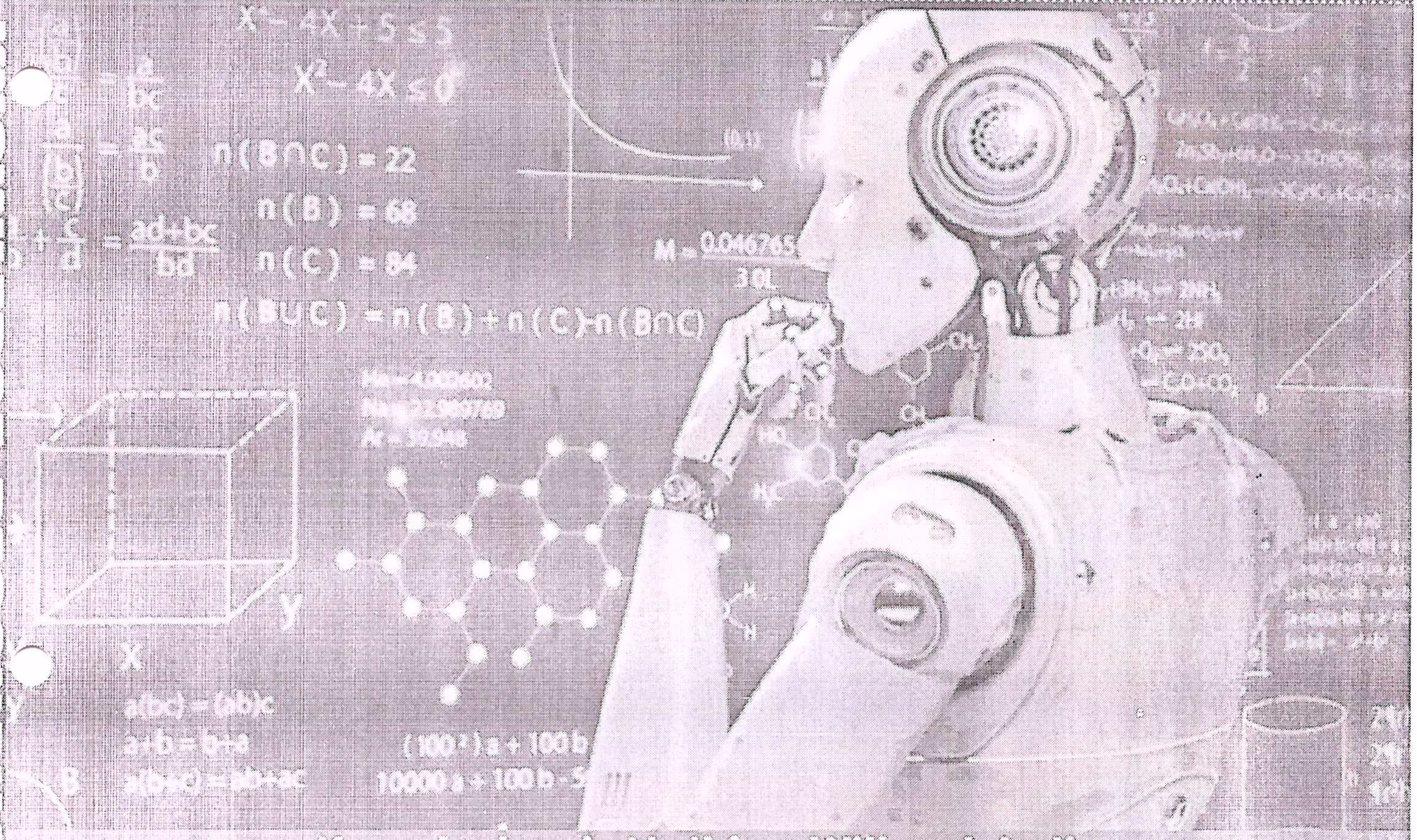

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THERMODYNAMIC AND ULTRASONIC PROPERTIES OF 1:1 BINARY MIXTURE OF M-CRESOL + N, N-DIETHYLAMINE AND METHANOL + ETHYL ACETATE IN BENZENE SOLUTIONS

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ABSTRACT

Ultrasonic waves are produced by transducer. The value of ultrasonic velocity (υ) with composition (c) in 1:1 binary mixture of m-cresol + N, N-diethylamine and Methanol + Ethyl acetate in benzene solutions indicate that ultrasonic velocity (υ) increases progressively as composition of Methanol increases in the mixture. The ultrasonic velocity and thermodynamic parameters of m-cresol + N,N-diethyl amine in benzene solution were reported. The value of ultrasonic velocity (υ) and composition (c) in a binary mixture of (m-cresol + N, N diethyl amine) in benzene solutions show that ultrasonic velocity (υ) increases as composition of m - cresol in the mixture increases. The curve is varying wave like, indicating a weak molecular interaction after mixing m-cresol and N, N diethyl amine. This curve is wave like changing in nature showing a molecular interaction between the Methanol and Aniline mixture is weak interaction. The ultrasonic velocity (υ). Thermodynamic compressibility (βa), free length (Lf) and acoustical impedance (Z) were calculated using standard relations.

Key words:

Adiabatic compressibility, Ethyl acetate, Thermodynamic, Ultrasonic

Introduction:

Transducer is a device, which converts one form of energy into another. Ultrasonic waves are produced by transducer. The system (1) is 1:1 binary mixture of m-cresol and N, N-diethylamine as well as Methanol + Ethyl acetate prepared in dilute solutions of benzene. The measurement of ultrasonic velocity (υ) and density (ρ) of the above liquid systems at various temperature have been carried out on using ultrasonic interferometer (1 MHz) of Mittal make and with calibrated class-A certificate density bottle (25 ml) respectively. Ultrasonic velocity (υ) and other thermodynamic parameters are determined from the following mathematical expressions,

1. $\upsilon = \lambda d \cdot f$ ------------------------------------(1.1)
2. $\beta a = 1/(\upsilon 2\rho)$ --------------------------------(1.2)
3. $Lf = K/(\upsilon \rho 1/2)$ -----------------------------(1.3)
4. $Z = \rho \upsilon$ ---------------------------------------(1.4)

Where K is Jacobsons temperature dependent constant

These equations have been written on MS Office Excel programme to calculate thermodynamic properties of the system. Molecular interactions in binary liquid mixture are explained from the plot of thermodynamic values and molecular concentrations in the mixture. Ultrasonic are fruitful in Detection of flaws in metal, Ultrasonic signaling, Depth sounding and sensing, Ultrasonic in metallurgy, Treatment of neuralgic pain and Detection of abnormal growth etc. Most materials are ultrasonically trans-parent [1-2] and allow the analysis of a broad variety of sample types, chemical reactions and processes. The wide frequency range [3] that can be covered by modem ultrasonic methods is from 10 kHz to 10 GHz.

Materials and Methods:

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The organic liquid compounds, m-Cresol, N, N-Diethylamine, Benzene, methanol, ethyl acetate are all bears functional group. Ultrasonic velocity and other physical properties of these molecules at room temperature are reported in the Table 1.

Table 1: Physical properties of some of the organic liquids considered in present research work

Sr. No.	Name of liquid	Density Kg/m^3	Ultrasonic velocity m/s	Ref.
1	Benzene	872.5	1310	1,10,15
2	Water	997.2	1494	1
3	n-Propanol	801.1	1234	1, 13
4	Methyl alchohol	791	1214	1
5	Ethyl Methyl- Ketone	788.7	1160	12
6	Aniline	1018.0	1682	1,14
7	Ethyl acetate	898.9	1187	1
8	m-Cresol	1034	1450	1
9	diethylamine	707	1500	1

Ultrasonic velocities were calculated on 1 MHz ultrasonic interferometer supplied by Mittal New Delhi, which is direct and simple device for calculating sound velocity in liquids. Diverse configuration of the one component with other in the range from 0 to 1 mole fractions were equipped by volume and then improved to mole fractions [4]. Acoustical investigation like ultrasonic velocity, adiabatic compressibility, molecular free length and acoustic impedance have been designed at four temperatures 250, 300, 350 and 400 C respectively. Additional factors are measure of intermolecular interactions as compared to derive ones [5, 6]. The magnitude values of υE, βaE, LfE and ZE indicate interaction of strength between the components [7].The chemical and structural units of liquid systems, rates and formation of complex can also be calculated by ultrasonic measurement. The ultrasonic velocity and density of the liquids can be engaged to estimate different thermodynamic factors of the liquids for example adiabatic compressibility (βa), intermolecular length (Lf) and acoustic impedance (Z). Ultrasonic analysis can now be easily performed in various branches and trades. [8]

Ultrasonic measurements of (m-Cresol + N, N-diethylamine)

Ultrasonic measurements of (m-Cresol + N, N-diethylamine) in Benzene m-Cresol + N,N, -diethylamine are prepared in seven different combinations of total ml and the combinations were 1+7+, 2+6, 3+5, 4+4, 5+3, 6+2 and 7+1. Each mixture was added to 50 ml of pure/benzene and each were kept in air tight 100 ml glass flask. Each solution was used to measure ultrasonic velocity (υ) at three different temperature 30, 35, and 400 C, The ultrasonic velocity (υ), Thermodynamic compressibility (βa), free length (Lf) .and acoustical impedance (Z) were calculated using standard relations. The ultrasonic velocity and thermodynamic parameters of m-cresol + N, N-diethyl amine in benzene solution are reported in Table 2.

Ultrasonic measurements of (methyl alcohol + ethyl acetate)

Methyl alcohol and ethyl acetate have been considered in the plan of work, because these two compounds have different functional groups and different dipole moments10. The two functional group - OH3 and CH3 C00 - may form hydrogen bonding when they were mixed in stoichiometric ratio. To get a perfect combination of two components, we have prepared seven different combinations of these two to get total volume of 40 cc of the mixture system. Hence, the seven binary mixtures were prepared and kept in airtight 100 ml glass flask. Density (ρ) of each mixture was measured at four different temperatures using a class - A certified density bottles 25 ml and single pan sensitive balance. Ultrasonic velocity of each binary mixture at four different temperatures 25, 30, 35 and 400C were measured by circulating hot water from a thermostat. The ultrasonic velocity (υ) and density (ρ) data of (methyl alcohol + ethyl acetate) at each temperature was used in the calculation of thermodynamic parameters such as adiabatic compressibility (βa), molecular free length (Lf) and acoustical impedance (Z). Table 3 and 4 indicates density (ρ), ultrasonic velocity (υ), adiabatic compressibility (βa), molecular free length (Lf) and acoustical impedance (Z) of seven different compositions of methyl alcohol and ethyl acetate at four different temperatures 25, 30, 35 and 400C.

RESULT AND DISCUSSION:

Ultrasonic velocity (υ) vs compositions of a binary mixture of (m-Cresol + N, Ndiethyl amine) in dilute solution of the benzenes are seen nonlinear indicating intermolecular interaction between the components of mixture (fig 1). Similarly the nature of the adiabatic compressibility (βa) vs composition of binary mixture in dilute solution of benzene fig 1 gives out a non-linearity in the nature. This also supports, that there may be molecular interaction between m-Cresol and N, N-diethyl amine components. [9]

Ultrasonic and thermodynamic properties of m-Cresol + N, N-diethyl amine:

Inspection of Table 2 in chapter IV show that the value of ultrasonic velocity (υ) and composition (c) in a binary mixture of (m-cresol + N, N diethyl amine) in benzene solutions show that ultrasonic velocity (υ) increases as composition of m-cresol in the mixture increases. The curve is varying wave like, indicating a weak molecular interaction after mixing m-cresol and N, N diethyl amine. Adiabatic compressibility (βa) of m-cresol + N, N diethyl amine (in benzene solution) with composition show a decrease in magnitude as composition of m-cresol increases and this nature is exactly in reciprocate nature of velocity composition curve Fig. 1(a). This curve is wave like in nature showing weak interaction between the m-cresol and N, N diethyl amine component. Fig. 1(b) shows a decrease in free length (Lf) with composition and fig. 1(c) shows an increase in impedance (Z) as increase in composition of m-cresol increases in the mixture. These both curves (Fig.1 b and c) of decrease in free length and increase of impedance indicating that there is weak interaction between the components of the mixture. The weak interaction may be due to the binary mixture is in dilute solutions where the polar molecules get occasional chance to come closer. [10]

Ultrasonic and thermodynamic properties of methyl alcohol + ethyl acetate:

The experimental values of ultrasonic velocity and density of methyl alcohol + ethyl acetate binary mixture along with thermodynamic parameters as a -function of temperature are recorded in Tables 3. These ultrasonic velocity and thermodynamic parameters such as adiabatic compressibility, molecular free length and acoustical impedance are plotted as a function of composition at various temperatures Fig. 2 (a) and (b). The value of ultrasonic velocity (υ) with composition (c) in a binary mixture of methyl alcohol + ethyl acetate show that ultrasonic velocity (υ) decreases as composition of methyl alcohol in the mixture increases.[11] The decreasing nature of curve indicates molecular interactions between the components of the mixture.[12]

Adiabatic compressibility (βa) of methyl alcohol + ethyl acetate show a increase with composition of methyl alcohol increases and this nature is exactly in reciprocate nature of velocity composition curve Fig. 2 (a). This curve is progressively changing in nature showing molecular interaction between the methyl alcohol and ethyl acetate component. Fig. 2(b) shows a increase in free length (Lf) with composition and impedance concentration curve shows a decrease in impedance (Z) as increase in composition of methyl alcohol in the mixture.[13] These both curves (Fig. 2 b) of increase in free length and decrease in impedance indicating that there is molecular interaction between the components of the mixture. This interaction between the molecules may be due to the functional groups of methyl alcohol and ethyl acetate binary mixture. [14]

In this work it finds that for all the binary systems, there is intermolecular interaction in solutions as well as in pure binary mixtures. All the thermodynamic calculations and graphs are carried out on MS Office Excel programme. All the results determined in this work explain intermolecular interaction satisfactorily and is in agreement with the literature results. [15]

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Table 2. Ultrasonic velocity and thermodynamic properties of (m-cresol+ N, N Diethyl amine) mixture in benzene solutions at different temperatures.

Temp. °K	Mole fraction of m-cresol in mixture	Density (ρ) Kg/m^{3}	Ultrasonic Velocity (υ) ms^{-1}	Compressibility (β_a) 10^{-10} m^{2} N^{-1}	Free length (L_f) 10^{11} m	Acoustical impedance (Z) 10^{6} Kg^{-1}m^{-1}
30	0.2	823.02	1266.11	7.57961	5.7127	1.042034
	0.3	830.07	1272.01	7.44568	5.6623	1.055857
	0.4	837.03	1280.52	7.28595	5.601	1.071834
	0.6	842.52	1285.4	7.18362	5.5632	1.082975
	0.7	848.02	1291.35	7.07141	5.5179	1.095091
	0.8	853.01	1294.05	7.00074	5.4902	1.103838
	0.9	857.11	1295.13	6.95563	5.4728	1.110069
35	0.2	819.03	1244.21	7.88702	5.88	1.019045
	0.3	827.02	1253.33	7.69756	5.8089	1.036529
	0.4	834.51	1262.63	7.51651	5.7419	1.053677
	0.6	839.04	1268.42	7.40783	5.6986	1.064255
	0.7	844.03	1272.11	7.32138	5.6652	1.073699
	0.8	850.05	1274.21	7.24559	5.6359	1.083142
	0.9	854.24	1274.21	7.21005	5.6227	1.088481
40	0.2	816.01	1227.18	8.13744	6.0262	1.001391
	0.3	823.03	1231.51	8.0114	5.9794	1.01357
	0.4	829.01	1241.54	7.82562	5.9096	1.029249
	0.6	835.11	1246.66	7.70478	5.8641	1.041098
	0.7	840.51	1253.01	7.57789	5.8171	1.053167
	0.8	846.06	1254.87	7.50588	5.7878	1.061695
	0.9	850.01	1256.01	7.45744	5.7689	1.067621

Table 3 a. Ultrasonic Velocity and other thermodynamic parameters for Methyl alcohol + Ethyl acetate at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility β_a 10^{-10} m^{-2} N^{-1}	Free length L_f m	Impedance Z Kgm^{2}s^{-1}
298	0	871.3	1148.09	8.707238	4.11E-12	1.000331
	0.125	866.3	1140.95	8.867444	4.16E-12	0.988405
	0.25	857	1136.67	9.031302	4.22E-12	0.974126
	0.375	846	1130.95	9.241508	4.3E-12	0.956784
	0.5	832.9	1123.81	9.506515	4.39E-12	0.936021
	0.625	822.1	1119.52	9.70536	4.47E-12	0.920357
	0.75	812.7	1115.81	9.88301	4.54E-12	0.906819
	0.875	799.1	1109.3	10.16953	4.64E-12	0.886442
	1	791	1213.85	8.580122	4.28E-12	0.960155
303	0	868.4	1126.66	9.07182	4.24E-12	0.978392
	0.125	864.4	1123.9	9.158617	4.27E-12	0.971499
	0.25	855.5	1117.61	9.358353	4.34E-12	0.956115
	0.375	844.2	1112.38	9.573005	4.42E-12	0.939071
	0.5	831.8	1107.91	9.794271	4.5E-12	0.92156
	0.625	822	1102.79	10.00328	4.58E-12	0.906493
	0.75	812.1	1100	10.17666	4.65E-12	0.89331
	0.875	797.5	1093.63	10.48404	4.76E-12	0.87217
	1	787.5	1199	8.833058	4.4E-12	0.944213

Table 3 b. Ultrasonic Velocity and other thermodynamic parameters for Methyl alcohol + Ethyl acetate at different temperatures.

Temp. °K	Mole Fraction c.	Density (ρ) Kgm^{-3}	US velocity U ms^{-1}	Compressibility β_a 10^{-10} m^{-2} N^{-1}	Free length L_f m	Impedance Z Kgm^{2}s^{-1}
308	0	865.3	1107.5	9.422059	4.37E-12	0.95832
	0.125	862.3	1101.36	9.560553	4.41E-12	0.949703
	0.25	850.8	1098.14	9.746689	4.48E-12	0.934298
	0 375	840.2	1093.95	9.945403	4.56E-12	0.919137
	0.5	829.5	1090	10.14684	4.63E-12	0.904155
	0.625	817.4	1086.82	10.35739	4.71E-12	0.888367
	0.75	808.9	1084.44	10.51221	4.77E-12	0.877204
	0.875	794.6	1078.66	10.81639	4.89E-12	0.857103
	1	783.6	1184.87	9.090006	4.51E-12	0.928464
313	0	863.2	1087.27	9.799722	4.5E-12	0.938531
	0.125	861.1	1085.78	9.850601	4.52E-12	0.934965
	0.25	847.3	1079.54	10.12711	4.62E-12	0.914694
	0.375	836	1077.27	10.30729	4.69E-12	0.900598
	0.5	825.9	1073.33	10.51008	4.77E-12	0.886463
	0.625	814.4	1070.66	10.71172	4.85E-12	0.871946
	0.75	805	1069.56	10.8591	4.91E-12	0.860996
	0.875	790.8	1063.91	11.17181	5.02E-12	0.84134
	1	780.7	1170.73	9.345495	4.62E-12	0.913989

Fig: 1(a) Plot of Ultrasonic Velocity 'υ' and Adiabatic Compressibility 'βa' versus Mole fraction of m-cresol + N, N diethyl amine at 303, 308, 313⁰K.

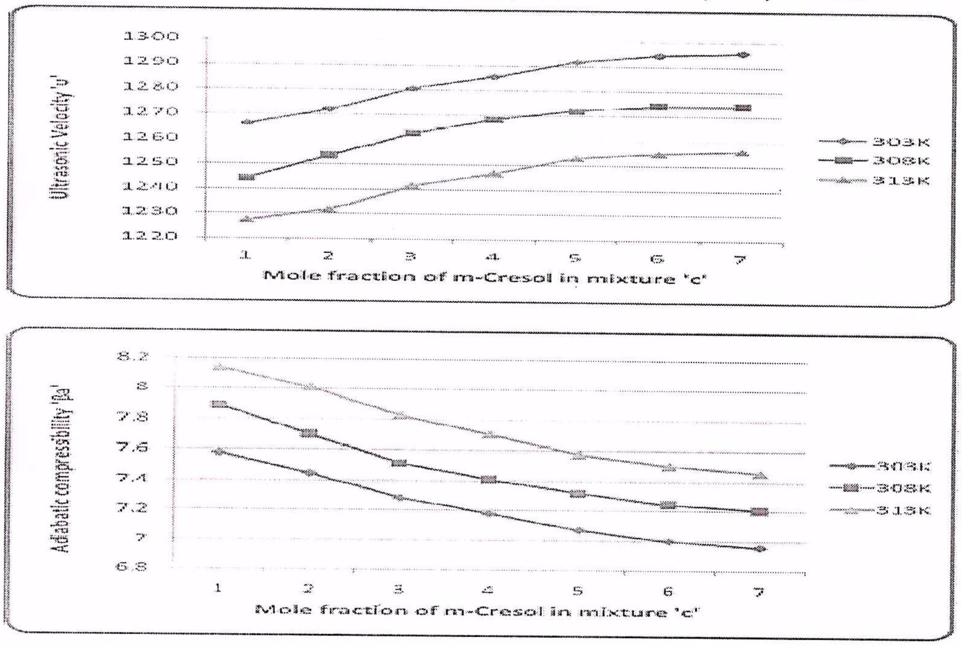


Fig: 1(b) Plot of Free Length 'Lf' versus Mole fraction of m-cresol + N, N diethyl amine at 303, 308, 313⁰K.

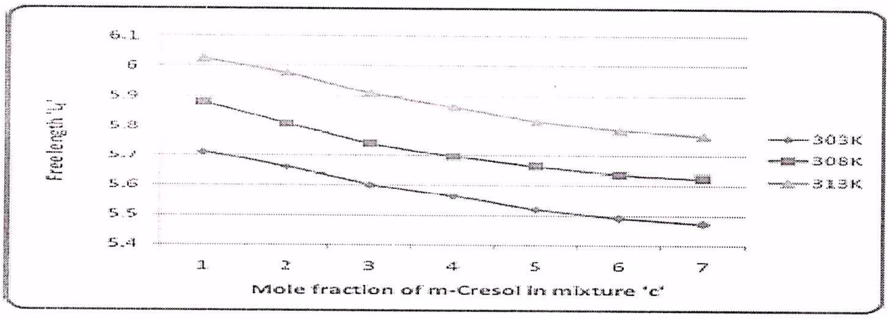


Fig:1(c) Plot of Impedance 'Z' versus Mole fraction of m-cresol + N, N diethyl amine at 303, 308, 313⁰K.

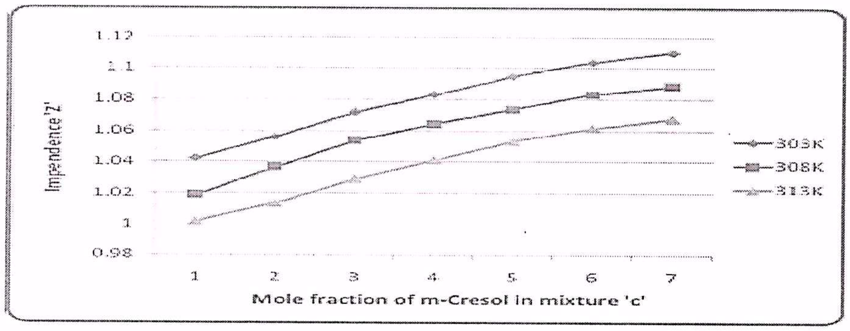


Fig: 2(a) Plot of Ultrasonic Velocity 'υ' and Adiabatic Compressibility 'βa' versus Mole fraction of Methanol + Ethyl acetate at 298, 303, 308, 313⁰K.

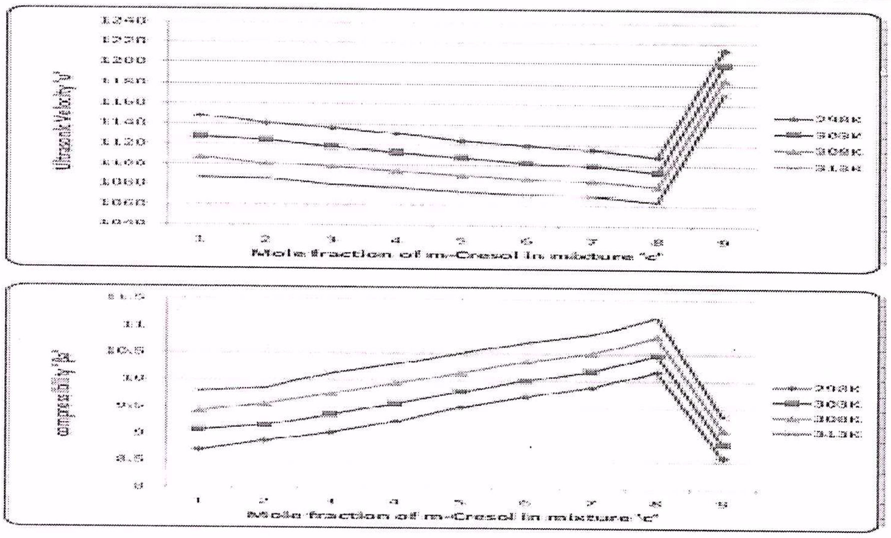
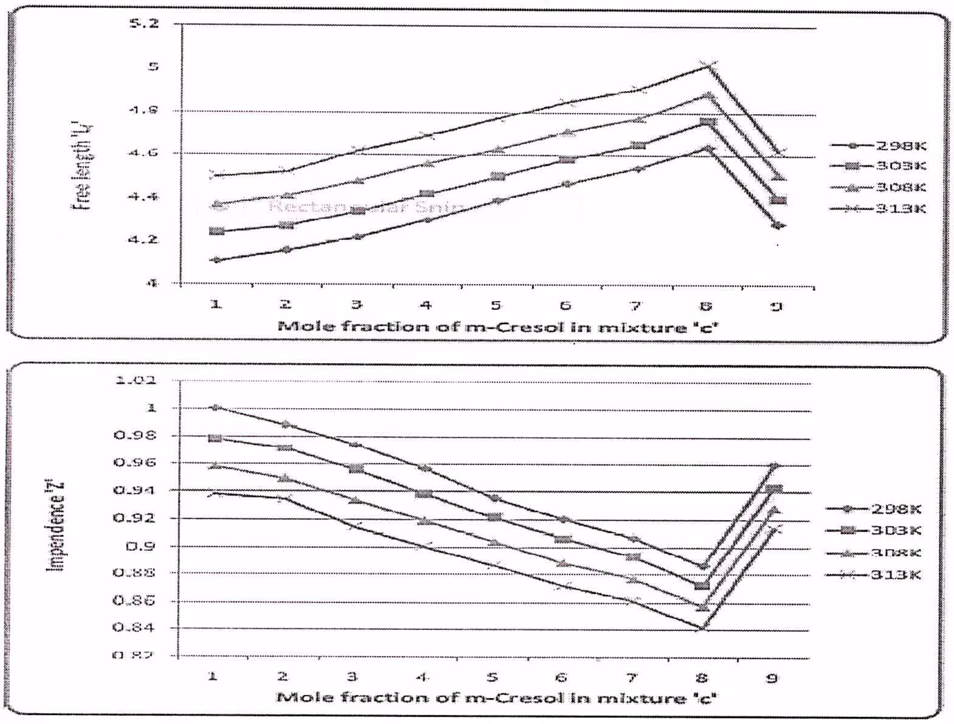


Fig: 2 (b) Plot of Free length 'Lf' and Acoustic Impedance 'Z' versus Mole fraction of Methanol + Ethyl acetate at 298, 303, 308 and 313^0K



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