Original Research Article
Annalen der Chemischen Forschung
Vol-2: No-1: 26-35: 2014
www.aocsr.com

Viscometric studies of Sodium chloride in various disaccharides and water-ethanol medium

Pankaj Srivastava*[1], Dheeraj Kumar[2]

*[1] Department of Chemistry, Vishweshwarya Institute of Engineering and Technology, Dadri G.B.Nagar-203207, Uttar Pradesh, India

[2]Department of Chemistry, K.R. Post graduate college, , Mathura-281001, Uttar Pradesh, India

Abstract

In the present work, experimental viscosities of sodium chloride in various disaccharide s (Lactose, Maltose and Sucrose) and water-ethanol medium are reported. The viscosity values of each of the systems under investigations have been found to decrease with increase in mole-fraction(X) of NaCl in solution. By using experimental viscosity, the Rheochor [R] and its excess values [R^E] have been calculated. The relationship between the viscosity and the composition of the mixtures are explained in terms of rheochor[R]..

Key Words: Lactose, Maltose, Sucrose, viscosity, Rheochor, Sodium chloride

Cite this article as: Pankaj Srivastava, Dheeraj Kumar. Viscometric studies of Sodium chloride in various disaccharides and water-ethanol medium. Annalen der Chemischen Forschung. 2014;2(1):26-35.

1.0 Introduction

Carbohydrates as well as salts in association with water are physiologically important as they play important role in various biochemical reactions. Carbohydrates represent a major part of the total caloric intake for the human beings as well as for most of the animals and many micro-organisms. Sodium ion on the other hand, maintains the osmotic pressure of body fluids and thus protects our body against the excessive fluid loss. It also functions in the preservation of normal irritability of muscle and the permeability of the cells. Water and ethanol mixtures have proved to be the most interesting due to the unique structural relationship of alcohols with pure water.

Viscosity measurements enable the investigators to investigate the intermolecular association and dissociation. They also provide valuable information about the size and the state of solvation of molecules in solution [1]. The temperature and concentration dependence of viscosity have been successfully employed [2, 3] to characterize the strength and nature of interactions among the molecules in solutions. Several attempts have been made to investigate the viscosity of aqueous solution of salts as well as of biochemical substances [4-8]. These investigations may throw light on the nature and the degree of interaction that are expected to be present in non-aqueous [9-11] and aqueous [12-14] binary mixtures. Several empirical relations [15] have been used to represent the concentration dependence of viscosity in binary liquid mixtures. The non-thermodynamic parameters such as Rheochor and its excess function may also be utilized to describe the molecular interactions [16]. Deviations from the linear dependence of viscosity and its derived parameters on mole fraction may account for the variation in the type and the degree of interaction [17].

The present study has been carried out to investigate the ideality and non-ideality of mixtures as a result of addition of sodium chloride to those of the disaccharides in water-ethanol medium. An attempt has also been made to predict the viscosity of mixtures by using the Rheochor values of the pure components.

2.0 Materials and methods

The disaccharides namely, Lactose(SDS), Maltose(SDS), Sucrose(BDH) and sodium chloride (Qualigens) used in the preparation of samples were of AR grade. They were dried at ~50^{o}C and kept in vacuum desiccators over P_2O_5 for 5-6 hrs before use. All the solutions were made by weight using a balance having an accuracy of ±0.1 mg.

Table-1: Experimental viscosity values (η x10^3, kg m^{-1}s^{-1}) as function of composition and temperature
(i)Lactose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.1	1.369	1.201	1.059	0.936
0.2	1.345	1.183	1.033	0.923
0.3	1.336	1.173	1.027	0.909
0.4	1.312	1.162	1.021	0.896
0.5	1.303	1.142	1.006	0.889
0.6	1.284	1.139	0.999	0.886
0.7	1.273	1.126	0.989	0.877
0.8	1.256	1.112	0.974	0.863
0.9	1.249	1.099	0.965	0.854

Absolute alcohol (Purity>99.9 mass percent, controlled by GLC) prepared from commercial alcohol was mixed with triply distilled water in the ratio 1:1 (v/v) for being used as solvent. A thermostatic bath was used to maintain the desired temperature during the measurements of viscosity. Thermal stability of the thermostat was found to be within ± 0.01K of the required value.

(ii) Sucrose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.2	1.373	1.215	1.044	0.926
0.3	1.349	1.191	1.028	0.918
0.4	1.325	1.174	1.022	0.910
0.5	1.301	1.151	1.004	0.899
0.6	1.292	1.134	1.000	0.878
0.7	1.276	1.118	0.987	0.869
0.8	1.259	1.102	0.986	0.862
0.9	1.250	1.098	0.978	0.861

The viscosity measurements were made with a Cannon-Ubbelohde type viscometer [18, 19]. To avoid the adsorption of moisture during the measurement, all the open ends of the three arms of viscometer were fitted with calcium chloride tubes. The reproducibility of the viscosity measurement was found to be within ± 0.005 $kgm^{-1}s^{-1}$.

(iii) Maltose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.1	1.342	1.189	1.042	0.930
0.2	1.329	1.175	1.031	0.919
0.3	1.311	1.166	1.023	0.910
0.4	1.298	1.149	1.012	0.902
0.5	1.285	1.145	1.001	0.890
0.6	1.272	1.126	0.991	0.884
0.7	1.262	1.118	0.982	0.871
0.8	1.252	1.107	0.975	0.867
0.9	1.243	1.098	0.966	0.858

3.0 Results and discussion

The experimental viscosity (η) data as functions of composition and temperature are presented in Table-1.The values have been least-squares fitted to a polynomial equation of the type,

$$\eta = \eta_o + \eta_1 m + \eta_2 m^2$$

The coefficients of this correlation procedure are listed in Table-2 along with the standard deviations. The viscosity values of each of the systems under investigations have been found to decrease with increase in mole- fraction (X) of NaCl in solution. It seems that the addition of sodium chloride affects the solvation of disaccharides which in turn, seems to be responsible for the decrease in viscosity.

Table-2: Least-squares fit parameters of the equation, $\eta = \eta_o + \eta_1 m + \eta_2 m^2$ at different temperatures

(i) Lactose in water-EtOH and NaCl

Temperature / K	η_0	η_1	$\eta_2 x10^2$	$\sigma x10^3$
293.15	1.397	-0.238	8.24	4.2
298.15	1.229	-0.202	6.94	5.8
303.15	1.070	-0.145	3.69	4.1
308.15	0.949	-0.135	3.82	2.9

(ii) Sucrose in water-EtOH and NaCl

Temperature / K	η_0	η_1	$\eta_2 x10^2$	$\sigma x10^3$
293.15	1.412	-0.239	6.67	4.3
298.15	1.248	-0.218	5.82	6.3
303.15	1.070	-0.146	4.23	2.7
308.15	0.959	-0.155	4.74	3.9

(iii)Maltose in water-EtOH and NaCl

Temperature / K	η_0	η_1	$\eta_2 x10^2$	$\sigma x10^3$
293.15	1.367	-0.202	7.49	2.2
298.15	1.206	-0.152	3.86	2.7
303.15	1.057	-0.127	3.25	1.5
308.15	0.940	-0.107	1.81	1.4

Figure-1 depicts the nature and the variation of viscosity with mole fraction(X), an examination of the plots suggests that a small deviation of viscosity occurs from the ideal behavior in all the systems. It has been found that the addition of more components may bring the system close to ideality. The small deviations apparently pointed out small magnitude of interactions. The negative deviations have been attributed to the presence of interactions due to the dispersive forces [20]. However plots of Figure-1 represents the systems where complexes are either not formed at all or very weakly associated complexes occur due to a sort of feeble interactions [21].

The relationship between the viscosity and the composition of the mixtures can be explained in terms of Rheochor [R],

$$[R] = (M/\rho).\ \eta^{1/8} = V.\ \eta^{1/8}$$

In which the symbols have their usual meaning. The Rheochor values have been found to decrease with increase in mole fraction as well as temperature in each of the systems under investigation.

The Rheochor values have been least- squares fitted to a polynomial equation,

$$[R] = [R]_o + [R]_1\, m + [R]_2 m^2$$

The coefficients have been listed in Table-3 along with the standard deviation. The obtained values are in excellent agreement with those values of [R].The deviation of Rheochor from its ideal behavior can be studied in terms of excess Rheochor [R^E], defined as-

$$[R^E] = [R] - \{(1\text{-}X)\,[R_1] + (X)\,[R_2]\}$$

The [R^E], although an extra thermodynamic property, characterizes the strength and the nature of interaction among the components of the mixture [15].

Table-3: Least-squares fit parameters of the equation, $[R] = [R]_o + [R]_1\, m + [R]_2\, m^2$ at different temperatures

(i) Lactose in water-EtOH and NaCl

Temperature / K	$[R]_0$	$[R]_1$	$[R]_2 x10^2$	$\sigma x10^3$
293.15	11.18	-0.510	9.90	3.1
298.15	11.01	-0.489	8.90	4.8
303.15	10.84	-0.436	5.22	4.9
308.15	10.70	-0.446	6.59	4.5

(ii) Sucrose in water-EtOH and NaCl

Temperature / K	$[R]_0$	$[R]_1$	$[R]_2 x10^2$	$\sigma x10^3$
293.15	11.17	-0.472	6.26	6.6
298.15	11.01	-0.453	5.00	3.4
303.15	10.82	-0.399	4.13	5.5
308.15	10.69	-0.435	5.70	6.5

(iii)Maltose in water-EtOH and NaCl

Temperature / K	$[R]_0$	$[R]_1$	$[R]_2 x10^2$	$\sigma x10^3$
293.15	11.14	-0.463	8.46	1.7
298.15	10.99	-0.422	4.58	2.9
303.15	10.82	-0.392	2.44	4.5
308.15	10.68	-0.390	2.15	2.4

The excess Rheochor values are listed in Table-4 and have been plotted as a function of composition at different temperatures (Figure- 2). The [R^E] values in general, have been found to be negative over the entire composition range. The minima of the [R^E] vs X curves lie near ~0.5 which flattens with rise in temperature.

Table-4: Excess Rheochor [R^E] x10^2 as functions of composition and temperature

(i) Lactose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.1	-1.42	-1.82	-0.13	-0.23
0.2	-2.24	2.64	-2.05	-0.45
0.3	-2.10	2.50	-1.61	-1.72
0.4	-3.00	2.40	-1.61	-2.02
0.5	-2.25	3.05	-1.97	-2.28
0.6	-2.80	1.70	-1.21	-1.02
0.7	-2.10	1.50	-1.21	-0.92
0.8	-1.64	1.34	-1.45	-1.55
0.9	-1.12	1.02	-1.52	-1.43

(ii) Sucrose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.2	-1.14	-0.84	-0.60	-0.75
0.3	-1.50	-1.20	-0.88	-1.41
0.4	-2.55	-1.80	-1.30	-1.61
0.5	-1.65	-1.76	-0.99	-1.17
0.6	-1.55	-1.80	-1.14	-1.01
0.7	-1.40	-1.30	-0.76	-1.21
0.8	-1.04	-1.04	-1.02	-0.50
0.9	-1.02	-0.92	-0.51	-0.16

The flattening of the curve with increase in temperature shows that the system is approaching towards ideality. Thus, in view of the above consideration, the systems seem to for very weak and unstable complexes which may be due to the hydrogen bonding as well as the dipole-dipole interactions.

(iii) Maltose in water-EtOH and NaCl

Mole fraction of NaCl (X)	Temperature / K			
	293.15	298.15	303.15	308.15
0.1	-1.14	-1.12	-0.33	0.67
0.2	-1.29	-1.25	-0.66	0.34
0.3	-1.57	-1.41	-0.52	0.12
0.4	-1.79	-1.61	-0.61	-0.42
0.5	-1.87	-0.97	-0.78	-0.78
0.6	-1.63	-2.01	-1.22	-0.42
0.7	-1.25	-1.21	-1.62	-0.62
0.8	-1.11	-1.45	-1.06	-0.46
0.9	-0.70	-0.72	-0.53	-0.53

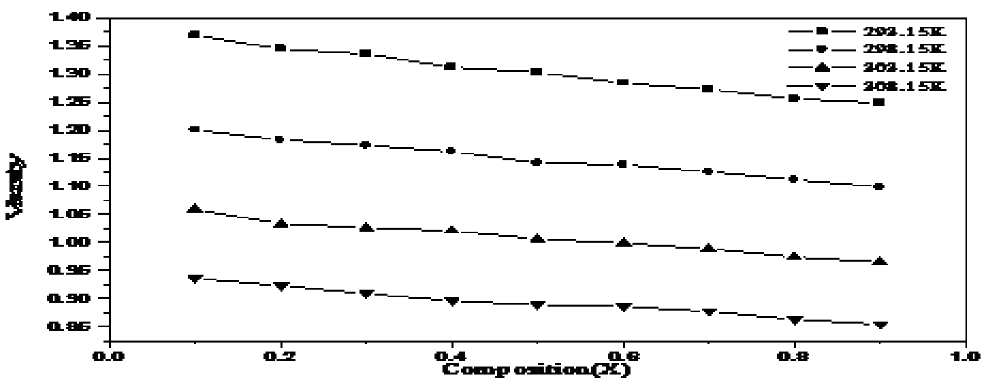


Figure-1.1: Plots of viscosity versus composition of Lactose in Water-EtOH and NaCl.

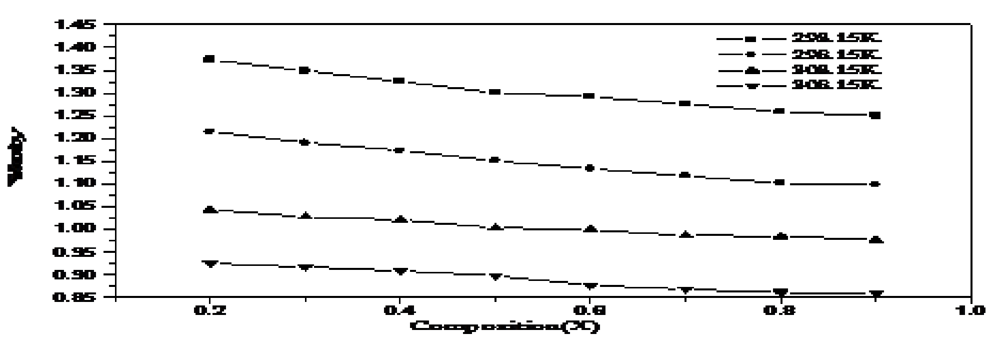


Figure-1.2: Plots of viscosity versus composition of Sucrose in Water-EtOH and NaCl.

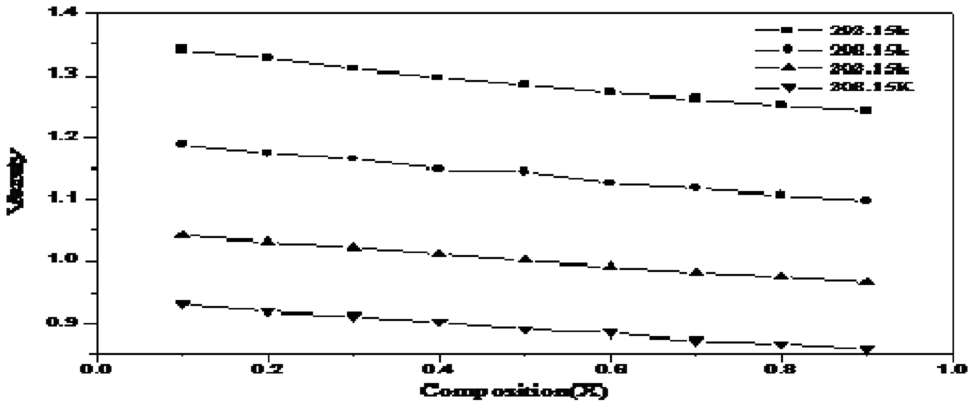


Figure-1.3: Plots of viscosity versus composition of Maltose in Water-EtOH and NaCl.

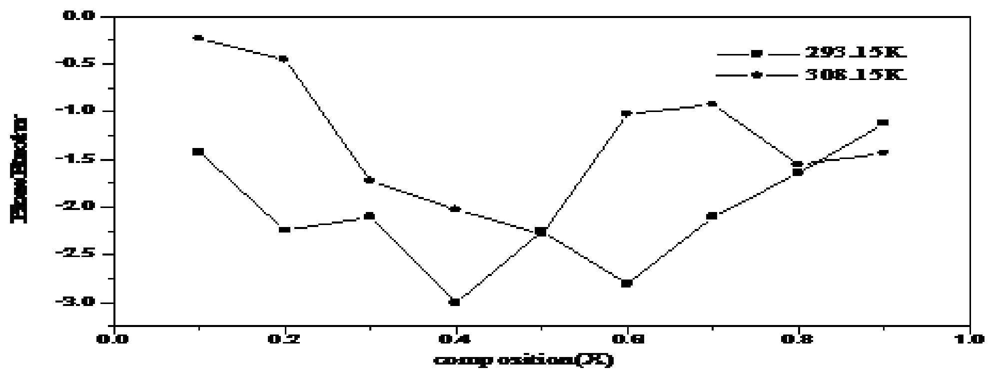
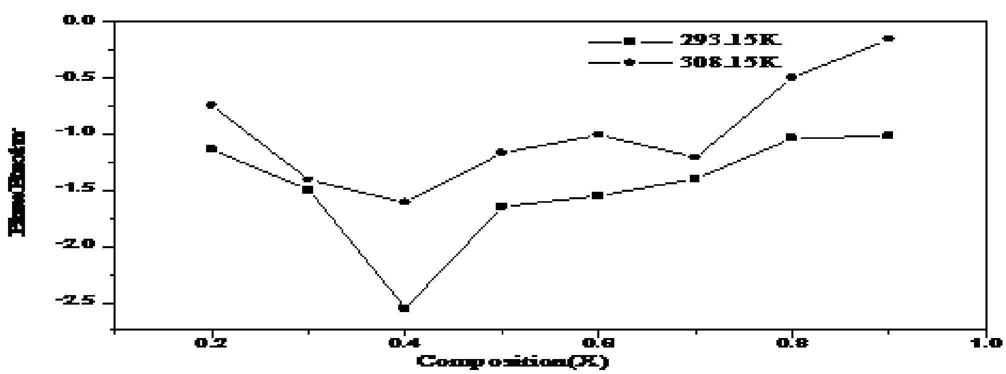


Figure-2.1: Plots of excess Rheochor versus Composition of Lactose in Water-EtOH and NaCl



a

nd

Figure-2.2: Plots of viscosity versus composition of Sucrose in Water-EtOH and NaCl.

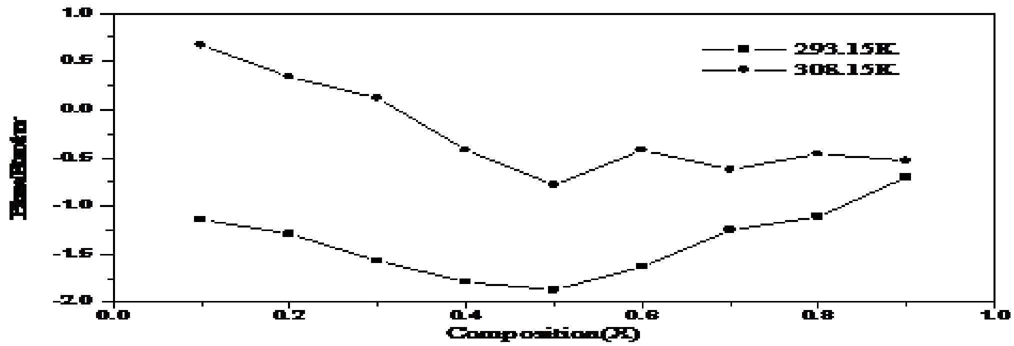


Figure-2.3: Plots of Viscosity versus Composition of Maltose in Water-EtOH and NaCl.

4.0 Conclusion

Aim of the present study was to investigate the ideality and non-ideality of mixtures as a result of addition of sodium chloride to those of the disaccharides in water-ethanol medium. Results from the present study indicate that tested systems seems to be for weak and form unstable complexes which may be due to the hydrogen bonding as well as the dipole-dipole interactions.

Reference

1. Stokes RH, Mills R. Viscosity of electrolytes and related properties. Pergamon Press, London; 1965.
2. Nigam RK, Mahl BS. Molecular interaction in binary liquid mixtures of dimethylslphoxide with chlroehanes and chlroehenes. Ind J Chem. 1971; 94: 1250-1255.
3. Rastogi RP, Nath J, Misra RL, Thermodynamics of weak interactions in liquid mixtures. I. Mixtures of carbon tetrachloride, benzene, toluene, and p-xylene. J Phys Chem. 1967; 71: 1277-1286
4. Ogawa T, Mizutani K, Yasuda M. Viscosity and Volumetric studies of some amino acids. Bull Chem Soc Jpn. 1984; 57: 2064-2069.
5. Ogawa T, Mizutani K, Yasuda M. Thermodynamic properties of peptide solutions. Bull Chem Soc Jpn., 1984; 57: 662-670.
6. Vishnu Singh. Thermodynamic studies of biomolecules. Ind J Chem. 1981; 20: 24-29. 7.
7. Mathieson JG, Conway BF. Viscometric studies of carbohydrates. J Sol Chem.1974; 3: 781-788.
8. Pandey JD, A. Shukla, R. D.Rai and K. Mishra, Ultrasonic, volumetric, and viscometric studies of tetracycline and its allied compound. J Chem Eng Data. 1989; 34: 29-31.
9. Islam MR, Ansari AA. Aqueous-Phase organometallic catalysis. Ind J Chem. 1982; 21A: 1057-1065.
10. Pandey JD, Chaturvedi CV, Pant N. Origins of low-frequency motions in biological macromolecules Chemica Scripta.1981; 18: 221-229.

11. Govindam K, Ravichandran G. Thixotropic studies of bioliquids. Ind J Pure Appl Phys. 1994; 32: 852-865.
12. Shukla A, Aradhana, Shukla RK. The quenching of photoluminescence of GaAs by surface acoustic waves .Acoust Lett. 1984; 7: 161-176.
13. Ramanjappa T, Rajagopal E, Subramanyam EV. Thixotropic behaviour of some important biomolecules. Acustica. 1983; 49: 261-276.
14. Ritu Mehra BB, Malav Joshi. Molecular Interaction Study of Lactose, DMF-H_2O and NaCl system using acoustic, viscometric and volumetric methods at different temperatures. J Chem Bio Phy Sci. 2011; 2A: 153-163
15. Partington JR. An advanced treatise on thixotrpy. Phys Chem. Longmans (London); 1951.
16. Corradini F, Marcheselli L, Marchetti A, Tagliazuchhi M, Tassi L, Tassi G. Thermophysical properties of some biomixtures. Bull Chem Soc Jpn. 1992; 65: 503-511.
17. Forte RJ, Moore WR. Methyl radical reactions with isopropanol and methanol, their ethers and their deuterated derivatives. Trans Faraday Soc.1966;62:112-122.
18. Cannon MR, Manning RE, Bell JD. Viscosity measurement-Kinetic energy correction and new viscometer. Anal Chem. 1960;32: 355-366.
19. Islam N, Islam MR, Ahmad R. Viscometric studies of salts in carbohydrate solutions. Ind J Chem. 1979; 17: 285-297.
20. Liler, Kosanovic. Hydrogen Bonding, ed. Hadzi, Pergamon Press (London); 1959. 529.
21. Cowie JMG, Toporowski PM. Association in the binary liquid system of dimethyl sulphoxide and water. Can J Chem. 1961; 39: 2240-2243.