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ACOUSTICAL STUDIES OF BENZAMIDE IN BINARY MIXTURE OF WATER WITH ETHANOL AND 2-PROPANOL

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ABSTRACT

Ultrasonic velocity and density measurement at different concentrations of benzamide were carried out in the mixture of water with the solvents ethanol and 2-propanol respectively for investigating solute-solvent interactions.The data obtained during the study is used for determining the most significant acoustic parameters like adiabatic compressibility (β_s), apparent molar compressibility (Φ_k), specific acoustic impendence (Z) and intermolecular free length (L_f). These parameters have been used to explore the interactions between benzamide in different compositions of water-ethanol and water-2-propanol system at 303.15 k.

Key words: Acoustic, Benzamide, Ultrasonics.

INTRODUCTION

The nature of molecular interactions in liquid mixutes plays an important role to explore the association behaviour of molecules both i.e. solute-solute and solvent interactions.

In recent years ultrasonic, velocity, density and viscosity studies in aqueous[1], pure non – aqueous[2] and mixed[3] electrolytic solutions have led to new insights in to the process of molecular interactions. However, very little experimental data on the solvation behaviour of ions are available in non – aqueous solvents.The knowledge of solution behaviour of a species is very essential to understand the solution chemistry. Awasthi etal[4] investigated the molecular association of acetamide and benzamide with ethanol in benzene at different concentration and temperature.

Benzamide, the simplest aromatic carboxylic amide is very polar due to nitrogen non bonded electron pair with the carboxylic group. It's basicity is weaker than amines. It is used in the synthesis of various organic compounds and the determination of glycine. In homogenous solvent system amides are hydrolysed with water only in presence of strong acids or base catalyst under heating. Bezamide is soluble in organic solvents such as ethanol, 2-propanol and slightly soluble in water. Therefore, it is interesting thoughts to study the interactions in water and solvent mixtures.

In this view, density and ultrasonic velocities of benzamide have been measured in various compositions of ethanol-water and 2-propanol-water system. The other thermodynamic parameters are

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obtained from this data and used to interpret the molecular interactions in 10%, 30%, 50%, 70% and 90% compositions.

EXPERIMENTAL

The ultrasonic velocity of mixtures was measured using a ultrasonic interferometer supplied by Mittal Enterprises New Delhi (Research model F-81) with an accuracy of 0.01%. The instrument was calibrated by measuring the velocity of double distilled water which was found to be1499.015 m/sec. at 303.15.K the measured value was found to be in very good agreement with the literature value[5].The temperature of all the systems was controlled by circulating water around the liquid cell from thermostatically controlled water bath.

The density of various system has been measured using density bottle (10 mL capacity,Borosile make) with the help of Contech make electronic balance with an accuracy (± 0.0001 g). The densities of the solvents and distilled water are in good agreement (< 0.3%) with the literature value[6]. The chemicals were of E-Merck quality. The benzamide (AR grade) with the purity of 99.5%.

The solvents ethanol and 2-propanol were purified by the standard procedure[7]. The distilled water was redistilled in conductivity apparatus and was stored in compact glass stoppered bottle.

Different compositions of ethanol-water and 2-propanol-water viz., 10%, 30%, 50%, 70% and 90% were prepared by mixing known masses of water and ethanol or 2-propanol in glass stoppered bottles.

RESULTS AND DISCUSSION

The various acoustic parameters such as adiabatic compressibility ($\beta_{s)}$, apparent molar compressibility (Φ_k), specific acoustic impendence (Z), intermolecular free length (L_f), relative association(R_A), apparent molar volume (Φ_v), have been evaluated using the standard relation[8,9]. The densities of pure water and the solvents ethanol, 2-propanol are in good agreement with the literature[6]. It is clear from Table 1 and 2 that density increases with the increase in the fraction of benzamide in different compositions of ethanol-water. Similar trend has been observed in case of 2-propanol-water system.

Increase in density with composition indicates the increase in solute-solvent interactions. From the Table 1 and Table 2, we observe the trends of all accoustical parameters with the variations in the concentration of benzamide in different compositions of the solvents ethanol and 2-propanol with water. It has been observed that ultrasonic velocity and densiy increases with the increasing in weight fraction of benzamide in different compositions of ethanol-water and 2-propanol-water.

The variation in ultrasonic velocity with the weight fraction of bezamide in ethanol-water and 2 propanol-water system show that ultrasonic velocity increase with increasing concentration of solute, gains a maximum value initially and then decreases slightly. It is also supported with the non linear behaviour of the graph (Fig. 1 and 2). The values of ultrasonic velocities increase sharply up to the 0.05 M conc. of ethanol-water mixture and then the velocities remain nearly constant. This non linear behaviour of velocity with concentration being different from ideal mixing behaviour indicates the occurance of complex through molecular interactions between unlike molecules of solute in solvents. This behavior is the result of structural changes occuring due to the formation of hydrogen bond complexes in the mixture[10].

Adiabatic compressibility for both the systems first decreases sharply with increase in concentration, reaches minimum at the same concentration were maximum velocity is observed and increases further slowly or remains almost constant. Such behaviour of adiabatic compressibility holds good for the structural changes present in the mixtures, that brings molecules to a closer packing. The presence of velocity maxima and adiabatic compressibility minima at the same concentration support the existence of complex formation through hydrogen bonding to be maximum at that concentration. Similar trends are reported earlier by the other researchers[11,12].

Specific acoustic impendence (Z) also increases till the increase in concentration. Increase in the value of specific accoustic impedance (Z) with concentration of benzamide indicate significant interaction between the component molecules[13].

Intermolecular free length (L_f), depends upon adiabatic compressibility and shows the behavior similar to that of compressibility and inverse to the velocity. It decreases with increasing concentrations.This behaviour of intermolecular free length is an inverse behavior and as suggested by Erying and Kincaid[14] model of sound propogation. An increase in intermolecular free length produces a decrease in ultrasonic velocity. Here on increasing the concentration the intermolecular free length is decreasing in each system and consequently the ultrasonic velocity increases. The decrease in L_f values with increase in velocity indicates that there is a significant interactions present between solute molecules due to which structural arrangements are considerably affected. The negative values of apparent molar compressibility (Φ_k) as well as decreasing trend of apparent molar volume (Φ_v) agree with strong solute-solvent interactions.

Table 1: Ultrasonic velocities (μ), densities (ρ) and derived parameters for benzamide in ethanol-water system at 303.15 K

% composition (w/w)	ρ g/cm^3	U_S x 10^3 cm/sec	β_sx10^{-12} cm^2/dyne	Φ_k x10^{-9} cm^2/ dyne.mol	Φ_v cm^3 mol^{-1}	Z x10^3 g/s.cm^2	L_f x10^{-6} ^{0}A	R_A
	0.80297	984	1.2862					
				0.02 M				
10%	0.8020	1290	0.7492	-3.3381	225.269	1034580.0	5.4617	0.9125
30%	0.8171	1308	0.7153	-3.6213	-930.802	1068766.8	5.3367	0.9266
50%	0.8259	1384	0.6321	-4.1730	-1582.13	1143045.6	5.0167	0.9191
70%	0.9162	1504	0.4824	-5.3700	-7565.757	1377964.8	4.3826	1.0389
90%	0.9579	1536	0.4424	-5.6941	-9948.670	1471334.4	4.1969	1.0283
				0.04 M				
10%	0.8121	1360	0.6656	-1.9455	-203.296	1104456.0	5.1479	0.9079
30%	0.8290	1400	0.6154	-2.1396	-833.480	1160600.0	4.9500	0.9179
50%	0.8385	1490	0.5371	-2.3953	-1175.509	1249365.0	4.6244	0.9093
70%	0.9291	1538	0.4550	-2.7613	-4095.432	1470765.3	4.2563	0.9970
90%	0.97312	1564	0.4201	-2.9200	-5319.364	1521959.6	4.0898	1.0384
				0.06 M				
10%	0.8171	1362	0.6597	-1.3142	-212.489	1112890.2	5.1251	0.9130
30%	0.8385	1402	0.6067	-1.4549	-736.8490	1175577.0	4.9149	0.9280
50%	0.8450	1496	0.5287	-1.6192	-890.858	1264120.0	4.5881	0.9151

Cont…

% composition (w/w)	ρ g/cm³	U_S x 10³ cm/sec	β_sx10⁻¹² cm²/dyne	Φ_k x10⁻⁹ cm²/ dyne.mol	Φ_v cm³ mol⁻¹	Z x10³ g/s.cm²	L_f x10⁻⁶ ⁰A	R_A
70%	0.9356	1540	0.4506	-1.8611	-2814.726	1440824.0	4.2356	1.0035
90%	0.9860	1560	0.4167	-1.9601	-3731.912	1538160.0	4.0732	1.0530
				0.08 M				
10%	0.8235	1364	0.6526	-1.0128	-242.346	1135530.0	5.0974	0.9298
30%	0.8400	1408	0.60005	-1.0999	-698.2332	1182720.0	4.88897	0.9283
50%	0.8867	1510	0.4946	-1.2982	-1334.7306	1338917.0	4.4376	0.9573
70%	0.9400	1546	0.4450	-1.4047	-2141.819	1453240.0	4.2092	1.0069
90%	0.9934	1556	0.4157	-1.4740	-2863.571	1545730.4	4.0683	1.0619
				0.1 M				
10%	0.8385	1366	0.6391	-8.3037	-383.522	1120236.0	5.0444	0.9360
30%	0.8674	1424	0.5685	-9.3845	-785.401	1235177.6	4.7576	0.9550
50%	0.9162	1512	0.4774	-1.0650	-1406.897	1385294.4	4.3598	0.9887
70%	0.9502	1548	0.4391	-1.1820	-1802.176	1470909.6	4.1812	1.0174
90%	0.9991	1552	0.4155	-1.1808	-2323.508	1550603.2	4.0673	1.0689

Table 2: Ultrasonic velocities (μ) and densities (ρ) and derived parameters for benzamide in 2-propanol-water system at 303.15 K

% compositon (w/w)	P g/cm³	U_S x10³ cm/sec	β_sx10⁻¹² cm²/dyne	Φ_k x10⁻⁹ cm²/ dyne.mol	Φ_v cm³ mol⁻¹	Z x10³ g/s.cm²	L_f x10⁻⁶ ⁰A	R_A
	0.7810	11041	1.0505					
				0.02M				
10%	0.7602	1360	0.7112	-2.0331	1912.670	1033872.0	5.3213	0.9080
30%	0.8093	1384	0.6452	-2.7295	-2093.496	1120071.2	5.0684	0.9610
50%	0.8592	1404	0.5902	-3.2824	-5684.182	1206316.8	4.8476	1.1000
70%	0.8967	1440	0.5377	-3.7198	-8128.729	129124.8	4.6269	1.0508
90%	0.9167	1560	0.4482	-4.2747	-9345.613	1430052.0	4.2244	1.0459
				0.04M				
10%	0.7692	1400	0.6632	-1.1967	649.364	1076880.0	5.1386	0.9099
30%	0.8102	1450	0.587	-1.5426	-1005.622	1174790.0	4.8344	0.9472
50%	0.8615	1480	0.5299	-1.8175	-2850.577	1275020.0	4.5933	1.0003
70%	0.9021	1520	0.4797	-2.0268	-4166.313	1371192.0	4.3703	1.0382
90%	0.9313	1568	0.4364	-2.1855	-50525.183	1460278.4	4.1684	1.0608

Cont…

% compositon (w/w)	P g/cm^3	U_S x10^3 cm/sec	β_sx10^{-12} cm^2/dyne	Φ_k x10^{-9} cm^2/dyne.mol	Φ_v cm^3 mol^{-1}	Z x10^3 g/s.cm^2	L_f x10^{-6} ^{0}A	R_A
0.06M								
10%	0.7746	1440	0.6225	-8.9264	333.260	1115424.0	4.9785	0.9077
30%	0.8219	1480	0.5554	-1.1073	-914.554	1216412.0	4.7025	0.9544
50%	0.8749	1520	0.4947	-1.2925	-2151.904	1329848.0	4.4381	1.0069
70%	0.9100	1568	0.4469	-1.4172	-2892.023	1426880.0	4.2182	1.0365
90%	0.9422	1600	0.4137	-1.5045	-3560.235	1507520.0	4.0585	1.0660
0.08M								
10%	0.8102	1436	0.5985	-7.4900	-427.313	1163447.2	4.8815	0.9503
30%	0.8463	1484	0.5365	-8.8123	-1091.804	1255909.2	4.6218	0.9818
50%	0.8978	1526	0.4788	-1.0082	-1930.024	1370042.8	4.3662	1.0319
70%	0.9154	1570	0.4431	-1.0704	-2217.553	1437178.0	4.2002	1.0422
90%	0.9876	1604	0.3935	-1.1784	-3225.514	15841104.0	3.9582	1.1164
0.1M								
10%	0.8219	1430	0.5949	-2.4721	-489.598	1175317.0	4.8668	0.9654
30%	0.8515	1490	0.5289	-7.1640	-917.661	1268735.0	4.5889	0.9865
50%	0.9022	1518	0.4810	-1.6608	-1585.605	1369539.6	4.3762	1.0388
70%	0.9242	1572	0.4378	-8.6562	-1852.525	1452842.4	4.1751	1.0518
90%	0.9927	1608	0.3895	-9.4795	-2608.201	1596261.6	3.9380	1.1213

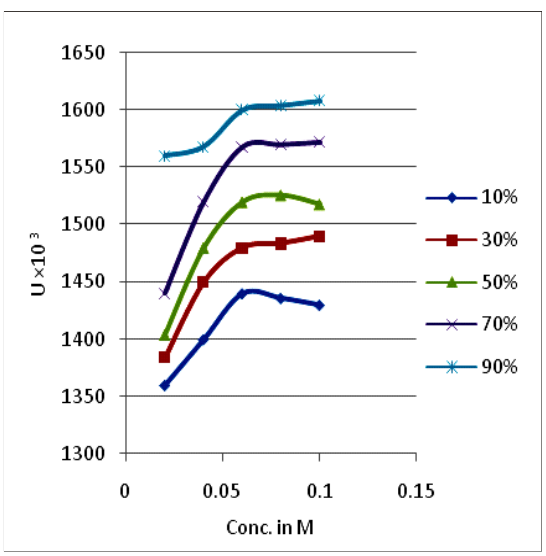

Fig. 1: Plots of ultrasonic velocity versus concentration at different compositions of 2-propanol

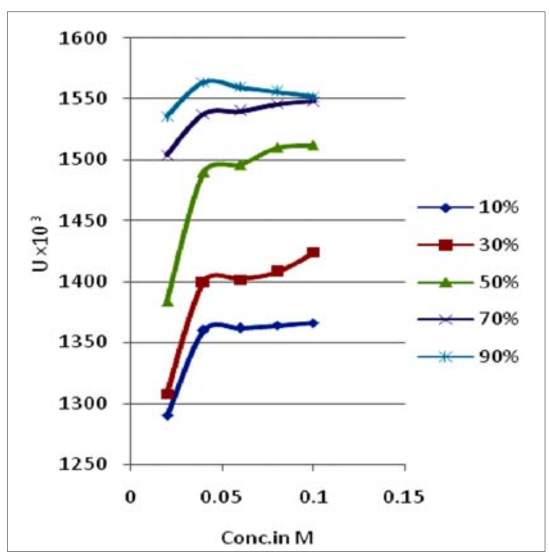

Fig. 2: Plots of ultrasonic velocity versus concentration at different compositions of ethanol

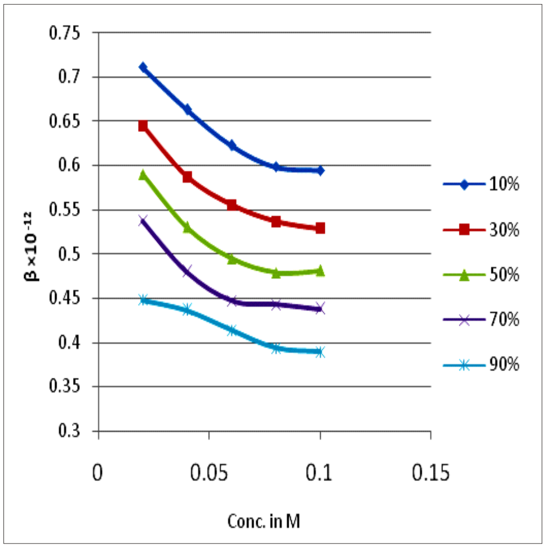

Fig. 3: Plots of adiabatic compressibility versus concentration at different compositions of 2-Propanol

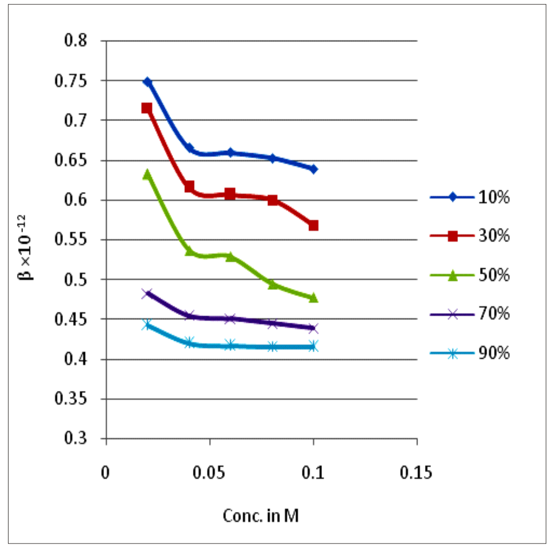

Fig. 4: Plots of adiabatic compressibility versus concentration at at different compositions of Ethanol

CONCLUSION

In the present studies, the investigated mixtures were chosen in order to study solute solvent interactions in a different composition of water with Ethanol and 2-Proanol at 303.15K.The values of the derived ultrasonic parameters agree with complexation due to strong intermolecular H-bonding of Benzamide in 90%composition of Ethanol and 2-Propanol with water.The extent of solute-solvent interactions is found to be increased on addition of the initial structure and formation of structure with added solvent.

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