Quantum Behaviour of Dielectricity in Dolomite of Balochistan, Pakistan

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Summary: The dielectric measurements on dolomite ($MgCO_3$ $CaCO_3$) in the frequency and temperature range 30Hz-100kHz and 300-700K, respectively are reported. The peaks in the imaginary part of permitivity are ascribed to the quantum behaviour of dielectricity. The ionic bonds between magnesium Mg^{++} with carbonate CO_3^- and C_a^{++} with CO_3^- are stretched due to polarization. This stretching of ionic bonds configures a space of its own in which energy at a characteristic frequency oscillates (quanta). The characteristic frequency is of ionized solitons.

Introduction

Polarization effects play a dominant role in dielectric properties of materials. The polarization is used to control the switching time in electronic devices. The electrical and optical properties of dielectrics are strongly influenced by the electric field. The dielectric relaxation in solids is extensively studied by Jonscher [1]. The variation of dielectric parameters with frequency of an applied filed is an essential feature of all dielectric materials. The mobility of charge carriers is extremely low in dielectrics and that the conduction takes place by hopping processes. Ionic conduction is an extreme form of hopping in which carriers (ions) jump through interstials and vacancies [2]. Jonscher also applied exponent laws for describing dielectric behaviour [3]. Dielectric and piezoelectric properties of magnesium based ceramics are studied by Sabolsky *et al.,* [4]. More recent literature on dielectric behaviour [5-15] emphasize on applications rather than looking into its physics. We observed some of fascinating results which do not fit into existing theories on dielectricity. Therefor, we need adequate conjecture or theory to confirm these newly observed experimental results [5-15]. We disagree with Jonscher theory [1, 3] because it neglects the microscopic aspects of dielectricity such as "quantum behaviour". We evolved a new idea by considering the imaginary part of permitivity of dielectricity which, to our knowledge, has never been considered. The imaginary part refers to some quantum mechanical effects.

Results and Discussion

We studied the dielectric properties especially the a.c.response of dielectric behaviour of dolomite ($CaCO_3.MgCO_3$) in the temperature range of 300-900 K and in the frequency range of 30 Hz-100 kHz. Dielectricity deals with polarized state of ions, or of atoms and of molecules. It gives response to frequency dependent switching at a characteristics relaxation time and follows a transient behaviour with rise and fall for charge accumulation and reduction, respectively. The dielectric behaviour can be harnessed in electronic devices. We observed distinct peaks of imaginary parts of permittivity in dolomite at certain frequencies. The number of such peaks of permittivity increased with increasing temperatures. There is, of course, a thermal agitation or a dynamic recovery process in the polarization. We conjecture that there is a polarized charge quantization. This is confirmed with our calculations. The ratio of imaginary to real parts of permittivity of the material is usually termed as dielectric losses [1,3] but this is not a measure of the microscopic changes occurring within charge.

We ascribe the peaked response of imaginary parts of permittivity to quantum behaviour. We infer this quantum state as thermally ionized solitons. We shall later develop a new theory on "quantum behaviour of dielectrics". The Clausius Mossotti equation and exponent laws on dielectricity need modifications. The ionic bonds due to polarization are stretched. This stretching configures space of its own in which energy at a characteristic frequency oscillates. The characteristic frequency is of thermally ionized solitons. Writing few equations such as:-

$$\text{Classical dipole moment} = q \times dl \qquad (1)$$

where dl is the separation between charges or ions.

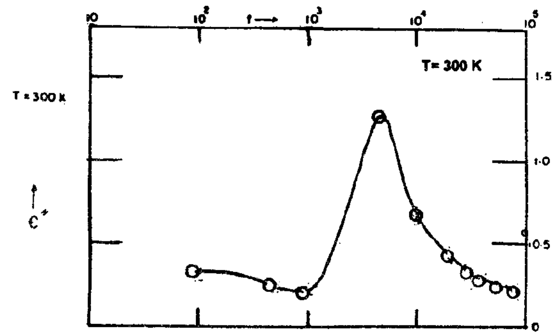

Fig. 1: Imaginary part of permitivity at 300 K.

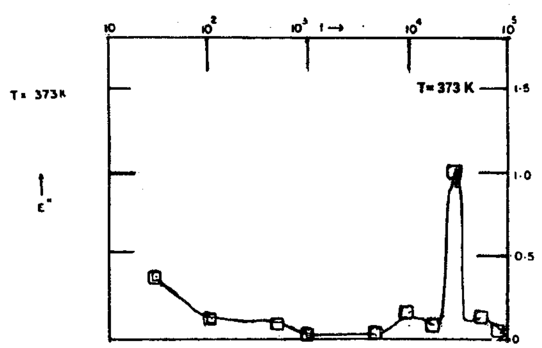

Fig. 2: Imaginary part of permitivity at 373 K.

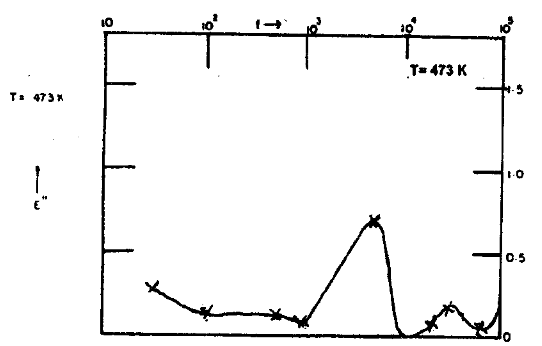

Fig. 3 Imaginary part of permitivity at 473 K.

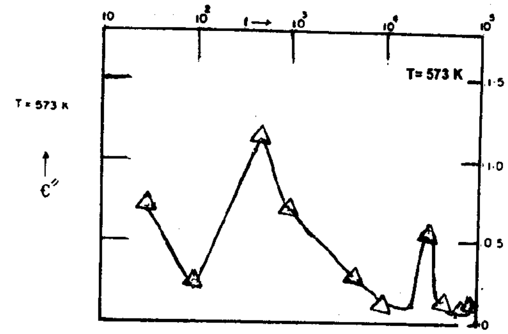

Fig. 4: Imaginary part of permitivity at 573 K.

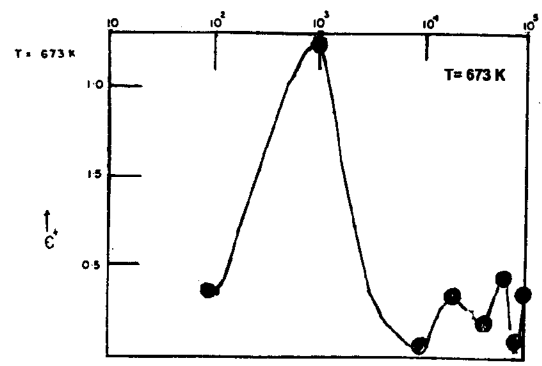

Fig. 5: Imaginary part of permitivity at 673 K.

Figs. 1 to 5 show the imaginary part of permittivity in dolomite in the temperature range 300K to 700K. Fig 6 shows the real part of permittivity of dolomite in the same temperature range. Surprisingly enough distinct peaks at relatively high frequencies are observed for imaginary part of dielectricity (Figs. 1 to 5) while inverted peaks at relatively low frequencies are observed for real part of dielectricity (Fig. 6).

We conjecture that the quantum mechanical dipole moment is charge quantization [16].

Quantum dipole moment = h $\sum$ q -- (2)

where h is Planck's constant.

The quantum mechanical calculations, for dolomite in temperature and frequency ranges of 300 K to 700 K and 30 Hz to 100 KHz, respectively only for imaginary part of permittivity ,.i.e., . ε'' . are summarized in Table-1.

The latter work on quantum mechanical theory of dielectrics will be reported.

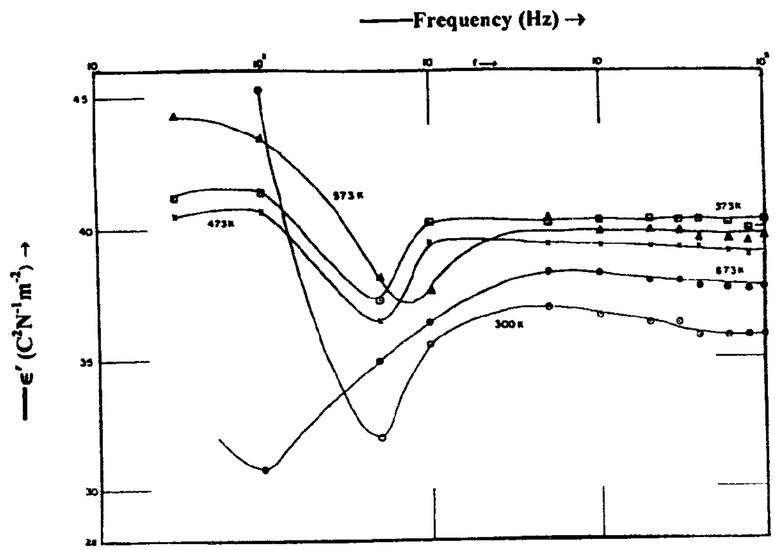

Fig. 6: Real part of permitivity at different temperatures.

Table-1: Quantum mechanical calculations for imaginary part of permitivity for peak frequencies (Figures 1-5).

Obs	Temp. (K)	Peak Frequency f (Hz)	Wave Length λ(m)	C_{quan}, Farad x 10^{-35}	Charge, Q (Coulomb)	p= ħ k, Joule-Sec-m^{-1} x 10^{-38}	d_{quan} =hQ, quan (Joule-CoulombSec)	E=h f, (e.V) x 10^{-11}
1.	300	5000	$6x10^4$	5.75	$2.76x10^{-32}$	1.10	$18.28x10^{-66}$	2.07
2.	373	30,000	$1x10^4$	0.69	$1.66x10^{-31}$	6.62	$1.10x10^{-64}$	12.40
3.	473	5,000	$6x10^4$	0.12	$2.76x10^{-33}$	1.10	$1.80x10^{-66}$	2.07
4.	573	500	$6x10^5$	1.10	$2.76x10^{-33}$	1.10	$1.80x10^{-66}$	0.21
5.	673	1,000	$3x10^5$	2.30	$5.5x10^{-33}$	0.22	$3.6x10^{-66}$	0.42

Experiment

Deposits of Dolomite (rare material) are found at a distance of about 11 km South of Wadh village in the vicinity of Khuzdar, a city in Balochistan. The dielectric measurement for dolomite ($MgCO_3.CaCO_3$) is performed by using a Decameter (Model DK-05) based on Schering bridge. It is an AC dielectric bridge. The decameter works in the frequency range of 30 Hz to 100 kHz. We designed a sample holder with heater and used chromal- alumel thermocouple. The temperature of the furnace is controlled by temperature controller in the range of 300K-1000K with a step of 5K.We also developed a temperature controller in our laboratory.

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