VISCOMETRIC STUDIES OF BINARY SOLUTION CONTAINING MALTOSE AND AQUEOUS SODIUM CHLORIDE SOLUTION AT DIFFERENT TEMPERATURES

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Abstract: **The knowledge of solution properties is often required for understanding the transport phenomena as well as industrial-chemical processes. Viscosity is a measure of the resistance of a fluid to flow. Molecular structure of the solution components and the intermolecular / interionic forces operating within the solution are primary factors affecting viscosity of a solution. Measurement of viscosity enables to investigate the molecular association and dissociation. Saccharides are very important for some physiological processes. In the present study the viscosity (η) have been measured and used to derive some parameters such as Shear's relaxation time (τ), rheochor [R] and change in rheochor (Δ[R]) as a function of temperature and concentration.**

IndexTerms **- Viscosity, Rheochor, Maltose, sodium chloride**

I. INTRODUCTION

The physico-chemical studies play a significant role in the understanding of the behaviour of biochemical/biological systems. To explain the behaviour of these biochemical/biological molecules; one must understand the ionic solutions in terms of ion-water and ion-ion interactions and also along with the solute-water interaction and also see how these interactions are altered in the presence of biochemical/biological systems.

Saccharides and their derivatives as the most abundant class of biomolecules are known to exist in wide range of forms, which is a reflection of their biological versatility and the great diversity of their biological functions such as structural, protective metabolic and recognition. They are not only the basic material for energy metabolism in organisms, but also play a significant role in the configuration of biological molecules [1,2].The study of carbohydrates has become a subject of increasing interest because of the multidimensional physical, biochemical and industrially useful properties of these compounds[3-6]. In addition to their importance in food, pharmaceutical and chemical industries, saccharides have received considerable attention for their ability to protect biological macromolecules [7, 8].

Inorganic salts when dissolved in water form aqueous electrolyte solutions. They play a significant role in chemical laboratories, industries and in nature, in the form of geothermal systems and biological processes of living organisms. Carbohydrates as well as salts are physiologically important in association with water in biochemical reactions. Understanding the behaviour of these in dilute aqueous solutions is of the utmost importance in biology and medicine.

Viscosity is an important transport property for process in petroleum, petrochemical and other industries involving fluid transportation, mixing, agitation, filtration, heat exchange and concentration. The temperature and concentration dependence of viscosity have successfully been employed [9] to characterize the strength and nature of the interaction among the molecules in solution. Viscosity measurements provide valuable information about the size and the state of salvation of molecules in solution[10]. Several attempts have been made to measure the viscosity of aqueous solutions of salts as well as of biochemical substances [11-14]. These investigations may throw some light on the nature and the degree of interaction that are expected to be present in non-aqueous [15-17] and aqueous [18, 19] binary mixtures. Deviations from the linear dependence or/ and relative change of viscosity and its derived parameters on mole fraction/ molarity may account for the variation in the type and the degree of interaction [20].

In the present study the effect of Maltose on 1M sodium chloride solutions are being investigated measuring the viscosity and derived parameters as functions of composition and temperature in order to know the intermolecular interactions.

EXPERIMENTAL:

Maltose used in this work was obtained from SRL (Mumbai) and used as such without further purification. Sodium chloride was purchased from E. Merck (India) and recrystallysed twice in triply distilled water before use. All the chemicals were of ≈99% purity. They were dried and kept in vacuum desiccators over P_2O_5 for several hours before use. All the solutions were made by weight using a balance having an accuracy of ±0.1 mg. Stock solutions of 1M sodium chloride was prepared in triply distilled water and used as solvents for the preparation of various molar solutions of Maltose.

Cannon-Fenske viscometer was used for the viscosity measurement of various solutions under study. The viscometer was calibrated with the triple distilled water. The viscosity coefficient values of water at different temperatures were taken from literature [21]. The viscosity coefficient (h) was calculated employing the following Poiseuille's equation,

$$\eta = \pi g h \rho t r^4/8vl \qquad [1]$$

where g, h, r, r, l and t are acceleration due to gravity, height of the column in the viscometer, density of the liquid, radius of the viscometer's capillary, length and time of fall for the liquid of volume v through the capillary, respectively. The above equation can also be written as

$$\eta = \rho\beta t \qquad [2]$$

where $\beta = \rho g h r^4/8vl$ is a constant for a given viscometer. The viscosity value of the test solution was calculated using the reported viscosity values of pure water at desired temperature. Equation [3] was employed for the calculation of viscosity values of solutions.

$$\eta_1 = (\rho_1 t_1 / \rho_2 t_2) \times \eta_2 \qquad [3]$$

where η_1 and η_2 are viscosity values of solution and solvent, respectively; ρ_1 and ρ_2 are density values of solution and solvent, respectively; and t_1 and t_2 are the time of fall of the solution and solvent, respectively. The reproducibility in viscosity measurements was found to be within ± 0.003×10^{-4} $Nm^{-2}s$.

Shear's Relaxation Time [t] provides significant information about the structure and dynamics of the solution. The relation to calculated shear's relaxation time using viscocity and adiabatic compressibility was given by Kinsler and Frey[22].

$$\tau = (4/3)\ \eta.\beta$$

The relationship between the viscosity and composition of mixture can be explained in terms of rheochor.[R][23].

$$[R] = \frac{\overline{M}}{\rho}\eta^{1/8}$$

Change in rheochor Δ[R] is calculated by the relation.

$$\Delta\ [R] = [R] - [R]_0$$

Where $[R_0]$ is the rheochor value of the solvent.

RESULT AND DISCUSSION:

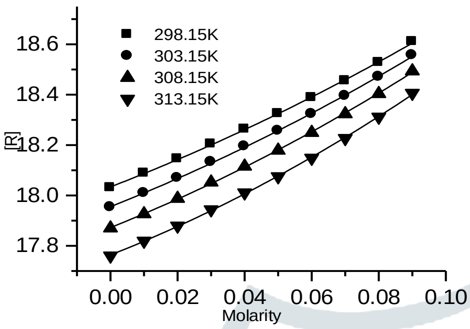
The viscous properties of a system under investigation have been reported which deals with the determination of Viscosity (η) experimentally. With the help of experimental data, Shear's relaxation time (τ), rheochor [R] and change in rheochor (Δ[R]) were calculated and reported alongwith viscosity values in Table 1. The discussion of results is in terms of molecular interactions among the molecules of the systems under consideration. The viscosity (η) and its derived parameters such as Shear's relaxation time (τ), rheochor [R] and change in rheochor (Δ[R]) provide valuable information about the size and the state of salvation layer of molecules in solution.

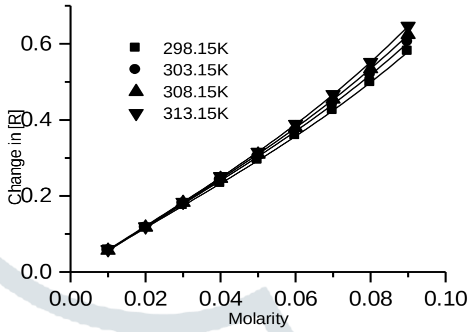
Table-1 Viscosity η (x 10^{-3} Nsm^{-2}), Shear's Relaxation Time (τ), Rheochor, [R], and Change in Rheochor Δ[R] for Maltose + Aqueous NaCl (1M) as a function of temperature and concentration

Molarity (Sucrose)	Viscosity η (x 10^{-3} Nsm^{-2})	Shear's Relaxation Time (τ)	Rheochor, [R]	Change in Rheochor Δ[R]
		298.15K		
0.00	0.9856	52.301	18.0301	
0.01	0.9890	52.331	18.0878	0.0577
0.02	0.9938	52.385	18.1452	0.1151
0.03	1.0002	52.638	18.2044	0.1743
0.04	1.0086	52.777	18.2627	0.2327
0.05	1.0192	53.145	18.3242	0.2941
0.06	1.0324	53.675	18.3876	0.3575
0.07	1.0482	54.166	18.4547	0.4246
0.08	1.0670	54.887	18.5279	0.4978
0.09	1.0894	55.862	18.6100	0.5799
		303.15K		
0.00	0.9027	47.829	17.9527	
0.01	0.9061	47.904	18.0091	0.0564
0.02	0.9109	47.968	18.0689	0.1162
0.03	0.9173	48.188	18.1326	0.1799
0.04	0.9257	48.430	18.1941	0.2414
0.05	0.9363	48.858	18.2556	0.3029
0.06	0.9495	49.344	18.3230	0.3703
0.07	0.9653	49.967	18.3945	0.4418
0.08	0.9841	50.786	18.4708	0.5181
0.09	1.0065	51.725	18.5565	0.6038
		308.15K		
0.00	0.8198	43.548	17.8698	
0.01	0.8232	43.600	17.9267	0.0569
0.02	0.8280	43.748	17.9874	0.1176
0.03	0.8344	44.001	18.0523	0.1826
0.04	0.8428	44.274	18.1155	0.2457
0.05	0.8534	44.703	18.1791	0.3093
0.06	0.8666	45.220	18.2492	0.3794
0.07	0.8824	45.862	18.3238	0.4540
0.08	0.9012	46.674	18.4038	0.5339
0.09	0.9236	47.622	18.4937	0.6239
		313.15K		
0.00	0.7368	39.250	17.7598	
0.01	0.7402	39.299	17.8191	0.0593
0.02	0.7450	39.474	17.8791	0.1193
0.03	0.7514	39.723	17.9438	0.1839
0.04	0.7598	40.068	18.0106	0.2509

0.05	0.7704	40.507	18.0750	0.3152
0.06	0.7836	41.053	18.1483	0.3885
0.07	0.7994	41.715	18.2267	0.4669
0.08	0.8182	42.545	18.3110	0.5512
0.09	0.8406	43.559	18.4060	0.6462

Viscosity values are found to increase with increasing concentration of Maltose. The increasing trend clearly explains the strength of solute-solvent interactions as well as the shape, size and charge of the solute molecules. Shear's relaxation time increases with concentration of Maltose. However it decreases with increasing temperature. Rheochor values have been found to increase with increase in molarity of Maltose (Fig 1.). The deviation of rheochor has been studied in terms of change in rheochor, Δ[R](Fig 2).





The change in rheochor, although an extra-thermodynamic property, characterizes the strength and nature of interaction among the components of the solution[23]. The positive values of change in rheochor are due to solute-solvent interaction. Δ[R] values increases with increasing molarity which may be attributed to an overall increase in the cohesive forces in the solution.

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