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# Dielectric Relaxation Study of Aniline with 1, 4-Dioxane using picosecond Time Domain Reflectometry method

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**ABSTRACT:** Complex dielectric spectra $\varepsilon^*(\omega)=\varepsilon'-j\varepsilon''$ of binary mixture of aniline with 1,4 Dioxane were obtained in the frequency range 10 MHz to 30 GHz using Time Domain Reflectometry(TDR) technique. The static dielectric constant ($\varepsilon_0$) and relaxation time ($\tau$ ) have been obtained. On the basis of these parameters, molecular interaction and dynamics of the molecules are predicated.

**Keywords:** Time domain refelctometry, complex dielectric spectra, relaxation time.

## I. INTRODUCTION:

The dielectric properties of a substance such as dielectric constant, dielectric loss, relaxation time have provided an insight into the structure of the molecules of the system. In liquids, the molecule has rotational freedom and its dispersion occurs at microwave frequency. Hence studying the dielectric properties at microwave frequency will reveal the dielectric relaxation of polar molecules and its variation with respect to the interaction with the neighbouring polar as well as non polar molecules. Patil et al. [1] In the present paper, the detail study of dielectric behaviour of aniline-1, 4 dioxane mixture in the frequency range of 10 MHz to 30 GHz using Time Domain Reflectometry (TDR) at temperature $25^0$C. From the dielectric parameters intermolecular interaction and dynamics of molecules are discussed.

## II. EXPERIMENTAL:

2.1 Materials:

Aniline (ANI) and 1, 4 Dioxane (DX) was obtained commercially (S.D. Fine Chemicals).

2.2 Apparatus:

The dielectric spectra were obtained by the time domain reflectometry (TDR) technique. The Tektronix model no. DSA8200 Digital Serial Analyzer sampling mainframe along with the sampling module 80E08 has been used for the time domain reflectometry (TDR). A repetitive fast rising voltage pulse with 18ps incident rise time was fed through coaxial line system of impedance 50 ohm. Sampling oscilloscope monitors changes in step pulse after reflection from the end of line. Reflected pulse without sample $R_1$ (t) and with sample $R_x$ (t) were recorded in time window of 2ns and digitized in 2000 points.

2.3 Data Analysis

The time dependent data were processed to obtain complex reflection coefficient spectra $\rho^*(\omega)$ over the frequency range from 10 MHz to 30 GHz as [2, 3].

$$\rho^*(\omega) = \left(\frac{c}{j\omega d}\right)\left[\frac{p(\omega)}{q(\omega)}\right] \quad (1)$$

where $p(\omega)\ \&\ q(\omega)$ are Fourier transforms of [$R_1$ (t)-$R_x$ (t)] and [$R_1$ (t) +$R_x$ (t)] respectively, c is the speed of light, $\omega$ is the angular frequency, d is the effective pin length and j= $\sqrt{-1}$ . The complex permittivity spectra $\varepsilon^*(\omega)$ was obtained from reflection coefficient $\rho^*(\omega)$ by applying calibration method as described earlier [4].The dielectric permittivity $\varepsilon'$ and dielectric loss $\varepsilon''$ of Aniline with1, 4 Dioxane at 25˚C are shown in Figure. From dispersion plot it is observedANI-DX system dielectric loss is independent of volume fraction of DX.

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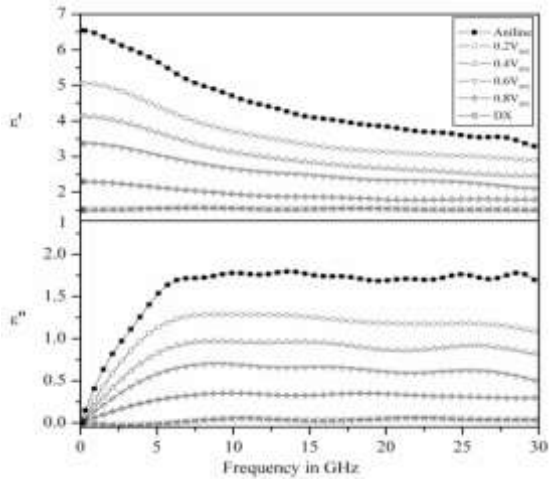


## III. RESULTS AND DISCUSSION:

The complex dielectric permittivity data were fitted to a Havriliak-Negami model using non linear least squares fit method in order to extract dielectric relaxation parameters with the following expression [5].

$$\varepsilon^*(\omega) = \varepsilon_\infty + \frac{\varepsilon_0 - \varepsilon_\infty}{[1+(j\omega\tau)^{1-\alpha}]^\beta} \quad (2)$$

where ε*(ω) is complex permittivity at an angular frequencyω, $\varepsilon_0$ is the static permittivity, $\varepsilon_\infty$ permittivity at high frequency, τ is the relaxation time, α is shape parameter representing symmetrical distribution of relaxation time and β shape parameter of an asymmetric relaxation curve. Equation (2) includes Cole-Cole (β=1) [6], Davidson-Cole (α=0) [7], and Debye (α=0, β=1) [8] relaxation models. The dielectric relaxation model for fitting dielectric parameters suitable for present systems is Davidson-Cole model. Therefore the complex permittivity spectra has been fitted in Davidson-Cole model with (α=0) and β ($0 < \beta \leq 1$) as one of the fitting parameters along with $\varepsilon_0$ &τ. The value of fitting parameter β in Havriliak-Negami expression obtained is in the range of 0.739 to 1 for different concentrations.

The values of dielectric parameters $\varepsilon_0$ and τ obtained from equation (2) for ANI-DX with volume fraction of DX at $25^0$C are reported in table. The experimental values of $\varepsilon_0$ and τ are in good agreement reported earlier [9, 10]. It can be observed that $\varepsilon_0$ decrease with increase in volume fraction of DX in ANI. Relaxation time (τ) in case of ANI it is almost independent of volume fraction of DX

| Vol. Frac. of DX | $\varepsilon_0$ | τ |
|---|---|---|
| 0.0 | 6.593(6) | 16.20(8) |
| 0.2 | 5.098(3) | 15.65(5) |
| 0.4 | 4.144(1) | 16.12(3) |
| 0.6 | 3.373(1) | 16.66(3) |
| 0.8 | 3.309(9) | 16.71(29) |
| 1.0 | 2.210(2) | 7.2(20) |

## IV. CONCLUSIONS:

The complex permittivity spectra of Aniline with DX have been studied at $25^0$C, using time domain reflectometry technique in the frequency range 10 MHz to 30 GHz. The values of $\varepsilon_0$ shows systematic change with increase in volume fraction of DX in the system. Relaxation time (τ) in case of Aniline it is almost independent of volume fraction of DX.

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