

A Study of the Dielectric behaviour using 'Q' Factor

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Abstract: The present study was "Dielectric behavior using 'Q' factor." The 'Q' meter BE 13, procured from Toshniwal Instruments is capable of measuring the inductance capacitance and circuit magnification (Q) at frequencies between 100 KHz and 30 KHz. The description of apparatus, in brief, has been given. The assessment of the result suggest that the Q meter provides a convergent method to obtain a fairly accurate estimate of the dielectric behaviour of liquid crystals and polymer. The method was that assign the 'Q' factors on dielectric behaviour used to compare 'Q' when this control is set at zero, the gain is 100% of normal and may be varied -10% about the normal values.

Keywords: Dielectric behaviour, Q factors, Cyclohexane, Relaxation mechanism, biological molecules etc.

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INTRODUCTION

The dielectric behaviour of biological molecules and liquid crystals is of considerable importance in asserting their electrical properties. The dielectric relaxation has been extensively studied by various workers/7,134-238/ in different frequency ranges. The dipolar rotation of liquid crystals had been investigated in terms of the perpendicular and parallel models, while that of the biological molecules in terms of α , β , and γ relaxations. Since it was observed that the frequency corresponding to maximum absorption falls in the radio frequency region for small biological molecules and simple liquid crystals, the two molecules, Gluteronitrile and cholesteryl deemonte have been investigated, using 'ES-15' 4 meter. ¹ In the present study, these two molecules have been investigated in dilute solutions of the four non-polar 11qu140. The dielectric relaxation has been discussed in terms of the relaxation time, the dipole moment and the activation energize.

The signal of required frequency is fed to an inductive, loop across which the voltage is metered and adjusted to a set level. A fraction of this loop consisted of a stout bar, the voltage across which offers a signal at low input impedance to a series resonant circuit of the coil under test and a variable low logs impactor incorporated in the instruments. The voltage across capacitor indicates the 'Q' and is detected by a Valve Voltmeter calibrated in terms of 'Q'.² The oscillator is modulated at 50 Hz, depth of modulation 50%, to avoid

the use of D.C. amplifier in valve voltmeter and to eliminate the sere setting. The capacitance and power factor of an unknown capacitor (dielectric cell) may be obtained by connecting it in parallel vwith the standard capacitor. The meter amplifier has a calibrated gain control between I and II stages, forming the basis for the method used to compare 'Q' when this control is set at sero, the gain is 100% of normal and may be varied -10% about the normal values.³ Using a standard coil the instrument is set up with an incremental capacitor, and the % Q dials at zero and a convenient reading The unknown coil is substituted for the standard coil with all the controls set as before the incremental capacitor and Q dials are adjusted so that the reading is obtained at established by means of set level control resonance.

The readings of the incremental capacitor measures the difference in inductance and that of a dial indicates directly the disparity to Q, between tent and standard coil.⁴

Operation- The indicator is calibrated in two ranges of a (10-100 and 40-400) and also a red line for level setting. The level is always to be reset by change in the frequency. The resonance (maximum Q) position may be read directly the noter.⁵

The capacitance (< 500 pr) may be measured by the substitution methods. To operate the 'Q' meter an

inductance (coil) must be connected across the appropriate terminals. The test circuit is first resonated with a low value of internal capacitance in parallel with the unknown capacitor on the 'capacitance' terminals. Removing the unknown capacitor, the circuit is resonated again using the variable capacitor, keeping the frequency unchanged.

The unknown capacitance is the difference between the two scale readings. The Power factor = $[Q_2 - Q_1 / Q_2 - x_1] c_1 / c_2 - c_2$, where 1 and 2 are the reading with and without the unknown capacitor respectively.^{6,7}

Theory- The evaluation of permittivity data (ϵ' and ϵ'') has been given by Harnas/15/ in detail, from the capacitance readings. The error observed in the estimation of ϵ' and ϵ'' values is ± 5 and $\pm a$ respectively. The dielectric constant say be given by:

$$\epsilon'' - 1 = \frac{\Delta c d}{c_0}$$

where $\Delta c d$ is the difference of capacitances with and without sample and $c_0 = c' - c_1$. The imaginary part (ϵ'') the complex permittivity.

$$\epsilon'' = \frac{\Delta v s - \Delta v c d}{2 c_0 / (m^2 - 1)}$$

Here $m = V_{max} / V_1$, obtained from the plot Q vs: $c_1 \Delta c v - s'$ difference with sample and $\Delta c m t$ at that with empty cell, c_0 is termed as the geometrical capacitance.

The dielectric constant and loss values obtained from static and optical dielectric constant have been plotted as Cole-Cole/32/ graphs.⁸ The macroscopic relaxation time and distribution function have been calculated, which lead to the evaluation of molecular relaxation time from Powles's relation/29/. The thermo- dynamical parameters have been determined from Byring rate equations/16/ and dipole moment has been calculated from Koga's method/107/.

Quality Factor: The Q value of a dielectric resonator is the ratio between the energy stored within the resonator to the energy dissipated cycle. It defines the losses in the material which are represented by :

$$Tg(\delta) = \frac{\epsilon''}{\epsilon'}$$

where δ is the loss angle, ϵ' the dielectric constant and ϵ'' the dielectric losses.

The Q factor equals to: $Q = \frac{1}{tg(\delta)} = \frac{\epsilon'}{\epsilon''}$

The higher the Q factor, the better the material.

A common way for expressing losses, as they are linear with the frequency, is to use the "Q times frequency" factor, also specified by $Q \times f$ where f is the measurement frequency.

Typical value for E4000 family:

$$\left. \begin{matrix} Q = 15000 \\ f = 10 \text{ GHz} \end{matrix} \right\} Q \times f = 150 \text{ 000 GHz}$$

The resultant frequency of a microwave system typically decreases as temperature increases. This system is then said having a negative temperature coefficient. But usually, a system is required to be stable with temperature in the whole operating range of temperature (-55°C/+125°C for example).⁸ Then this frequency shift with temperature can be compensated using a dielectric resonator with a positive temperature coefficient.

E Series	PROPERTIES	APPLICATIONS
2000	High Q factor for high stability DRO designs. Mass-production capacity	<ul style="list-style-type: none"> o Alarm-detection systems, door openers. o Anti-collision radar for automotive. o Communication equipments. o Low Noise Block (LNB) converters for DBS.
3000	High linearity of frequency with temperature	<ul style="list-style-type: none"> o DRO for military and space applications
4000	Very high Q factor for filter designs	<ul style="list-style-type: none"> o Satellite multiplexing filter devices. o Radio-links for communication systems (LMDS) o Anti-collision radar for automotive o Military radars
5000	High dielectric constant for reduced dimension systems	<ul style="list-style-type: none"> o Duplexers, filters o Cellular base stations
6000	High Q factor for low frequency applications	<ul style="list-style-type: none"> o Low Noise Block (LNB) converters for DBS. o Security systems, detectors o Filters
7000	Ultra High Q factor for filter designs	<ul style="list-style-type: none"> o Satellite multiplexing filter devices. o Radio-links for communication systems (LMDS) o Military radars

METHOD

The 'Q' factors of the dielectric behaviour that acetone and dimethylformamide were calculated theoretically. To do this, the researchers adapted the electrical conductivity of both acetone and dimethylformamide at various temperatures. So a method was used to compare 'Q' when this control is set at zero, the gain is 100% of normal and may be varied -10% about the normal values.⁹

RESULTS

The cholesteryl decanoate and glutaronitrile molecules have been investigated as the dilute solution in non-polar solvents vis., benzene, carbon-tetrachloride, 1-4, dioxane and cyclohexane over the temperature range (295-311 K). permittivity data has been measured using 'Q' meter. The static (.3 MHz) and optical (sodium line) dielectric constants have been measured using dipolemeter and Abbe refractometer, The temperatures had been regulated throughout the observations by the flowing water through the glass jacket of the dielectric coll.

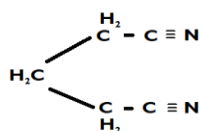


Fig-1(a) GLUTARONITRILE

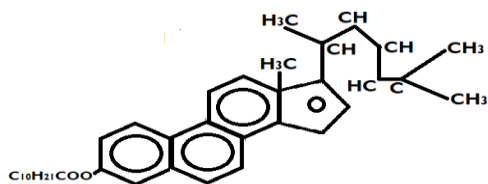


Fig-1(b) CHOLESTRYL DECANOATE

The permittivity data in the frequency range (0.3–9.0 Mis) and at optical frequency have been reported in fig-1(a,b) along with the weight fractions of solute in the dilute solutions, The chemical structure of the investigated molecules is depicted in fig-1 reports, the relaxation times (τ_1 and τ_2), the distribution function (f) and the dipole moment (p) values along with the thermodynamical parameters, of the two molecules in the solvents and denote the $\log \tau = T$ vs. $1/2$ plots, employed in the calcula-A HE. Soln. of A. The dielectric permittivity data at optional, radio and statue frequencies in different solvents at different temperature are : 0.0550* on 1-4 dioxane, 0.0202* on Benson, .0194* on Cyclohexane, and 0.0146* On carbon tetrachloride. The results conforms the subjects.

DISCUSSION

As expected, the molecular relaxation time (τ) is observed to be smaller than the macroscopic relaxation time (τ_m). The ranges of the two relaxations times are (12.9–41.4 ns and 14.1 - 43.5 ns) in all the three solvents vis, benzene, cyclohexane and 1-4, dioxane. The relaxation time increases in the order of the solvent's benzene, cyclohexane, 1-4,dioxane. The distribution function (f), is observed to be large. It varies from .23 to .57, exhibiting wide distribution in the relaxation mechanism of these systems. The dipole moment values are 3.78 D, 3.56 D and 3.39 D in the solvent bensene, cyclohexane and diczane respectively. These values are in agreement with the reported values/ 138/of 3.5 D. The large values may be attributed to the presence of a bonds of the molecule.

The enthalpies of activation (AH) of glutaronitrile in the solvents benzene, cyclohexane and dioxane are fig-1 and 11.5 KJ mol⁻¹ respectively, exhibiting the solvent effect on the entropy values (AS), from -17.4 to -21.6 J mol⁻¹ degl, indicating the ordered state of the system at The free energy values (AF) increase these temperatures, with the increase of the temperature. 9.52 Cholesteryl desmonte.¹⁰

This molecule had been dissolved in all the four solvents to study the dielectric relaxation behaviour. molecular (1) and macroscopic (2) relaxation times are observed to vary in the ranges of 20.2 to 33.1 ns

and 21.8 to 35.6 ns respectively in all the solvents.¹¹ The bulky size of this molecule/fig-1 (b)/is basically responsible for the longer relaxations time. This is in agreement with the earlier reported values/136/. The distribution function has also been observed to be larger (.14 - .44) in this system. It exhibits the distributed relaxation behaviour. The dipole moment values are quite large for this system.

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