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Der Pharma Chemica, 2014, 6(2):375-377
(http://derpharmachemica.com/archive.html)

ISSN 0975-413X
CODEN (USA): PCHHAX

Dielectric response of some polar liquids in non polar solvent benzene at microwave frequency

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ABSTRACT

The dielectric behavior of three polar liquids such as Methyl acetate ,Methylene dichloride and 2-Methoxy Ethanol in non-polar solvent benzene have been studied at microwave frequency of 21.4 GHz at 300K. Different dielectric parameters like Dielectric constant (ε') and dielectric loss(ε'') at microwave frequency, static dielectric constant (ε_0) and optical dielectric constant (ε_α) are determined. Using these parameters the various relaxation time Viz., Average relaxation time(τ_0), Molecular relaxation time(τ_1) and Group relaxation time(τ_2) of individual component have been calculated. It has been observed that the relaxation time is very closely related with molecular parameters, such as size, shape and nature of the solute molecule.

Keywords: delectric constant ,relaxation time, dielectric loss Methyl acetate ,Methylene dichloride ,2-Methoxy Ethanol

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INTRODUCTION

The phenomenon of dielectric relaxation of binary mixtures of polar liquids in non–polar solvents at microwave frequencies has been attempted by many workers [1–4]. Dielectric studies of binary liquid mixtures of polar–polar are also important for understanding the intermolecular interactions and the consequent structural rearrangement of molecules in solution [5–10].Limited information on the system of rigid and non-rigid polar mixtures available even at a single temperature. The dielectric relaxation studies of rigid and non-rigid polar liquid in non-polar solvent are expected to throw more light on the solute-solute and solute- solvent interactions. The dielectric relaxation studies on binary mixtures are important for understanding the Hydrogen bonding and inter molecular interactions in the mixture. In order to provide the experimental data of the polar liquid in non-polar solvent and to test the existing theoretical relation in microwave frequency region, three polar liquids namely Methyl acetate, Methylene dichloride and 2-Methoxy ethanol are selected in a pure form and mixed them with non-polar liquid (Benzene) at different proportions. They are exposed to optical frequency and microwave frequency. The study is expected to provide better under-standing of the nature of molecular orientation. Molecules of solutes under investigation are rigid and non-rigid type and of various sizes, they are associative and non-associative in nature. More-over it is expected that relaxation behavior of mixture should depend on the concentration of individual component.

MATERIALS AND METHODS

The organic compounds selected for the present work are benzene (non polar) as Methyl acetate ,Methylene dichloride and 2-Methoxy Ethanol . All the chemicals used in the present investigations were obtained commercially

with the purity of 99% specification. Benzene was purchased from Ranboxy ,Fine chemicals Ltd, India. Methyl acetate, Methylene dichloride and 2-Methoxy Ethanol were purchased from Nice Chemicals ,Pvt Ltd., Cochin , India.

The liquid systems for different desired concentration for the study were prepared by weight at laboratory temperature. The methods of investigation in the present dielectric study involved, concentration variation of dielectric solutions of a suitable range of solute concentrations in a polar solvent. The preferred range for all the systems varies from 0.01 to 0.10 weight fraction in step of 0.01.The measurement of dielectric constant **ε'** at microwave frequency and dielectric loss ε" were carried out in the K band at microwave frequency 21.4 GHz. The dielectric constant ε' and dielectric loss ε" of sample are obtained by using the following set of equations.

Dielectric Constant

$$\varepsilon' = (\lambda_0 / \lambda_C)^2 + (\lambda_0 / \lambda_d)^2 [1 - (\alpha_d \ \lambda_d / 2\pi)^2]$$

Dielectric Loss

$$\varepsilon'' = 1/\pi \ (\lambda_0 / \lambda_d)^2 \alpha_d \ \lambda_d$$

where,

λ_C = cut-off wavelengths of the microwave
λ_0=free space wave lengths of the microwave
λ_d =wave length in the dielectric

Dielectric constant of the samples at optical frequency $\boldsymbol{\varepsilon_\alpha}$ are computed with Abbe's refractometer using sodium D-line.

Static dielectric constant $\boldsymbol{\varepsilon_0}$ of samples are measured with LCR Bridge which is based on heterodyne beat method. The loss tangent is calculated by the formula

Tan δ =**ε"/ ε'**

The value of distribution parameter -α, most probable relaxation time τ_0, relaxation time τ_1, for molecular rotation and Relaxation time τ_2 for intra molecular rotation are determined experimentally .The expression used to compute distribution parameters α, and various relaxation times can be calculated

$$\tau_1 = a'' / \omega (a' - a_\infty)$$
$$\tau_2 = a_0 - a' / \omega a''$$
$$\tau_0 = (\tau_1 \tau_2)^{1/2}$$

a_0, a', a", a_∞ are Higasi's parameters determined by plotting the measured values of **ε'** , **ε", ε_0, ε_∞** against weight fraction of the solution.

RESULTS AND DISCUSSION

The relaxation time (τ) of three pure compounds and their mixtures of Methylene dichloride, Methyl acetate and 2-methoxy ethanol in a non-polar solvent Benzene at 300K using different concentration are calculated. The relaxation time by Higasi's method were determined [11,12]. The values of distribution parameters for the pure compounds and their mixtures were determined. Dipole moment is calculated by both Higasi's method and Guggenheim's method .The dipole moments of the molecules, presently studied by both methods matches.

The various relaxation time Viz., Average relaxation time (τ_0), Molecular relaxation time (τ_1) ,Group relaxation time(τ_2)and relaxation time by Gopalakrishna method($\boldsymbol{\tau_{1GK}}$) and distribution parameters for various systems in Benzene at 300K of individual component and their binary mixtures have been reported in table 1. Dipole moment is calculated by both Higasi's method and Guggenheim's method matches each other.

Relaxation times, Distribution parameter(α) for various systems in Benzene at 300K

Relaxation times

Systems	τ_1	τ_2	τ_0	τ_{1GK}	α
Methylene dichloride	5.2864	11.6935	7.8623	5.6761	0.4444
Methyl aetate	4.3116	12.6111	7.3739	4.7870	0.3259
2 Methoxy ethanol	1.6420	25.3519	6.4537	1.5969	0.6799
Methylene dichloride+ Methyl aetate	4.6821	12.2406	7.5705	5.2023	0.2943
Methylene dichloride+2 Methoxy ethanol	2.6839	16.9572	6.7462	2.6937	0.5163
Methyl aetate+2 Methoxy ethanol	2.7321	17.6813	6.9503	2.7661	0.5255

Dipole moments for various systems in Benzene at 300K

Systems	Dipolemoment	
	μ_g	μ_h
Methylene dichloride	1.5916	1.5841
Methyl aetate	1.7172	1.7092
2 Methoxy ethanol	2.0387	2.0294
Methylene dichloride+ Methyl aetate	1.6468	1.6382
Methylene dichloride+2 Methoxy ethanol	1.8231	1.8136
Methyl aetate+2 Methoxy ethanol	1.8647	1.8550

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