



Physico-chemical analysis on liquid mixtures of aqueous solutions of lithium sulphate and lithium hydroxide at different temperatures

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Abstract

The present communication reports the experimental values of the density, ultrasonic velocity and viscosity of the various compositions of liquid mixtures of aqueous solutions of Lithium sulphate (Li_2SO_4) and Lithium hydroxide (LiOH) at 303, 308, 313 and 318K. From these experimental measurements the thermo-acoustical parameters such as acoustic impedance (Z) and adiabatic compressibility (β_{ad}) has been calculated. The variations in these parameters have been correlated to derive the intermolecular interactions taking place between the mixtures of present study.

Keywords: viscosity, ultrasonic velocity, adiabatic compressibility and acoustic impedance

Introduction

Ultrasonic investigation techniques have become a powerful tool in providing information regarding physicochemical properties of the liquid mixtures [1-2]. These physicochemical properties of liquid mixtures are having great importance in the field of science and industrial engineering for developing reliable predictive models for understanding the nature of intermolecular interactions in the mixtures [3-5].

The aim of present study is to investigate the variation of thermo acoustical parameters of binary liquid mixture of aqueous solutions of Lithium sulphate and Lithium hydroxide with molar concentrations and temperatures. The variation of these parameters with molar concentration may be helpful in pharmaceutical and food industries to prepare various drug dosages, solution, tablets, capsule, gel and injection in solution form [6-9].

Materials and Methods

Aqueous solution (1N) of LiOH and Li_2SO_4 were prepared with double distilled water. The chemicals used were of analytical grade (Merk>99%). The solutions were left for sufficient time to allow them to have complete ionization. The binary mixtures of desired compositions were prepared by mixing known volumes of two prepared solutions. The ultrasonic velocities were measured at 2MHz with a single crystal variable path interferometer (F-81 D Mittal make) with an accuracy of 0.01%. The densities of aqueous solutions and mixtures were measured with a pycnometer of bulb volume 10cc. The viscosity of the liquids was measured by an Ostwald Viscometer.

The density and ultrasonic velocity for all binary mixtures were measured experimentally. Various acoustic parameters like, adiabatic compressibility (β_{ad}) and specific acoustic impedance (z) were evaluated from the measured values of ultrasonic velocity (u) and density (ρ) using following relations [10-15]

$$u = \lambda f \quad (1)$$

$$\beta_{ad} = \frac{1}{u^2 \rho} \quad (2)$$

$$z = u\rho \quad (3)$$

Where λ is wave length, f is the frequency of ultrasonic wave, and ρ is the density of solution.

Results and Discussion

The experimental values of density, ultrasonic velocity, viscosity, adiabatic compressibility and acoustic impedance with the varying mole fractions of the binary mixture and with the varying temperature are presented

in tables 1. The variations of these parameters with varying mole fraction are also presented in figure 1 to 5 for the binary mixtures.

Table 1: Values of Density, Viscosity and Ultrasonic velocity for the binary mixture of LiOH and Li₂SO₄ with varying mole fraction

Mole fraction of Li ₂ SO ₄	Temperature °K	Density (g/cm ³)	Viscosity (CP)	Ultrasonic velocity (m/s)	Adiabatic Compressibility (×10 ⁻¹⁰ Kg ⁻¹ ms ²)	Acoustic Impedance (×10 ³ kg/m ² /sec.)
0.0	303	1.02324	1.0308	1590.015	3866	1626.97
	308	1.02049	0.9456	1596.798	3843	1629.52
	313	1.01841	0.8562	1605.576	3809	1635.13
	318	1.01626	0.8024	1609.965	3796	1636.14
0.2	303	1.02684	1.0414	1584.030	3881	1626.55
	308	1.02428	0.9561	1592.606	3849	1631.27
	313	1.02217	0.8663	1599.990	3822	1635.46
	318	1.02013	0.8120	1604.162	3809	1636.45
0.4	303	1.03036	1.0625	1578.656	3894	1626.58
	308	1.02810	0.9753	1584.838	3873	1629.37
	313	1.02600	0.8836	1592.424	3844	1633.83
	318	1.02390	0.8278	1598.909	3820	1637.12
0.6	303	1.03399	1.0306	1581.636	3866	1635.40
	308	1.03187	0.9442	1588.237	3842	1638.85
	313	1.02990	0.8605	1597.434	3805	1645.20
	318	1.02770	0.8024	1602.419	3789	1646.81
0.8	303	1.03757	1.0678	1577.681	3872	1636.95
	308	1.03560	0.9796	1585.992	3839	1642.45
	313	1.03369	0.8875	1593.434	3810	1647.12
	318	1.03153	0.8254	1599.616	3789	1650.05
1.0	303	1.04111	1.0810	1575.651	3869	1640.43
	308	1.03942	0.9923	1585.626	3827	1648.13
	313	1.03751	0.8999	1592.800	3799	1652.55
	318	1.03539	0.8407	1598.394	3780	1654.96

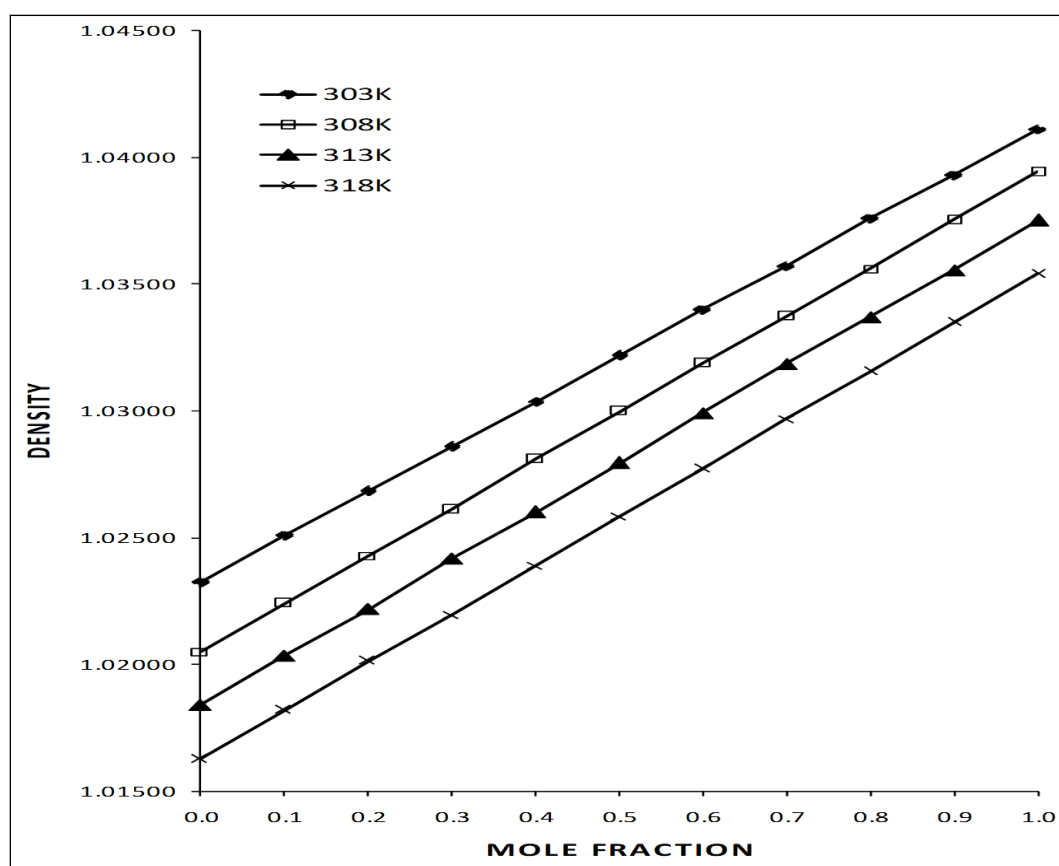


Fig 1: Variation of Density (gm/cm³) for the binary mixture of LiOH & Li₂SO₄ with varying mole fraction

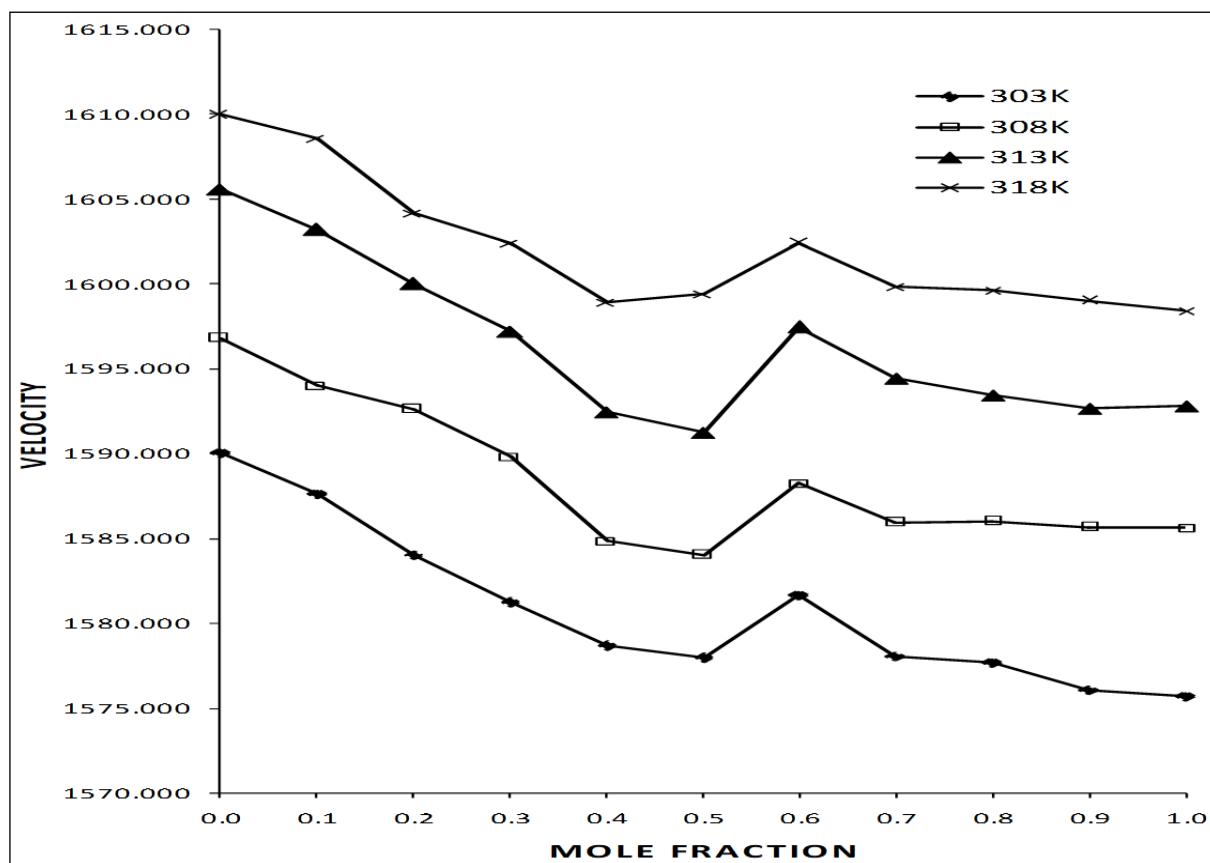


Fig 2: Variation of Ultrasonic Velocity (m/s) for the binary mixture of LiOH & Li₂SO₄ with varying mole fraction

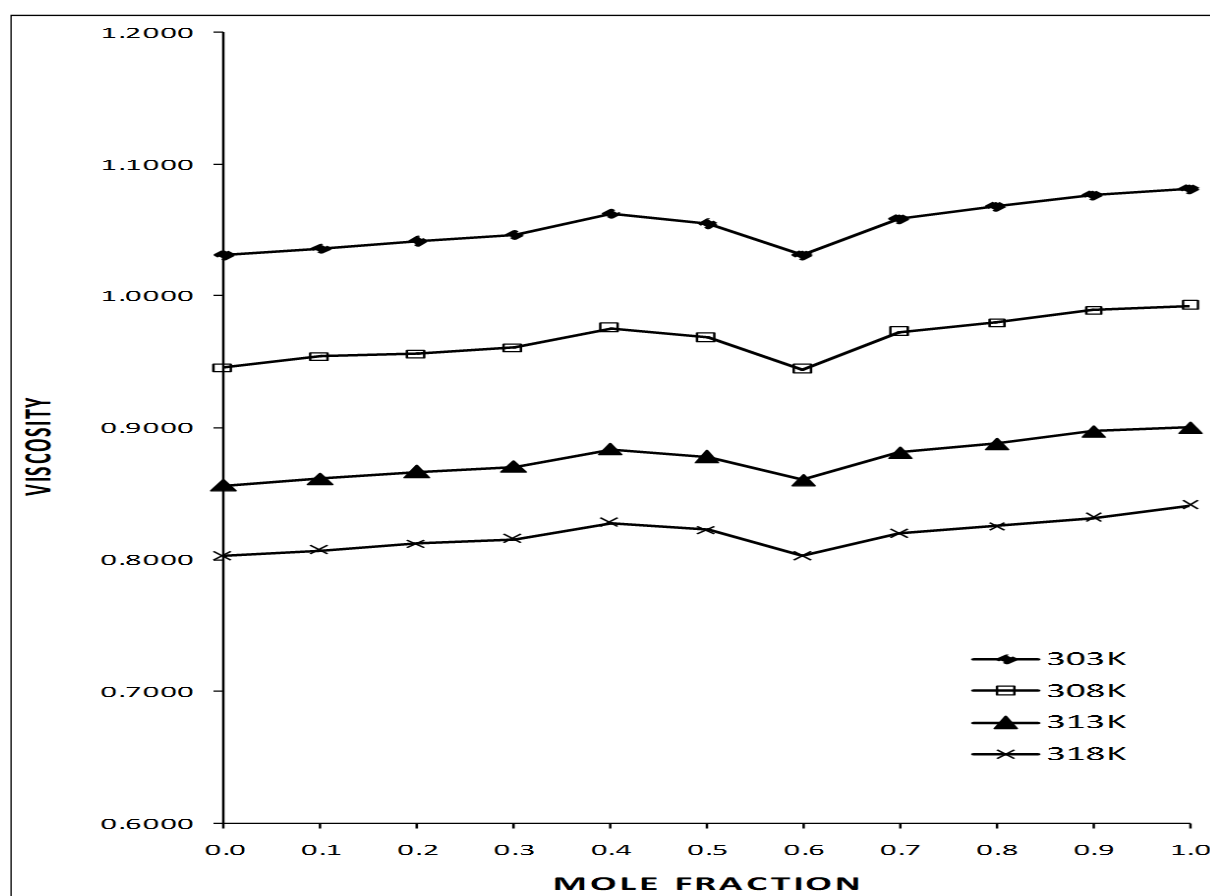


Fig 3: Variation of Viscosity (centipoise) for the binary mixture of LiOH & Li₂SO₄ with varying mole fraction

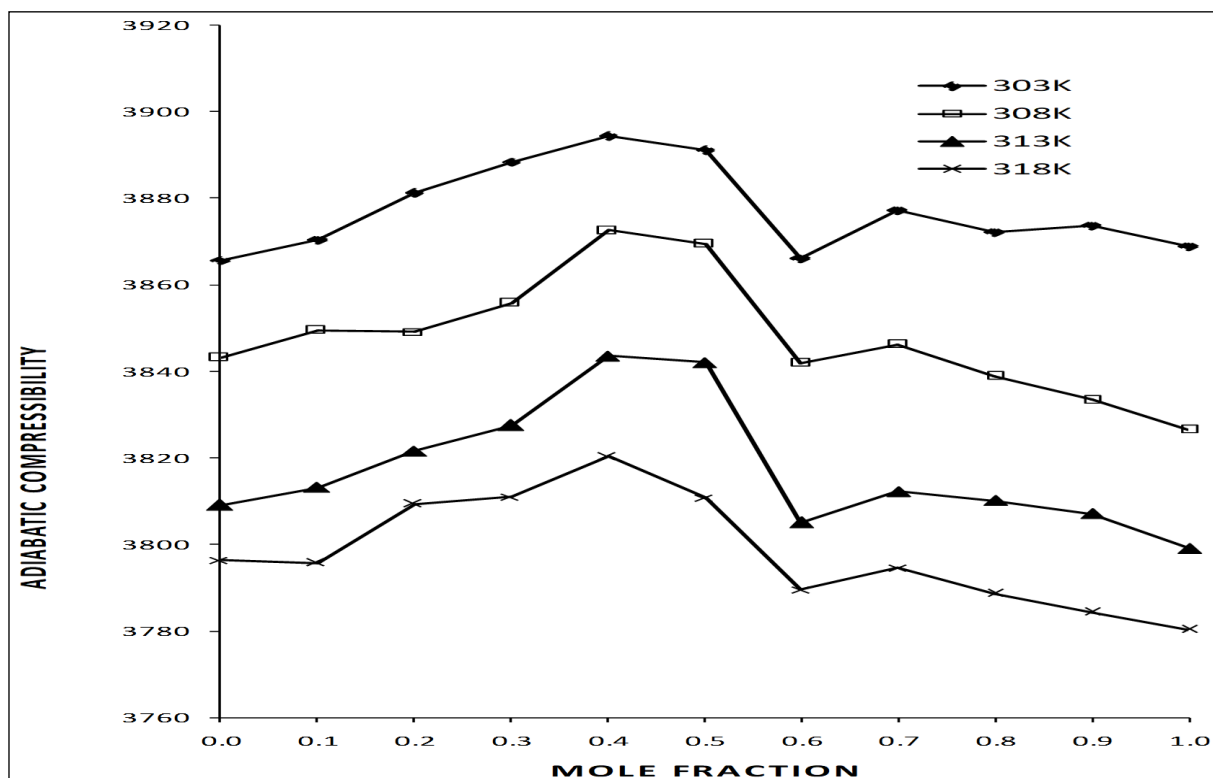


Fig 4: Variation of Adiabatic Compressibility ($\times 10^{-10} \text{ Kg}^{-1} \text{ ms}^2$) for the binary mixture of LiOH & Li_2SO_4 with varying mole fraction

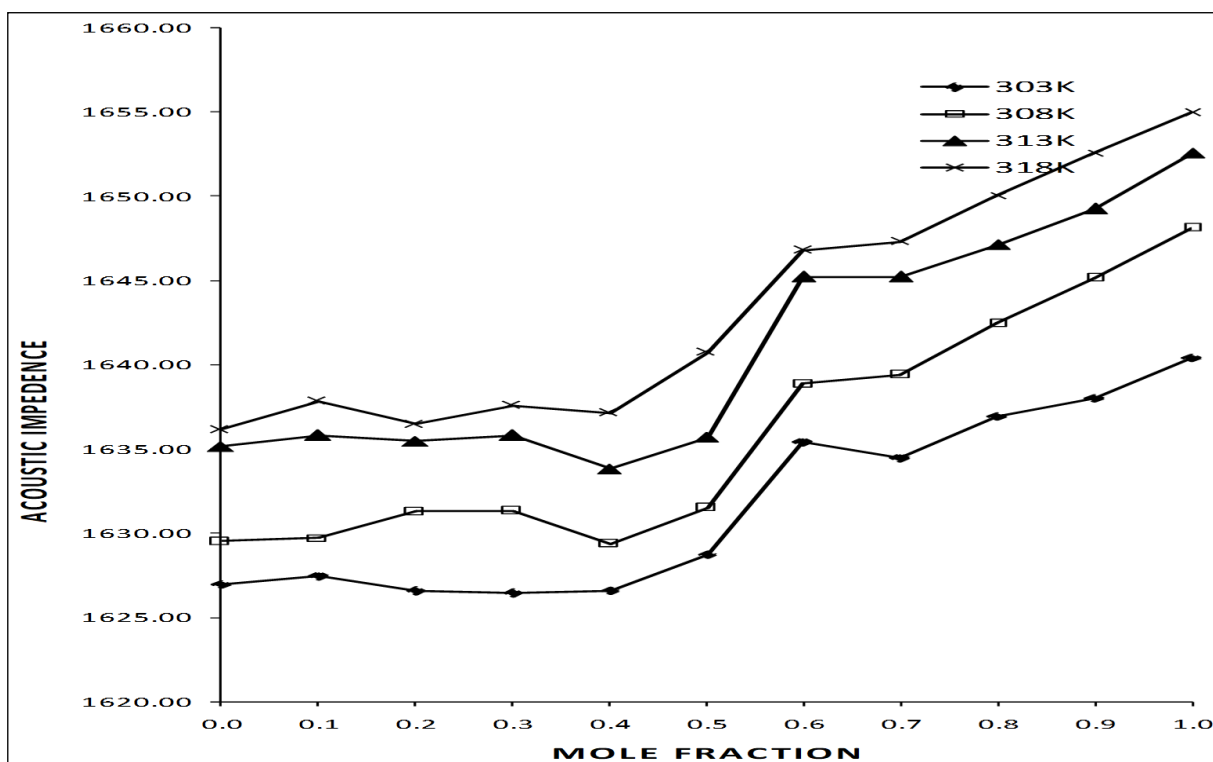


Fig 5: Variation of Acoustic Impedance ($\times 10^3 \text{ kg/m}^2/\text{sec.}$) for the binary mixture of LiOH & Li_2SO_4 with varying mole fraction

Density

The density of binary mixture increases linearly as the mole fraction of Li_2SO_4 is increased in solution. Figure 1 shows that the variation of density with mole fraction of Li_2SO_4 is almost linear. The density increases due to the increase in number of heavier sulphate ions in mixture [16]. As the temperature is increased the density of mixture gets decreased.

Ultrasonic velocity

The ultrasonic velocity as indicated in figure 2 is found decreasing non-linearly with increasing mole fraction of Li_2SO_4 indicating that the ultrasonic velocity decreases with density of solution but at the specific mole fraction 0.6 of Li_2SO_4 the ultrasonic velocity increases, probably at this mole fraction, a complex is formed that does not allow the ultrasonic wave to travel freely in the solution and hence the ultrasonic velocity decreases. On further increasing the mole fraction of Li_2SO_4 (above 0.6) the velocity again decreases nonlinearly. The increase in the velocity at this specific mole fraction shows some significant interaction between the solute and solvent molecules. The similar behaviour has earlier been reported by some other workers [17, 18].

Viscosity

Viscosity increases non-linearly with increasing the mole fraction of Li_2SO_4 . The increase in viscosity of the solution on increasing salt concentration is confirmed by some other workers [19-20]. At mole fraction 0.6 of Li_2SO_4 the viscosity shows a sudden decrease in its value. On increasing the temperature, the viscosity of mixture decreases for all mole fractions and the amount by which the viscosity suddenly decreases at complex forming mole fraction 0.6 is more at higher temperature.

Adiabatic compressibility

The adiabatic compressibility (β_{ad}) is a measure of inter molecular association or repulsion due to the presence of unlike molecules in the solution. The variation of adiabatic compressibility with mole fraction of Li_2SO_4 is shown in figure 4. The compressibility increases with increasing mole fraction of Li_2SO_4 in the solution and attains a sudden fall at 0.6 mole fraction of Li_2SO_4 . On further increasing the mole fraction it starts decreasing. The reverse behaviour of compressibility occurs because of the structural changes present in the mixtures that bring the molecules to a close packing [21]. The presence of velocity maxima and compressibility minima at same mole fraction of Li_2SO_4 supports the existence of complex formation through hydrogen bonding to be maximum at that concentration.

Acoustic impedance

When ultrasonic wave travels through a solution certain part of it travels through the solution and rest gets reflected by the ions [22, 23]. The characteristic that determines the backward movement of wave is known as acoustic impedance (z). As shown in figure 5 the acoustic impedance is found to increase with increasing mole fraction of Li_2SO_4 in solution. The higher impedance indicates the presence of bulkier solvated (Li_2SO_4) ions, due ion-solvent interaction that restricts the free flow of ultrasonic wave. The variation of acoustic impedance (z) further proves the formation of complex at (0.6) mole fraction of Li_2SO_4 .

Conclusion

The nonlinear variation of ultrasonic velocity and associated acoustical parameters gives the idea of solute-solvent interaction and complex formation in the binary mixture of $\text{Li}(\text{OH})$ and $\text{Li}_2(\text{SO}_4)$. The variation of ultrasonic velocity with temperature indicates breaking of hetero and homo association of molecules in the binary liquid mixtures.

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