ABSTRACT:

The dielectric properties of binary mixture Glycerol (Gly) with N-Methylacetamide (NMA) has been carried out with varying concentrations at different temperatures in the frequency range between 10MHz-20GHz using time domain reflectometry (TDR) technique. Dielectric parameters namely static permittivity ($\varepsilon_0$), relaxation time ($\tau$) were obtained from complex permittivity spectra $\varepsilon*(\omega)$, using nonlinear least squares fit method. These values are used for the calculation of Bruggeman factor. All the systems show a systematic change in dielectric parameters with temperature and concentration. On the basis of above parameters, intermolecular interaction and dynamics of molecules at molecular level are predicted. The dielectric behavior of this binary mixture is found to agree well with the modified Bruggeman equation.

KEYWORDS: Dielectric parameters; Time domain Reflectometry; Bruggeman factor.
using LCR meter by R.J. Sengwa and co-authors [10].

2. EXPERIMENTAL SET UP AND DATA ACQUISITION:

The chemicals, used in the present work are Glycerol and N- Methylacetamide (NMA), are of spectroscopic grade and used without further purification. The solution are prepared at eleven different volume fractions of N- Methylacetamide (NMA) from 0 to 1 in Glycerol in step of 0.1. These volume fractions are converted to mole fractions for further calculations.

The complex permittivity spectra of the samples are studied using time domain reflectometry (TDR) method [11-15]. The Hewlett Packard HP 54750 sampling oscilloscope with HP 54754A TDR plug - in module is used. A fast rising step voltage pulse of about 39 ps rise time generated by a pulse generator was propagated through a coaxial line system of characteristic impedance of 50 Ω. The transmission line system under test was placed at the end of the coaxial line in the standard military application (SMA) coaxial cell conector with 3.5mm outer diameter & 1.35 mm effective pin length. All measurements were done under open load conditions.

The change in the pulse after reflection from the sample placed in the cell was monitored by the sampling oscilloscope. In this experiment, a time window of 5ns was used. The reflected pulses without sample R, (t) & with sample R, (t) were digitized in 1024 points in the memory of the oscilloscope & transferred to a pc through 1.44 MB floppy diskette drive.

A temperature controller system with a water bath & thermostat has been used to maintain the constant temperature within the accuracy limit of + or - 273 k. “Figure 1”. Shows Block Diagram of Experimental setup.

Fig. 1 Block Diagram of Dual Channel TDR Unit

The time dependent data were processed to obtain complex reflection coefficient spectra, ρ*(ω) over the frequency range from 10 MHz to 20 GHz using Fourier transformation [16, 17] as

\[
\rho^*(\omega) = \left[ \frac{c}{j\omega l} \right] \begin{bmatrix} p(\omega) \\ q(\omega) \end{bmatrix}
\]

(1)

Where p (ω) and q (ω) are Fourier transforms of [R, (t) - R, (t)] and [R, (t) +R, (t)], respectively. C is the velocity of light, w is angular frequency and d is the effective pin length and j = root (-1).

The complex permittivity spectra ε*(ω) were obtained from reflection coefficient spectra, ρ*(ω) by applying a bilinear calibration method [1]. The experimental values of ε*(ω) are fitted the Debye equation [18].

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

(2)

where ε∞, ε0, and τ as fitting parameters. The value of ε∞ was kept to be constant as the fitting parameters are not sensitive to ε∞. A non-linear least squares fit method [19] used to determine the values of dielectric parameters. Bruggeman factor, help to depict intermolecular interaction among the liquids.

This formula states that static permittivity of binary mixture (εmon), Solute A (ε0A), and solvent B (ε0B), can be related to volume fraction of solvent (ΦB) in mixture.

The Modified Bruggeman equation [20] for mixture is given by expression

\[
f_B = \left( \frac{\varepsilon_{0m} - \varepsilon_{0B}}{\varepsilon_{0A} - \varepsilon_{0B}} \right) \left( \frac{\varepsilon_{0A}}{\varepsilon_{0m}} \right)^{1/3} = 1 - \Phi_B
\]

(3)

According to above equation linear relationship is expected which will give a straight line when fB plotted against ΦB. Any deviation from this linear relation indicates molecular interaction.

3. Results and discussion

The values of the dielectric parameters ε0 and τ obtained from “equation (2)” for GLY-NMA system with the mole fraction of NMA at four different temperatures are recorded in “Table 1”. From “Table 1”. It can be observed that static permittivity ε0 & relaxation time τ increase with increase in mole fraction of NMA in GLY. Same type of change has been observed at four temperatures under study.

In an ideal mixture of polar liquids, if the molecules are non-interacting linear variation in the values of static dielectric constant and relaxation time with concentration is expected.
However the relationship for dielectric constant and relaxation time is nonlinear with change in mole fraction of NMA in Glycerol. The non-linear variation in dielectric constant and relaxation time with change in mole fraction of NMA in Glycerol suggests weak intermolecular interaction due to shielded charge distribution in NMA molecules and exposed charged distribution in Glycerol i.e intermolecular association is taking place in all these systems [21].

### Table 1: Dielectric parameters for binary mixture of Glycerol + NMA, \( \chi_{\text{NMA}} \) mole fraction of N-methylacetamide.

<table>
<thead>
<tr>
<th>( \chi_{\text{NMA}} )</th>
<th>( \varepsilon_0 )</th>
<th>( \varepsilon' )</th>
<th>( \varepsilon'' )</th>
<th>( \tau(\text{ps}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.8967</td>
<td>100</td>
<td>0.107266</td>
<td>211</td>
</tr>
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<td>0.0968</td>
<td>0.7942</td>
<td>10.4</td>
<td>0.926816</td>
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<td>0.1943</td>
<td>0.6924</td>
<td>2.6</td>
<td>0.653639</td>
<td>288</td>
</tr>
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<td>0.5913</td>
<td>0.3</td>
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<td>288</td>
</tr>
<tr>
<td>0.3914</td>
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<td>0.02</td>
<td>0.107266</td>
<td>288</td>
</tr>
<tr>
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<td>0.3980</td>
<td>0.002</td>
<td>0.0107266</td>
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</tr>
<tr>
<td>0.5913</td>
<td>0.3071</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.6924</td>
<td>0.2162</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.7942</td>
<td>0.1253</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.8967</td>
<td>0.0344</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

NMA in the mixture as shown in “Figure 2”. The values of \( f_B \) shows deviation above linearity from the ideal Bruggeman behavior for all concentrations in the temperature range 288 K to 318 K. This confirms the intermolecular interaction in the mixture. Several similar observations have been reported in the literature [4, 5, 9 and 22].

### 4. CONCLUSIONS

The study provides information that static permittivity, relaxation time and Bruggeman factor of binary mixture of Glycerol (Gly) - N-Methylacetamide (NMA) are depending on temperature and Concentration. Molecular interactions in Glycerol- N-Methylacetamide system were discussed in terms of Bruggeman factor. One observes significant deviation from the Bruggeman factor. The dielectric behavior of this binary mixture is found to agree well with the modified Bruggeman equation.

### REFERENCES


Mahesmalkar et al.


