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Thermoacoustic Study of Electrolytic Solutions of Aloe Vera Juice at 303.15k

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Abstract- Acoustical parameters such as adiabatic compressibility, acoustic impedance, intermolecular free length and bulk modulus have been estimated using standard relations from measured values of Ultrasonic velocities and densities in extensive range of concentrations at 303.15K temperature and 2MHz frequency for NaCl + Aloe vera juice and $MgCl_2$ + Aloe vera juice system to study the ion-solvent interactions. During the investigation in non-aqueous solutions of electrolytes we have observed the interesting feature of a linear decrease of ultrasonic velocity with increase in concentration of NaCl and $MgCl_2$ unruly to the normal type of behavior exhibited in general by electrolytes.

Keywords- Binary mixture, ion-solvent interactions, Aloe vera juice, Bulk modulus

I. INTRODUCTION

Aloe vera [1-3] is well known medicinal plant worldwide. There are several specie of the genus 'Aloe'. Nowadays aloe vera is most widely used for both commercial and therapeutic purpose. Research has been proved that taking aloe vera in food or juice form, reduce carbohydrate level in blood. The juice of Aloe vera (AV juice) mixed with milk is consumed for kidney infection, cure and heal rashes and vaginal infections. It also helps in soothing and balancing acid in stomach [4]. Therefore it is necessary to explore some more valuable facts about Aloe vera. The propagation of ultrasonic waves in liquid affects its physical properties and hence the physicochemical behavior of the polar and non-polar liquid mixtures can be described by means of the ultrasonic waves. Ultrasonic is a versatile non-destructive technique (NDT) [5-6] and highly useful for the investigation of various physical properties such as elastic constant, bulk modulus etc. A survey of literature proves that acoustical parameters are very useful in understanding the nature and strength of molecular interactions in the binary and ternary liquid mixtures. Recently an ultrasonic investigation has been considerably used to determine the ion-solvent interactions in aqueous and non-aqueous solutions containing electrolytes and non- electrolytes [7]. In solution of ionic solute the attraction between the solute and solvent is of ion-dipole type. When electrolyte is added to the solvent it causes volume contraction. This is due to interactions between ions and solvent molecules. It may affect other acoustical parameters may be affected. Present paper is an attempt to calculate acoustical parameters such as acoustical impedance (Z), adiabatic compressibility (βa), Intermolecular free length (L_f) and bulk modulus (K) from experimentally derived values of electrolytic solutions of NaCl and $MgCl_2$ in extensive range of concentrations and at 303.15K temperature to study the ion-solvent interactions.

II. MATERIAL AND METHODOLOGY

The material and method used in all the measurement and calculation details are given in our communication Chouhan MS et al. (2016) [8]. All the chemicals used were of Analytical Reagent (AR) grades with minimum assay of 99.9%. The speed of ultrasonic sound waves were obtained by using ultrasonic interferometer (Mittal Enterprises, New Delhi) at a fixed frequency of 2 MHz with an accuracy of ± 2 ms^{-1}.

III. THEORY

The experiment was performed at fixed frequency 2MHz and temperature 303.15K. Various parameters such as acoustic impedance (Z), adiabatic compressibility

(βa), intermolecular free length (L_f) and bulk modulus (K) were measured using standard relation,

$$Z = \rho U \quad \ldots\ldots\ldots (1)$$

$$\beta_a = 1/U^2\rho \quad \ldots\ldots\ldots (2)$$

$$L_f = k/U\rho^{1/2} \quad \ldots\ldots (3)$$

$$K = U^2\rho \quad \ldots\ldots\ldots (4)$$

Where k is Jacobson's constant which depends on temperature and is given by relation-

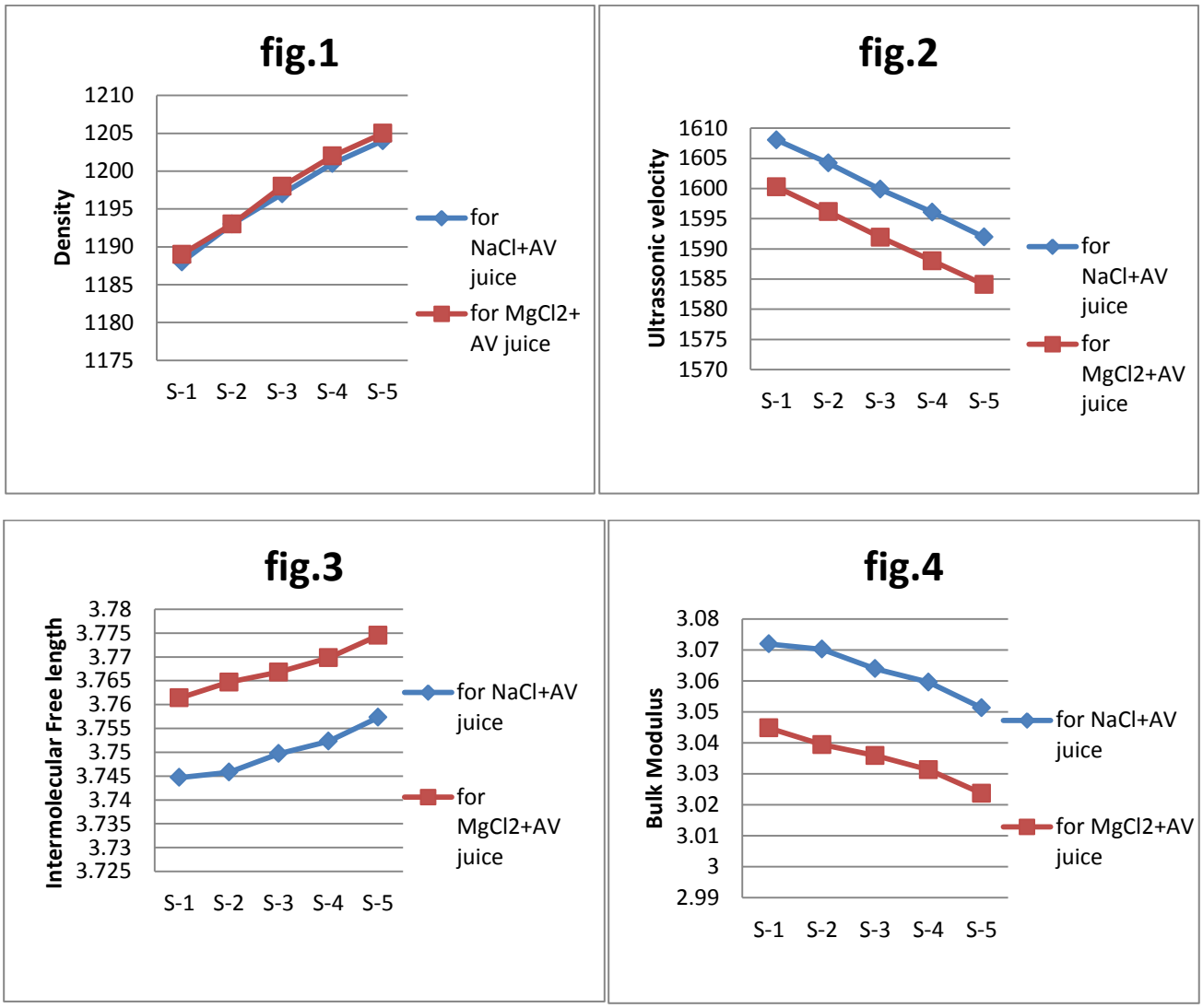
$k = (93.875 + 0.375T) \times 10^{-8}$, where T is the absolute temperature.

Table 1: NaCl +Aloe vera juice

Sample concentration	Abbreviation	Density ρ kg/m^3	Ultrasonic velocity U (m/s)	Acoustic Impedance $Z\times10^6$ ($kg\ m^{-2}\ s^{-1}$)	Adiabatic compressibility $\beta a\times10^{-10}$ (Pa^{-1})	Intermolecular Free Length L_f (Å)	Bulk Modulus $K\times10^9$ (Nm^{-2})
1.0gm NaCl +20ml Aloe vera juice	S-1	1188	1608.05	1.9103	3.2552	3.7447	3.0719
2.0gm NaCl +20ml Aloe vera juice	S-2	1193	1604.21	1.9138	3.2571	3.7458	3.0702
3.0gm NaCl +20ml Aloe vera juice	S-3	1197	1599.87	1.9151	3.2638	3.7497	3.0636
4.0gm NaCl +20ml Aloe vera juice	S-4	1201	1596.08	1.9168	3.2684	3.7523	3.0596
5.0gm NaCl +20ml Aloe vera juice	S-5	1204	1591.95	1.9167	3.2772	3.7573	3.0513

Table 2: $MgCl_2$+ Aloe vera juice

Sample concentration	Abbreviation	Density ρ kg/m	Ultrasonic velocity U (m/s)	Acoustic Impedance $Z\times10^6$ ($kg\ m^{-2}\ s^{-1}$)	Adiabatic compressibility $\beta a\times10^{-10}$ (Pa^{-1})	Intermolecular Free Length L_f (Å)	Bulk Modulus $K\times10^9$ (Nm^{-2})
1.0gm $MgCl_2$ +20ml Aloe vera juice	S-1	1189	1600.25	1.9026	3.2842	3.7614	3.0448
2.0gm $MgCl_2$ +20ml Aloe vera juice	S-2	1193	1596.15	1.9042	3.2901	3.7647	3.0394
3.0gm $MgCl_2$ +20ml Aloe vera juice	S-3	1198	1591.93	1.9071	3.2937	3.7668	3.0359
4.0gm $MgCl_2$ +20ml Aloe vera juice	S-4	1202	1588.02	1.9088	3.2989	3.7698	3.0313
5.0gm $MgCl_2$ +20ml Aloe vera juice	S-5	1205	1584.08	1.9088	3.3071	3.7745	3.0237



IV. RESULT AND DISCUSSION

Ultrasonic investigation has been carried out on pure Aloe Vera juice containing sodium chloride and magnesium chloride at 303.15K temperature and 2MHz frequency in extensive range of concentration to investigate the ion-solvent interactions [9-14].

From table-1 and table-2 it reveals that the density of binary mixture increased with increasing concentration of solute into the solvent (**fig. 1**). It is because of the presence of solute ions which turns the medium thicker. From **fig. 2** it is clear that the ultrasonic velocity (USV) linearly decreased with increase in concentration for both the systems containing NaCl and $MgCl_2$. However USV is higher in sodium chloride solution than in magnesium chloride solution for same concentration. This is because of dissociation of electrolyte in the medium. This behavior can be endorsed to study the intermolecular free length. The intermolecular free length (L_f) is an important physical property of liquid mixtures which mainly affects the sound velocity. Change in ultrasonic velocity in solution depends upon the increase or decrease of molecular free length after mixing the component. **Fig. 3** shows that the intermolecular free length (L_f) increases with decrease in ultrasonic velocity. This indicates that, there is a weak interaction between the ion and solvent molecules. When the concentration of NaCl and $MgCl_2$ is increased, the thickness of oppositely charged ionic atmosphere may increase due to decrease in ionic strength. This is suggested by the increase in acoustic impedance and increase in adiabatic compressibility in both the systems. Bulk modulus (K) determines how compressible a system is. Higher the value of bulk modulus indicates that it is difficult to compress the system. Table 1 and 2 suggest that the bulk modulus decreases (**fig. 4**) in both the systems against the different concentrations. Hence, it is confirmed that there is weak

interaction between solute ant solvent. Another reason of decrease in bulk modulus is increasing intermolecular free length of liquid mixtures.

V. CONCLUSION

Weak existence of solute – solvent interactions present in the system with varying degrees and the order of the electrolytes as $MgCl_2$ < NaCl. It is concluded that the concentration of the solute and nature of the solvent play an important role in determining the interactions occurring in the solution. Hence it is evident that the ultrasonic velocity measurement in the given medium serves as a powerful probe in characterizing the physicochemical properties of the medium. The study highlights the factors involved in ion- solvent interaction and opens up a new way of investigation in this field.

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