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A study on volumetric and thermo-acoustic properties of amino-acetic acid in aqueous solution

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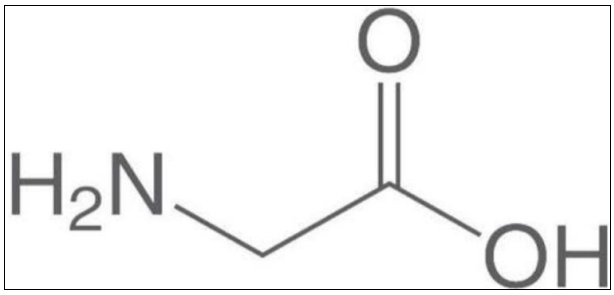
Abstract
In the present study, the ultrasonic velocity, density measurements have been carried out for binary mixture of amino-acetic acid in aqueous sodium chloride in the concentration range of (0.02-0.2 M) at 283K, 288K, 293K, 298K, having the frequency at 2MHz using ultrasonic Interferometer. Experimental data have been used to calculated the thermo-acoustical parameters adiabatic compressibility (β), Wada's constant (W), Rao's constant(R), Molar volume (Vm), change in adiabatic compressibility(Δβ), relative change in adiabatic compressibility(Δβ/β) and Thermal conductivity, to investigate the nature and strength of molecular interaction in binary mixture of (amino-acetic acid + NaCl + H_2O). The result are discuss in the existing of the solvent - solvent interaction shows that result in attractive force for the structure making tendency and solute - solute interaction show that result in electro-strictive force for the structure braking tendency.

Keywords: Ultrasonic velocity, density, Intermolecular interaction, volumetric properties, thermo-acoustical properties

Introduction
The ultrasonic method is a versatile non-destructive technique use for the understanding physicochemical properties of liquid and also behave like a powerful probe assess the acoustic characteristics of the binary and ternary combination and determine the intermolecular interaction. This combination is use to find the various pharmaceutical, medical and technological application [1, 2]. The measurements of the ultrasonic velocity and density is employed to analyse interactions in pure liquid mixtures as well as ionic interactions in solutions [3]. It is also explaining the pure binary ternary liquid mixture of the Amino acid and saline salt, It is a vital substance used by our body to absorb and transport nutrients, to maintain the proper fluid balance. The interaction of saline salt and amino acid in the water is based on the length of the hydrogen chain of the amino acid and nature of the salt [4, 5].
As the part of our study of the aqueous binary system contain salt and Amino-acetic acid, the activity of the organic compound and salt are obtained in the Amino-acetic acid + NaCl + H_2O and the binary system was studied in the limited domain of temperature and concentration for the Amino-acetic acid. The result are determine at the concentration between (0.02 - 0.2) mol/kg at four temperature 283K, 288K, 293K, 298K [6] and the parameters obtain in this study related to velocity and density are useful to derive an insight into the molecular interaction. In this paper we compute and discuss various thermoacoustic parameters. [7].

Experimental procedure
Material
Chemicals of the AR grade are listed below which are obtain from Mumbai's Himedia Lab Pvt Ltd. Without any additional raffination, all of these chemicals are utilized. The concentration (0.02-0.2 mol/kg) of Amino-acetic acid in 0.2 aqueous saline salt are changed with weight and Before usage, all of the glass was cleaned with acetone and distilled water, then dried.



Essential amino acid – Amino-acetic acid Molecular formula - H_2NCH_2COOH Molar mass - 75.07 g/mol CAS No. - 56-40-6 EC No. - 200-272-2 Universal Solvent - water Mol. formula - H_2O Mol.wt. - 18.01528g/mol Saline Salt - sodium Chloride Mol. formula -NaCl Mol. wt. - 58.44 g/mol CAS No. 7647-15-7 EC No. 231-598-3

Fig 1: Structure of Amino-acetic acid

Method

Using an analogue ultrasonic velocity interferometer, which was utilized to measure the ultrasonic velocity at frequency 2MHz with an overall accuracy of 0.0001m/s, an ultrasonic wave was generated by a quartz crystal exiting a radio frequency oscillator. The desired solution was added to the cell and the outside jacket was cycled with water at a consistent temperature. 30 minutes were given for the call to equilibrate before the measurement was taken.

For further accuracy, the density of the solution was precisely determined using a digital electronic balance (Contech -34) and a 10ml specific gravity bottle with an accuracy of 210-2kg/m3 and 0.0001gm, respectively. The triple measurement was averaged. Utilizing an automatic thermostatic water bath with a 1K precision allowed for the maintenance of the experimental temperature [8].

Defining relation

Various acoustic and Thermo-acoustic parameters are used in the present study are determined by using the following relation [9].

- Adiabatic Compressibility(β) = $1/U^2\rho$
- Change in Adiabatic Compressibility ($\Delta\beta$) = $\beta - \beta_0$
- Relative Change in Adiabatic Compressibility ($\Delta\beta/\beta$) = $(\beta - \beta_0)/\beta$
- Rao's Constant(R) = $V_m U^{1/3}$
- Wada's Constant(W) = $V_m\ \beta^{-1/7}$
- Thermal Conductivity (k) = $\{3.0*(\rho N_A/M)^{2/3} K_B U\}$
- Molar Volume (Vm) = $\{M_{eff}/\rho\}$

Result and Discussion

Plots of the ultrasonic velocity and density fluctuations of amino-acetic acid with aqueous sodium chloride at various doses (0.02-0.2mol/kg) and temperatures (283K, 288K, 293K, and 298K) are used for the systematic analysis of these variations. Figure 1-9 illustrates all of these.

It has been noted that the ultrasonic velocity exhibits an increasing variance as the molal concentration increases. As a result, it demonstrates that association occurs with intermolecular contact [10]. It has been found that the density of every solution in the aqueous NaCl solution increases as the concentration of the solution increases, as would be predicted, and decreases as the temperature rises because the system's thermal energy weakens the intermolecular force [11].

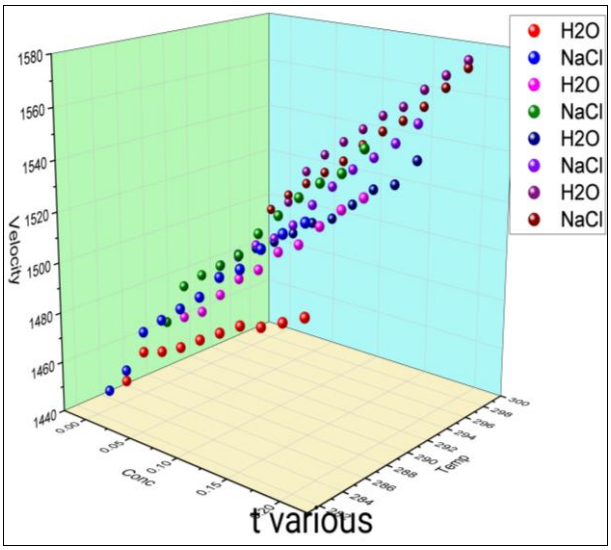


Fig 2: Ultrasonic velocity at various temp. & conc.

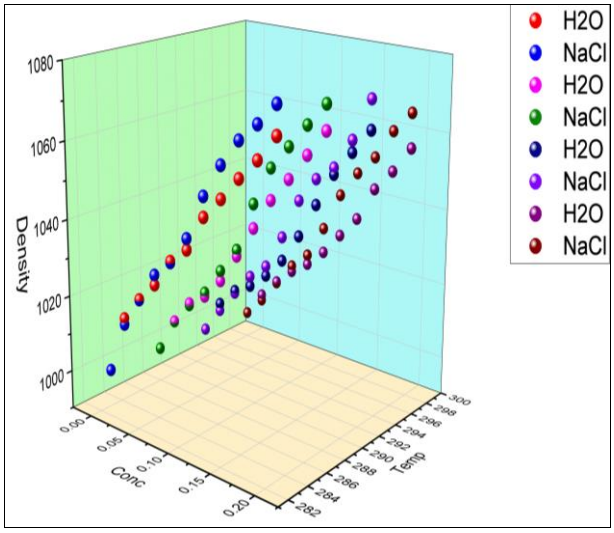


Fig 3: Density at various temp. & conc.

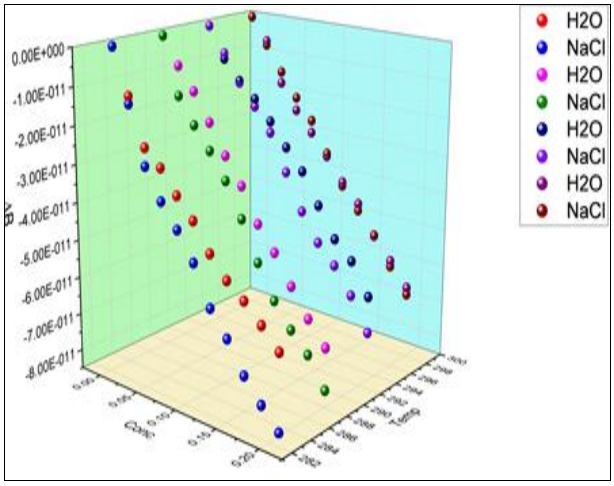


Fig 4: Change in adiabatic Compressibility at various temp. & conc.

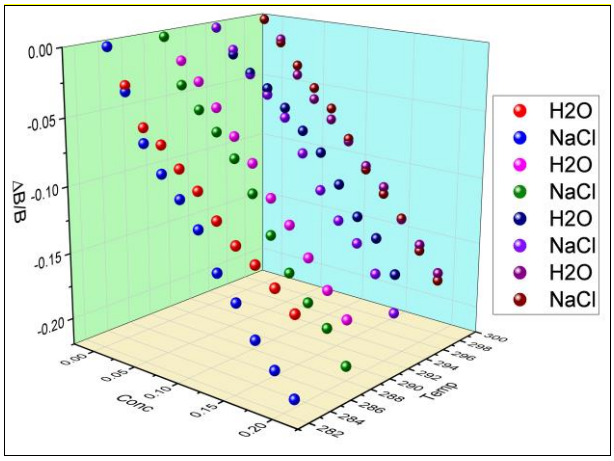


Fig 5: Relative change in adiabatic Compressibility at Various temp.& conc

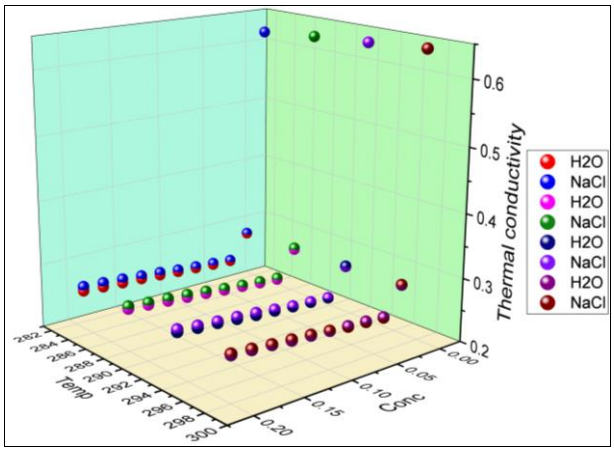


Fig 6: Thermal conductivity at various temp. and conc.

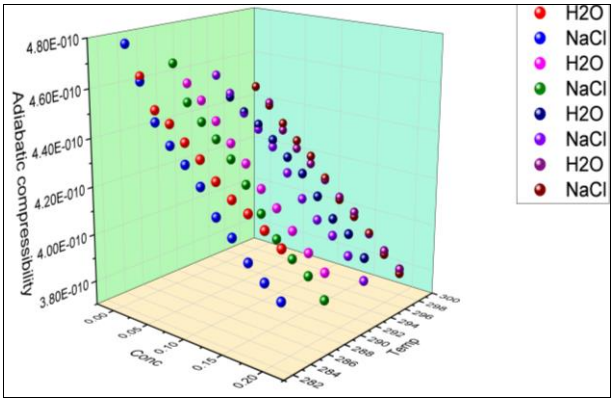


Fig 7: Adiabatic Compressibility at Various temp. & conc.

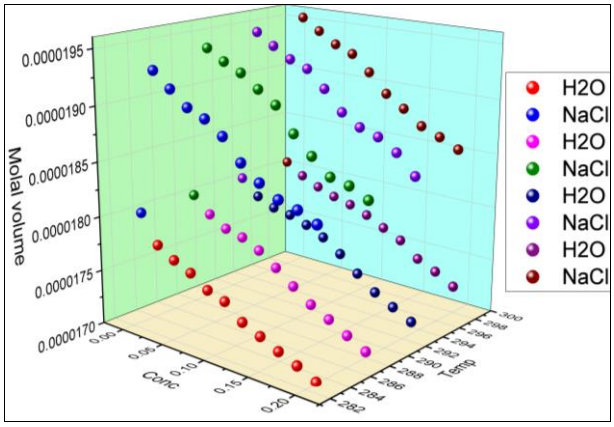


Fig 8: Molal volume at various temp. & conc.

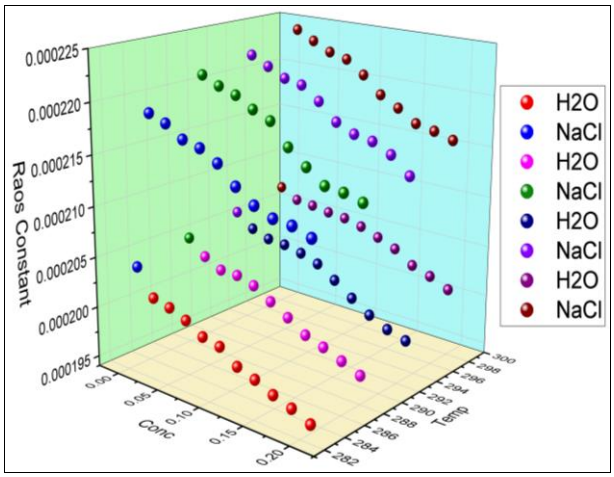


Fig 9: Rao's Constant at Various temp. & conc.

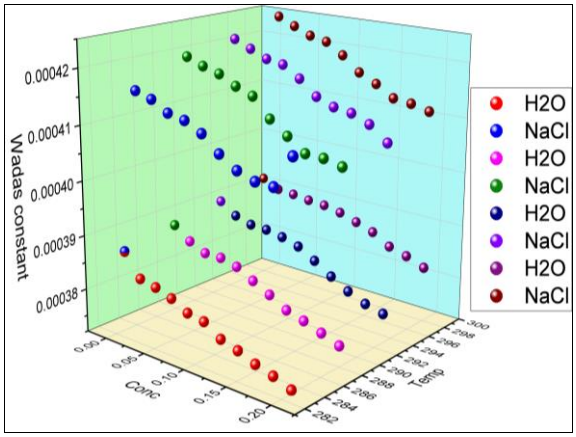


Fig 10: Wada's Constant at Various temp. & conc.

The negative value of Δβ and Δβ/β is caused by how the solute and solvent interact, increasing in Δβ and Δβ/β value, an increase in the concentration of zwitterions or amino acids may be linked to a system's total cohesive force increasing. Aminoacetic acid +Water+ Sodium Chloride. This cohesive force may be shows result of the zwitterions - ion and zwitterions-water dipole interaction in solution [12]. From the table 2, it has been noted that the thermal conductivity of water is increase, as the temperature rises as compared to the concentration, it is observed that the thermal conductivity slightly increases with the increase in concentration and the temperature show that the energy is flow when the molecule is close to each other. This is means that, in the given system intermolecular interaction take place [13].

With an increase in concentration, the adiabatic compressibility falls for all four different temperatures, there may be an aggregation of solvent molecules surrounding solute molecules, which would result in a decrease in adiabatic compressibility. The decrease of the adiabatic compressibility with concentration of the amino- acetic acid + NaCl + H_2O studied here show that the formation of a greater number of tightly bound system [14].

With a little variation, the value of the molar volume falls as the solute concentration rises. The stronger molar volume value denotes a weaker solute-solvent interaction [15]. The measure of the Rao's constant and Wanda's constant of amino-acetic acid solution show their respective values have increased as a result of increased concentration. These differences suggested that the tightly packed nature of the medium favors an increase in the solute-solvent interaction [16].

Table 1: The value of Velocity, Density and Wada's constant at different temperature and concentration

Conc.	Velocity		Density		Wadas Constant	
	H2O	NaCl	H2O	NaCl	H2O	NaCl
	283.15 K					
0	1447.427	1447.427	999.7	999.7	0.00038678	0.000386834
0.02	1454.25	1458.516	1015.264	1013.627	0.00038264	0.000416505
0.04	1468.689	1476.616	1021.803	1021.64	0.00038205	0.000415597
0.06	1471.531	1483.892	1027.014	1029.573	0.00038103	0.000413853
0.08	1475.804	1490.734	1034.468	1034.108	0.00037942	0.00041325
0.1	1481.304	1497.623	1038.653	1041.439	0.00037894	0.000411694
0.12	1486.512	1507.379	1047.892	1052.91	0.00037687	0.000408984
0.14	1491.739	1512.578	1053.423	1061.379	0.00037598	0.000406954
0.16	1493.812	1522.103	1059.361	1068.143	0.00037474	0.000405905
0.18	1497.963	1529.586	1064.701	1072.78	0.00037385	0.0004058
0.2	1502.304	1535.556	1071.192	1078.245	0.00037263	0.000411482
288.15 K						
0	1466.032	1466.032	999.103	999.103	0.00038839	0.000388394
0.02	1470.612	1483.517	1008.314	1008.27	0.00038613	0.00042045
0.04	1475.307	1490.374	1014.836	1014.34	0.00038479	0.000419274
0.06	1484.667	1496.443	1018.192	1019.27	0.00038483	0.000418429
0.08	1493.447	1502.827	1023.849	1026.48	0.00038409	0.000416822
0.1	1499.309	1513.428	1031.734	1033.371	0.00038243	0.000415677
0.12	1508.438	1522.421	1040.235	1046.379	0.00038084	0.00041234
0.14	1513.392	1531.155	1048.497	1056.469	0.00037905	0.00041003
0.16	1522.348	1538.428	1054.823	1062.7	0.00037816	0.000407752
0.18	1530.436	1543.74	1061.734	1068.88	0.00037704	0.000407666
0.2	1536.783	1554.349	1068.496	1074.761	0.00037586	0.00040696
293.15 K						
0	1481.496	1481.496	998.2	998.2	0.00038986	0.000389862
0.02	1488.361	1487.301	1007.287	1005.31	0.00038779	0.000421837
0.04	1493.132	1494.436	1012.499	1011.83	0.00038688	0.000420499
0.06	1497.934	1499.421	1015.301	1017.94	0.00038675	0.000419136
0.08	1503.589	1506.869	1019.63	1022.223	0.00038620	0.00041863
0.1	1509.883	1517.172	1025.213	1031.524	0.00038529	0.000416607
0.12	1513.612	1526.39	1033.099	1042.531	0.00038347	0.000413953
0.14	1521.122	1534.877	1042.649	1049.363	0.00038143	0.000412694
0.16	1528.904	1541.205	1051.643	1053.384	0.00037961	0.000412227
0.18	1532.634	1548.304	1058.29	1061.398	0.00037825	0.000410891
0.2	1543.496	1557.217	1064.83	1072.461	0.00037744	0.000408318
298.15 K						
0	1498.101	1498.101	997	997	0.00039150	0.000391509
0.02	1503.304	1506.371	1003.936	1002.38	0.00039001	0.000424415
0.04	1518.439	1513.273	1009.338	1009.023	0.00038978	0.000423005
0.06	1527.347	1519.826	1013.832	1015.438	0.00038939	0.000421646
0.08	1534.463	1526.349	1017.36	1019.98	0.00038919	0.000420961
0.1	1541.321	1534.832	1022.154	1028.853	0.00038856	0.000418918
0.12	1548.361	1541.97	1028.23	1039.369	0.00038753	0.000416237
0.14	1553.401	1547.834	1034.117	1046.497	0.00038643	0.000414658
0.16	1561.63	1554.931	1043.368	1051.874	0.00038451	0.000412602
0.18	1568.53	1563.793	1049.239	1059.791	0.00038357	0.000412198
0.2	1575.632	1572.749	1056.345	1065.463	0.00038228	0.000411383

Table 2: The value of Molal volume, Thermal conductivity, and Rao's constant at different temperature and concentration

Conc.	Molal Volume		Thermal Conductivity		Raos Constant	
	H2O	NaCl	H2O	NaCl	H2O	NaCl
	283.15 K					
0	1.80E-05	1.80E-05	0.62144773	0.62144773	0.0002039	0.0002039
0.02	1.78E-05	1.93E-05	0.28773044	0.28826421	0.00020131	0.000219231
0.04	1.77E-05	1.92E-05	0.24713163	0.24843906	0.00020091	0.000218626
0.06	1.76E-05	1.91E-05	0.24845098	0.25095399	0.00020025	0.000217506
0.08	1.75E-05	1.90E-05	0.25037662	0.25285088	0.00019923	0.000217097
0.1	1.74E-05	1.89E-05	0.25198706	0.25521848	0.00019889	0.000216111
0.12	1.73E-05	1.87E-05	0.25437035	0.25876389	0.00019759	0.000214428
0.14	1.72E-05	1.86E-05	0.25616223	0.26104687	0.00019701	0.000213168
0.16	1.72E-05	1.85E-05	0.25748127	0.26380561	0.00019622	0.000212468
0.18	1.71E-05	1.84E-05	0.25906371	0.26586922	0.00019563	0.000212306
0.2	1.70E-05	1.84E-05	0.26086937	0.26781260	0.00019485	0.000211709
288.15 K						

0	1.80E-05	1.80E-05	0.62918511	0.62918511	0.00020489	0.000204893
0.02	1.79E-05	1.94E-05	0.28963834	0.29217149	0.00020346	0.000221639
0.04	1.78E-05	1.93E-05	0.24711552	0.24955792	0.00020260	0.000220878
0.06	1.78E-05	1.93E-05	0.24923129	0.25138540	0.00020259	0.000220323
0.08	1.77E-05	1.91E-05	0.25163293	0.25364698	0.00020209	0.0002193
0.1	1.76E-05	1.90E-05	0.25391598	0.25657815	0.00020104	0.000218562
0.12	1.74E-05	1.88E-05	0.25686336	0.26026424	0.00020002	0.000216481
0.14	1.73E-05	1.87E-05	0.25906969	0.26343737	0.00019889	0.000215032
0.16	1.72E-05	1.85E-05	0.26164999	0.26572842	0.00019831	0.000213706
0.18	1.71E-05	1.85E-05	0.26418777	0.26767872	0.00019759	0.000213518
0.2	1.71E-05	1.84E-05	0.26640857	0.27050597	0.00019683	0.000213052
293.15 K						
0	1.81E-05	1.81E-05	0.63543871	0.63543871	0.00020579	0.000205796
0.02	1.79E-05	1.95E-05	0.29293495	0.29234317	0.00020448	0.000222491
0.04	1.78E-05	1.94E-05	0.24971712	0.24982510	0.00020388	0.00022163
0.06	1.78E-05	1.93E-05	0.25098221	0.25166651	0.00020377	0.000220757
0.08	1.78E-05	1.92E-05	0.25264532	0.25362554	0.00020339	0.00022041
0.1	1.77E-05	1.91E-05	0.25462815	0.25690630	0.00020279	0.000219133
0.12	1.76E-05	1.89E-05	0.25656431	0.26030263	0.00020163	0.00021747
0.14	1.74E-05	1.88E-05	0.25942382	0.26289226	0.00020034	0.000216663
0.16	1.73E-05	1.87E-05	0.26224839	0.26465002	0.00019919	0.000216342
0.18	1.72E-05	1.86E-05	0.26399476	0.26721580	0.00019832	0.000215455
0.2	1.71E-05	1.84E-05	0.26695993	0.27061832	0.00019779	0.000213847
298.15 K						
0	1.81E-05	1.81E-05	0.64204580	0.64204580	0.00020681	0.000206811
0.02	1.80E-05	1.95E-05	0.29521942	0.29551597	0.00020585	0.000224079
0.04	1.79E-05	1.94E-05	0.25342074	0.25250601	0.00020567	0.000223173
0.06	1.78E-05	1.93E-05	0.25566352	0.25467317	0.00020539	0.0002223
0.08	1.78E-05	1.93E-05	0.25745021	0.25652833	0.00020522	0.000221843
0.1	1.77E-05	1.91E-05	0.25941258	0.25944787	0.00020480	0.000220552
0.12	1.76E-05	1.89E-05	0.26162914	0.26242758	0.00020413	0.00021887
0.14	1.76E-05	1.88E-05	0.26348168	0.26462859	0.00020341	0.000217867
0.16	1.74E-05	1.87E-05	0.26645479	0.26675178	0.00020219	0.000216675
0.18	1.74E-05	1.86E-05	0.26863515	0.26961650	0.00020158	0.000216289
0.2	1.73E-05	1.86E-05	0.27106849	0.27212726	0.00020076	0.000215756

Table 3: The value of the change in adiabatic Compressibility, Relative change in adiabatic Compressibility, and Adiabatic Compressibility at different temperature and concentration

Conc.	Δβ		Δβ/ β		Adiabatic compressibility	
	H2O	NaCl	H2O	NaCl	H2O	NaCl
	283.15 K					
0	0	0	0	0	4.77E-10	4.77E-10
0.02	-1.17E-11	-1.37E-11	-0.0251664	-0.0295256	4.66E-10	4.64E-10
0.04	-2.38E-11	-2.85E-11	-0.0523578	-0.0635795	4.54E-10	4.49E-10
0.06	-2.78E-11	-3.64E-11	-0.0617961	-0.0824278	4.50E-10	4.41E-10
0.08	-3.36E-11	-4.23E-11	-0.0757504	-0.0972434	4.44E-10	4.35E-10
0.1	-3.87E-11	-4.93E-11	-0.0881683	-0.1152584	4.39E-10	4.28E-10
0.12	-4.56E-11	-5.95E-11	-0.1055795	-0.1422815	4.32E-10	4.18E-10
0.14	-5.09E-11	-6.57E-11	-0.1192453	-0.1594266	4.27E-10	4.12E-10
0.16	-5.44E-11	-7.34E-11	-0.1286856	-0.1815567	4.23E-10	4.04E-10
0.18	-5.89E-11	-7.90E-11	-0.1406878	-0.1983836	4.19E-10	3.98E-10
0.2	-6.38E-11	-8.41E-11	-0.1543027	-0.2139070	4.14E-10	3.93E-10
288.15k						
0	0	0	0	0	4.66E-10	4.66E-10
0.02	-7.13E-12	-1.50E-11	-0.0155395	-0.0333940	4.59E-10	4.51E-10
0.04	-1.30E-11	-2.19E-11	-0.0286440	-0.0492498	4.53E-10	4.44E-10
0.06	-2.01E-11	-2.76E-11	-0.0451829	-0.0629535	4.46E-10	4.38E-10
0.08	-2.78E-11	-3.43E-11	-0.0634559	-0.0796240	4.38E-10	4.31E-10
0.1	-3.45E-11	-4.32E-11	-0.0800772	-0.1022594	4.31E-10	4.22E-10
0.12	-4.32E-11	-5.34E-11	-0.1022777	-0.1294385	4.22E-10	4.12E-10
0.14	-4.93E-11	-6.20E-11	-0.1183426	-0.1534515	4.16E-10	4.04E-10
0.16	-5.66E-11	-6.81E-11	-0.1384449	-0.1713020	4.09E-10	3.98E-10
0.18	-6.36E-11	-7.30E-11	-0.1581127	-0.1858512	4.02E-10	3.93E-10
0.2	-6.94E-11	-8.06E-11	-0.1751741	-0.2092408	3.96E-10	3.85E-10
293.15k						
0	0	0	0	0	4.56E-10	4.56E-10
0.02	-8.28E-12	-6.76E-12	-0.0184778	-0.0150307	4.48E-10	4.50E-10
0.04	-1.34E-11	-1.39E-11	-0.0303224	-0.0314400	4.43E-10	4.43E-10

0.06	-1.75E-11	-1.95E-11	-0.0398286	-0.0446024	4.39E-10	4.37E-10
0.08	-2.26E-11	-2.56E-11	-0.0521610	-0.0594461	4.34E-10	4.31E-10
0.1	-2.86E-11	-3.53E-11	-0.0667978	-0.0837535	4.28E-10	4.21E-10
0.12	-3.39E-11	-4.47E-11	-0.0803215	-0.1086691	4.23E-10	4.12E-10
0.14	-4.19E-11	-5.19E-11	-0.1011534	-0.1283781	4.15E-10	4.05E-10
0.16	-4.96E-11	-5.68E-11	-0.1220454	-0.1420600	4.07E-10	4.00E-10
0.18	-5.42E-11	-6.34E-11	-0.1346530	-0.1613755	4.02E-10	3.93E-10
0.2	-6.22E-11	-7.19E-11	-0.1579048	-0.1870309	3.94E-10	3.85E-10
298.15k						
0	0	0	0	0	4.47E-10	4.47E-10
0.02	-6.16E-12	-7.27E-12	-0.0139645	-0.0165268	4.41E-10	4.40E-10
0.04	-1.72E-11	-1.41E-11	-0.0400509	-0.0326634	4.30E-10	4.33E-10
0.06	-2.41E-11	-2.06E-11	-0.0569741	-0.0482475	4.23E-10	4.26E-10
0.08	-2.95E-11	-2.61E-11	-0.0705579	-0.0619950	4.17E-10	4.21E-10
0.1	-3.51E-11	-3.43E-11	-0.0852381	-0.0831733	4.12E-10	4.13E-10
0.12	-4.13E-11	-4.23E-11	-0.1016853	-0.1044460	4.06E-10	4.05E-10
0.14	-4.62E-11	-4.81E-11	-0.1152193	-0.1204955	4.01E-10	3.99E-10
0.16	-5.39E-11	-5.37E-11	-0.1371484	-0.1366047	3.93E-10	3.93E-10
0.18	-5.95E-11	-6.11E-11	-0.1536751	-0.1582497	3.87E-10	3.86E-10
0.2	-6.56E-11	-6.75E-11	-0.1720279	-0.1778225	3.81E-10	3.79E-10

Conclusion

With increasing amino-acetic acid content, trends and fluctuations in thermos-acoustic parameters are seen, which provides vital and helpful information regarding the nature of the intermolecular forces in the combination. The presence of solvent-solvent interactions demonstrates that they produce an electro-strictive force for structure-braking tendencies and an attracting force for structure-making interactions. As a result, it serves as an effective probe for characterizing the physico-chemical characteristics of medium.

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