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Dielectric Relaxation of Nitrobenzene in Benzene Medium at Different Temperature

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ABSTRACT

The dielectric constant(ε') and loss(ε")of polar liquids solutions of benzene have been determined at different temperature (29^0C,35^0C,40^0C,45^0C)at fixed microwave frequency (10.15 GHz)were carried out by Gopala Krishna single frequency concentration method which based on Debye equation has been utilized to analyze the dielectric data (ε' and ε") to obtain relaxation time (τ) electric dipole moment (μ). It is observed that dielectric constant and loss varies with concentration linearly. The studies report a determination of relaxation time (τ) electric dipole moment (μ) of Nitrobenzene in benzene solution at different temperature.

Key words: Dielectric constant, Dilute solution, Relaxation time, Dipole moment

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INTRODUCTION

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

MATERIALS AND METHODS

All polar liquids (Merck Specialties) and non-polar Benzene (sd-fine chem.) of AR grade obtained commercially and were used without any further purification. Dilute solutions of polar liquid 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 in liquiddielectric cell. The liquid sample was hold vertically in a liquid 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. The Smyth's equations[6],[7] are used to calculate dielectric constant, dielectric losses at microwave frequency.

$$\varepsilon' = \left(\frac{\lambda_0}{\lambda_c}\right)^2 + \left(\frac{\lambda_0}{\lambda_d}\right)^2 . (1)$$

$$\varepsilon'' = \frac{2}{\pi}\left(\frac{\lambda_o}{\lambda_d}\right)^2 \cdot \frac{\lambda_g}{\lambda_d} \cdot \frac{d\rho}{dn} . (2)$$

Where,

λ_0 - Wavelength of microwave radiation.
λ_c– Cut off wavelength in the wave guide.
λ_d - Wavelength of microwave radiation in liquid medium.

The procedure of measurement on X-band is describe elsewhere[4-6]

A Gopala Krishna method[8] based on Debye molecular model, eq.(3) is is used to determine a relaxation time(τ) eq.(4) and electric dipole moment (μ) from eq.(5).

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

Where,

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

$\tau = \frac{1}{2\pi f}\left(\frac{dY}{dX}\right)$ (4)

$$\mu^2 = \frac{9kTM}{4\pi Nd_0}\left[1+\left(\frac{dY}{dX}\right)^2\right]\frac{dX}{dW} (5)$$

Where, the meaning of symbols and variation ofX and Y are depend on concentrations of the polar liquid in non-polar medium.

RESULTS AND DISCUSSION

The physical and Molecular constants of polar and non polar compounds are mentioned in table.1, below

TABLE 1: The physical and Molecular constants of polarandnon polar compounds.

Comp.	Mol.wt	M.P. °c	B.P. °c	R.I.	Density Gm/cc
Benzene	78.11	05	80	1.5010	0.874
Nitrobenzene	123.11	5.6	210	1.5513	1.196

The determined values of dielectric constant (ε') and dielectric losses (ε'') of Acetone in benzene solution are reported in Table.2.

TABLE. 2

Temp.	Wt. fra.	ε′	ε″	X	Y
29^0C	0.0108	2.4174	0.1464	0.3216	0.02249
	0.0135	2.4853	0.3527	0.3352	0.05227
	0.0161	2.6377	0.6099	0.3641	0.08362
	0.0187	2.6665	0.9897	0.3847	0.13036
35^0C	0.0108	2.3320	0.1232	0.3080	0.01969
	0.0135	2.4177	0.2669	0.3233	0.04088
	0.0161	2.4276	0.4290	0.3287	0.0650
	0.0187	2.4727	0.6436	0.3428	0.0945
40^0C	0.0108	2.2474	0.0911	0.3002	0.01446
	0.0135	2.4002	0.1765	0.3193	0.02730
	0.0161	2.4239	0.2938	0.3248	0.0448
	0.0187	2.4519	0.4068	0.3405	0.0594
45^0C	0.0108	2.1881	0.0812	0.2812	0.1220
	0.0135	2.3821	0.1123	0.3024	0.2014
	0.0161	2.4142	0.1542	0.3177	0.3210
	0.0187	2.4312	0.2925	0.3305	0.4819

To determine relaxation time (τ) Y and X are plotted at different temperature, which linear fig (1)(a),(b),(c) and(d).

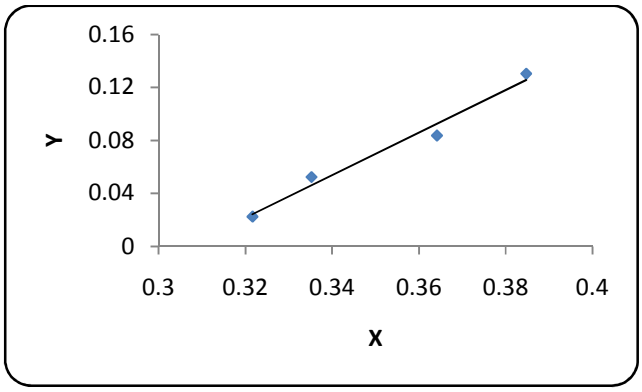

Fig.1(a): Linear behaviour of X and Y nitrobenzene at 29^0C

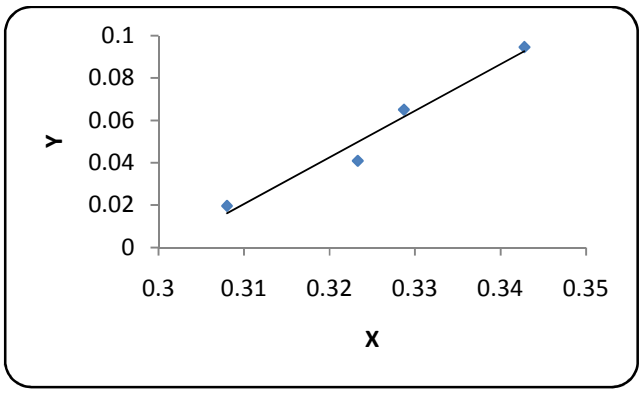

Fig1(b): Linear behavior of X and Y nitrobenzene at 35^0C

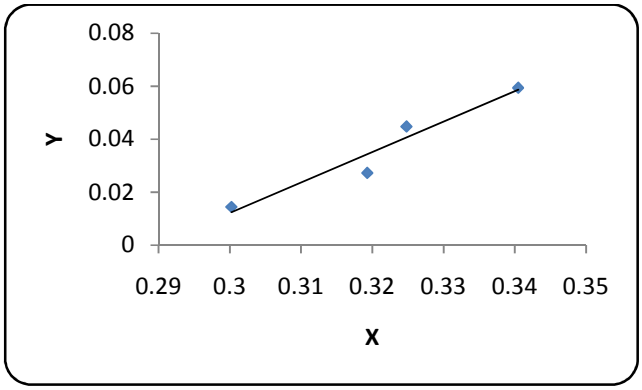

Fig1(c): Linear behavior of X and Y nitrobenzene at 40^{0}C

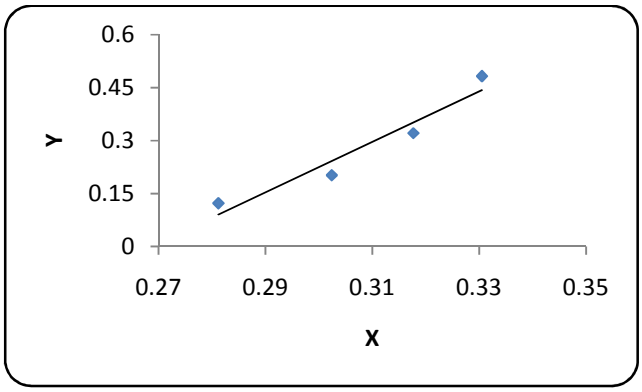

Fig.1(d): Linear behaviour of X and Y nitrobenzene at 45^{0}C

X and W are plotted which is also linear .

fig (2)(a),(b),(c)and (d). Determines Dipole moment (μ)of polar liquids in non- polar benzen medium at different temperature.

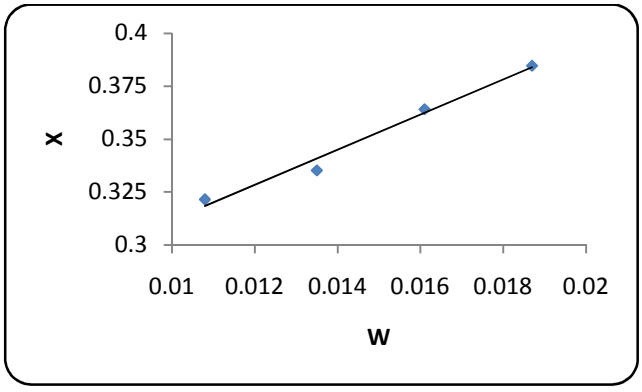

Fig.2(a): Linear behavior of W and X of nitrobenzene at 29^{0}C

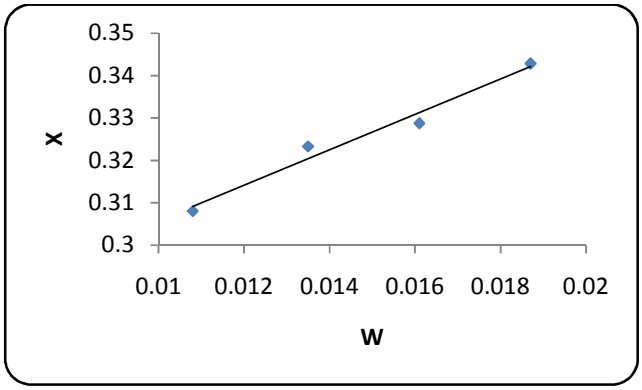

Fig2(b): Linear behaviour of W and X of nitrobenzene at 35^{0}C

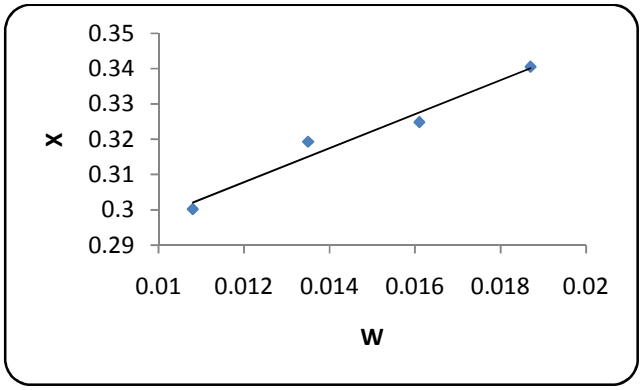

Fig.2(c): Linear behaviour of W and X of nitrobenzene at 40^{0}C

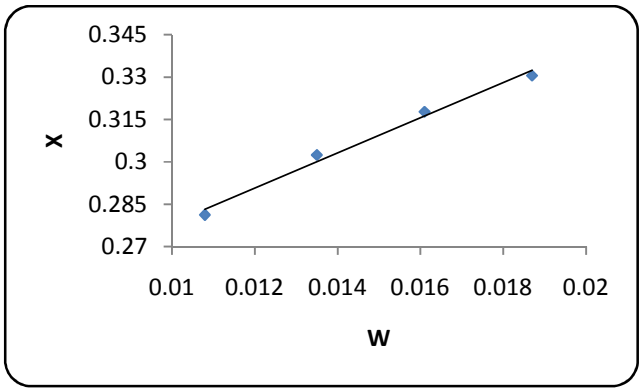

Fig.2(d): Linear behaviour of W and X of nitrobenzene at 45^{0}C

Determines Dipole moment (μ)and relaxation time (τ) of polar liquid Nitrobenzene at different temperature in non-polar benzen medium is given in Table 2. below.

TABLE. 2

Sr. No.	Temp.	Wt. fra.	Relaxa-tion time in ps	Dipole moment in μ D
1	29^0C	0.0108 0.0135 0.0161 0.0187	11.42	4.3119
2	35^0C	0.0108 0.0135 0.0161 0.0187	9.69	4.3425
3	40^0C	0.0108 0.0135 0.0161 0.0187	8.55	4.3856
4	45^0C	0.0108 0.0135 0.0161 0.0187	7.46	4.4112

CONCLUSION

The values of dielectric constant (ε'), and dielectric loss (ε'')of polar liquids in dilute solution of benzene increases as function of concentration of polar substance. The concentrations of the solution were sufficiently dilute to minimize the solute-solute interaction. The relaxation time of polar liquid is decreases as the temperature is increases indicating that the thermal agitation hamper the rotational motion of the polar solute.The change in the dipole moment of polar liquid is small as the increase the temperature.This small change in dipole moment on increase in temperature indicates that energy is absorbed by polar molecules in non polar benzene medium.Dielectric constant of Nitrobenzene is decreases with increase in temperature. The value of relaxation time and electric dipole moment of polar molecules in non-polar benzene are obtained and compared with literature value.[9-12]

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