Dielectric Relaxation Study of 2-Ethoxyethanol with Pyridine and 2- Aminopropane with Nitrobenzene in Dilute Solutions of Benzene at Microwave Frequency

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ABSTRACT - Dielectric relaxation behavior of two binary liquid mixtures, viz., 2-ethoxyethanol + pyridine and 2-aminopropane + nitrobenzene in dilute solutions of benzene has been studied at X-band (9.8 GHz). The experimental relaxation time (τ) of the systems is determined by a concentration variation method of Gopala Krishna. Relaxation time (τ) is determined by using a theoretical treatment of Madan. A theoretical relation for determining (τ) values for non-associated behavior of binary mixture is also proposed. The results are interpreted in terms of intermolecular interactions of the relaxing groups in the mixture. The relaxation time (τ) values determined from the proposed theoretical equation are consistent with the values determined from the Madan's relation.

KEY WORDS - Dielectric relaxation, Polar liquids, Dielectric constant, Dielectric Loss, Dipole moment, Microwave absorption.

I. INTRODUCTION

Dielectric relaxation studies in polar mixture in non-polar solvent are helpful in predicting the presence or absence of polar complexes in a liquid mixture[1-3]. The present investigations have been undertaken in examining the possibilities of complex formation between two different solutes to gain more information. Comparatively less information about dielectric relaxation is available on 2-aminopropane and 2-ethoxyethanol. In this investigation, measurements of dielectric constant and loss have been carried out in binary mixtures of varying concentrations of 2-ethoxyethanol and pyridine (called here as system I) and 2-aminopropane and nitrobenzene (called here as system II) in dilute solutions of benzene at 9.8 GHz, at a room temperature. Since the dielectric data for these systems were not available prior to these investigation. In system I, the relaxing groups have small relaxation time difference where as in system II have a large difference.

II. EXPERIMENTAL

The chemicals have been obtained commercially with a purity of 99% specification and they are further purified by distillation before their measurements. However, 2-aminopropane is used without any further purification. Solutions of varying concentrations were prepared at room temperature. Dielectric measurements have been carried out on X- band (9.8 GHz) microwave frequency at room temperature.

Dielectric constant (ε') and loss (ε") of the solution have been determined by using standing wave method of Smyth[4] and described in paper[5]. The accuracy in the measurement of ε' and ε" is found to be +2% and +5% respectively. The dielectric data have been used to determine the values of relaxation time (τ) by using Gopala Krishna method[6].

III. RESULTS AND DISCUSSION

The relaxation time (τ) of a binary mixture of non-associated behavior may be assumed to be linearly dependent on their concentrations is determined by a theoretical relation given as

$$\tau = c_1\tau_1 + (1-c_2)\tau_2 \qquad (1)$$

where τ_1 and τ_2 are relaxation times of solute 1 and 2 respectively in non-polar medium and c is the mole fraction of the first solute in their mixture. Another theoretical relation to represent molecular behavior of a binary mixture in non-polar solvent is given by Madan[7] as

$$\frac{1}{\tau} = \frac{c_1\mu_1^2}{c_1\mu_1^2+[1-c_1)\mu_2^2]\tau_1-} + \frac{(1-c_1)\mu_2^2}{c_1\mu_1^2+[1-c_1)\mu_2^2]\tau_1} \qquad (2)$$

where, c is mole fraction of the first solute in the mixture, μ_1 and μ_2 are dipole moments of the first and second solute

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respectively in the non-polar medium, τ_1 and τ_2 are relaxation times of the first and second solute respectively in the non-polar medium. The values of relaxation times and dipole moments respectively, used in theoretical relations (1) and (2) are 1.75 pS, 1.10 D for 2-aminopropane[5], 10.80 pS, 4.15 D for nitrobenzene[5], 4.67 pS, 2.04 D for 2-ethoxyethanol[5] and 3.16 p S, 2.14 D for pyridine[5]. The values of relaxation times determined by using equations (1) and (2) are recorded in Table-1 along with the experimental values.

Equations (1) and (2) gave values of relaxation times for a mixture of non-associative type molecules. The (τ) values for the system (I) and (II) are represented in Table-1 along with the experimental values. 2-Ethoxyethanol is a molecule which has internal hydrogen bonding and pyridine is a rigid polar molecule. In system (I) the experimental values of the relaxation times for different combining ratios of the mixture are found to be slightly larger than the values as determined by the equations (1) and (2). The similar trend is found for the system (II).

Table-1: Dielectric Relaxation Times of Binary Liquid Mixtures in Dilute Solutions in Benzene at Microwave Frequency

Dipolar Mixture	Relaxation Time τ (pS)		
	Experiment	Eqn. (1)	Eqn. (2)
2- ethoxyethenol + pyridine (mole fraction of 2-ethoxyethenol in mixture)			
1.00	4.67	4.67	4.67
0.82	6.34	4.39	4.27
0.62	4.30	4.06	3.91
0.40	3.75	3.76	3.59
0.20	3.58	3.46	3.36
0.00	3.16	3.16	3.16
2-aminopropane + nitrobenzene (mole fraction of 2-aminopropane in mixture)			
1.00	1.75	1.75	1.75
0.70	6.54	4.46	6.24
0.50	8.22	6.27	8.06
0.30	9.00	8.08	9.38
0.14	9.67	9.55	10.20
0.00	10.80	10.80†	10.80

† at 10°C (Reference 5)

IV. CONCLUSION

The results obtained from the present study are consistent with the results obtained earlier[8-10]. Thus the proposed relation (1) is simple and gives consistent results with the relation (2) proposed by Madan. The proposed relation (1) represents satisfactorily whether relaxing units in the mixture have large or small relaxation time difference. Hence, it is concluded that in spite of weak attractive interactions between the components of the mixture, some complex must be forming inside the solutions.

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