

NOTE

Dielectric Behaviour of Binary Polar Liquid Mixtures in Dilute Solutions of Benzene at Microwave Frequency†

B.M. SURYAVANSHI* and S.C. MEHROTRA‡

Department of Physics, Institute of Science, Nagpur-440 001, India

Dielectric relaxation behaviour of two binary systems, viz., 2-aminopropane + nitrobenzene and 2-ethoxyethanol + pyridine in dilute solutions of benzene have been studied at 9.54 GHz and at room temperature. A concentration variation method of Gopala Krishna is used to determine the experimental relaxation time (τ) of the systems. A theoretical treatment of Madan is used to determine (τ) values. A theoretical relation for determining (τ) values for non associated behaviour of binary mixture is also proposed. The results are interpreted in terms of intermolecular interactions of the relaxing groups in the mixture. The (τ) values determined from the proposed theoretical equation are consistent with the values determined from the Maddan's relation.

Key Words: Polar liquids, Dielectric relaxations, Dipole moment, Microwave absorption.

Studies of dielectric relaxation in polar mixture in non polar solvent are helpful in predicting the presence or absence of polar complexes in a liquid mixture¹⁻³. The present investigations is an extension of our earlier studies⁴ and has been undertaken in probing 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 paper, measurements of dielectric constant and loss have been carried out in binary mixtures of varying concentrations of 2-aminopropane and nitrobenzene (called here as system I) and 2-ethoxyethanol and pyridine (called here as system II) in dilute solutions of benzene at 9.54 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 large relaxation time difference where as in system II have a small difference.

All the chemicals used in the present investigations were obtained commer-

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‡Department of Electronics and Computer Science, Dr. B.A. Marathwada University Aurangabad (M.S.).

cially with a purity of 99% specification and they were 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 (9.54 GHz) microwave frequency at room temperature.

Dielectric constant (ϵ') and loss (ϵ'') of the solution have been determined by using standing wave method of Smyth⁵ and described in an earlier paper⁴. The accuracy in the measurement of ϵ' and ϵ'' is found to be ± 2 and $\pm 5\%$ respectively. The dielectric data have been used to determine the values of relaxation time (τ) by using Gopala Krishna method⁶.

A theoretical relation for determining the relaxation time (τ) of a binary mixture of non associated behaviour may be assumed to be linearly dependent on their concentrations and is given as

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

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 behaviour of a binary mixture in non polar solvent is given by Maddan⁷ as follows.

$$\frac{1}{\tau} = \frac{c_1\mu_1^2}{[c_1\mu_1^2 + (1 - c_1)\mu_2^2]\tau_1} + \frac{(1 - c_1)\mu_2^2}{[c_1\mu_1^2 + (1 - c_1)\mu_2^2]\tau_2} \quad (2)$$

where, c -mole fraction of the first solute in the mixture. μ_1 and μ_2 -dipole moments of the first and second solute respectively in the non polar medium. τ_1 and τ_2 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-amino propane⁴, 10.80 pS, 4.15 D for nitrobenzene⁴, 4.67 pS, 2.04 D for 2-ethoxyethanol and 3.16 pS, 2.14 D for pyridine⁴. 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). 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. The results obtained from the present study are consistent with the results obtained earlier^{1, 8-10}. Thus the proposed relation 1 is simple and gives consistent results with the relation 2 proposed by Maddan¹. The proposed relation 1 represents satisfactorily whether relaxing units in the mixture have large or small relaxation time difference.

TABLE-1
DIELECTRIC RELAXATION TIMES OF BINARY LIQUID MIXTURES IN DILUTE SOLUTIONS IN BENZENE AT X-BAND (9.54 GHz) MICROWAVE FREQUENCY AT 16°C

Dipolar mixture	Relaxation time t (p S)		
	Experiment	Eqn. 1	Eqn. 2
2-aminopropane + nitrobenzene (mole fraction of 2-aminopropane in mixture)			
1.00	1.75	1.75	1.75
0.70	6.83	4.46	6.24
0.50	8.34	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
2-ethoxyethanol + pyridine (mole fraction of 2-ethoxyethanol in mixture)			
1.00	4.67	4.67	4.67
0.82	6.50	4.39	4.27
0.62	4.50	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

† at 10°C (Reference 4)

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REFERENCES

1. M.P. Madan, M. Shelfoon and I. Cameron, *Can. J. Phys.*, **55**, 878 (1977).
2. J. Prakash and B. Rai, *Indian J. Pure Appl. Phys.*, **24**, 187 (1986).
3. N.E. Hill, W.E. Vaughan, A.H. Price and M. Davies, *Dielectric Properties and Molecular Behaviour*, Van Nostrand Reinhold, London (1969).
4. B.M. Suryavanshi and S.C. Mehrotra, *Indian J. Pure Appl. Phys.*, **29**, 482 (1991).
5. W.M. Heston (Jr.) A.D. Franklin, E.J. Hennelly and C.P. Smyth, *J. Am. Chem. Soc.*, **72**, 3443 (1950).
6. K.V. Gopala Krishna, *Trans. Farad. Soc.*, **53**, 767 (1957).
7. M.P. Madan, *Can. J. Phys.* **58**, 20 (1980).
8. A. Schallmach, *Trans. Farad. Soc.*, **42**, 180 (1946).
9. D.J. Denney, *Chem. Phys.*, **30**, 1019 (1959).
10. S.K. Saxena and M.C. Saxena, *Indian J. Pure Appl. Phys.*, **19**, 556 (1981).