Dielectric Relaxation of Polar Molecules in Benzene Medium at Microwave

S. B. Gedam and B. M. Suryavanshi

***Abstract*—The dielectric constant (ε') and loss(ε")of polar liquids in solutions of benzene have been determined at room temperature (270C)at fixed microwave frequency (10.15 GHz). 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 Polar liquids in benzene solution at room temperature.**

***Index Terms*—Dielectric constant, dilute solution, relaxation time, dipole moment.**

I. 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 aelectrical 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 27^0Cat single microwave frequency (10.15GHz.). The results are discussed to interpret molecular structure n terms of relaxation time (τ) and electric dipole moment (μ) of the dipole in the medium.

II. Experimental

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 ensure 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 liquid dielectric 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.

Manuscript received March 10, 2013; revised May 16, 2013.

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$$\varepsilon' = \{\lambda_0/\lambda_c\}^2+\{\lambda_0/\lambda_d\}^2 \quad (1)$$

$$\varepsilon'' = 2/\pi[\lambda_0/\lambda_d]^2[\lambda_g/\lambda_d]^2 \quad (2)$$

where,

λ_0 - Wavelength of mirowave radiation.

λ_0 - Cutoff wavelength in the wave guide.

λ_d- Wavelength of mirowave 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, (3) is used to determine a relaxation time(τ) (4) and electric dipole moment (μ) from (5).

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

where,

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

$$\tau = (1/\omega)(dy/dx) \quad (4)$$

$$\mu^2 = 9KTM/4\pi Nd_0\{1+(dy/dx)^2\}dx/dw \quad (5)$$

where, the meaning of symbols are standered and variation of x and y are depend on concentrations of the polar liquid in non-polar medium.

III. Result and Discussion

The physical and Molecular constants of polar and non polar compounds are mentioned in Table I, below

TABLE I: The Physical and Molecular Constants of Polar Andnon Polar Compounds

Comp.	Mol.wt	M.P. ^oc	B.P. ^oc	R.I.	Density Gm/cc
Benzene	78.11	05	80	1.5010	0.874
Acetone	58.08	-94	56	1.3585	0.791
Pyridine	79.10	-42	115	1.5102	0.978
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 II.

To determine relaxation time (τ) Y and X are plotted, which is linear Fig. 1.

X and W are plotted which is also linear Fig. 2 determines Dipole moment (μ) of polar liquids in non- polar benzen medium .

DOI: 10.7763/IJAPM.2013.V3.226

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

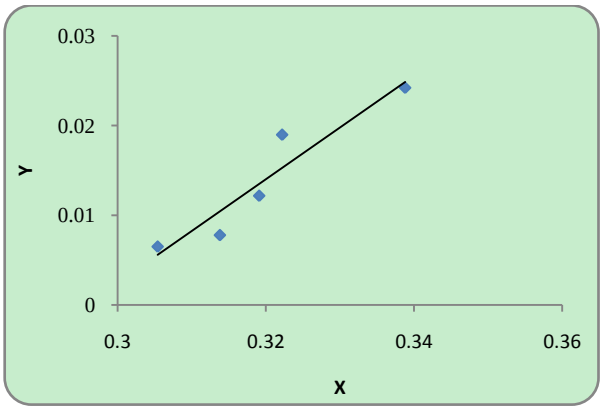

Fig. 1. Linear behavior of acetone between Y and X.

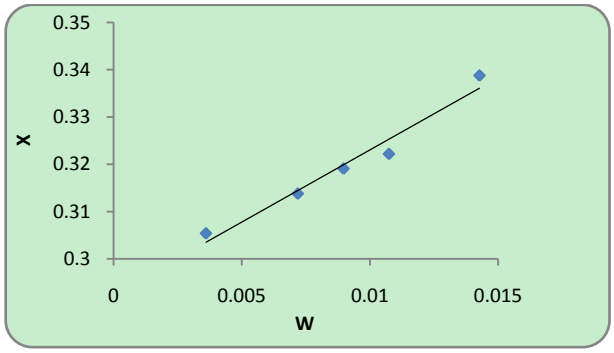

Fig. 2. Linear behavior of X and W for acetone in benzene.

TABLE II: THE DETERMINED VALUES OF DIELECTRIC CONSTANT (ε') AND DIELECTRIC LOSSES (ε'') OF ACETONE IN BENZENE SOLUTION

SN	Wt. fraction (W)	ε'	ε''	X	Y
1	0.003607	2.3188	0.04043	0.3054	0.006502
2	0.007188	2.3719	0.04960	0.3138	0.007784
3	0.008969	2.4045	0.07871	0.3191	0.012168
4	0.01074	2.4225	0.1238	0.3222	0.01897
5	0.01427	2.5309	0.1658	0.3388	0.02420

TABLE III: THE DETERMINED VALUES OF DIELECTRIC CONSTANT (ε') AND DIELECTRIC LOSSES (ε'') OF PYRIDINE IN BENZENE SOLUTION

SN	Wt. fraction (W)	ε'	ε''	X	Y
1	0.01107	2.3064	0.0531	0.3035	0.008589
2	0.01325	2.3747	0.0627	0.3144	0.009826
3	0.01542	2.4140	0.1073	0.3207	0.01651
4	0.01759	2.4314	0.1243	0.3235	0.01897
5	0.01974	2..4712	0.2032	0.3304	0.03043

To determine relaxation time (τ) and dipole moment (μ) X and Y are plotted, which linear Fig. 3.

X and W are plotted which is also linear fig (4) determines Dipole moment (μ)of polar liquids in non- polar benzen medium.

A plot of Y versus X is linear and which determines the value of relaxation time and a plot of X versus W (weight fraction) determine the value of electric dipole moment of Pyridine.

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

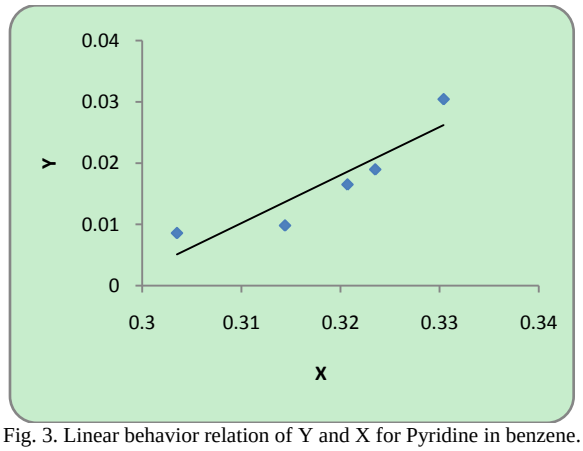

Fig. 3. Linear behavior relation of Y and X for Pyridine in benzene.

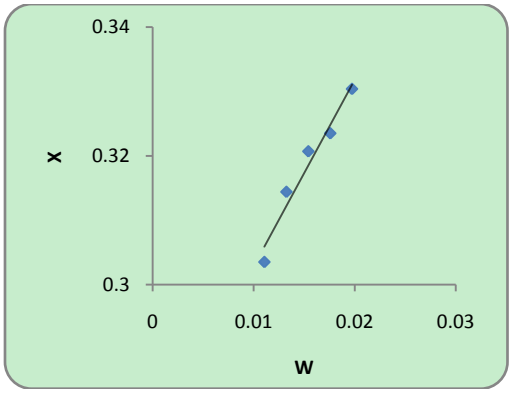

Fig. 4. Linear behavior of X and W for pyridine in benzene.

TABLE IV: THE DETERMINED VALUES OF DIELECTRIC CONSTANT (ε') AND DIELECTRIC LOSSES (ε'') OF NITROBENZENE IN BENZENE SOLUTION

SN	Wt. fraction (W)	ε'	ε''	X	Y
1	0.002729	2.3196	0.07866	0.3057	0.01264
2	0.005443	2.4083	0.1901	0.3207	0.02929
3	0.008143	2.4159	0.3220	0.3242	0.04928
4	0.010528	2.4782	0.3473	0.3341	0.05164
5	0.013499	2.5476	0.5648	0.3503	0.08069

To determine relaxation time (τ) Y and X are plotted, which is linear Fig. 5.

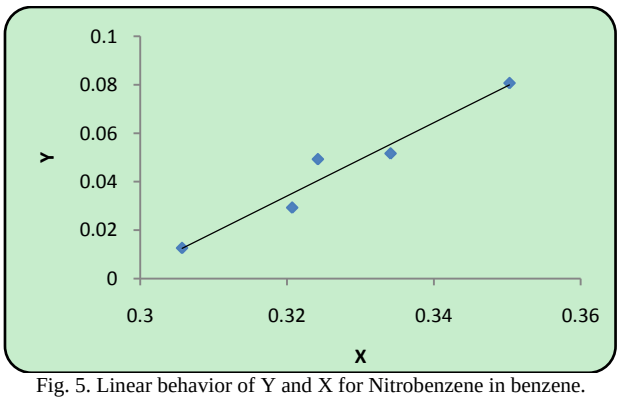

Fig. 5. Linear behavior of Y and X for Nitrobenzene in benzene.

X and W are plotted which is also linear Fig. 6 determines Dipole moment (μ) of Nitrobenzene in non- polar benzene medium.

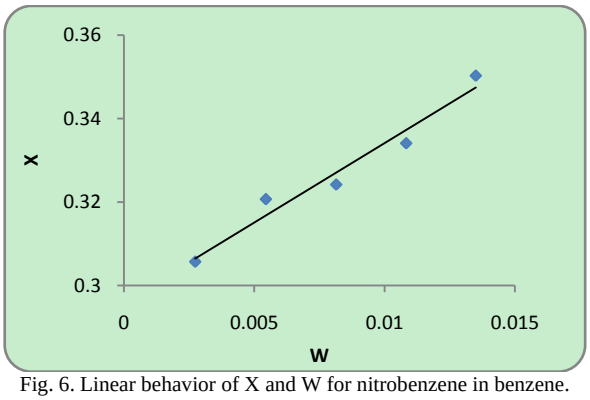

Fig. 6. Linear behavior of X and W for nitrobenzene in benzene.

Determines Dipole moment (μ) and relaxation time (τ) of polar liquids in non- polar benzen medium is given in Table V. below.

TABLE V: DETERMINES DIPOLE MOMENT (μ) AND RELAXATION TIME (τ) OF POLAR LIQUIDS IN NON-POLAR BENZEN MEDIUM

Polar Liquids	Mol. Wt.	Relaxation Time in ps		Dipole moment in D	
		Exp	Lit.	Expt	Lit
Acetone	58.0	2.3940	2.15	2.4801	2.67
Pyridine	79.10	3.319	4.35	2.2799	2.25
Nitrobenzene	123.11	10.738	11.0	4.3208	3.96

IV. CONCLUSIONS

The values of dielectric constant (ε'), and dielectric loss (ε'') of polar liquids in dilute solution of benzene increase as function of concentration of polar substance. The concentrations of the solution were sufficiently dilute to minimize the solute-solute interaction. 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].

ACKNOWLEDGMENT

F. A. Author thank to Dr. L. H. Khalsa, Pricipal, M. G. College Armori for encouragement and UGC WR Pune for grant of Teacher fellowship under faculty improvement program {F.No.32-09(WRO)}.S. A. Auther thanks to UGC WR Pune for grant of Minor research Project (No. F.4)-10/2003 to develop X-band bench in the department.

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