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# Investigations of Glycol-ethanol Systems by Ultrasonic Method

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Ultrasonic investigations have been employed to understand the polymer-solvent interactions in solutions. Glycol-solvent interaction has been investigated by ultrasonic method over a wide range of concentration at 303 K. The ultrasonic velocities (U), densities (ρ) and viscosities (η) are determined for ethanolic solutions of ethylene glycol (EG), diethylene glycol (DEG), triethylene glycol (TEG) at 303 K. The acoustical parameters are investigated for glycol-ethanol systems at 303 K.

**Key Words: Glycols, Critical concentration, Acoustical parameters, Glycol-solvent, Ethanol interactions.**

## INTRODUCTION

Ethylene glycols (EGs) are water-soluble polymers and hence they find wide applications in industry. They are used in pharmaceutical formulations, as surface-active agents, fibre forming materials in textile industry and in the preparation of lubricants and mold releasing agents[1]. There are experimental and theoretical studies on the motions of polymeric molecules in solution[2]. There are two types of movements of polymeric molecules, *viz.*, localized movements and cooperative movements. At high concentrations and in the case of high molecular weight polymers, polymer-polymer interactions are significant and affect the mobility of the polymer. However, in dilute solutions, the interaction between polymer molecules and solvent molecules are of importance. Ultrasound can be used to study the segmental motion of polymeric molecules and the glass transition temperature of polymers can be determined by ultrasonic method[3]. It is also possible to observe the cooperative motion using ultrasound and hence the existence of strong intermolecular interactions within the polymer can be determined. Ultrasonic velocity measurements have been employed by several workers mainly to understand the polymer-solvent interactions in solutions. The ultrasonic techniques have been excellent tools for non-destructive testing and imaging in the recent years. When ultrasonic waves are propagated through polymeric materials, they are influenced by the structure of the polymers, due to molecular relaxation processes[4-6].

## EXPERIMENTAL

E. Merck samples of ethylene glycol (EG), diethylene glycol (DEG) and triethylene glycol (TEG) were used after vacuum distillation. Ethanol (99 %) used as solvent was purified by distillation. Solutions of various concentrations were prepared by addition of accurately weighed sample of the compound to required weight of ethanol to obtain solution of desired concentration.

The ultrasonic velocities of the solutions were measured using an ultrasonic interferometer (F-81) with a single crystal at a frequency of 2 MHz supplied by Mittal Enterprises, New Delhi. The accuracy in the velocity measurement is ± 0.05 %. The cell temperature was maintained constant at 303 K by an ultra-thermostat (Julabo U-3) maintained at an accuracy of ± 0.1 K. The densities of solutions were measured at 303 K using specific gravity bottles with an accuracy of ± 0.001 $Kg/m^3$. The viscosities were measured at 303 K using an Ostwald viscometer with an accuracy of ± 1 %. The acoustical parameters were calculated from the measured ultrasonic velocity (U), density ($\rho$) and viscosity ($\eta$) of ethylene glycols in ethanol solutions at 303K[7,8].

**Theoretical formulations:**

$$\text{Absorption coefficient } \alpha/f^2 = 8\pi^2\eta/3\rho U^3 \ N_p m^{-1} s^2 \qquad (1)$$

## RESULTS AND DISCUSSION

Ultrasonic studies have been made on ethylene glycols in benzene and methanol media mainly to understand the polymer-solvent interactions and to evaluate solvation number[9-11]. Hassan and Isa[12] have suggested that the absorption coefficient values can be correlated with the molecular weight of polymers and it can be used to determine the molecular weight of certain polyvinyl alcohols. It has been found that the trend in ultrasonic velocity in ethylene glycol polymers depends on concentration of the solution, polarity of the medium and molecular weight of the polymer. However, in dilute solution, the absorption coefficient ($\alpha/f^2$) depends mainly on the number average molecular weight, especially in the concentration range at which the polymer-solvent interaction is maximum.

The ultrasonic velocities (U), densities ($\rho$) and viscosities ($\eta$) are determined for ethanolic solutions of ethylene glycol, diethylene glycol, triethylene glycol at 303 K. Absorption coefficient ($\alpha/f^2$) was computed. The data are presented in Table-1. The trend in the values of U, $\rho$, $\eta$ and $\alpha/f^2$ with concentration in the systems indicate that the molecular interactions between ethylene glycol and ethanol molecules are maximum at 5 % concentration at 303 K. Fig. 1 contains the plot of ultrasonic velocity (U) against concentration (C). These plots establish the presence of strong

TABLE-1
ULTRASONIC VELOCITY (U), DENSITY ($\rho$), VISCOSITY ($\eta$) AND ABSORPTION COEFFICIENT ($\alpha/f^2$) OF VARIOUS CONCENTRATION (C) OF ETHYLENE GLYCOLS IN ETHANOL AT 303 K

| C (%) | U (ms$^{-1}$) | $\rho$(Kg m$^{-3}$) | $\eta$(cp) | $\alpha/f^2/10^{-14}$ ($N_p m^{-1} s^2$) |
|---|---|---|---|---|
| ETHYLENE GLYCOL | | | | |
| 1 | 1212.7 | 816.47 | 0.00129 | 2.34 |
| 2 | 1212.0 | 819.67 | 0.00132 | 2.37 |
| 4 | 1223.4 | 825.04 | 0.00139 | 2.41 |
| 5 | 1231.8 | 828.39 | 0.00139 | 2.37 |
| 6 | 1234.7 | 829.98 | 0.00143 | 2.41 |
| 8 | 1237.4 | 836.93 | 0.00150 | 2.48 |
| 10 | 1242.9 | 844.02 | 0.00157 | 2.55 |
| DIETHYLENE GLYCOL | | | | |
| 1 | 1222.2 | 820.51 | 0.00133 | 2.34 |
| 2 | 1224.5 | 822.78 | 0.00136 | 2.38 |
| 4 | 1232.7 | 828.01 | 0.00144 | 2.44 |
| 5 | 1233.1 | 830.65 | 0.00147 | 2.48 |
| 6 | 1237.9 | 832.93 | 0.00146 | 2.44 |
| 8 | 1240.1 | 838.33 | 0.00154 | 2.53 |
| 10 | 1244.7 | 843.74 | 0.00161 | 2.60 |
| TRIETHYLENE GLYCOL | | | | |
| 1 | 1226.1 | 823.17 | 0.00136 | 2.35 |
| 2 | 1227.9 | 825.80 | 0.00137 | 2.43 |
| 4 | 1232.1 | 830.79 | 0.00143 | 2.36 |
| 5 | 1234.4 | 834.63 | 0.00148 | 2.49 |
| 6 | 1244.9 | 838.11 | 0.00158 | 2.57 |
| 8 | 1246.2 | 843.75 | 0.00160 | 2.58 |
| 10 | 1251.5 | 850.72 | 0.00169 | 2.66 |

polymer-solvent interactions. Fig. 2 contains plots of viscosity ($\eta$) against concentration (C). The viscosity values increase with the increase in concentration. It may be pointed out that this concentration range is the same as that reported by earlier workers in the study of several polymers.

Earlier workers have observed that increase in the molecular weight led to a decrease in amplitude of the ultrasonic attenuation in the case of polyvinyl alcohol polymers, which is typical of modification of segmental motion of the polymers[13]. The increase in the values of the acoustic attenuation with increase in concentration was attributed to a modification in the nature of the inter-molecular attraction. In the present study, we found that the absorption coefficient ($\alpha/f^2$) values increase with the increase in concentration and molecular weight of the ethylene glycols. Thus, it is the change in the intermolecular attraction (cooperative movement), which is of prime importance in the amplitude of the ultrasonic attenuation of the

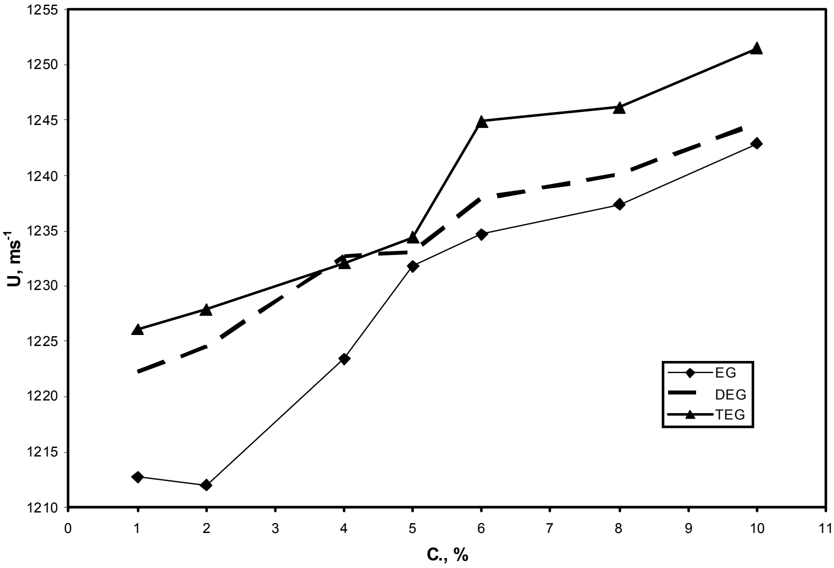

Fig. 1. Concentration *vs.* ultrasonic velocity

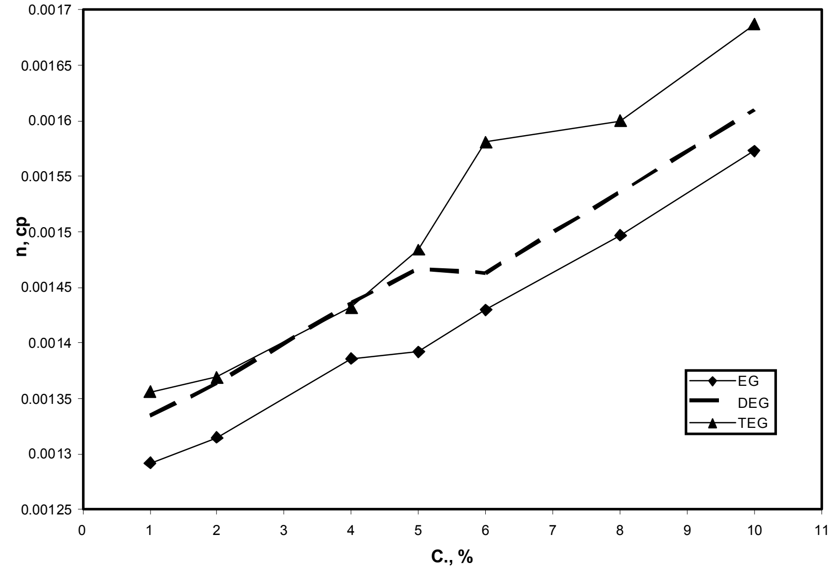

Fig. 2. Concentration *vs.* viscosity

ethylene glycols chosen in the present study. Further, the increase in concentration led to the deviation from linear dependence and this observation was considered to be indicative of polymer involvement interaction.

## Conclusion

The variation in the acoustical parameters with concentration for ethylene glycol, diethylene glycol and triethylene glycol in ethanol suggests that there are strong polymer-solvent interactions at 5 % concentration. In the case of low molecular weight polymers the change in the acoustical parameters could be explained as due to cooperative movement of the polymer molecules and the segmented relaxation are less significant, especially in dilute solution.

## REFERENCES

1. H. Hassler and H. Bauer, *J. Kolloid. Z.*, **230**, 194 (1969).
2. V. Kannappan and S. Kothai, *Indian J. Pure Appl. Phys.*, **40**, 17 (2002).
3. V. Kannappan, S. Mahendran, P. Sathyamoorthy and D. Roopsingh, *J. Polym. Mater.*, **18**, 409 (2001).
4. W. Bell, A.M. North, R.A. Pethrick and P.B. Teik, *J. Chem. Soc. Faraday Trans. II*, **75**, 1452 (1979).
5. V. Arumugam, A. Akalya, J.F. Rajasekaran and R. Balakrishnan, *J. Polym. Mater.*, **17**, 371 (2000).
6. M.L. Lakhampal, S.C. Sharma, B. Krishnan and R.N. Parshar, *Indian J. Chem.*, **14A**, 642 (1976).
7. V. Kannappan and S. Kothai, *J. Acous. Soc. Ind.*, **29**, 169 (2001).
8. S. Kothai, Ph.D. Thesis, University of Madras (2003).
9. N.B. Graham, M. Zulfiqar, N.E. Nwuchuku and A. Rashid, *Polymer*, **30**, 528 (1989).
10. A.V. Rajulu, R.L.L. Reddy and G.B. Rao, Advances in Ultrasonics, 132 (2001).
11. V. Kannappan and S. Kothai, *J. Polym. Mater.*, **19**, 419 (2002).
12. S.K. Hassan and S.O. Isa, *Brit. Polym. J.*, **21**, 333 (1984).
13. S.V. Naidu, A. Varadarajulu and K.C. Rao, *J. Polym. Mater.*, **7**, 149 (1990).

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