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Concentration and Frequency Dependent Dielectric Permittivity and Dielectric Loss Study of Brucine - Chloroform Solution using Time Domain Reflectometry (TDR)

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Abstract: ***Dielectric permittivity (ε') and dielectric loss (ε'') of Brucine-Chloroform solution over a frequency range of 10 MHz to 30 GHz have been measured using Time Domain Reflectometry (TDR). Observations are taken for different molar concentrations of Brucine-Chloroform (0M to 0.3M) at 298°K. Step pulse without sample $R_1(t)$ and with sample $R_x(t)$ were recorded in time window of 5nS and digitized in 2000 points. The effect of concentration and frequency on dielectric permittivity and dielectric loss has been presented in this paper.***

Keywords: Dielectric permittivity; Dielectric Loss; Brucine; TDR

1. Introduction

Brucine is a natural alkaloid which comes under Indole Group II [1]. Brucine was discovered in 1819 by Pelletier and Caventoy in the bark of Strychnos nux-vomica tree. The structure of Brucine related to Strychnine [2]. Brucine having anti-tumor effect [3]. It is also used in Chinese medicine as analgesic agent[4]. Brucine has antiproliferative effects in different cancer cell lines [5]. It affects on all portion of central nervous system [6]. Its molecular formula is $C_{23}H_{26}N_2O_4$. And its molecular mass is 394.46 gm/Mole. In this paper, using TDR, effect of concentration and frequency on dielectric permittivity (ε') and dielectric loss (ε'') for Brucine-Chloroform solution at 298°K has been presented. Chloroform is non-polar solvent.

2. Experimental

2.1 Material

Brucine (2-3 Dimethoxystrychnine) was purchased from OTTO Chemie India.

2.2 Experimental Setup

The time domain Reflectometry is used to describe a technique of observing time dependence reflection response of sample under study. H.Fellmer - Feldegg [7] developed TDR for measurement of dielectric loss and dielectric permittivity at very high frequency range. The schematic block diagram of the experimental setup of TDR [8,9] is shown in Fig.1

The TDR setup consists of broadband sampling oscilloscope with TDR module.

The Tektronics DSA-8200 sampling oscilloscope having 50 GHz bandwidth and TDR module 80EO8 with step generator was used. The complex permittivity spectra were studied using TDR method [10-12].

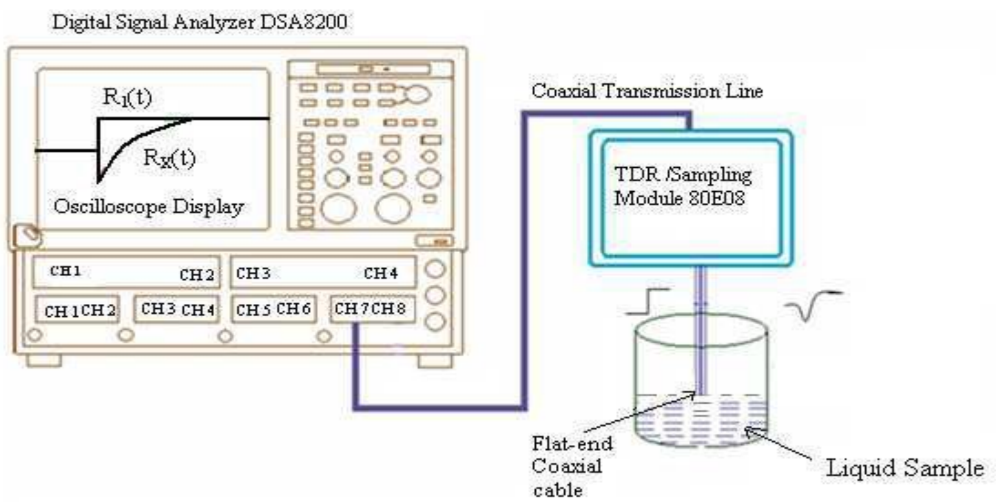

Figure 1: Experimental setup of TDR

2.3 Experimental Procedure

Considering the solubility and molecular mass of Brucine, solutions of different concentrations 0M, 0.06M, 0.12M, 0.18M, 0.24M, and 0.3 M were prepared. Chloroform is used as solvent for preparing solutions. A step pulse was incident and reflected pulse was recorded by sampling Oscilloscope. Reflected pulse without sample R_1 (t) and with sample R_x (t) were recorded with time window 5 nS and digitised in 2000 points. Observations are made for various Brucine-Chloroform solutions at 298°K.

3. Result and Discussion

The reflected pulse without sample $R_1(t)$ and with sample $R_x(t)$ for 0.3 M Brucine-chloroform solution at 298° K was recorded and is as shown in Fig.2

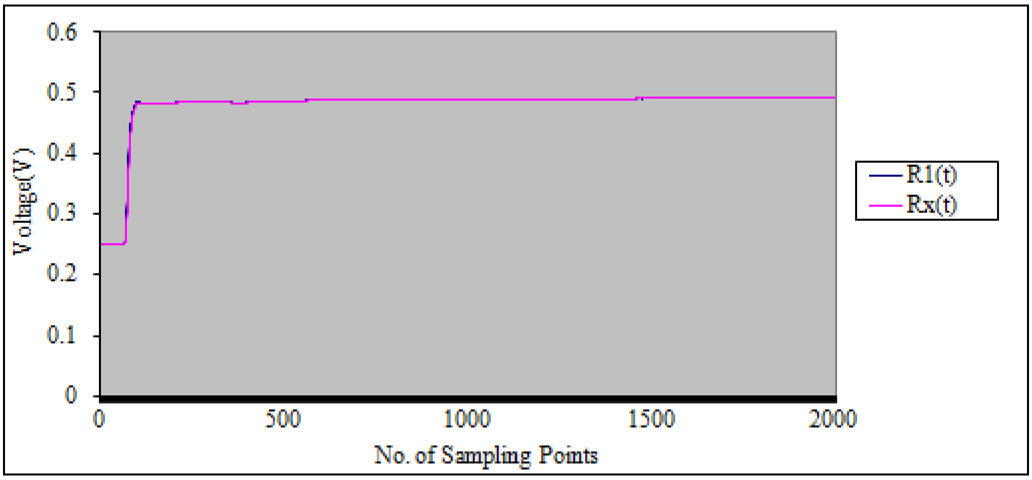

Figure 2: Reflected pulses without sample $R_1(t)$ and with sample $R_x(t)$ for 0.3M Brucine-Chloroform Solution at 298°K

The reflected pulse without sample $R_1(t)$ and with sample $R_x(t)$ were subtracted (equation (1)) by using computer software which is as shown in Fig3.

$$p(t) = [R_1(t)-R_x(t)] \quad \text{-- (1)}$$

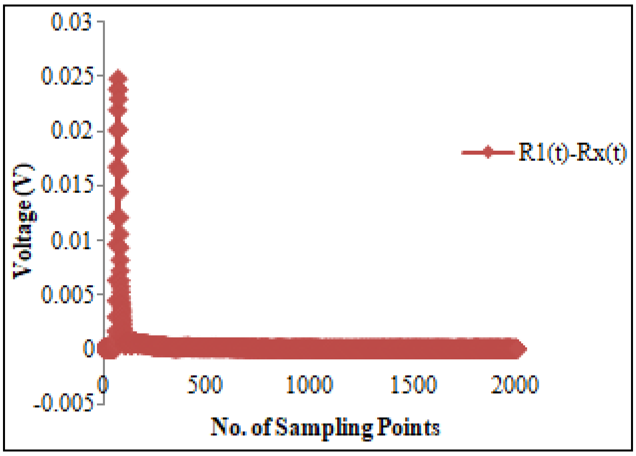

Figure 3: Sample pulse of $R_1(t)$ - $R_x(t)$ for Brucine-Chloroform solution at 298 °K.

These reflected pulses are added (equation (2)) by using computer software and is as shown in Fig.4

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

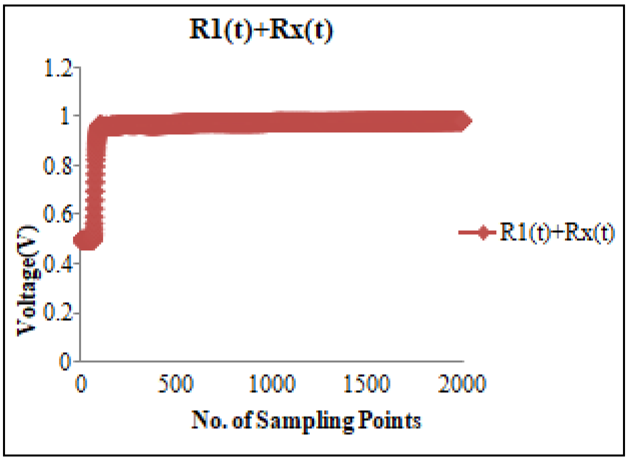

Figure 4: Sample pulse of $[R_1(t) + R_x(t)]$ for for Brucine-Chloroform solution at 298 °K

The frequency domain data is obtained from time domain data by using Fourier Transform by taking into consideration summation and Samulon method [13, 14].

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

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

p(ω) and q(ω) are fourier transform of p(t) and q(t) respectively and is as per the equations (3), (4). The reflection coefficient spectra ρ*(ω) were determined over the frequency range of 10MHz to 30 GHz.

$$\rho*(\omega) = \frac{c}{j\omega d}\frac{p(\omega)}{q(\omega)} \quad \text{-- (5)}$$

ρ*(ω) is as per the equation (5).

The complex permittivity ε*(ω) = ε'-j ε'' is obtained from reflection coefficient spectra by applying the bilinear calibration method suggested by Cole [15].

Dielectric permittivity (ε') and dielectric loss (ε'') over frequency range 10 MHz to 30 GHz at 298°K is as shown in Table 1.

Table 1: *Dielectric permittivity (ε') and dielectric loss (ε'') for Brucine Chloroform solution with frequency*

Concentration in Molar →	0 M		0.3M	
Frequency in GHz ↓	ε'	ε''	ε'	ε''
0.01	4.816346645	1.11E-03	4.580975533	2.20E-03
0.1	4.816271305	1.40E-02	4.580508709	2.77E-02
1	4.811950684	0.112161718	4.554377556	0.217546627
2	4.799263477	0.227851674	4.481203079	0.420080006
3	4.778364658	0.349063963	4.371577263	0.595465124
4	4.749578953	0.474929243	4.24090147	0.735386789
5	4.713326454	0.602045953	4.105836868	0.836682975
6	4.670177937	0.725521326	3.981487989	0.901393235
7	4.620974064	0.84054482	3.879369497	0.936484516
8	4.566953182	0.94393146	3.805980921	0.95334053
9	4.509798527	1.035194874	3.761563301	0.966697037
10	4.451335907	1.116777062	3.738920212	0.992134213
11	4.392718315	1.193102479	3.723271847	1.041244149
12	4.333521843	1.268375278	3.695560932	1.115375042
13	4.271864891	1.343938351	3.640462875	1.202323914
14	4.206078529	1.417197824	3.55516839	1.281040072
15	4.136388302	1.483412623	3.451220751	1.332832456
16	4.0648489	1.538911462	3.347389221	1.350356698
17	3.993919611	1.583141565	3.260235071	1.338668585
18	3.92539525	1.618728757	3.198932886	1.310798287
19	3.860269547	1.650260687	3.164814711	1.28266418
20	3.798980474	1.682603836	3.152825117	1.269202232
21	3.741509914	1.719214439	3.152904272	1.28109622
22	3.687333822	1.760818362	3.151410103	1.32124126
23	3.635571718	1.804967999	3.134147406	1.381473064
24	3.585348845	1.846929789	3.092122078	1.442181826
25	3.535883665	1.881708741	3.027898312	1.478057384
26	3.486034632	1.906181216	2.957291365	1.469566107
27	3.433917761	1.92011559	2.903382778	1.41372335
28	3.377412558	1.925768495	2.886709452	1.327261686
29	3.315633297	1.926692247	2.917739153	1.241804957
30	3.254791498	1.926572561	2.986748219	1.19565618

Complex permittivity spectra for Brucine-Chloroform solution for various concentrations at 298°K is as shown in Fig.5

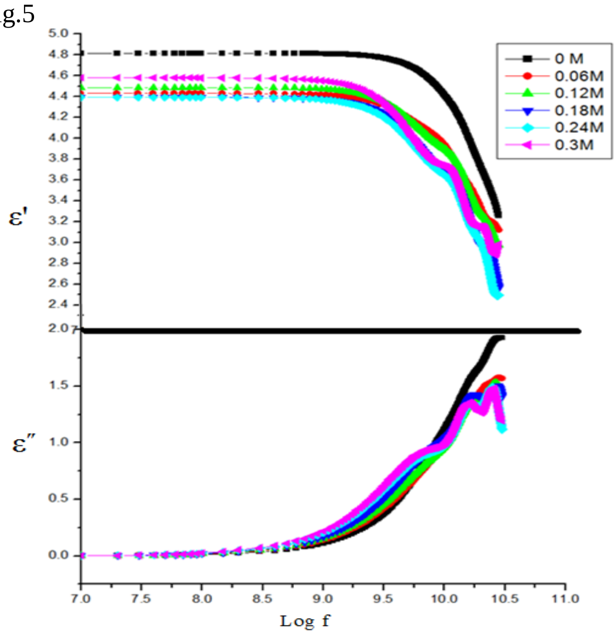

Figure 5: Complex permittivity spectra for Brucine – Chloroform solution for various concentrations at 298^0K

4. Conclusion

Dielectric permittivity (ε') drops with increase in concentrations of Brucine in Chloroform. As frequency increases, the material's net polarisation drops as each polarisation mechanism ceases to contribute and hence dielectric permittivity decreases. Dielectric loss (ε'') increases with increase in frequency, approaches its maximum value at frequency of 25 GHz. With increase in concentration, the dielectric loss also increases.

5. Acknowledgement

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