Dielectric Properties of 2-Chloroaniline and Ethylene Glycol Using Microwave Frequencies

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Abstract:_

The dielectric parameters studies in the microwave frequency region X-band on complex dielectric constant for the binary mixture are reported. The method employed adjustable plunger cavity technique. The values of dielectric constant (ε′), dielectric loss (ε″) have been experimentally determined for binary liquid mixture of 2-Chloroaniline+Ethylene glycol 2-CA+EG at 10.985 GHz microwave frequency. The values of ε′ and ε″ have been used to evaluate the loss tangent (tan δ), molar polarization (*P12*) activation energy (*Ea*) of viscous flow have also been estimated. These parameters have been used to explain the formation 1:1 complex in the system.

Keywords: - Dielectric parameters, Binary mixture, Molar polarization, Intermolecular interaction

Introduction:-

It is well known that the thermo physical properties, of liquid systems such as density, viscosity, dielectric constant, refractive index among others, are strictly related to the molecular interactions present in different binary liquid mixtures. The variation of these properties with composition gives us important data about intermolecular interactions and the structure of pure and binary mixture of 2-CA+EG. There is a wide range of possible interactions between the components of a mixture, such as hydrogen bonding, molecular associations, charge transfer, dipole-dipole and dipole-induced dipole interactions (1). As a consequence of these interactions, deviations occur from ideal behavior of dielectric constant and viscosity.

Experimental:-

2-Chloroaniline (GC Grade) from Merck Schuchardt, Germany and Ethylene glycol (AR Grade) were obtained from Spectrochem PVT.LTD. Mumbai. India. Without further purification the two liquids according to their proportions by volume were mixed well and kept 6 h in well stoppered bottles to ensure good thermal equilibrium. 2-CA is used as solute and EG as solvent.

Measurements:-

The dielectric constant (ε ') and dielectric loss (ε") have been measured using microwave X-band bench oscillating frequency of 10.985 GHz using source of Reflex klystron 2 K 25 (USSR) by Surber (2). The densities and viscosities of the pure components and their mixtures were measured by using DMA 35 portable vibrating density meter. Anton paar Autria (Europe) and viscosity by LVDL, V-pro II Brook field viscometer (USA). A plunger waveguide is converted into a cavity by introducing a coupling hole in the entrance and shorting the other end with the calibrated plunger. The sample occupies the entire volume of the cavity. The frequency is kept constant and the length of the plunger cavity is changed. Hence several nodes appear as one increase the length of the cavity plunger. Whenever the length of the cavity equals the half integral multiples of the guide wavelength inside the medium, the plunger waveguide resonates. The distance through which the plunger is move between two successive cavity nodes gives half of the wavelength (λd) of the microwave inside the medium. The measurement of reflected power at resonance gives the attenuation coefficient of the sample (3). Refractive indices for sodium *D*-line were measured by using Abbe's refractometer, microwave power measured by PM-437 (Attest) power meter, Chennai, India. Rectangular wave guide working TE10 mode, 10 dB, Vidyut Yantra Udyog, India. To hold the liquid sample in the liquid cell, thin mica window whose VSWR and attenuation were neglected is introduced between the cell and rest of microwave bench. The values of and for low loss liquids are calculated according to Heston *et al.* (4) formula.

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

$$\varepsilon'' = \frac{2}{\pi}\left(\frac{\lambda_0}{\lambda_d}\right)^2 \cdot \frac{\lambda_g}{\lambda_d}\left(\frac{d\rho}{dn}\right) \qquad \ldots\ldots\ldots\ldots\ldots\ldots .. 2$$

Where λ_c is the cut-off wavelength, λ_0 is the free space wavelength, λ_d is the wavelength in dielectric medium, λ_g is the wavelength in empty wave guide parameters and ρ is inverse voltage standing wave ratio.

Table 1. Values of mole fraction (X) of 2 CA density (ρ), viscosity (η), refractive index (*n*), dielectric constant (ε′), dielectric loss (ε″), loss tangent (*tan* δ), activation energy (Ea) and molar polarization (P_{12}) for binary liquid mixture.

X	ρ gm/cm^3	η CP	*n*	ε′	ε″	tan δ	Ea, Kcal/mol	P_{12}
0.0000	1.101	14.2	1.416	12.413	0.5224	0.0420	4.8652	34.162
0.7026	1.1146	13.0	1.429	5.666	0.4207	0.0741	4.6215	33.125
0.1499	1.1480	12.2	1.449	6.454	0.3215	0.0498	4.5134	36.215
0.2409	1.1412	11.6	1.458	7.858	0.2245	0.0285	4.4215	38.214
0.3459	1.1542	10.7	1.478	8.452	0.1245	0.0147	4.3210	39.145
0.4685	1.1643	9.66	1.513	9.124	0.5549	0.0608	4.2209	40.231
0.6134	1.1742	8.55	1.544	10.425	0.6458	0.0619	4.1987	45.652
0.7873	1.1872	7.44	1.555	11.564	0.5321	0.0460	4.1578	47.126
1.0000	1.201	3.32	1.578	12.789	0.4321	0.0337	4.1125	48.124

Results and Discussion:-

The values of density (ρ), viscosity (η), refractive index (*n*), dielectric constant (ε′), dielectric loss (ε″), loss tangent (*tan* δ), activity energy (Ea) and molar polarization (P_{12}) for viscous flow with increasing mole fraction of 2-CA for the binary mixtures of 2-CA+EG are reported in Table 1. Density, Refractive Index and Activation Energy. The density of binary mixture of 2-CA+EG are increasing as mole fraction of 2-CA in the binary mixture is increasing. This is expected because density of pure 2-CA is more than that of pure EG. It can also be seen that viscosity (η), and activation energy (Ea) is increasing with increase in mole fraction of 2-CA in the binary mixture. This increase in η and Ea is further supported by the increase in density of the binary mixture with increase in mole fraction of 2-CA. Viscosity, Increases in viscosity (η) for the acid amine and EG mixture due to the formation of dissociated ions in the mixture. Dielectric permittivity values of dielectric constant decrease (ε') with increase in mole fraction of 2-CA in the binary mixture. This can be attributed to the decrease in hydrogen bonding in the binary mixture. This is because there is dipole-dipole interaction in pure 2-CA and strong hydrogen bonding as in pure EG. Non linear behavior of dielectric constant versus mole fraction of 2-CA indicates the formation of complex in the binary mixture. Variation of loss tangent (tanδ) and mole fraction (X) of 2-CA is reported in Table 1. It shows that the absorption in the mixture is greater than that in pure liquid. In our case the formation of complex will increase the dielectric absorption. Molar polarization (P_{12}) suggests 1:1 type complex formation in the binary mixture.

Conclusion:-

From the above results, it can be conclude that the dielectric properties of the studied mixture indicates some molecular interactions, because of glycols are associate liquids; they can interact with each other and with 2-chloroaniline molecules. Dielectric constant and viscosity were the most affected parameters from these interactions.

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