Dielectric Measurement Of Binary Polar Liquid Mixture At Microwave

S.B. Gedam[1]*,Dr.Gopal Panda[2]

[1]*,[2]Department of Physics, Sarvepalli Radhakrishnan University ,Bhopal (India).
E-mail:- dr.shashigedam@rediffmail.com[1]

***Corresponding Author:** S.B. Gedam
* Department of Physics, Sarvepalli Radhakrishnan University ,Bhopal (India).
E-mail:- dr.shashigedam@rediffmail.com

Abstract
Dielectric constant (ε') and loss factor (ε") of dilute solutions of binary mixture acetophenone and nitrobenzene of equal mass in benzene medium at room temperature have been determined experimentally using Smyth's method at Microwave bench (X-band). Gopalakrishna's single frequency method was used to determine the microscopic relaxation (τ) of binary mixture of acetophenone and nitrobenzene in benzene medium. The results obtained in this work are in agreement with literature values and explains binary molecular interactions.

Keywords : Dielectric constant, Dilute solution, Microwave frequency, Relaxation time

INTRODUCTION

Studies of dielectric constant, of polar liquids and especially in dilute solutions in non-polar medium have a important role in liquid state[1-5]Dielectric constant is a molecular property of substances, which is due to contribution from orientation, vibration and electronic polarization. Dielectric investigation mainly probe weak forces and help to understand intermolecular reorientational dynamics of the solute as well. In the present paper, we have carried out dielectric measurements of binary mixture acetophenone and nitrobenzene a polar liquid in a non-polar medium (benzene) at single microwave frequency (10.15GHz.) and at room temperature. The results are discussed to interpret molecular structure in terms of relaxation time (τ) of reorientation motion of the dipole in the medium.

MATERIALS AND METHODS

The acetophenone and nitrobenzene (LOBA Chemi) and non-polar benzene (sd-fine chem..) of AR grade obtained commercially and ware used without any further purification. Dilute solutions of, acetophenone and nitrobenzene of equal mass for few dilute concentrations in benzene. The solution were mixed well and kept for 12Hrs. in a well stopper volumetric flask to ensured good thermal equilibrium. These systems in non-polar benzene were assumed to be dilute solutions.

The X-band microwave bench was used to measure the wavelength of the microwave radiation and double minimum position in liquid dielectric cell. The liquid sample was hold vertically in a liquid dielectric cell by supporting a thin mica sheet whose VSWR and attenuation were assumed negligible small. The liquid dielectric cell was attached at the end of microwave bench and maintained at room temperature. The procedure of measurement on X-band is describe elsewhere[4-6] The Smyth's method [6-7] are used to calculate dielectric constant, dielectric losses at microwave frequency.

$$\varepsilon' = \{\lambda 0 / \lambda c\}2+\{\lambda 0/\lambda d\}2 \quad \text{----------(1)}$$

$$\varepsilon'' = 2/\pi[\lambda 0 / \lambda d]2[\lambda g/\lambda d]2 \quad \text{----------(2)}$$

Where,
λ0 - Wavelength of microwave radiation.
λc– Cut off wavelength in the wave guide.
λd - Wavelength of microwave radiation in liquid medium.
A Gopala Krishna method [8] based on eq.(3) is is used to determine a relaxation time(τ) eq.(4) of polar liquid.

$$[\varepsilon^*_1/\varepsilon^*_2]=[\varepsilon\infty-1]/[\varepsilon\infty-2]+[4\pi\eta\mu 2/9KT][1/(1+j\omega\tau) \quad \text{----------(3)}$$

Where,

$$\varepsilon^*=\varepsilon'-j\varepsilon''$$

$$X=\varepsilon'+\varepsilon'2+ \varepsilon''2-2/(\varepsilon'+2)2+ \varepsilon''2$$

$$Y= 3\varepsilon''/ (\varepsilon'+2)2+ \varepsilon''2$$

$$\tau = (1/\omega)(dy/dx) \quad \text{----------(4)}$$

Where, X and Y are the variables are depending on concentrations of the polar liquid in non-polar medium.

RESULT AND DISCUSSION

The determined values of dielectric constants (ε') and dielectric losses (ε'') of binary mixture, acetophenone and nitrobenzene in benzene are reported in Table 1, below.

Table 1: determined values of dielectric constants (ε') and dielectric losses (ε'') of binary mixture , Acetophenone and Nitrobenzene

S.N.	Cons.	ε'	ε''	n 2=ε ∞	X	Y	τ in ps
1	0.2	2.2953	0.2020	2.3801	0.3031	0.03277	8.4104
2	0.4	2.4258	0.5185	2.3801	0.3313	0.07833	
3	0.5	2.4399	0.6419	2.3801	0.3381	0.09568	
4	0.6	2.4639	0.7391	2.3801	0.3458	0.1083	

plot a graph between Y and X is plotted, which is linear fig (1).

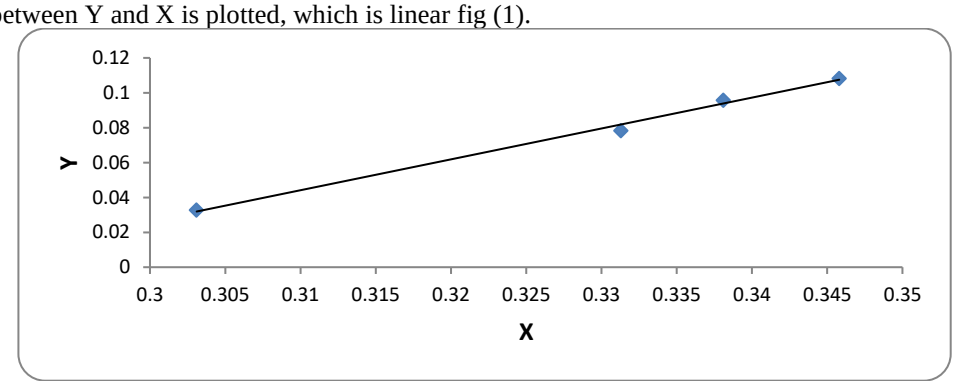

Fig (1) linear behavior between Y and X

From the slop of the linear plot (dy/dx) substituted in equ. (4) and the relaxation time (τ) of the acetophenone , nitrobenzene binary mixture was determined .

Fig (2a) Linear behavior dielectric constant (ε'), and dielectric loss (ε'') against concentration

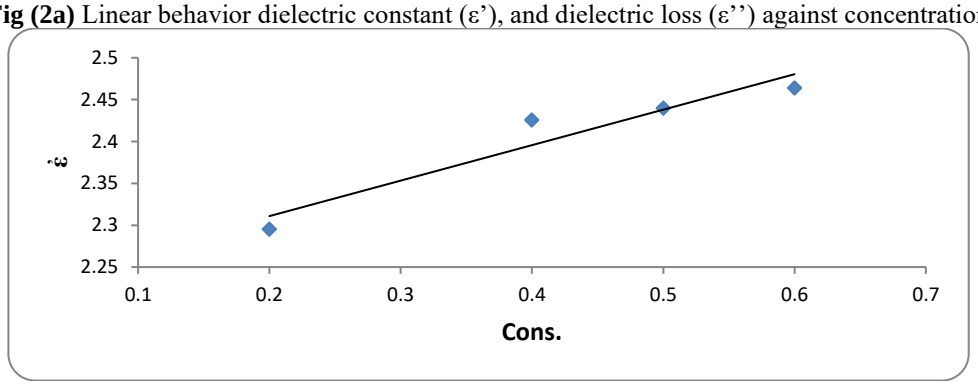

Fig (2a)

Fig (2b) Linear behavior dielectric loss (ε'') against concentration

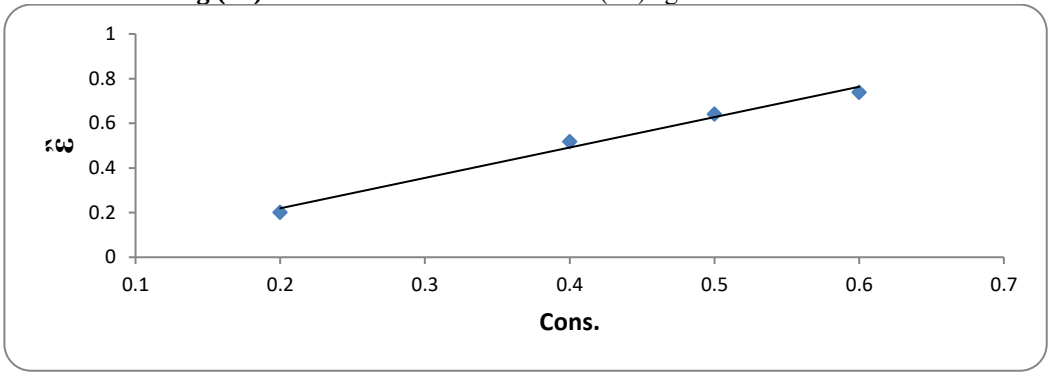

Fig (2b)

CONCLUSIONS

The values of dielectric constant (ε'), and dielectric loss (ε'') binary mixture, acetophenone and nitrobenzene in dilute solution of benzene is increases as function of concentration of polar substance. There vary with the concentration of the solution were sufficiently dilute to minimize the solute-solute interaction. The optical dielectric constant remains constant for all concentrations indicating the entire medium acts like benzene medium in the binary mixtures, the relaxation time of binary mixture is average value of the relaxation times of the individual polar liquid; hence relaxation time of one polar liquid is affecting the relaxation time of other polar in binary mixture. The values of relaxation time (τ) = 8.4104ps of binary mixture acetophenone and nitrobenzene in benzene agree well with the values quoted in the literature [9-12]

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