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Investigation of acoustic parameters of skin care herbal extract Papaya leaves using ultrasonic techanique

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ABSTRACT
The concept of beauty and cosmetics dates back to ancient mankind and civilization. Generally herbal cosmetics are also referred to as natural cosmetics. Herbal cosmetics are formulated, using different cosmetic ingredients to form the base in which one or more herbal ingredients are used to cure various skin ailments and also herbal cosmetics are the products in which herbs are used in crude or extract form. Herbal cosmetics using various permissible cosmetic ingredients to form the base in which one or more herbal ingredients are used to provide defined cosmetic benefits called as herbal cosmetics. Herbal extract of papaya leaves is widely used in the skin care treatment. This includes herbal extracts, oil, protein and bioactive materials from plant and animal. Ultrasound assisted extraction process is the modern method used in allied industries. In the present study, our aim is to find the activity of present drug by ultrasonic velocity measurement in aqueous medium. Intermolecular interaction study plays an important role in development of molecular sciences. The ultrasonic velocity of liquid is fundamentally related to the binding forces between the atoms or molecules. Ultrasonic parameters provide valuable information about various inter and intramolecular interactions in solutions. The ultrasonic velocity (v), density (d) and viscosity (η) for the aqueous solution of skin care herbal extract of papaya leaves of different concentration at 2MHz frequency have been measured at 298.15K, 303.15K and 308.15K. The data is used to evaluate the ultrasonic parameter such as adiabatic compressibility (β_S), intermolecular free length (L_f), acoustic impedance (Z), relative association (R_A), relative strength (r), relaxation time (τ) etc. These calculated values are interpreted to elucidate the molecular interactions in the liquid mixture.

Keywords: Skin care herbal extract, Papaya leaves, Ultrasonic velocity, Acoustic parameters.

INTRODUCTION

Papaya leaves skin care herbal extract are widely used in the medicinal field. The dried leaf extract was potent against some of the bacteria which standard antibiotics were not able to inhibit. The disparity between the activities of the extract and the standard antimicrobial drug may be due to the mixtures of bioactive compounds present in the extract compared to the pure compound contained in the standard antibiotics. The demonstration of activity against the test bacteria provides scientific bases for the local usage of these plants in the treatment of various ailments[**1-3**].

Ultrasonic technique is the most important and universally accepted technique to study the physical and chemical properties of solution[**4-7**]. The measurement of ultrasonic velocity in liquid and liquid mixtures provides valuable information about the physico chemical parameters and the nature of molecular interaction in them[**8, 9**].

Number of workers have carried out ultrasonic studies of liquid in aqueous as well as non-aqueous medium[**10, 11**]. The Physical and Chemical behavior of solutions and their molecular interactions can be studied by measuring the density, viscosity and ultrasonic velocity [**12**]. Measurements of these parameters with respect to different concentration and temperature at 2MHz frequency will help to determine the acoustic parameters such as adiabatic compressibility (β_S), intermolecular free length (L_f), acoustic impedance (Z), relative association (R_A), relative strength (r), relaxation time (τ) etc.

In the present work, the ultrasonic velocity, density and viscosity of papaya leaves solution in water were measured at 298.15K, 303.15K and 308.15K temperature and 0.25%, 0.5%, and 1% concentration at 2MHz frequency. The experimental data is used for the calculation of various thermodynamic and acoustic parameters by which molecular interaction in solution can be interpreted.

METHODOLOGY

All the chemicals used were of analytical Range. Double distilled water was used for the preparation of solutions. A special thermostatic water bath arrangement was made to maintain constant temperature. 1%, 0.5%, 0.25% solutions of papaya leaves extract were prepared by taking accurate weights on electronic digital balance. (Model CB/CA/CT-series, Contech, having accuracy $\pm$ 0.0001 g).

Ultrasonic velocity through 1%, 0.5%, 0.25% solution of papaya leaves extract in water was measured with the Mittal type (Model,M-83,Mittal Enterprizes) multifrequency ultrasonic interferometer at different frequencies with an accuracy of ± 2 m/s. All the readings were taken at 298.15K, 303.15K, and 308.15K viscosity of solution was measured by Ostwalds viscometer and density of solution was measured by Digital Densitometer (DMA-35, Anton paar).

By using Density, Viscosity and Ultrasonic velocity, following acoustic parameters are calculated,

Adiabatic compressibility:-

$\boldsymbol{\beta_s = 1/v^2\rho}$ Where v = Ultrasonic velocity, ρ = Density.

Specific acoustic impedance:-

$\boldsymbol{Z = v.\rho_s}$ ρ_s = Density of solution

Intermolecular free length:-

$\boldsymbol{L_f = K . \sqrt{\beta}}$ K = Jacobsons constant(631)

β = Adiabatic compressibility of solution

Relative association:-

$\boldsymbol{R_A = \rho_o/\rho_s(v_o/v_s)^{1/3}}$

Relaxation time:-

$\boldsymbol{\tau = 4/3\ \beta\ \eta}$ Where η =Viscosity

Relative strength:-

$\boldsymbol{r = 1 - (v \backslash v_\infty)^2}$ v = velocity, $v_\infty = 1600 ms^{-1}$

RESULTS AND DISCUSSION

The experimentally determined values are listed in following tables.
Variation of density with concentration and temperature of papaya leaves extract is shown in Table No.1 and in Fig.1.The density increases with increasing concentration and decreases with increase in temperature. The increase in values of density with increase in concentration suggests the increase in magnitude of intermolecular interaction like dipole-dipole and hydrogen bond. Increase of concentration result in increase in number of particles in given region which leads shrinkage in volume of solution and hence density increases with increase in concentration. The decrease in values of density with increase in temperature is mainly due to decrease of intermolecular forces due to thermal agitation. Increase in density indicates structure maker property solvent due to added solute.

Variation of viscosity with concentrations and temperatures of papaya leaves extract is shown in Table No.1 and in Fig.2. The viscosity increases with increasing concentration and increases with decrease in temperature. The increasing values of viscosity shows that there is strong attraction between solute and solvent molecules whereas the increase in values of viscosity with decrease in temperature shows increase in intermolecular forces due to increasing the thermal energy of the system. This might be involving association of water molecules with papaya leaves extract. Viscosity increases with decreasing number of small molecules and increasing number of bulk entities or less mobile molecules which is observed in the papaya leaves extract.

Ultrasonic velocity passing through the medium is highly sensitive to the structure and interactions present in the liquid medium because it is fundamentally related to the binding force between the components of the liquid mixture. Ultrasonic velocity measurement provides an important tool to study the liquid state. The ultrasonic velocity values change with concentration in the liquid mixture which can be explained in terms of different types of interactions present in the system.

The measurements of ultrasonic velocity of liquid mixtures are useful to study the strength of molecular interactions in them. The variations in these values of ultrasonic velocity for the solution of papaya leaves extract at 2MHz frequency is shown in Table No.1 and Fig.3. The ultrasonic velocity has close relation with concentration and temperature. In the liquid mixture of papaya leaves extract and water, ultrasonic velocity values increases with increase in concentration at 2MHz shown in Fig.3.

Adiabatic compressibility values are calculated and represented in Table No.2 and Fig.4 From the measured data, it is observed that adiabatic compressibility increases with decrease in concentration of the solute in the liquid mixture. The liquid mixture studied here shows increase in adiabatic compressibility as the concentration decreases which may be due to the hydrogen bond formation. The hydrogen bond formation weakens the intermolecular forces resulting in the increase of adiabatic compressibility which indicates that the molecules are not closely packed.

The Table No.2 and Fig.5 show variation in the values of papaya leaves extract of acoustic impedance at frequency 2MHz. The observed values show molecular interactions between solute and solvent. It is observed from Fig.5 that acoustic impedance values show variations at different temperatures and at different concentration. This indicates the strong molecular interaction like hydrogen bond formation and dipole-dipole interactions between the component molecules. As the concentration increases, the acoustic impedance values increase as shown in Fig.5.

In the papaya leaves extract, the intermolecular free length increases with decrease in concentration. It may be due to increase in the number of bulky solute particles and repulsive forces existed between them shown in the Fig.6, It indicates that as concentration of the system increases at particular temperature, solute molecule and solvent molecules arrange themselves resulting in closed packed structure may be due to the formation of hydrogen bond between them. Due to this closed packed arrangement, distance between these molecule decreases and intermolecular free length decreases.

Table 1: Density, Viscosity and Ultrasonic velocity (at frequency 2MHz) of papaya leaves extract solution

Sr. No.	Temp. (K)	Conc. (%)	Density ρ (Kg/m^3)	Ultrasonic velocity Vs (m/s)	Viscosity $\times 10^{-3}$ η (Kg m^{-1} s^{-2})
1	298.15	1	1002	2098.9	0.4884
		0 .5	999.3	2000.63	0.4635
		0.25	997.6	1759.56	0.4706
2	303.15	1	1001.8	1819.5	0.4458
		0.5	999.2	2000.68	0.4291
		0.25	997.4	1719.84	0.4361
3	308.15	1	1001.4	2043.44	0.4106
		0.5	999	2049.06	0.3944
		0.25	997.1	1910.32	0.3937

Table 2: Acoustic Parameters of papaya leaves extract solution in water at 2MHz.

Sr. No.	Temp. (K)	Conc. (%)	Adiabatic compressibility $\beta_s \times 10^{-5}$ (pa^{-1})	Specific acoustic impedance $Z \times 10^5$ (Kgm^{-2} Sec^{-1})	Intermolecular free length(m) $L_f \times 10^{-8}$	Relative association R_A	Acoustic relaxation time τ x10^{-8}	Relative strength (r)
1	298.15	1	22.74	21.03	2.96	0.964	1.48	-0.72
		0 .5	24.96	19.99	3.10	0.982	1.54	-0.56
		0.25	32.22	17.55	3.52	1.027	2.02	-0.20
2	303.15	1	30.26	18.22	3.44	1.016	1.79	-0.29
		0.5	24.96	19.99	3.12	0.987	1.42	-0.56
		0.25	33.72	17.15	3.63	1.040	1.96	-0.15
3	308.15	1	23.98	20.46	3.09	0.978	1.31	-0.63
		0.5	23.79	20.47	3.08	0.980	1.25	-0.64
		0.25	27.32	19.04	3.30	1.005	1.43	-0.42

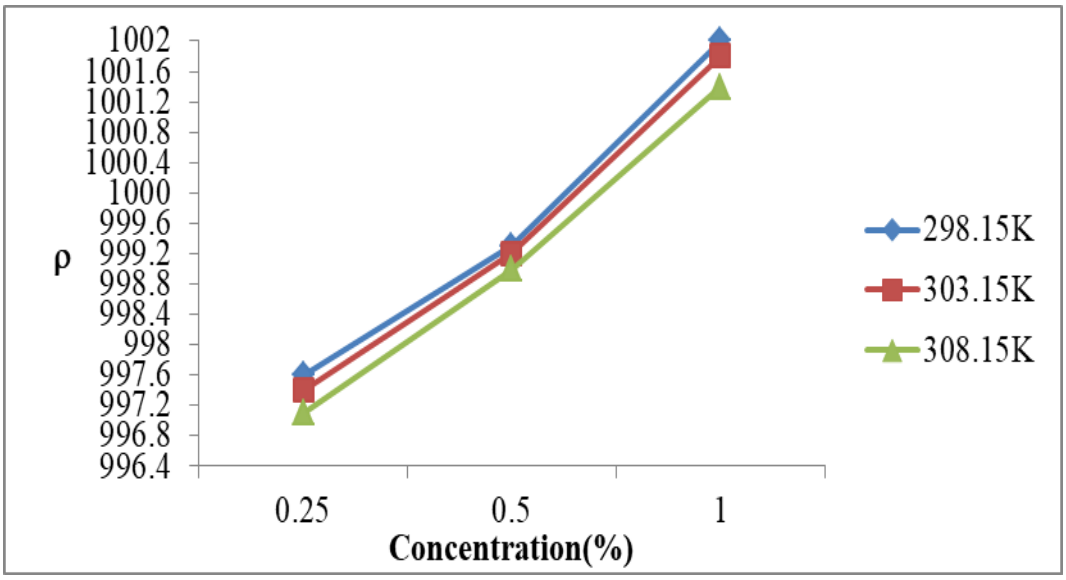

Fig. 1: Density (ρ) Vs Concentration

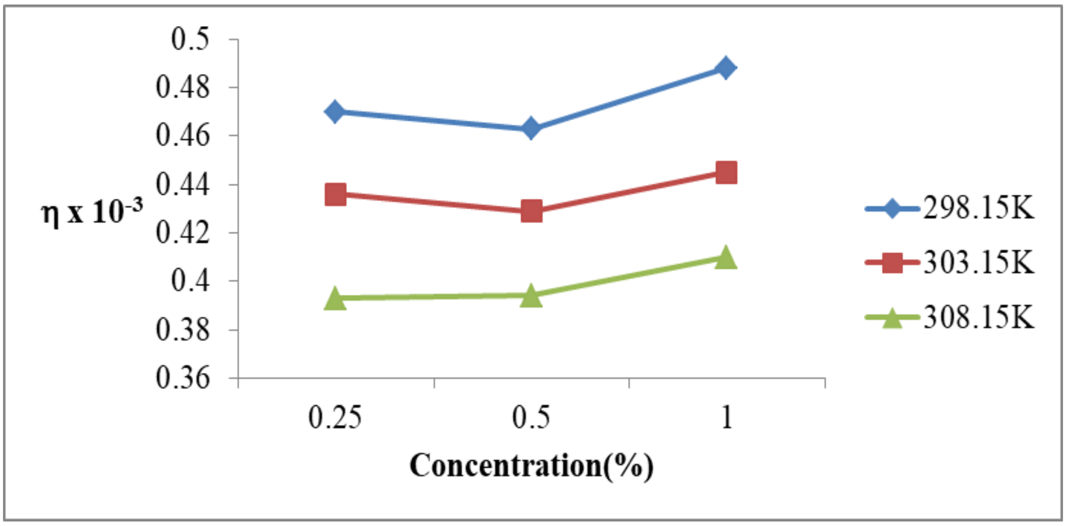

Fig. 2: Viscosity (η) Vs Concentration

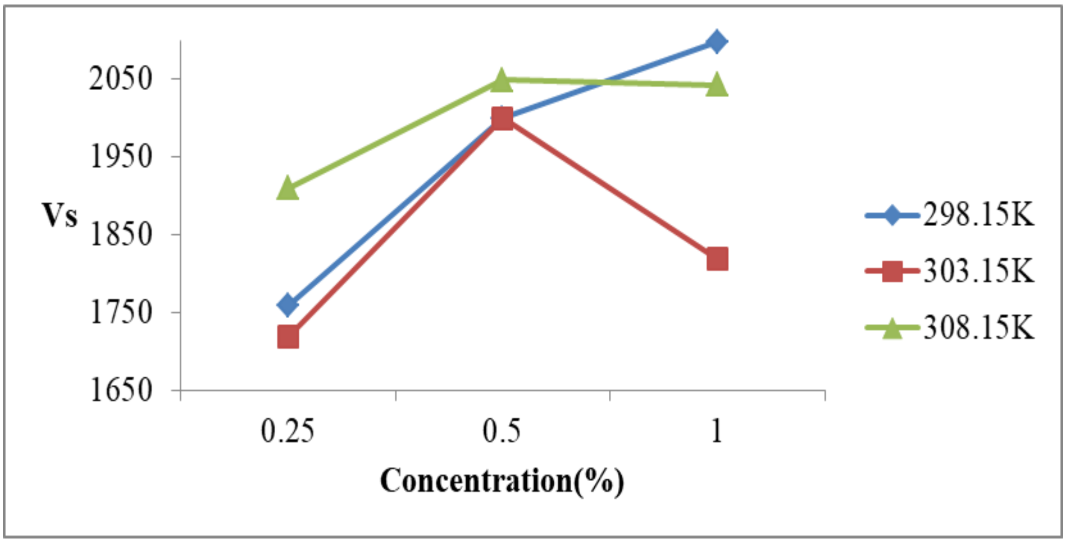

Fig. 3: Ultrasonic Velocity (Vs) Vs Concentration at 2MHz

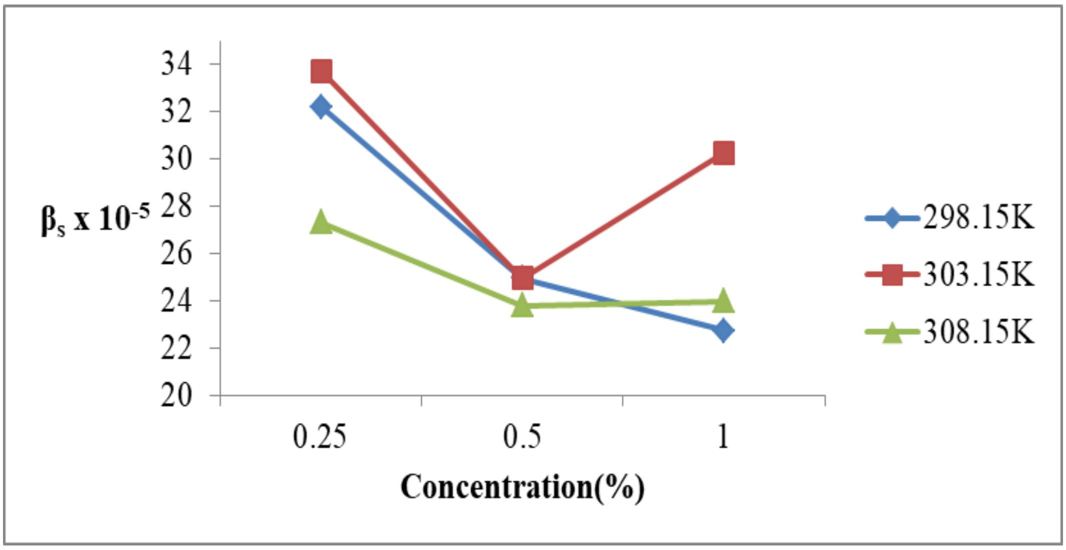

Fig. 4: Adiabatic Compressibility (β_s) Vs Concentration at 2MHz

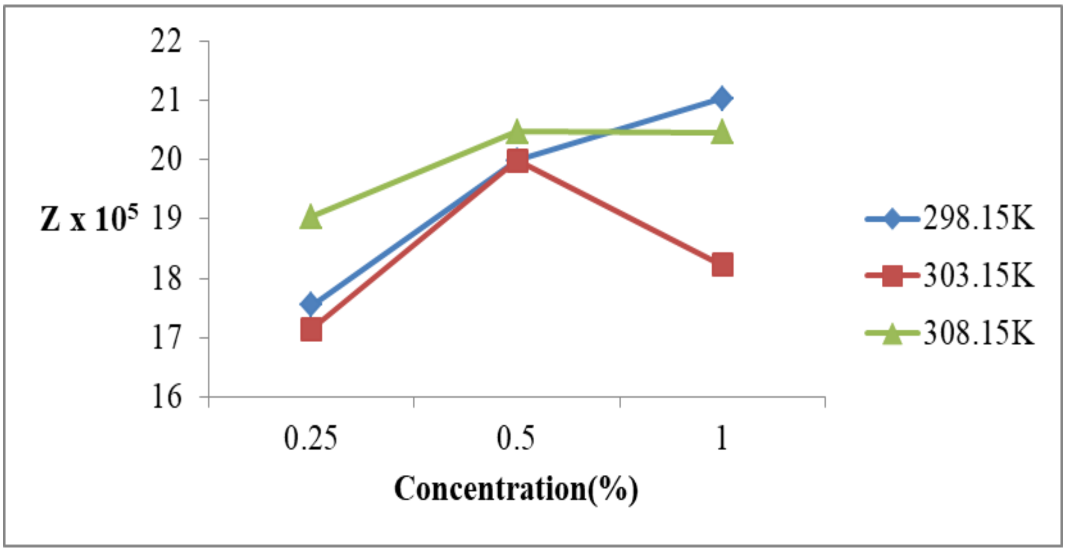

Fig. 5: Acoustic Impedance (Z) Vs Concentration at 2MHz

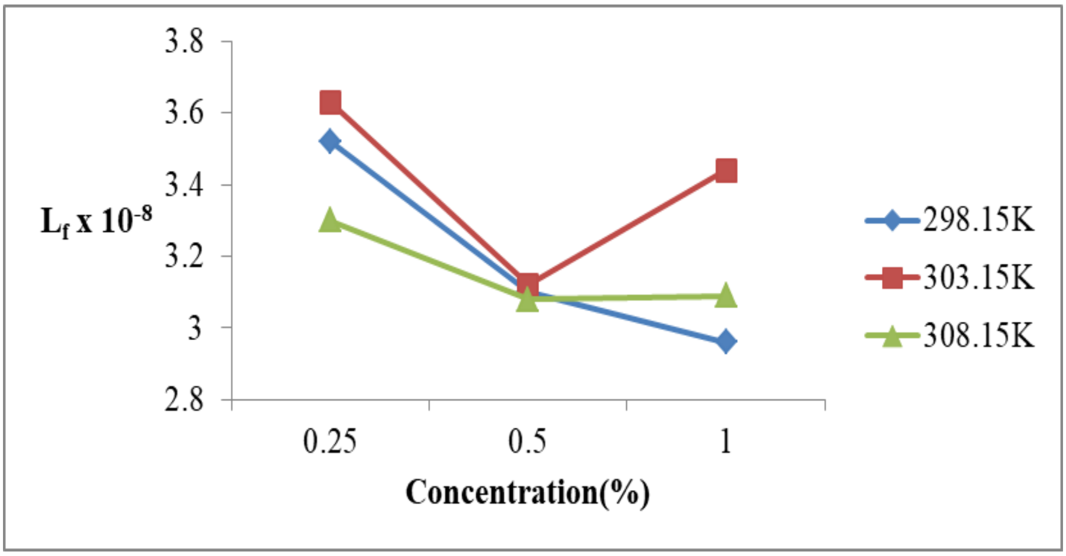

Fig. 6: Intermolecular Free Length (L_f) Vs Concentration at 2MHz

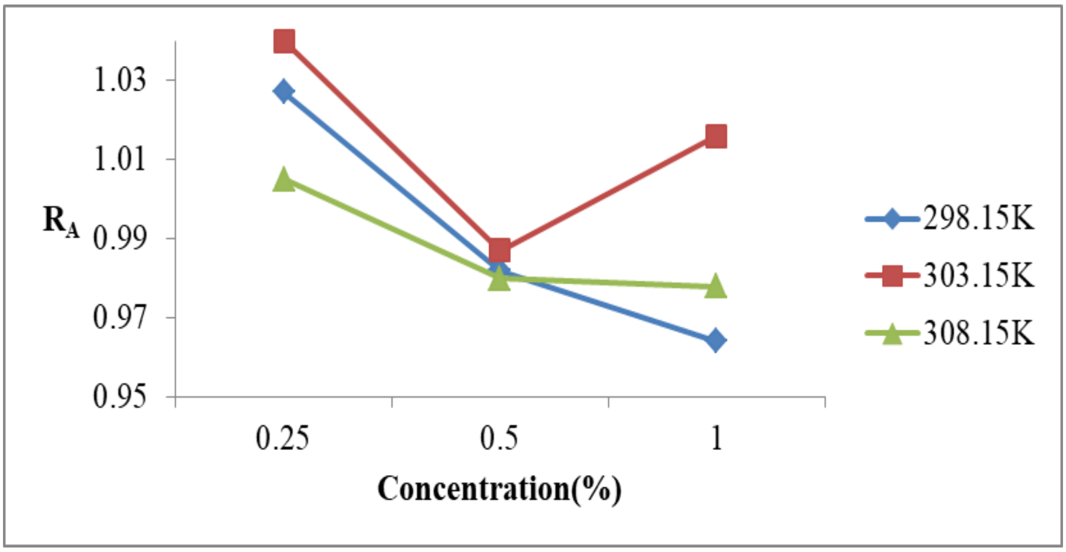

Fig. 7: Relative Association (R_A) Vs Concentration at 2MHz

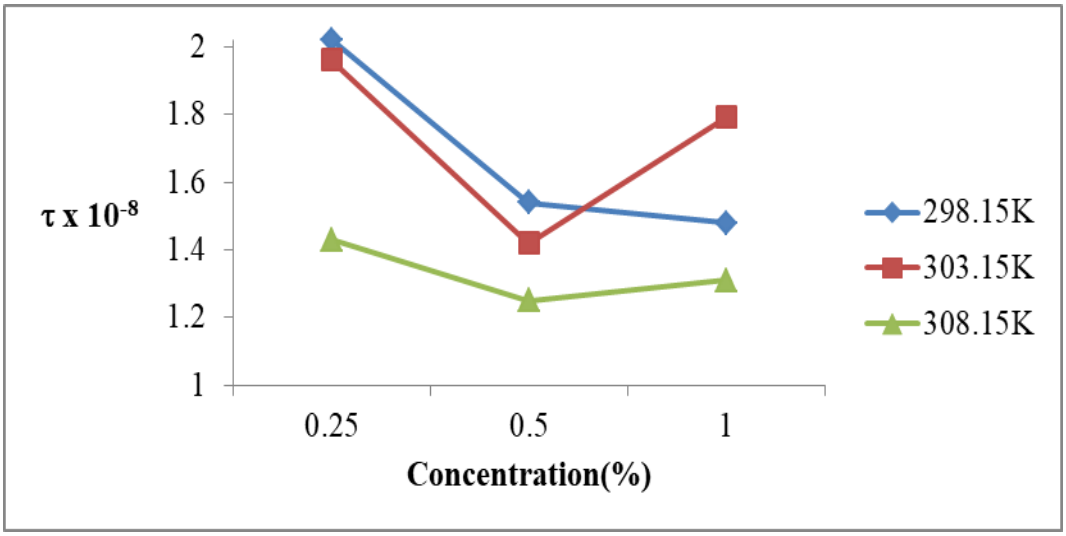

Fig. 8: Acoustic Relaxation Time (τ) Vs Concentration at 2MHz

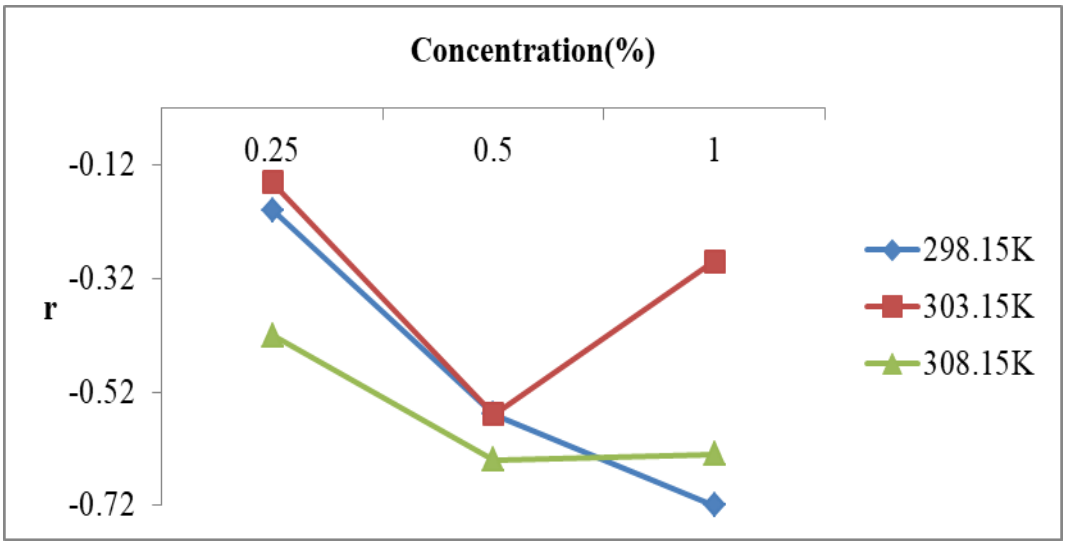

Fig. 9: Relative Strength (r) Vs Concentration at 2MHz

The values of relative association (R_A) of papaya leaves extract are calculated and show in Table No.2 and Fig.7. The property relative association is useful to study and understand the molecular interactions. Mainly it is influenced by Breaking up of the associated solvent molecules on addition of solute in it and the salvation of solute molecule. The former leads to the decrease and later to the increase of relative association. It is seen that the values of relative association decrease with increase in concentration. It may be association of solvent molecules with solute molecules which shows the weak solute-solvent intermolecular interaction than solvent–solvent intermolecular interactions. The value of relative association decreases with increase in concentration shown in Fig.7 at 2MHz frequency.

The values of acoustic relaxation time (τ) are calculated for the papaya leaves extract at 298.15K, 303.15K and 308.15K. These values are given in Table No.2 and shown in Fig.8. It is found that for the solution of papaya leaves extract, acoustical relaxation time (τ) increases with decrease in concentration at frequency 2MHz. The variation in the acoustic relaxation time with concentration indicates that it is due to the changes in the viscosity of the solution due to both concentration and temperature. Increase in values of acoustic relaxation time with concentration may be due to salvation process of solvent molecules suggesting solute-solvent interaction.

The values of relative strength (r) are calculated for the papaya leaves extract at 298.15K, 303.15K and 308.15K. These values are given in Table No.2 and shows in Fig.9. It is found that for the solution of papaya leaves extract, relative strength (r) increases with decrease in concentration at frequency 2MHz. The variations with temperature are not regular. The effect of increases in the temperature appears to increase the excess properties suggesting the presence of specific molecular interaction.

The variation in the acoustical parameters with temperature and concentration for papaya leaves extract in water suggests that there are strong solute-solvent interactions at 2MHz frequency.

Conflicts of interest: The authors stated that no conflicts of interest.

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