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Viscosities of lithium chloride in different composition of lactose at different temperatures

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ABSTRACT

Relative viscosities for the solutions of lithium chloride in 2, 4 and 6 wt. % lactose at different temperatures i.e. 303.15K, 308.15K, 313.5K and 318.15K have been determined. The data have been evaluated using the Jones–Dole equation and transition state theory of relative viscosity of electrolytic solutions and the obtained parameters have been interpreted in terms of solute–solute and solute–solvent interactions. The activation parameters of viscous flow have been obtained which depicts the mechanism of viscous flow. Lithium chloride behaves as structure breaker in 2, 4 and 6 wt. % lactose at different temperatures i.e. 303.15K, 308.15K, 313.5K and 318.15K.

Keywords: Viscosities, lithium chloride, lactose, structure-breaker.

INTRODUCTION

The thermodynamics and transport properties of dilute solutions provide information about solute solute and solute - solvent interactions and can be used for the development of molecular models for describing the thermodynamic behavior of solutions. Studies on viscosities of ionic solutions are of great help in characterizing the structure and properties of solutions. Various types of interactions exist between the ions in the solutions and of these, ion–ion and ion–solvent interactions are of current interest in all the branches of chemistry. These interactions help in better understanding of the nature of solute and solvent, i.e. whether the solute modifies or distorts the structure of the solvent. The solution structure is of great importance in understanding the nature of bioactive molecules in the body system. The survey of literature [1–20] show that although many studies have been carried out for various electrolytic solutions, little attention has been paid to the behavior of lithium chloride in different composition of lactose at different temperatures. Such data are expected to highlight the role of lithium chloride in different composition of lactose in influencing the viscosity *B*-coefficient, in different composition of lactose. Hence, the present investigation has been undertaken to provide better understanding of the nature of lithium chloride in different composition of lactose and to throw light on solute–solvent interactions.

MATERIALS AND METHODS

Water used for solutions had specific conductance in range 0.1- 1.0 × 10⁻⁶ Ω⁻¹cm⁻¹. Lithium chloride and lactose (Anala R) were dried over anhydrous calcium chloride for more than 48h and used as such. All the solutions were prepared by weight and conversion of molality to molarity was done by using the standard expression [21]. The concentration range of lithium chloride in 2, 4 and 6 wt. % of lactose solutions was 0.01 to 0.12 m. The density was measured with the help of DSA (Density and Sound Analyser) 5000, AntonPaar, GmbH, Garz, Austria. Viscosity

was determined with the help of capillary type Viscometer [22]. All measurements were made in a water bath maintained at 303.15K, 308.15K, 313.5K and 318.15K.

RESULTS AND DISCUSSION

The experimental results of relative viscosities (Table I) has been analyzed on the basis of Jones- Dole equation [23]

$$\frac{\eta_s}{\eta_o} = 1 + A\sqrt{C} + BC \quad (1)$$

Where η_s and η_o are viscosities of solution and solvent respectively, C is the molar concentration and A and B are constants. The values of A and B have been determined from the intercept and slope of linear plots of $(\eta_s/\eta_o - 1)/\sqrt{C}$ versus \sqrt{C} . The sample plot of $(\eta/\eta_o - 1)/C^{1/2}$ for lithium chloride in 2 % lactose at different temperatures is shown in figure I. The values of A and B of different solutions are recorded in Table II.

Parameter A of Jones-Dole equation represents the contribution from solute-solute interactions [24]. The values of A, shows that ion-ion interactions for lithium chloride in different composition of lactose solutions decreases with increase in temperature, which may be due to more solvation of solute ions.

The B parameter which measures the structure making/breaking capacity of an electrolyte in a solution also contain a contribution from structural effects and is responsible for solute-solvent interactions in a solvent [25]. It has been emphasized by a number of workers that dB/dT is an important criteria [26] for determining the solute-solvent interactions. Viscosity study of a number of electrolytes has shown that structure-maker will have negative dB/dT and structure-breaker will have positive dB/dT. The temperature effect on B - coefficient for lithium chloride in different composition of lactose solutions shows a positive sign of dB/dT thus behaves as structure-breaker in 2, 4 and 6 wt. % lactose. The sample plot of B versus T for lithium chloride in 2 wt. % of lactose solution is shown in fig. II.

Transition State Theory:

Viscosity data has also been analysed on the basis of transition state theory of relative viscosity of electrolytic solutions as suggested by Feakins *et al.* [27-28]. The values of $\Delta\mu_1^0$ (Free energy of activation per mole of solvent) and $\Delta\mu_2^0$ (Free energy of activation per mole of solute) is calculated by using the following relations:

$$\Delta\mu_1^0 = RT \ln (\eta_0 V_1^0 / hN) \quad (2)$$

$$\Delta\mu_2^0 = \Delta\mu_1^0 + RT/V_1^0 [1000B - (V_1^0 - \phi_v^0)] \quad (3)$$

Where R, h and N are gas constant, Planck constant and Avogadro's number respectively; T is absolute temperature and V_1^0 is partial molar volume of solvent.

For mixed solvents, each solvent mixture was treated as pure and the molar volume taken as a mean volume defined [29] as:

$$V_1^0 = \frac{x_1 M_1 + x_2 M_2}{d_0} \quad (4)$$

where x_1 , M_1 and x_2 , M_2 are the mole fractions, and molecular weights of water and lactose respectively, and d_0 is the density of solvent (water + lactose).

The values of V_1^0 , $\Delta\mu_1^0$ and $\Delta\mu_2^0$ are recorded in Table III. In the earlier prediction it is suggested that for structure maker normally $\Delta\mu_1^0 > \Delta\mu_2^0$ and for breaker $\Delta\mu_1^0 < \Delta\mu_2^0$ [27, 28, 30]. From the Table III it is found that $\Delta\mu_1^0 < \Delta\mu_2^0$ for lithium chloride in 2, 4 and 6 wt. % lactose solutions. It suggests that lithium chloride behave as structure-breaker in 2, 4 and 6 wt. % lactose solutions. This may be due to increase in interactions of solute ions by the solvent molecules as a result of weakening of forces among solvent molecules at transition state.

The values of $\Delta\mu_2^0$ at various temperatures can also be used to calculate the activation entropy for lithium chloride in 2, 4, 6 wt. % lactose solutions:

$$\frac{d(\Delta\mu_2^0)}{dT} = -\Delta S_2^0 \quad (5)$$

The activation enthalpy (ΔH_2^0) has been calculated with the help of following expression [30]:

$$\Delta H_2^0 = \Delta\mu_2^0 + T\Delta S_2^0 \quad (6)$$

and the values are also recorded in Table IV. It is evident from table 5 that both enthalpy and entropy of activation are negative for lithium chloride in 2, 4 and 6 wt. % lactose solutions at different temperatures, which suggest that the transition state is associated with bond-breaking and increase in order.

Table I: Viscosities and relative viscosities for lithium chloride in 2, 4, 6 wt. % lactose solutions at different temperature

Molality (m)	Viscosity η (cP)	Relative Viscosity η/η_0
Lithium Chloride in 2% Lactose		
Temperature = 303.15K		
0.00	0.82456	-
0.01	0.82727	1.00329
0.02	0.82883	1.00517
0.04	0.83144	1.00834
0.06	0.83380	1.01120
0.08	0.83597	1.01383
0.10	0.83807	1.01637
0.12	0.84009	1.01883
Temperature = 308.15K		
0.00	0.74410	-
0.01	0.74628	1.00294
0.02	0.74763	1.00474
0.04	0.74993	1.00783
0.06	0.75205	1.01069
0.08	0.75408	1.01341
0.10	0.75599	1.01599
0.12	0.75787	1.01852
Temperature = 313.15K		
0.00	0.67025	-
0.01	0.67190	1.00246
0.02	0.67303	1.00415
0.04	0.67503	1.00713
0.06	0.67689	1.00990
0.08	0.67871	1.01262
0.10	0.68047	1.01525
0.12	0.68221	1.01785
Temperature = 318.15K		
0.00	0.61582	-
0.01	0.61701	1.00192
0.02	0.61795	1.00345
0.04	0.61972	1.00632
0.06	0.62144	1.00912
0.08	0.62311	1.01183
0.10	0.62472	1.01445
0.12	0.62640	1.01718
Lithium Chloride in 4% Lactose		
Temperature = 303.15K		
0.00	0.84827	-
0.01	0.85107	1.00330
0.02	0.85262	1.00513
0.04	0.85519	1.00817
0.06	0.85749	1.01088
0.08	0.85965	1.01342

0.10	0.86168	1.01581
0.12	0.86367	1.01816
Temperature = 308.15K		
0.00	0.76312	-
0.01	0.76532	1.00288
0.02	0.76664	1.00461
0.04	0.76892	1.00759
0.06	0.77099	1.01031
0.08	0.77294	1.01286
0.10	0.77481	1.01531
0.12	0.77666	1.01774
Temperature = 313.15K		
0.00	0.68751	-
0.01	0.68924	1.00251
0.02	0.69036	1.00414
0.04	0.69236	1.00705
0.06	0.69420	1.00972
0.08	0.69598	1.01232
0.10	0.69769	1.01480
0.12	0.69939	1.01727
Temperature = 318.15K		
0.00	0.62992	-
0.01	0.63118	1.00200
0.02	0.63215	1.00353
0.04	0.63390	1.00631
0.06	0.63558	1.00898
0.08	0.63729	1.01168
0.10	0.63890	1.01425
0.12	0.64051	1.01680
Lithium Chloride in 6% Lactose		
Temperature = 303.15K		
0.00	0.88665	-
0.01	0.88955	1.00326
0.02	0.89111	1.00503
0.04	0.89368	1.00792
0.06	0.89591	1.01045
0.08	0.89800	1.01280
0.10	0.89998	1.01503
0.12	0.90188	1.01718
Temperature = 308.15K		
0.00	0.78562	-
0.01	0.78787	1.00286
0.02	0.78916	1.00450
0.04	0.79138	1.00733
0.06	0.79337	1.00987
0.08	0.79526	1.01227
0.10	0.79707	1.01458
0.12	0.79884	1.01683
Temperature = 313.15K		
0.00	0.70594	-
0.01	0.70778	1.00261
0.02	0.70890	1.00420
0.04	0.71089	1.00700
0.06	0.71269	1.00956
0.08	0.71442	1.01201
0.10	0.71607	1.01434
0.12	0.71772	1.01668
Temperature = 318.15K		
0.00	0.64591	-
0.01	0.64745	1.00238
0.02	0.64845	1.00393
0.04	0.65024	1.00669
0.06	0.65189	1.00925
0.08	0.65350	1.01174
0.10	0.65504	1.01414
0.12	0.65656	1.01649

Table II: Values of A and B parameters of Jones – Dole equation for Lithium Chloride in different composition of Lactose at different temperatures

Temperature (K)	A ($\text{dm}^{3/2} \text{mol}^{-1/2}$)	B ($\text{dm}^3 \text{mol}^{-1}$)
Lithium Chloride in 2% Lactose		
303.15	2.414	0.087
308.15	1.958	0.098
313.15	1.376	0.109
318.15	0.695	0.124
Lithium Chloride in 4% Lactose		
303.15	2.497	0.078
308.15	1.963	0.090
313.15	1.498	0.100
318.15	0.844	0.124
Lithium Chloride in 6% Lactose		
303.15	2.557	0.068
308.15	2.021	0.080
313.15	1.689	0.089
318.15	1.402	0.096

Table III: Values for $V_1^0, \phi_v^0, \Delta\mu_1^0$ and $\Delta\mu_2^0$ for lithium chloride in different composition of lactose at different temperatures

Temperature T (K)	V_1^0 ($\text{cm}^3 \text{mol}^{-1}$)	ϕ_v^0 ($\text{cm}^3 \text{mol}^{-1}$)	$\Delta\mu_1^0$ (kJ mol^{-1})	$\Delta\mu_2^0$ (kJ mol^{-1})
Lithium Chloride in 2 % Lactose				
303.15	18.287	5.045	61.396	71.606
308.15	18.318	8.756	62.149	74.530
313.15	18.352	11.019	62.890	77.366
318.15	18.392	11.835	63.676	80.522
Lithium Chloride in 4 % Lactose				
303.15	18.487	6.774	61.494	70.557
308.15	18.518	8.823	62.242	73.402
313.15	18.553	10.107	62.985	75.847
318.15	18.603	10.757	63.766	80.237
Lithium Chloride in 6 % Lactose				
303.15	18.682	7.348	61.632	69.235
308.15	18.714	9.015	62.343	71.998
313.15	18.749	10.059	63.081	74.191
318.15	18.790	10.576	63.859	76.176

Table IV: Values of $T\Delta S_2^0$, AND ΔH_2^0 for lithium chloride in different composition of lactose at different temperatures

Temperature (K)	$T\Delta S_2^0$ (kJ mol^{-1})	ΔH_2^0 (kJ mol^{-1})
Lithium Chloride in 2% Lactose		
303.15	-179.365	-107.758
308.15	-182.323	-107.793
313.15	-185.281	-107.916
318.15	-188.240	-107.718
Lithium Chloride in 4% Lactose		
303.15	-190.896	-120.339
308.15	-194.045	-120.643
313.15	-197.194	-121.347
318.15	-200.342	-120.105
Lithium Chloride in 6% Lactose		
303.15	-139.546	-70.311
308.15	-141.848	-69.850
313.15	-144.149	-69.958
318.15	-146.451	-70.275

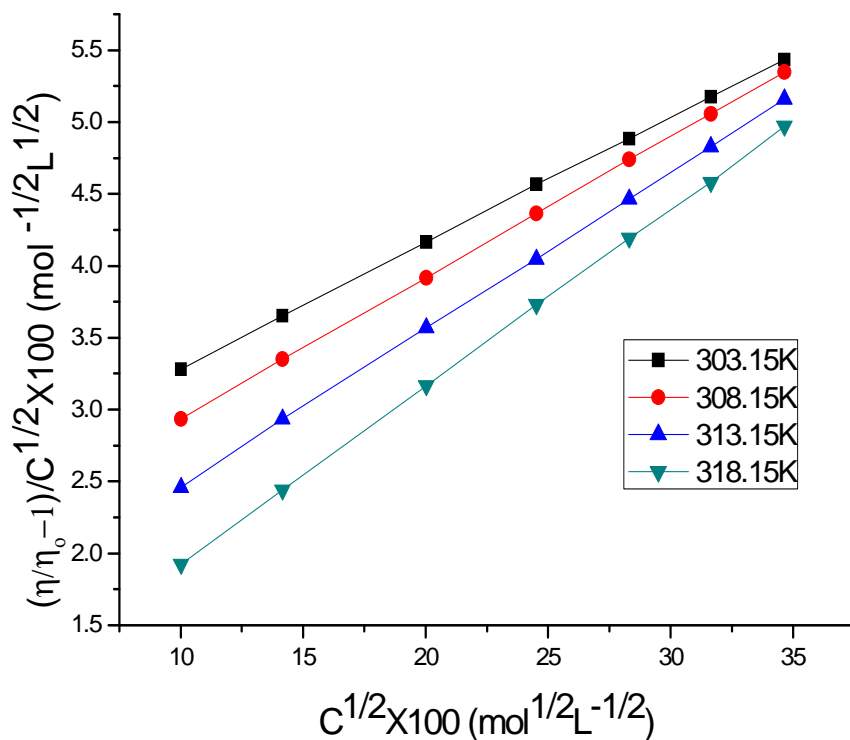


Fig. I: Plots of $(\eta/\eta_0 - 1)/C^{1/2}$ Vs $C^{1/2}$ for lithium chloride in 2 % lactose at different temperatures.

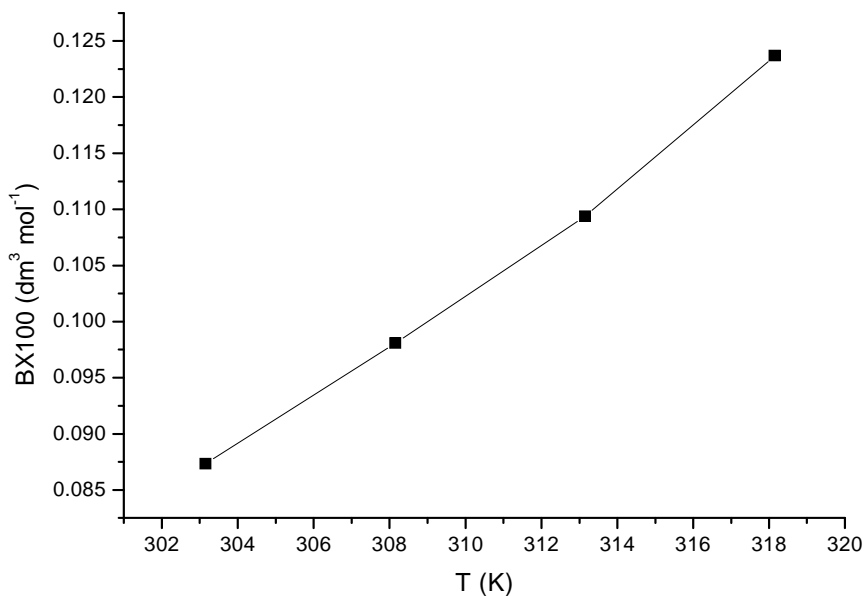


Fig. II: Plot of B Vs T for lithium chloride in 2 % lactose.

CONCLUSION

Densities and viscosities of lithium chloride in 2, 4, 6 wt. % lactose solutions have been determined experimentally at different temperatures i.e. 303.15K, 308.15K, 313.5K and 318.15K. The conclusions drawn from viscosity measurements are in agreement with those obtained from transition state treatment to obtain contribution of solutes to free energy of activation for viscous flow of solvent. The variation of B with T is depicted and shows it is positive for lithium chloride in 2, 4 and 6 wt. % lactose solutions studied revealing the structure breaking nature of lithium chloride in 2, 4 and 6 wt. % lactose solutions. These parameters are found to be sensitive in exploring the interactions between the component molecules, which enable us to have a better understanding of liquid mixtures.

REFERENCES

- [1]. R K Wadi;R K Goyal;*J. Soln. Chem.*,**1992**, 21163.
- [2]. M L Parmar;V N Ch Rao;S K Bhardwaj;*Indian J. Chem.*,**1992**, A31, 716.
- [3]. J D Pandey;P Jain;V Vyas;*Can. J. Chem.*,**1994**, 72, 1486.
- [4]. M L Parmar;M K Chauhan;*Indian J. Chem.*,**1995**,A34, 434.
- [5]. S P Jauhar;B Markandeya;V P Kapila;*Indian J. Chem.*,**1997**,A36,898.
- [6]. M L Parmar;S Sharma;*Res. J. Chem. Environ.*, **1998**, 2, 17.
- [7]. J D Pandey; Y Akhtar;A K Sharma;*Indian J. Chem.*,**1998**,A37, 1094.
- [8]. M L Parmar;*J. Indian Council. Chem.*,**1998**,15,10.
- [9]. A P Mishra;S K Gautam;*Indian J. Chem.*,**2001**, A40, 100.
- [10]. M L Parmar ;*J. Indian Council. Chem.*,**2002**, 19, 24.
- [11]. P K Kipkemboi;A J Easteal;*Indian J. Chem.*, **2002**, A41, 1139.
- [12]. M L Parmar;D K Dhiman;R C Thakur;*Indian J. Chem.*, **2002**, A41, 2032.
- [13]. D Das;B Das;D K Hazra;*J. Soln. Chem.*, **2002**, 31, 425.
- [14]. D Das;B Das;D K Hazra;*J. Soln. Chem.*, **2003**, 32, 77.
- [15]. D Das;B Das; D K Hazra;*J. Soln. Chem.*, **2003**, 32, 85.
- [16]. A Choudhury;A Jha;M N Roy;*J. Indian Chem. Soc.*,**2003**, 80, 632.
- [17]. M L Parmar;R K Awasthi;M K Guleria;*Indian J. Chem.*,**2004** , A43,41.
- [18]. D Das;D K Hazra;*Indian J. Chem.*, **2004**, A43,505.
- [19]. A P Mishra;*Indian J. Chem.*, **2004**, A43,730.
- [20]. Tsierkezos;L E Molinou;*Z. Phys. Chem.*,**2004**,218,211.
- [21]. GK Ward; FJ Millero; *J. Soln. Chem.*, **1974**, 3, 417.
- [22].RLBlokhra; M L Parmar;*Aust. J. Chem.*, **1974**, 27, 1407.
- [23].G Jones; M Dole; *J. Am. Chem. Soc.*, **1929**, 51, 2050.
- [24]. H Falkenhagen; M Dole;*Phys.Z.*, **1929**, 30, 611.
- [25].ER Nightingale; "Chemical Physics of Ionic Solution", eds. BE Conway and RGBarradas; John Wiley, New York, **1966**, 93.
- [26]. TSSharma; JC Ahluwalia;*Rev. Chem. Soc. London*, **1973**, 2, 217.
- [27]. R L Blokhra; Satish Kumar;*Indian Journal of Chemistry*, **1989**, 28A, 1087-1089.
- [28]. D Feakins; W E Waghorne; K G Lawrence;*J. Chem. Soc. Faraday TransI*, **1986**, 563.
- [29]. M L Parmar;D K Dhiman; R C Thakur;*Indian J. Chem.* **2002** , A412032.
- [30].D Feakins; D J Freemantle; K G Lawrence;*J. Chem. Soc. Faraday TransI*, **1974**, 795.