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RESEARCH ARTICLE

Dielectric Study of Phenacetin at a Microwave Frequency

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Abstract

The dielectric parameters of phenacetin are studied in the dilute solution of carbon tetrachloride at a microwave frequency of 9.265 GHz at four different temperatures (303K, 313K, 323K and 333K). The calculations are done for five different mole fractions of Phenacetin. Dielectric constant (ε') and Dielectric loss factor (ε'') have been measured with the help of method given by Heston et al. Static permittivity (ε_0) and dielectric constant at optical frequency (ε_∞) are measured by using dipole meter and Abbe's Refrectometer respectively. The observations show that the values of dielectric parameters decrease with increase in temperature and increase with the increase in weight fraction. The measured values of these dielectric parameters have been used to calculate the dielectric relaxation time (τ) whose values are found to decrease with temperature.

Keywords: Dielectric Parameters, Dielectric Relaxation Time, Phenacetin

Introduction

The dielectric properties are important to understand the structure of the molecules and it also helps to understand the inter and intra-molecular interaction of molecules in pure liquids and in their binary and ternary mixtures. This information may be used in areas such as industrial, biological and pharmaceutical purposes. (Rana *et al.*, 2016). Such dielectric studies have been done by many researchers and they investigated that it helps to understand solute-solute and solute-solvent interactions in the solutions (Kumar *et al.*, 2010).Phenacetin is a pain killer which is found in the form of white crystalline solid.It can be dissolved in pyrimidine and acetone easily.

Materials and Methods

In the present investigation, five different mole fractions of Phenacetin (0.01, 0.015, 0.02, 0.025, 0.03) are dissolved in the dilute solution of 1 mole of carbon tetrachloride to make dilute solutions. Here CCl_4 of AR grade is used as a solvent which was procured from Merck and Phenacetin was purchased from the Central Drug House, Delhi.Its molecular formula is C_{10}-H_{13}-N-O_2. Its chemical structure is shown below (Fig. 1).

The values of dielectric constant and dielectric loss were determined at constant microwave frequency 9.265 GHz by using X-band microwave bench with the help of the double minima method for low loss liquids given by Heston *et. al.* The overall estimated accuracy in measurements of ε' and ε'' is about ± 1 % and ± 5% respectively. The values of dielectric permittivity at low frequencies (ε_0) and at optical frequencies (ε_∞) are determined by using dipole meter and Abbe's refractometer respectively (Jain *et al.*, 2012). All the measurements are performed at different temperatures using a constant temperature circulating water bath fitted with a thermostat having temperature stability of the order of ±0.1°C.

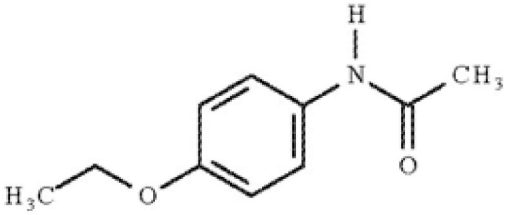

Fig.1. Chemical Structure of Phenacetin

For dilute solutions in non-polar solvents ε', ε'', ε_0 and ε_∞ can be expressed as linear functions of concentrations (Franklin *et al.*, 1950; Higasi *et al.*, 1971) in the following manner:

$$\varepsilon' = \varepsilon'_1 + a' W_2 \quad (1)$$

$$\varepsilon'' = a'' W_2 \quad (2)$$

$$\varepsilon_0 = \varepsilon_{10} + a_0 W_2 \quad (3)$$

$$\varepsilon_\infty = \varepsilon_{1\infty} + a_\infty W_2 \quad (4)$$

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Here subscript 1 refers to the pure solvent, 2 to the solute, while 0 refers to the static or low frequency case and ∞ refers to the infinite or optical frequency case, W_2 is taken as the weight fraction of the solute a′, a″, a_0 and a_∞ are the slopes of above mentioned linear equations. The values of the relaxation times τ_0, τ_1 and τ_2 are calculated by using the method given by (Higasi,1966).The relaxation time for overall molecular rotation (τ_1) is defined by

$$\tau_1 = \frac{1}{\omega}\left\{\frac{a''}{a'-a_\infty}\right\} \qquad (5)$$

Whereas the relaxation time for intermolecular rotations (τ_2) is given by

$$\tau_2 = \frac{1}{\omega}\left\{\frac{a_0-a'}{a''}\right\} \qquad (6)$$

Here ω is the angular frequency corresponding to the microwave frequency at which the experiment is performed. The most probable relaxation time (τ_0) is then obtained by employing the following relation:

$$\tau_0 = \frac{1}{\omega}\left(\frac{A^2+B^2}{C^2}\right)^{\frac{1}{2(1-\alpha)}} \qquad (7)$$

Where

$$1-\alpha = \frac{2}{\pi}\tan^{-1}\frac{A}{B} \qquad (8)$$

And

$A = a''(a_0 - a_\infty)$

$B = (a_0 - a')(a' - a_\infty) - (a'')^2$

$C = (a' - a_\infty)^2 (a'')^2$

Results and Discussion

In the present paper X-band microwave bench is used to calculate ε' and ε'' for different mole fractions of Phenacetin at four different temperatures (303K, 313K,

Table 1. Values of different dielectric parameters (ε', ε'', ε_0 and ε_∞) for different weight fraction of phenacetin at four different temperature.

W. Fraction	Temp. 303 K.							
	Є'	Є''	$Є_0$	Є∞	α	τ_0 (ps)	τ_1 (ps)	τ_2 (ps)
0.010721	2.144	0.115	2.389	2.106	0.813	4.937	2.239	6.881
0.015709	2.145	0.117	2.405	2.108				
0.021202	2.146	0.127	2.435	2.109				
0.026375	2.148	0.132	2.453	2.111				
0.031477	2.150	0.138	2.469	2.112				
	Temp. 313 K							
	Є'	Є''	$Є_0$	Є∞	α	τ_0 (ps)	τ_1 (ps)	τ_2 (ps)
0.010721	2.143	0.090	2.378	2.089	0.822	4.429	2.127	6.023
0.015709	2.144	0.102	2.397	2.090				
0.021202	2.145	0.117	2.419	2.093				
0.026375	2.147	0.131	2.434	2.095				
0.031477	2.148	0.136	2.457	2.096				
	Temp. 323 K.							
	Є'	Є''	$Є_0$	Є∞	α	τ_0 (ps)	τ_1 (ps)	τ_2 (ps)
0.010721	2.140	0.073	2.363	2.085	0.817	2.277	2.086	5.023
0.015709	2.142	0.083	2.389	2.086				
0.021202	2.143	0.116	2.411	2.088				
0.026375	2.146	0.119	2.429	2.089				
0.031477	2.145	0.132	2.453	2.091				
	Temp. 333 K.							
	Є'	Є''	$Є_0$	Є∞	α	τ_0 (ps)	τ_1 (ps)	τ (ps)
0.010721	2.139	0.060	2.349	2.072	0.816	2.064	2.006	4.572
0.015709	2.141	0.081	2.370	2.075				
0.021202	2.140	0.109	2.394	2.079				
0.026375	2.143	0.110	2.416	2.080				
0.031477	2.144	0.114	2.436	2.082				

323K and 333K) in the dilute solution of carbon tetrachloride. The values of ε_0 are determined by using dipole meter whereas the values of ε_∞ are determined by using Abbe's refractometer at different temperatures for the samples mentioned above. These values are then used to calculate different relaxation times like average relaxation time (τ_0), molecular relaxation time (τ_1) and group relaxation time (τ_2) of molecules. The given table 1 has different values of dielectric parameters with weight fraction and temperature as well as the values of various relaxation times. The table shows that the values of ε', ε'', ε_0 and ε_∞ increases linearly with the increase in the weight fraction of the solute i.e. Phenacitin. This behavior indicates that there is no change in the nature (Jain et al 2012) of the rotating molecular entities in the CCl_4 solutions. This may be due to the dipole-dipole interaction of pure liquid (Nemmaniwara *et al.,* 2014). The values of distribution parameter(α) are lying between 0.812 to 0.822. This shows the presence of more than one relaxation processes. Its value is a measure of the distribution of relaxation times.

This table also shows that the values of all the dielectric parameters decrease with temperature. It indicates the existence of inter molecular and intra molecular association in the solution. To minimize the solute-solute interaction the concentrations of the solutions were made sufficiently dilute (Gedam and Suryavanshi, 2013). The values of different relaxation times of the samples in the given table are decreasing with temperature. This may possibly be due to increase in the molar volume (Ganesh *et al.,* 2014).The decrease in relaxation time with temperature may also be due to the fact that the cluster of molecules break slowly with rise in temperature. The relaxation process of the molecules arise due to not only its intermolecular rotation but an intra-molecular rotation also contribute to it which shows that there is an additional intra molecular relaxation process exists to the overall relaxation process.The relaxation time depends upon the size and shape of the molecular entities(Vyas *et al.,* 2011) in the solutions. Thus the relaxation studies can provide useful information about the nature of molecular orientation process (Khan *et al.,* 2010)

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