High Frequency Dielectric Behavior of Aqueous Mixture of Niacin

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Abstract: ***This paper consists of the work undertaken of the study of dielectric constant of aqueous solution of Niacin for various concentrations. The time domain reflectometry technique used for the study in the frequency range from 10MHz to 30GHz. The relaxation time(τ), The static dielectric constant(ε_0), dielectric constant at higher frequency(ε_∞) of mixture of Nicotinic acid with water have evaluated at 25^{0}c.***

Keywords: Alkaloids, Dielectric constant, TDR, Relaxation time

1. Introduction

Niacin (Nicotinic acid) is a alkaloid of pyridine type. It is found in variety of foods like chicken, fish cereal, liver etc. It also created by synthesized from tryptophan. If need of Nicotinic acid, we can get from Amino acid which exist in most of the forms of protein. It also involved in both DNA repair and the production of steroid hormones in the adrenal gland. It is colorless solid, soluble in water. Nicotinic acid used to lower cholesterol, Triglycerides (types of fat) and treat coronary artery disease. Its molecular formula is $C_6H_5NO_2$. [1].

Very few researchers have worked on an Nicotinic acid in various field. Hence we have chosen the Nicotinic acid for study. The dielectric properties of nicotinic acid with water at various concentrations at 25°C is studied using Time Domain Reflectometry Technique in frequency range 10 MHz to 30 GHz. The dielectric behavior of this solution is explained by Cole - Devidson model. The dielectric constant, dielectric loss, is evaluated. The dielectric constant is one of the important physiochemical properties of the mixed solvent, which enhance most of the biological, pharmaceutical, chemical, analytical laboratory applications etc. [2, 3]

2. Experimental Method

A) Materials: Niacin 99% was obtained commercially from Sisco Research laboratories Pvt. Ltd. India. The solution was prepared by mixing the niacin acid with water.

B) Measurements: The dielectric constants and relaxation time of various mixtures of solutions was measured by TDR, the Tektronix model No. DSA8200 digital serial analyzer sampling mainframe along with the sampling module 80E08.TDR dielectric measurement systems consist of step generator, which is produce fast rising pulse of the order of picoseconds. A train of suitable fast rising pulses is applied to a transmission line usually a co-axial line with characteristic impedance 50 Ω.A co-axial line is connected to sampling device (sample holder), the systematic block diagram of the experimental set up for TDR is shown in Figure1..A suitable fast rising pulseR_1(t) is applied to a transmission line and incident to the sample under study and its reflected part R_X(t)from the sample solution in the sample holder is shown in figure (2) [4,8].

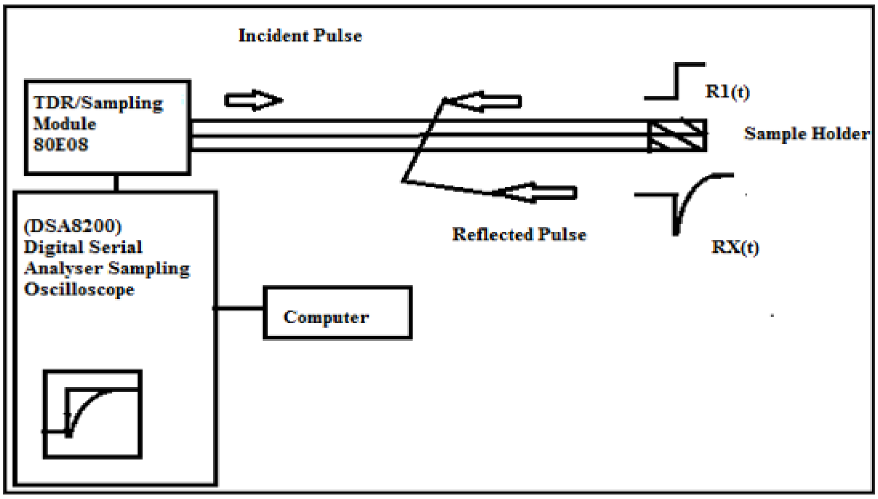

Figure 1: Systematic

Block Diagram of Time Domain Reflectometry

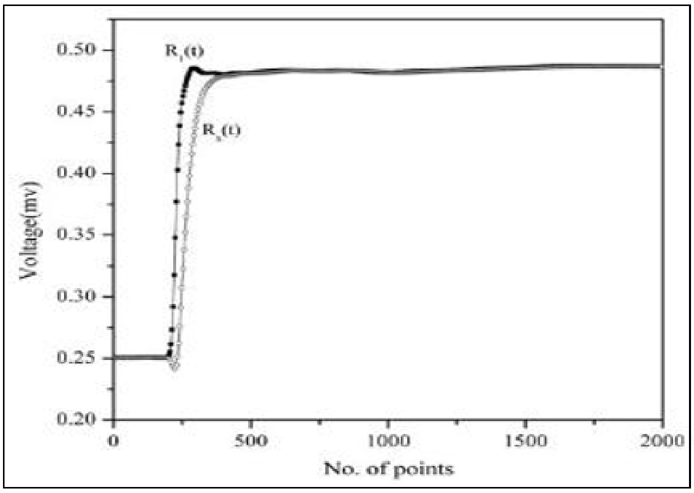

Figure 2: Reflected pulses without sample R_1 (t) and with sample R_X (t)

3. Result and Discussion

The recorded pulses are added [q (t) =R_1 (t) +Rx (t)] and subtracted [p (t) =R_1 (t) - Rx (t)]. Further the Fourier transformation of p (t) and q (t) was obtained by Summation and Samulon method for the frequency range 10 MHz to 30 GHz. The complex reflection spectra were determined as follows.

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

Where p (ω) and q (ω) are Fourier transformation of p (t) and q (t) respectively, cis speed of light, ω is the angular frequency, d is effective length and j =√ 1

The complex permittivity spectrum of the Niacin (Nicotinic acid) mixtures solution is an asymmetric shape and it is determined by the Harviliak – Negami (HN) equation [11]. The complex dielectric permittivity data were fitted to HN model using non – linear least square fit method in order to extract dielectric relaxation time with the following expression [6, 11].

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

Where ε_0 is the static dielectric constant, ε_∞ is the dielectric constantan high frequency. τ is relaxation time, the □&□ are symmetric and asymmetric distribution of relaxation time respectively. The Havriliak– Negami equation includes the relaxation model as a limiting form.

1) If α = 0 and β = 1 then single Debye equation.
2) 0 <= α <= 1 then it would be Cole – Cole model of symmetric distribution of relaxation times.
3) α = 0 and β varied such that 0 <= β <=1 this behavior is identified as Cole Davidson (CD) asymmetric distribution of relaxation time.

The value of static dielectric constant (ε□□), dielectric relaxation time (τ) and dielectric constant high frequency (ε□□□ are reported in table – 1 for Nicotinic acid - water mixture. The relaxation time observed to decreases systematically as increase in concentration as shown in table1.

Table 1: Dielectric parameter of Niacin - water mixture.

Conc.	ε_0	τ (PS)	ε_∞	β
0.01	81.42	8.69	2.00	0.946
0.02	81.07	8.41	2.00	0.934
0.03	80.28	8.34	2.00	0.922

With the increase in concentration of solution the decrease in dielectric constant and systematic change in the dielectric parameters of the solution can be explain on the basis of molecular interaction. The decrease in τ values with increase concentration is indicating that number of dipoles decrease in solution. The intermediate structure formed rotates fast there by giving the decrease value of τ in solution.

Conclusion

The dielectric properties of Niacin - water mixture have studied using time domain reflectometry technique in the frequency range 10 MHz to 30 GHz at25^{0}C temperature and various concentrations. The deviation in dielectric constant and relaxation times from ideality may be due to interaction in Niacin - water mixture dielectric constant and relaxation time goes on decreasing as concentration increases.

From the observed result we can conclude that dielectric constant, relaxation time of Niacin - water mixture are depending on concentration.

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