

# **DIELECTRIC RELAXATION STUDY OF BINARY MIXTURES OF DIMETHYL SULFOXIDE AND ETHANOL**

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**ABSTRACT :** The dependence of dielectric relaxation on frequency, temperature, pressure and other external factors has been used to investigate the correlation between the morphology and electrical properties of macromolecules. Study of molecular interaction of Dimethyl Sulfoxide with Ethanol has been carried out at sampling frequency 12.4 GHz and at temperatures 15°C, 20°C, 25°C & 30°C. Time domain reflectometry (TDR) in reflection mode has been used as a technique. The static dielectric constant ( $\epsilon_0$ ), dielectric relaxation time ( $\tau$ ) and thermodynamic parameters of binary mixtures were obtained from complex reflection spectra.

**KEYWORDS :** Dimethyl Sulfoxide, Ethanol, Dielectric relaxation, Time domain reflectometry, Fourier transformation, Dielectric constant, Relaxation time.

## **I INTRODUCTION**

Time domain reflectometry (TDR) is an effective approach to understand molecular interactions in liquid. It is very interesting to correlate dielectric parameters to molecular dynamics in aqueous solutions. Study of aqueous solutions to understand change in amount of hydrogen bonding, change in size of molecular entities as well as their speed of rotation, in presence of different types of solutes was carried out by many research groups in field of dielectric spectroscopy.

The basics of molecular interaction in solution are hydrogen bonding. Hydrogen bonding occurs between a proton donor and proton acceptor group. The hydroxyl ( -OH ) group is a proton donor as well as proton acceptor. Dimethyl sulfoxide (CH<sub>3</sub>)<sub>2</sub>SO an aprotic polar solvent is not a hydrogen bond donor because it does not have a hydrogen attached to an oxygen or to a nitrogen, so there are no positively charged hydrogens to form ion-dipole interactions. Aprotic polar solvents have a partial negative charge on the surface of their molecules that can solvate cations, but the partial positive charge is on the inside of the molecules, which makes it less accessible.

## **II EXPERIMENTAL**

Time domain reflectometry (TDR) in reflection mode has been used as a technique. In TDR a fast rising step pulse of 25 ps is incident on the binary mixture kept in the cell. The binary mixtures were prepared at different volume percentage of Dimethyl sulfoxide (CH<sub>3</sub>)<sub>2</sub>SO in Ethanol in steps of 10 vol. % within a  $\pm 0.01$  % error limit. The reflected pulse from the cell is sampled with incident pulse in sampling oscilloscope. The reflected pulse from sample contains the information regarding dielectric

behaviour of binary mixture. The reflected pulse without sample  $R_1(t)$  and with sample  $R_x(t)$  were digitized in 1024 points and stored on disc.

**International Journal of Innovative Research in Science,  
Engineering and Technology**

(ISO 3297: 2007 Certified Organization)

**Vol. 2, Issue 8, August 2013**

**III DATA ANALYSIS**

The time dependent data were processed to obtain complex reflection coefficient spectra  $\rho^*(\omega)$  using Fourier transformation (Samulon [1]; Shannon [2]) as

$$\rho^*(\omega) = \frac{c p(\omega)}{j\omega d q(\omega)}$$

Where  $p(\omega)$  and  $q(\omega)$  are Fourier transforms of  $(R_1(t)-R_x(t))$  and  $(R_1(t)+R_x(t))$ , respectively,  $c$  is the velocity of light,  $\omega$  is the angular frequency, and  $d$  is the effective pin length.

The complex permittivity spectra  $\epsilon^*(\omega)$  were obtained from reflection coefficient spectra  $\rho^*(\omega)$  by using the bilinear calibration method (Cole [3] et al.). The experimental values of  $\epsilon^*(\omega)$  are fitted with the Debye equation (Havriliak and Negami [4]; Cole and Cole [5]; Davidson and Cole [6])

$$\epsilon^*(\omega) = \epsilon_\infty + \frac{\epsilon_0 - \epsilon_\infty}{(1 + j\omega\tau)}$$

with  $\epsilon_0$ ,  $\epsilon_\infty$  and  $\tau$  as fitting parameters. A nonlinear least- squares fit method (Bevington [7] ) was used to determine the values of dielectric parameters. The values of static dielectric constant ( $\epsilon_0$ ) and dielectric relaxation time ( $\tau$ ) are listed in table 1.

**Table 1:** Temperature dependent dielectric parameters for Dimethylsulfoxide – Ethanol mixture

Volume fraction of DMSO	15 <sup>o</sup> C		20 <sup>o</sup> C		25 <sup>o</sup> C		30 <sup>o</sup> C	
	$\epsilon_0$	$\tau_{ps}$	$\epsilon_0$	$\tau_{ps}$	$\epsilon_0$	$\tau_{ps}$	$\epsilon_0$	$\tau_{ps}$
0.0	26.51	159.58	26.13	150.77	25.28	139.30	25.04	127.44
0.1	29.89	110.58	29.61	108.78	28.68	99.66	28.32	94.12
0.2	31.87	95.05	32.45	91.63	31.44	84.14	30.57	79.92
0.3	37.89	78.12	34.27	68.15	33.99	67.84	34.32	62.00
0.4	40.61	73.02	37.53	61.51	39.17	63.74	38.27	57.96
0.5	42.47	62.03	41.35	54.11	41.15	53.15	40.73	51.67
0.6	45.25	57.20	44.46	47.33	43.52	46.69	43.55	45.83
0.7	48.91	44.77	47.19	42.34	47.14	37.76	46.06	36.35
0.8	54.22	41.68	52.34	40.41	52.36	36.73	52.70	35.46
0.9	56.05	39.02	56.22	38.46	54.63	34.11	54.34	33.07
1.0	53.24	35.97	52.59	28.39	52.21	26.33	52.12	26.19

The thermodynamic parameters molar enthalpy of activation  $\Delta H$  and the molar entropy of activation  $\Delta S$  were obtained using equation

$$\tau = \frac{h}{KT} \exp[(\Delta H - T\Delta S) / RT]$$

and are listed in table 2.

**International Journal of Innovative Research in Science,  
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**Vol. 2, Issue 8, August 2013**

**Table 2:** Activation enthalpy and entropy of Dimethylsulfoxide – Ethanol mixture

Volume fraction of DMSO	Enthalpy ( $\Delta H$ ) KJ/mole	Entropy ( $\Delta S$ ) $J^{\circ}K\text{mole}$
0.0	8.4645	-0.0277
0.1	5.8008	-0.0340
0.2	5.7329	-0.0325
0.3	7.6923	-0.0242
0.4	7.1188	-0.0255
0.5	5.8108	-0.0287
0.6	7.4713	-0.0221
0.7	8.2811	-0.0177
0.8	5.9610	-0.0252
0.9	6.4777	-0.0229
1.0	12.5608	-0.0125

**IV RESULT AND CONCLUSION**

The static permittivity increases with addition of Dimethylsulfoxide in Ethanol. This raise in permittivity is due to increase in effective dipole moment per unit volume in mixture. Relaxation time is very sensitive parameter related to molecular size as well as mobility of molecules in liquid. Relaxation time for aqueous solutions of Dimethylsulfoxide – Ethanol decreases rapidly up to 50 % concentrations and then decreases slowly with increase in volume fraction of solute in ethanol mixture. The variation in relaxation time shows that, the decrease in amount of hydrogen bonding between solute and solvent molecules, which leads to smaller molecular structures rotating fast.

**ACKNOWLEDGEMENTS**

The authors are greatly obliged to UGC for the financial support through Minor Research Project Scheme.

**REFERENCES**

- [1]Samulon H.A. Spectrum analysis of transient response curves, *Proc. IRE*1951,39,175-186.
- [2] Shannon C.E., Communication in the presence of noise, *Proc. IRE* 1949,37,10.
- [3] Cole R.H.; Berbarian J.G.; Mashimo S.; Chryssikos G.; Burns A.; Tombari E. Time domain reflection methods for dielectric measurements to 10 GHz, *J. Appl. Phys.* 1989,66,793-802.
- [4] Havriliak S. &Negami S. A complete plane analysis of  $\alpha$ -dispersion in some polymer systems *J. Polym. Sci. Polym. Symp.* 1966,99-117.
- [5] Cole K.S. & Cole R.H. Dispersion and absorption in dielectrics, *J.Chem. Phys.* 1941,9,341-345.
- [6] Davidson D.W.; Cole R.H. Dielectric relaxation in Glycerin, *J. Chem. Phys.* 1950,18,1417.
- [7] Bevington P. R., *Data reduction and error analysis for the physical sciences*; McGraw Hill: New York, 1969.