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Dielectric Relaxation Study of Quinine-Methanol using Time Domain Reflectometry Technique .

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Abstract:

The dielectric relaxation study of quinine with methanol mixture at high frequency range from 10MHz to 30GHz using time domain refletrometry (TDR) technique at 25^{0}C with various concentrations. The Time Domain Reflectometry system in reflection mode has been used to measure the dielectric parameters i.e. the static dielectric constant (ε_0), The relaxation time (τ), dielectric constant at higher frequency (ε_∞) and distribution parameters of mixture of quinine with methanol are evaluated.

Key words: Dielectric constant, TDR, Relaxation time.

1. Introduction

Quinine ($C_{20}H_{24}N_2O_2$) is an Alkaloid, is organic chemical compounds which mostly contain basic Nitrogen atoms and also hydrogen, carbon, oxygen. It is almost insoluble in water and soluble in alcohol, ether, glycerol, chloroform. It contains two major fused-ring systems, the aromatic quinoline and the bicyclic quinulidine. It is obtain from the bark of the cinchona tree. It is used for the treatment of malaria also treat lupus and arthritis .Quinine having fever reducing painkilling and bitter test. Methanol is the simplest alcohol and is a light volatile, also polar liquid.

In this paper we have studied the dielectric parameter of quinine –methanol mixtures for various concentrations in frequency range from 10MHz to 30GHz at 25^0 C. The dielectric constant is one of the most important physiochemical properties of the mixed solvent, which enhance most of the biological, pharmaceutical, chemical, physical, analytical laboratory applications [1, 2]. Dielectric parameter study deals with the ability of materials to store electric energy in the form of polarization which is very important to get information about intermolecular interaction between the components.

2. Experimental

2.1 Materials

Quinine 99% was obtained commercially from Anand Agency, Pune. The solutions were prepared by mixing the Quinine - methanol in volume.

2.2 Measurements:

The dielectric relaxation spectra of aqueous solutions have been obtained by the time domain reflectometry (TDR) technique. The Tektronics model no. DSA8200 Digital Serial Analyzer sampling mainframe along with the sampling module 80E08 has been used for the measurement as in fig.1. A repetitive fast rising voltage pulse with 18 ps incident rise time was fed through coaxial line system of impedance 50 Ω. Sampling oscilloscope monitors changes in step pulse after reflection from the end of line. Reflected pulse without sample R_1 (t) and with sample R_x (t) were recorded in time window of 2 ns and digitized in 2000 points as shown in fig.2. The Fourier transformation of the pulses and data analysis were done earlier to determine complex permittivity spectra $\varepsilon^*(\omega)$ using non linear least squares fit method [3].

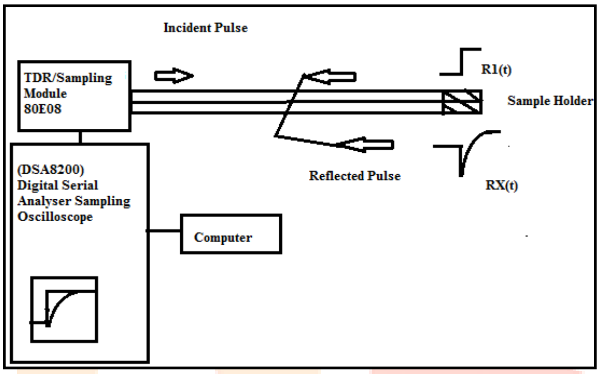

Fig. 1 Block Diagram of Time Domain Reflectometry.

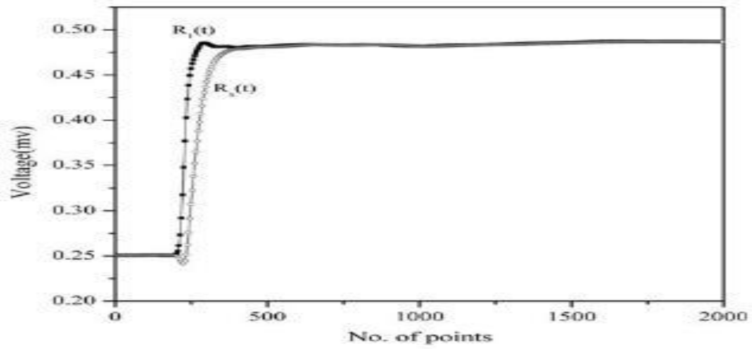

Fig. 2 Reflected pulses without sampleR_1 (t) and with sample R_X (t).

2. Data analysis

The step pulses recorded without sample R_1 (t) and with sample R_X (t) and are subtracted and added to get

$$p(t) = [R_1(t) - R_X(t)] \quad 01$$

$$q(t) = [R_1(t) + R_X(t)] \quad 02$$

The processing of the data was carried out to yield complex reflection coefficient $\rho^*(\omega)$ over a frequency range of 10 MHz to 30 GHz were determined as follows

$$\rho^*(\omega) = \frac{c}{j\omega d}\frac{p(\omega)}{q(\omega)} \quad 03$$

Where $p(\omega)$ and $q(\omega)$ are Fourier transforms of p(t) and q(t) obtained using summation and Samulon methods respectively. Also is the velocity of light, ω is angular frequency and d is effective pin length (0.17 mm). The complex permittivity spectra ε*(ω) was obtained from reflection coefficient spectra ρ*(ω) by applying the bilinear calibration method suggested by Cole [4]. The complex permittivity spectra for quinine –methanol mixture as a function of frequency from 10 MHz to 30 GHz.

3. Results and discussion

The general form of the dielectric relaxation model is given by the Havriliak-Negami equation [5, 6].

$$\varepsilon^*(\omega) = \varepsilon_\infty + \frac{(\varepsilon_0 - \varepsilon_\infty)}{[1+(j\omega\tau)^{(1-\alpha)}]^\beta} \qquad 04$$

Where ε_0 is the static permittivity, ε_∞ is the permittivity at high frequency, τ is the relaxation time, α and β are the empirical parameters for the distribution of relaxation times with values between 0 and 1. The Havriliak-Negami equation includes three relaxation models as limiting forms. The Debye model ($\alpha = 0$ and $\beta = 1$) implies a single relaxation time while the Cole – Cole model ($0 \le \alpha \le 1$ and $\beta = 1$) and Cole-Davidson ($\alpha = 0$ and $0 \le \beta \le 1$) both suggest a distribution of relaxation times. The magnitudes of α and β indicates the width of the distribution. The alcoholic solutions of quinine volume percentage concentrations could fit Cole-Davidson type dispersion. Therefore, here $\alpha=0$ and $0\le\beta\le1$ and experimental values of ε*(ω) were fitted to the Cole-Davidson equation as,

$$\varepsilon^*(\omega) = \varepsilon_\infty + \frac{\varepsilon_0 - \varepsilon_\infty}{(1+j\omega\tau)^\beta} \qquad (5)$$

The values of ε_0, τ & ε_∞ are fitting parameter. A non-linear least squares fit method was used to determine the values of dielectric parameters [7, 8].The values of ε_0,ε_∞, τ(ps) with volume % of water concentration for quinine-methanol mixture at 25^0 C as in Table 1. The errors in the last significant digits are also reported. The deviation in dielectric constant and relaxation time from ideality may be due to interaction in Quinine- methanol mixture and as dielectric constant and relaxation time goes on decreasing as concentration goes on increases.

Table 1. Dielectric relaxation parameters of quinine-methanol mixture at25^0C.

System	Vol.% of quinine	ε_0	τ	ε_∞	β
Quinine-Methanol	0	33.75(2)	53.20(1)	3.32(2)	0.93
	10	30.37(7)	50.40(0)	2.82(5)	0.95
	20	27.25(5)	48.60(7)	2.24(4)	0.90
	30	26.00(4)	48.30(1)	2.32(3)	0.94
	40	25.30(3)	48.10(9)	3.43(2)	0.90
	50	25.00(3)	47.00(1)	3.06(1)	0.87
	60	24.40(7)	48.50(4)	2.69(2)	0.89
	70	23.476)	50.40(6)	3.01(1)	0.87
	80	23.00(7)	51.80(2)	3.13(1)	0.88
	90	22.20(8)	51.50(2)	2.96(1)	0.89
	100	20.36(7)	52.23(7)	2.49(1)	0.90

5. Conclusion

The dielectric properties of Quinine methanol mixture have studied using time domain reflectomentry technique in the frequency range 10 MHz to 30 GHz. At various concentrations the deviation in dielectric constant and relaxation times from ideality may be due to interaction in Quinine- methanol mixture dielectric constant and relaxation time goes on decreasing as concentration goes on increases.

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