Research Article

A Study on Interactions Present in Aqueous Acetic Acid Solution; Viscometric Study At 293K

Kailash Tamta*, N.D. Kandpal and Bhuwan Chandra

Physical Chemistry laboratory, Department Of Chemistry, Kumaun University, S.S.J. Campus, Almora 263601, Uttarakhand, India

Abstract

In the present study we have investigated the interactions of acetic acid present in aqueous solution at 293K viscometrically. The viscosity parameter has been calculated from Jones-Dole equation. The trends of varation in interaction parameter have been explained with the variation of concentration with the acid. The existence of solute and solvent interaction has been analysed in the light of structure maker/ structure breaker nature of solute. The presence of ionic, non-ionic/ ion pairs have been discussed in the study. The study is useful for the advancement of solution chemistry.

Keywords: Acetic Acid, Jone-Dole equation, interaction parameter, viscosity

***Correspondence**

Author: Kailash Tamta

Email: ktamta.85@gmail.com

Introduction

The molecular interactions of the solvent molecule with solute place an important role in governing the behaviour of the solution. These interactions also depend upon the nature of the polar and non polar solute. The nature of the interaction plays an important role in the mechanist path and rate of chemical reaction and kinetic studies [1]. An ionic solute when placed in different sovent system like non aqueous, organic and aqueous influence the kinetic, thermodynamics, spectroscopic properties including transport properties considerably [2-7]. The variation in structure characteristics of the solvent system takes place due to the presence of solute by induced perturbation resulting from the specific interaction and orientations of the slvent around the ions [8]. The total solvent and solute interaction energy is responsible for affects of solvent on the chemical and physical phenomenon. The investigations of the volumetric, viscometric and thermodynamic property of solvent has been the important area of the research for understanding the behavior of intermoleculer and the intramolecular interaction present in solution [9-11]. Solute induced modification/perturbation in the water structures have been studied by many workers [12].

Acetic acid is a weak acid. When the acid is added to water there is an interaction between acetic acid and water molecules. In order to find the nature of interaction present in acetic acid-water system the study has been undertaken. In the present study Viscosity of aqueous solutions of acetic acid has been measured at different concentrations. In the concentration range 0.5 mol dm^{-3} to 15.0 mol dm^{-3}. The data has been used to calculate the interaction parameters using Jone – Dole equation, which indicates the nature of interaction in water.

Materials and Methods

The GR grade of the GH acetic acid (E.merck) was used for making solutions using the doubly distilled water. The viscosity measurements were taken in a calibrated suspended level viscometer (Infusil india pvt.Ltd.). The viscometer was placed in a thermostated water bath (Tanco) having accuracy ± 0.1K for the constant tempertaure. The solution of acetic acid of known concentration was taken in the viscometer and the flow time of the solution was measured with the help of stopwatch (Raser). The densities of the solutions were measured using a 15ml double arm Pyknometer having accuracy ± 0.00001gr/ml and a single pan electronic balance (Citizen).

Results and Discussions

The viscosity of a solution depends on the temperature and concentration of acetic acid. At each concentration from 0.5 to 15.0 mol dm^{-3}, the value of viscosity relative viscosity η/η_0 was measured. Where η and η_0 are viscosity of solution and solvent respectively which are listed in **Table 1**.The viscosity data has been analysed using Jone-Dole equation (1) [13].

$$(\eta/\eta_0-1)/\sqrt{C} = A+B\sqrt{C} \qquad (1)$$

Where η is viscosity of the solution, η_0 is the viscosity of water, C is the concentration of acid,A is a measure of solute-solute interaction and B is a measure of solute-solvent interaction.The values of A and B-coefficient were obtained from the intercept and slope of linear plot of $(\eta/\eta_0-1)/\sqrt{C}$ versus $\sqrt{C}$ as shown in **Figures 1-2**.

Table 1 Variation of viscosity of aqueous acetic acid with concentration at 293K

S. No.	Concentration (mol dm^{-3})	η/η_0	(η/η_0-1)	$\sqrt{C}$	$(\eta/\eta_0-1)/\sqrt{C}$
1	0.5	1.06	0.06	0.70	0.085
2	1.0	1.12	0.12	1.00	0.120
3	1.5	1.18	0.18	1.22	0.147
4	2.0	1.25	0.25	1.41	0.177
5	2.5	1.32	0.32	1.58	0.202
6	3.0	1.38	0.38	1.73	0.220
7	3.5	1.44	0.44	1.87	0.235
8	4.0	1.51	0.51	2.00	0.255
9	4.5	1.57	0.57	2.12	0.268
10	5.0	1.66	0.66	2.23	0.295
11	5.5	1.75	0.75	2.34	0.320
12	6.0	1.76	0.76	2.44	0.311
13	6.5	1.84	0.84	2.54	0.331
14	7.0	1.90	0.90	2.65	0.340
15	7.5	2.0	1.0	2.73	0.366
16	8.0	2.04	1.04	2.82	0.368
17	8.5	2.10	1.10	2.91	0.378
18	9.0	2.20	1.20	3.00	0.400
19	9.5	2.26	1.26	3.08	0.420
20	10.0	2.32	1.32	3.16	0.417
21	11.0	2.45	1.45	3.31	0.438
22	12.0	2.55	1.55	3.46	0.447
23	13.0	2.70	1.70	3.60	0.472
24	14.0	2.70	1.70	3.74	0.454
25	15.0	2.71	1.71	3.87	0.441

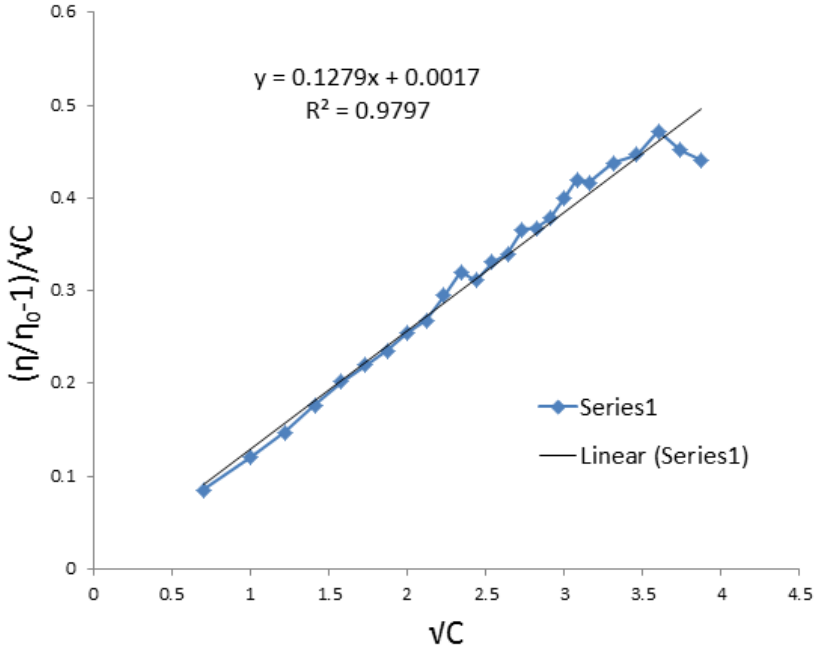

Figure 1 Plot between $(\eta/\eta_0-1)/\sqrt{C}$ and $\sqrt{C}$

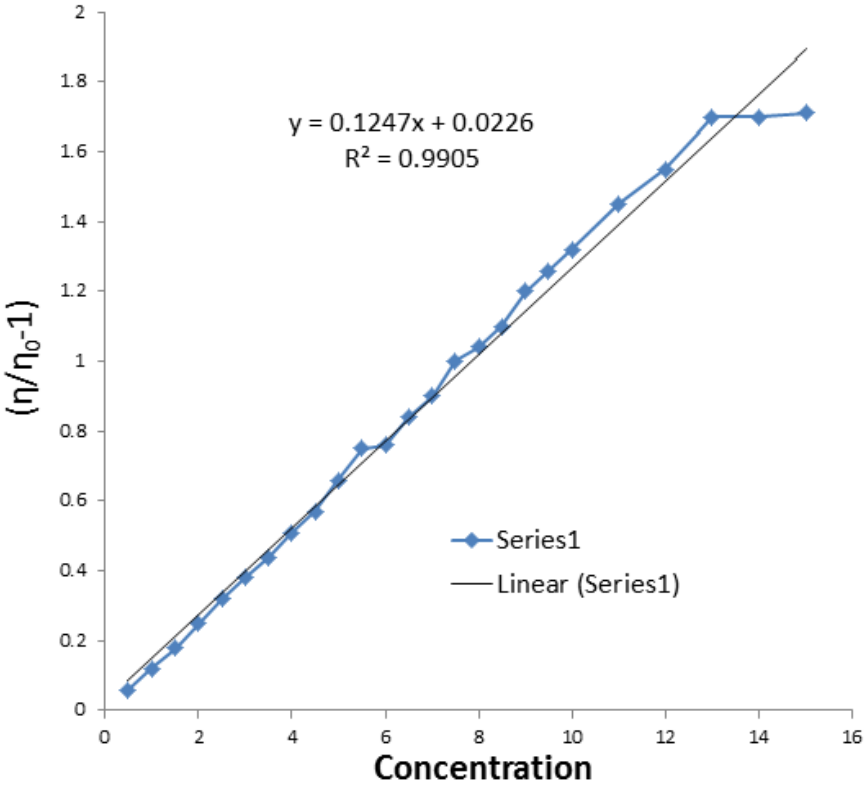

Figure 2 Plot between (η/η_0-1) & concentration

It is clear that the plot between √C and $(\eta/\eta_0-1)/\sqrt{C}$ have linear nature which is applicable for Jone-Dole equation, in the whole concentration range. The value of interaction parameter is given in the bottom of table. The value of B coefficient is positive which indicate the presence of solute – solvent interaction. The interaction of acetic acid with water is due to the presence of the carbonyl and hydroxyl groups in the carboxylic acid group which could. Provide hydrogen bonding interactions [14]. The presence of ion solvent interactions in water presence of co solvent tetra hydro furan and dioxane has been confirmed for acetic acid – solvent systems by ultrasonic study [15].

Conclusion

The positive value of B coefficient shows that acetic acid has structure making effect on water structure. The graph between (η/η_0-1) & concentration is shown in Figure 2. The viscosity values of η/η_0 are directly proportional to molar concentration C & given by Straudinger equation –

$$(\eta/\eta_0-1) = K\ C\ n$$

Where K is a constant for a given solution.C is molar concentration of monomer.n is number of monomer in the polymeric form The value of K obtained in the plot is 0.06 when we consider the formation of cyclic dimer by hydrogen bonding between two molecules of acetic acid.It indicates that the association between acetic acid & water molecules takes place in a dimeric/ polymeric structure.

Acknowledgements

The authors are thankful to Prof. Raj N Mehrotra former Professor and Head Chemistry Department, Jodhpur University for his valuable suggestion in this research work.

References

[1] A. Kumar, curr. Sci, 1996, 71, 289.
[2] A. Bhattacharya, A. K. Mandal, S. C. Lahiri, Electrochimica Acta, 1980, 25, 559.
[3] S. K. Maiti, A. K. Chattopadhyay, S. C. Lahiri, S. C, Elecrochimica Acta, 1980, 25, 1487.
[4] A. K. Bhattacharya, A. Pal, S. C. Lahiri, Zeitschrift fur Physikalische Chemie, 1990, 271, 397.

[5] A. K. Bhattacharya,S. C. Lahiri, J. Ind. Chem. Soc, 1995, 72, 791.
[6] R. Mandal, S. C. Lahiri, Zeitschrift fur Physikalische Chemie, 1998, 205, 69.
[7] R. Mandal, J. Gangopadhyay, S. C. Lahiri, Zeitschrift fur Physikalische Chemie, 2005, 219, 795.
[8] R. Bhattacharya, S. C. Lahiri, J. Ind. Chem. Soc, 2008, 85, 1249.
[9] S. Thirumaran, N. Prakash, J. Ind. Chem. Soc, 2012, 89, 497.
[10] S. Thirumaran, A. N. Kannappan, Global, Journal of Molecular Sciences, 2009, 4, 160.
[11] S. B. Lomte, M. J. Bawa, A. O. Dhokte, M. K. Lande, B. R. Arbad, J. Ind. Chem. Soc, 2011, 88, 1697.
[12] Y. Marcus, Chemical Reviews, 2009, 109, 1346.
[13] R. Loshali, B. Chandra, N. Sah, N. D. Kandpal, Int. J. Chem. Sci, 2014, 12, 1439.
[14] Q. Gao, K. T. Leung, J. Chem. Phy, 2005, 123, 074325.
[15] A. S. Aswar, P. G. Rohankar, V. R. Chaoudhari, Ind. J. Chem, 2001, 40A, 860 – 862.

Publication History
Received 26th Dec 2017
Revised 10th Jan 2018
Accepted 15th Jan 2018
Online 30th Jan 2018