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Study On Thermoacoustic Properties Of Binary Liquid Mixtures Of α-Campholenic Aldehyde With 1-Propanol

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Abstract:
Background: *The ultrasonic velocity (u), density (ρ), and viscosity (η) of binary liquid mixtures of α-Campholenic Aldehyde (α-CPA), a terpene based key ingredient widely used in perfume industries, with 1-propanol have been measured at different temperatures for various solute-solvent concentrations. The experimental values of these fundamental acoustic parameters were obtained for each liquid combination and the results were then interpreted to confirm the said interactions. These values were further used to calculate some other allied parameters and enumerated in terms of molar concentration and temperatures. The acoustical characteristics used imply a significant relationship of these with both concentration as well as temperature taken for binary mixtures*.
Keywords: *Ultrasonic velocity, Viscosity, Density, 1-propanol, molecular interactions.*

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I. Introduction

The ultrasonic studies [1-8] have been extremely useful for gaining a deeper understanding of molecular interactions and the structural behaviour of molecules when mixed together. The measurement of fundamental parameters ultrasonic velocity, density and viscosity of binary mixtures has provided an enormous amount of information on molecular interactions and their structural behaviour between solute and solvent. Chemicals derived from terpenes and those obtained from their oxygenated derivatives are valuable chemicals that find applications in the food, fragrance, flavour and pharmaceutical industries [5]. α-CPA is a colourless clear to pale yellow terpene-based perfumery ingredient widely used as an effective substitute of naturally occurring perfumery compound. Further, the alcohols have been extensively studied as solvents in binary and ternary mixtures, the data on binary mixtures of alcohols with α-CPA with temperature variation is scanty. The molecules containing the –OH groups will form associative liquids due to hydrogen bonding. To understand hydrogen bonding, an understanding of the effects of molecules with other functional groups is essential. Alcohols are strongly associated in solution because of dipole–dipole interaction and hydrogen bonding. They are excessively use in chemistry, biology and studies on hydrogen bonding in liquid mixtures. Alcohols are extensively used as solvents. In the view of its abundant utility, we have planned to study of its binary mixture with α-CPA.

II. Experimental details

The chemicals used as a solvent was purchased from S. D. Fine Chemicals, India. Binary mixtures were prepared by weighing the liquids from electronic balance of sensitivity 0.0001 g in weighing bottles. After that, a stock solution was prepared which was diluted to different desired molar concentration. The densities and viscosities of the liquids have been measured at two temperatures with a specific gravity bottle and Cannon Fenske viscometer. An electrically operated constant temperature circulating water bath (Mittal Enterprises, New Delhi) was used to keep the temperature constant during the experimental observations. The ultrasonic velocities were determined by using a single frequency ultrasonic interferometer of frequency 2 MHz (Model: F-05 Mittal Enterprises, New Delhi). For accurate calibration of instruments, the values of density (ρ), viscosity (η) and ultrasonic velocity (u) of pure 1-propanol was determine at 303.15 K which is found very close to the standard data prescribed in the available literatures [9, 10].

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III. Results and discussions

The experimental values of density, viscosity and ultrasonic velocity of the binary mixtures of α-CPA with 1-propanol measured at two temperatures as a function of molar concentration are listed in Table I. These fundamental measured values are further used to compute the derived parameters, such as adiabatic compressibility (κ), acoustic impedance (Z), molecular free length (L_f) and molar volume (V_m). The expressions used for the calculation of derived parameter, which are available in literature [11, 12] are as follows-

Adiabatic compressibility $\kappa = \frac{1}{\rho u^2}$ $---------(1)$

Acoustic impedance $Z = \rho u$ $---------(2)$

Molecular free length $L_f = \frac{K_T}{u\rho^{1/2}}$ $---------(3)$

Molar volume of the liquid mixture $V_m = \frac{\bar{M}}{\rho}$ $---------(4)$

Where $\bar{M}$ is mean molecular weight of the mixture and $K_T = (93.875 + 0.345T)\times10^{-8}$.

With the help of the above equations, the drive parameters are calculated and plotted as function of molar concentration at two different temperatures as shown in figure below. Further, it can be seen from the table that the measured values of density, viscosity and ultrasonic velocity at both temperatures increase with the increase in molar concentration of α-CPA. However, these values decrease with the increase in temperature. The variation in the measured value of fundamental parameters can be attributed to the intermolecular interaction in the binary mixture. The increase in adiabatic compressibility with the increase in temperature and decreases with the increase of solute concentration indicate the interactions between solvent-solute due to aggregation of solvent molecules around solute molecules [13]. The increasing trend of acoustic impedance shows increase of restriction with concentration of solute and confirms the presence molecular interactions between the molecules of the binary mixture. Further, it is well known that intermolecular free length is most important tool to predict the molecular interactions in the binary mixtures. Eyring and Kincaid model [14] proposed that ultrasonic velocity increases with the decrease in intermolecular free length and vice-versa in a binary mixture, supporting the present findings. The molar volume is found to be increases with concentration of solute however very small difference is observed corresponding to different temperatures.

Table: The measured values of density (ρ), viscosity (η) and ultrasonic velocity (u) of binary mixtures in terms of molar concentration at different temperatures.

Conc. (Moles/L) (M)	**ρ×10³ (kg/m³)**		**η (mPa.s)**		**u (ms⁻¹)**	
	298.15 K	303.15 K	298.15 K	303.15 K	298.15 K	303.15 K
0.0	0.8006	0.7954	1.625	1.59	1205.2	1191.2
0.1	0.8015	0.7962	1.658	1.627	1208.2	1193.2
0.2	0.8026	0.7974	1.692	1.662	1211.0	1195.2
0.3	0.8038	0.7985	1.721	1.690	1215.2	1196.8
0.4	0.8046	0.7994	1.752	1.725	1220.6	1200.2
0.5	0.8056	0.8005	1.786	1.758	1223.0	1203.0
0.6	0.8068	0.8019	1.821	1.788	1226.2	1206.8
0.7	0.8085	0.8032	1.852	1.815	1229.6	1208.2
0.8	0.8098	0.8046	1.886	1.849	1232.0	1211.6
0.9	0.8121	0.8062	1.922	1.878	1236.2	1214.8
1.0	0.8142	0.8092	1.952	1.907	1240.2	1218.0

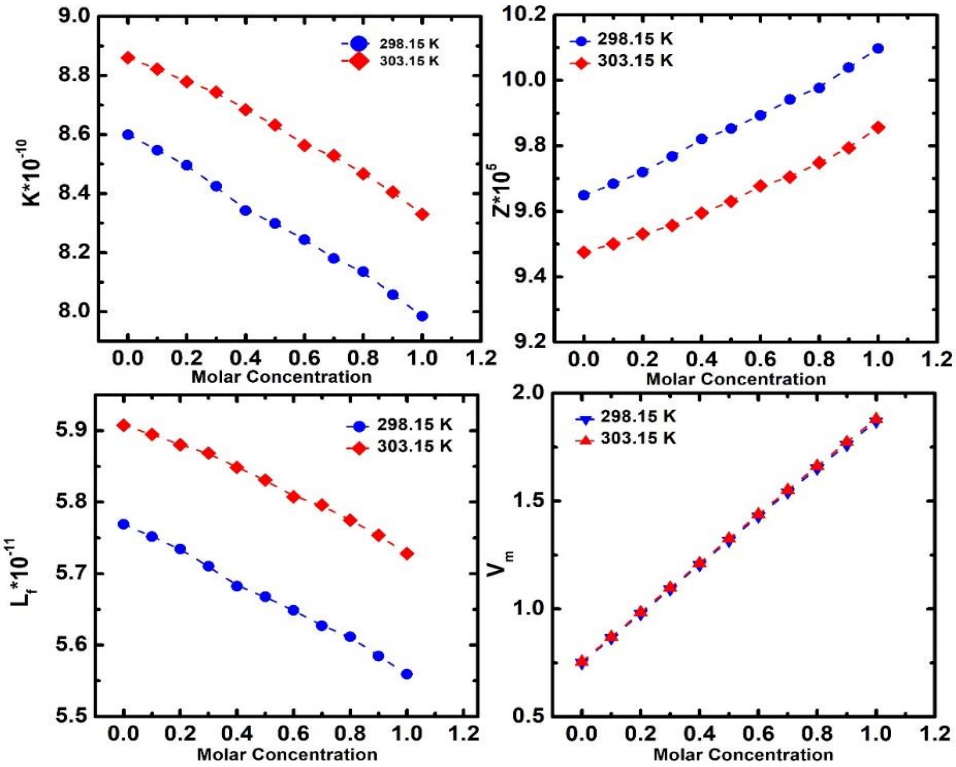

Figure: Variation in κ, *Z*, L_f and V_m as a function of molar concentration and at different temperatures (298.15, and 303.15 K).

IV. Conclusion

The experimental values of density, viscosity and ultrasonic velocity for the binary mixtures of 1-propanol with α-CPA at 298.15 and 303.15 K are measured in different compositions of solute. Variation in experimentally measured and derived parameters values confirms the presence of molecular interaction between the molecules of the binary mixtures. All the fundamental parameters are found to increase with molar concentration and decrease with the increase of temperature. L_f increases with the increase of temperature thereby increasing the distance between surface of the two molecules. The L_f is large, ultrasonic velocity has a low value at the same temperature. The molar volume is found to be increases with concentration of solute however very small difference is observed corresponding to different temperatures. The linear variation in the measured values show the absence of any complex mixture formation in experimental molar concentration range.

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