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Study of Static Dielectric Constant and Relaxation Time of Brucine-Chloroform Solution using Time Domain Reflectometry

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Abstract: The complex permittivity, static dielectric constant and relaxation time of Brucine – Chloroform solution for different concentration have been studied using time domain Reflectometry at temperature 298°K, in frequency range 10 MHz to 30 GHz. The effect of Brucine concentration in non-polar solvent chloroform on static dielectric constant (ε_0) and relaxation time (τ) was studied. The static dielectric constant slightly decreases and relaxation time increases with concentration of Brucine.
Index Terms: Brucine; Dielectric constant; Relaxation time; TDR.

I. INTRODUCTION

Brucine was discovered in 1819 by Pelletier and Caventou in the bark of Strychnos nux vomica tree. It comes under the Indole- II group of alkaloid [1]. It is a natural alkaloid. It was closely related to Strychine [2]. Brucine is large chiral molecule, it is used in chiral solution. It is also called 2-3 Dimethoxystrychnine. Brucine is used for medical use. It has anti-tumor properties [3]. It is poisonous alkaloid, hence it is also used as a pesticide. [4, 5] . Molecular formula is $C_{23}H_{26}N_2O_4$. It dissolves in alchohol and chloroform. It's molecular mass is 394.46 gm/Mole. As per use in medical and agricultural field, it is necessary to study in depth. In this paper, I present effect of Brucine concentration on static dielectric constant and relaxation time at temperature 298°K using time domain Reflectometry. .

II. EXPERIMENTAL

A. Material

Brucine (2-3 Dimethoxystrychnine) was obtained from OTTO Chemie India. Considering the molecular mass and solubility of Brucine in chloroform, molar solutions 0M, 0.06M, 0.12M, 0.18M,0.24M, 0.3M were prepared. Chloroform is non-polar solvent.

B. Experimental Setup

Digital serial Analyser sampling oscilloscope DSA-8200 (Tektronics), sampling TDR module 80E08 with step generator was used. Bandwidth of DSA-8200 is 50 GHz [6,7]. To maintain temperature 298°K, temperature control system was used. The Fig. 1 shows block diagram of TDR.

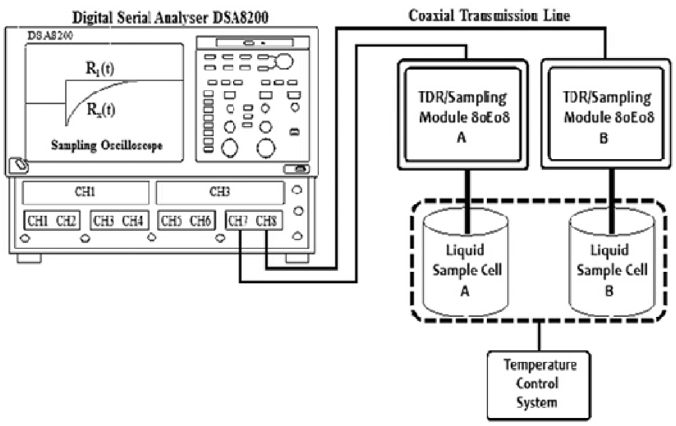

Fig. 1 Experimental setup of TDR

C. Experimental Procedure

By maintaining temperature 298°K constant, the reflected pulse without sample R_1 (t) and with sample R_x (t) were recorded in time window 5 ns and Considering the digitized in 2000 points for Brucine-chloroform solution of different concentration using TDR technique between frequency range 10 MHz to 30 GHz.

III. RESULT AND DISCUSSION

The complex coefficient ρ*(ω) over frequency range 10MHz to 30GHz determined as

$$\rho*(\omega) - \frac{c}{j\omega d}\frac{p(\omega)}{q(\omega)} \quad \text{-- (1)}$$

Where, p(ω) and q(ω) are Fourier Transform of time domain p(t) and q(t). If The reflected pulse without sample is $R_1(t)$ and with sample is $R_x(t)$. Then,

$$p(t) = [R_1(t)-R_x(t)] \quad \text{-- (2)}$$

$$q(t) = [R_1(t)+R_x(t)] \quad \text{-- (3)}$$

p(ω) and q(ω) in equation (1), obtained by summation and Samulon method [7, 8]

$$p(\omega) = T\ \sum_{n=0}^{N} \exp(-i\omega nT)p(nT) \quad \text{-- (3)}$$

$$q(\omega) - \frac{T}{1-\exp(-j\omega T)}\ [\sum_{n=0}^{n}(q(nT)-q(n-1)T)\exp(-j\omega nT)] \quad \text{-- (4)}$$

The complex permittivity spectra ε*(ω) is obtained from reflection coefficient spectra ρ*(ω) by using Bilinear calibration method suggested by Cole [10-12].

Due to brucine concentration to the dielectric polarization, the dielectric spectra for brucine- chloroform solution are more complicated. The dielectric relaxation for Brucinr-Chloroform solution is described by Harilliak and Negami equation [13].

$$\varepsilon*(\omega) = \varepsilon_\infty \mid (\varepsilon_0 \quad \varepsilon_\infty)/[1 + (j\,w\,\tau)^{1-\alpha}]^{\beta} \quad \text{--(5)}$$

Where, ε_0 is static dielectric constant, ε_∞ is dielectric constant at high frequency, τ is relaxatioon time, α and β are distribution parameter.

Brucine chloroform solution for all concentration could fit Debye type dispersion [14]. Therefore α =0 , β = 1 and experimental values ε*(ω) were fitted to Debye equation as

$$\varepsilon*(\omega) = \varepsilon_\infty + \frac{(\varepsilon_0 - \varepsilon_\infty)}{(1+jw\tau)} \quad \text{---(6)}$$

By using, nonlinear square fir method, static dielectric constant ε_0 an relaxation time τ for different concentration at 298°K are determined which is as shown in Table 1.

Table 1: Dielectric relaxation parameters for solution of Brucine – chloroform at different concentration at temperature 298°K

298^{0}K			
Concentration of Brucine in Molar (M)	ε_∞	ε_0	τ(ps)
0	2 (1)	4.82 (1)	6.87 (4)
0.06	2.30 (3)	4.41 (3)	9.12 (7)
0.12	2.04 (5)	4.43 (4)	10.08 (9)
0.18	2.03 (3)	4.36(3)	11.04 (7)
0.24	2.04 (7)	4.34 (8)	12.28 (15)
0.3	2.62 (1)	4.31 (3)	13.52 (29)

(Note – The number in bracket indicate error, for e.g. 6.87(4) means 6.87 ± (0.04))

Variation of static dielectric constant with molar concentration of Brucine at temperature 298° K is as shown in Fig. 2

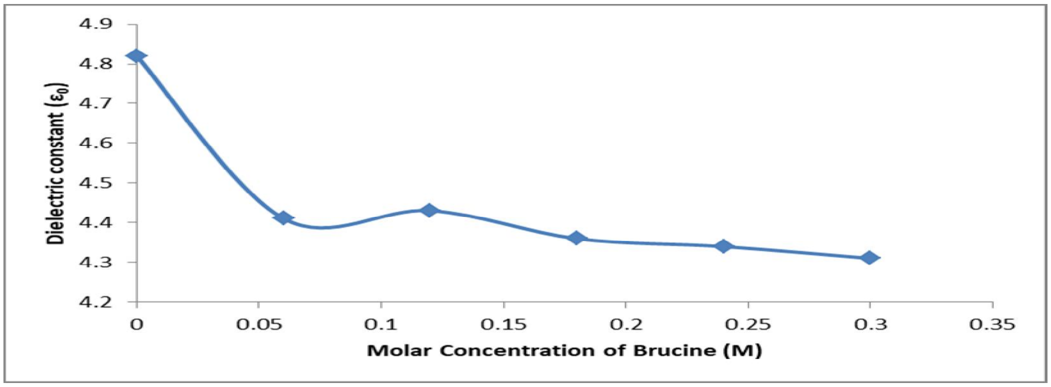

Fig.2 Variation of static dielectric constant with molar concentration of Brucine at temperature 298° K

Similarly, variation of relaxation time with molar concentration of Brucine in chloroform at 298° K is as shown in Fig.3

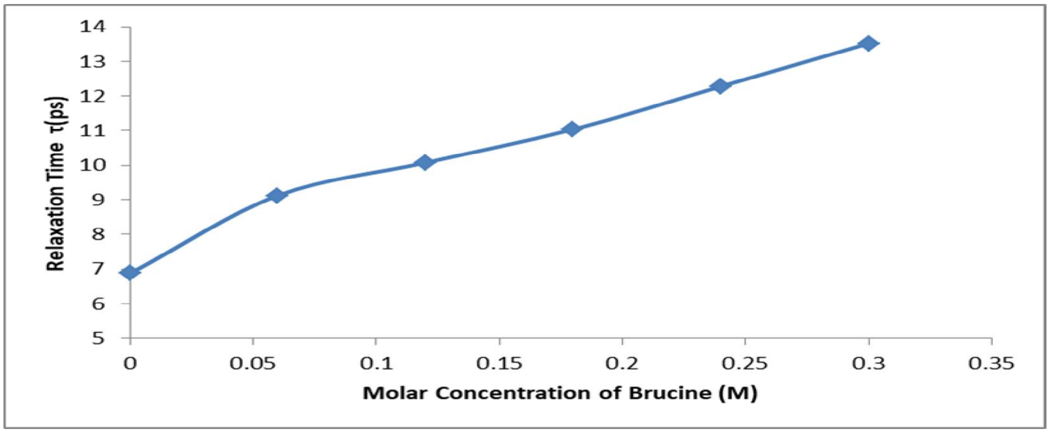

Fig.2 Variation of relaxation time with molar concentration of Brucine in chloroform at 298° K

IV. CONCLUSION

The Dielectric constant is mainly dependent on dipole moment and number of molecules per unit volume. Static dielectric constant (ε_0) decreases with increase in concentration of Brucine. The relaxation time increases with increase in concentration of Brucine.

V. ACKNOWLEDGEMENT

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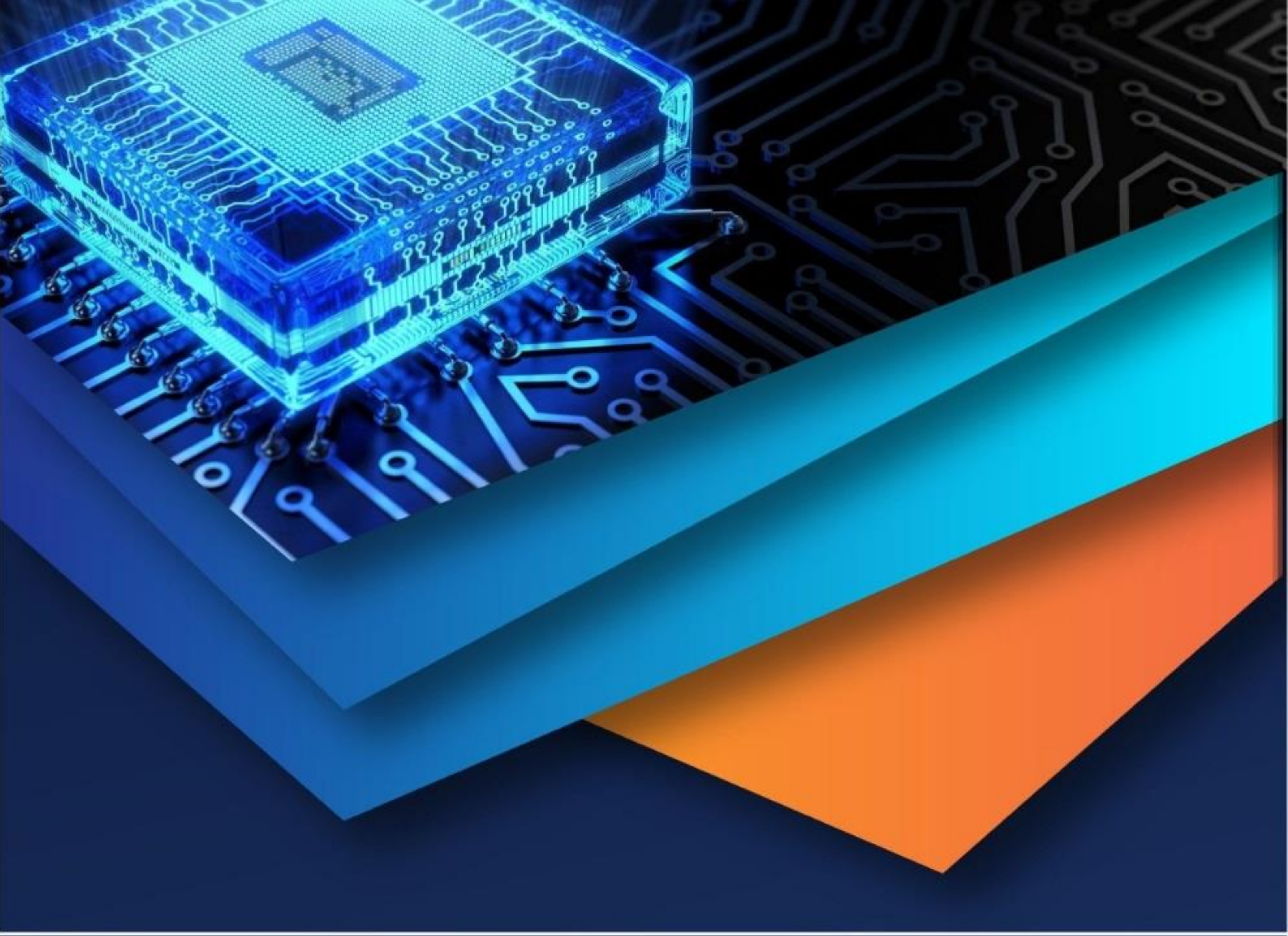

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