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Dielectric and Photoconductivity Studies of an L-Cysteiniumchloridenicotinamide Monohydrate

KEYWORDS

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ABSTRACT *Interest in L-Cysteine crystals have been increased due to super ionic conduction and its usual electro-optic properties. Optically clear single crystal of LCNM was grown by slow evaporation method. Dielectric constant and dielectric loss have been obtained as a function of frequency between 50 Hz -5 MHz and temperature range between 40°C-100°C. The photoconductivity study is also carried out for LCNM crystal and the results were discussed.*

1. Introduction

A non-linear optical frequency conversion material is of vital role in the field of photonics and optoelectronics applications. NLO crystals are not only confined because of their NLO properties. They also study other characteristics such as hardness and dielectric, as these will determine technological utility of developed materials [1]. Organic materials have drawn the attention of material scientists because of their piezoelectric, pyroelectric, non-linear optics and electro- optical applications [2]. Materials with large second-order optical nonlinearities, short transparency cut-off wavelengths and stable physicochemical performances are needed in order to realize many of these applications [3]. Dielectric properties of an organic material, nicotinamide [4] and L-Cysteine Sodium Nitrate Chloride [5] were reported earlier.

Here we report the growth of non-linear organic crystal L-Cysteiniumchloride Nicotinamide Monohydrate (LCNM) by slow evaporation technique at room temperature. Good transparent crystals are harvested. From single crystal X-ray diffraction studies carried out, itis found that the LCNM crystal has its monoclinic structure with lattice parameters a=7.21Å, b=6.72Å, c=7.54Å, V=365Å^3, β=99.47°.

2.1. Dielectric Measurement

Dielectric properties are the useful methods for characterization of electrical response in crystalline and ceramic materials. A study of the dielectric properties provides information about electric fields within the solid materials. Frequency dependence of these properties gives a great insight into the materials applications. Dielectric properties are correlated with electro-optic property of the crystals: particularly when they are non-conducting materials [6]. Microelectronic industries need low dielectric constant materials as an interlayer dielectric [7]. LCNM crystal cut in the appropriate dimensionof 0.6mm thickness and 13.65mm^{2}area of cross section is subjected to dielectric measurements. Silver paste is coated on both the surfaces of the sample to make a firm contact between the crystal and the copper electrodes. The capacitance and dissipation factor of the parallel plate capacitors formed by the copper plate and electrodes having the sample as a dielectric medium had been measured using HIOKI 3532 LCR HITESTER. The studies are carried from 40°C to 100°C for a frequency varying from 50 Hz to 5 MHz. The variation of dielectric constant with log frequency is shown in Fig. 1. The dielectric constant is calculated using the formula,

$$\varepsilon_r = \frac{Ct}{\varepsilon_0 A} \qquad (3)$$

Where C is the capacitance (F), t the thickness (m), A the cross-sectional area (m^2) of the sample and is the absolute permittivity of the free space having a value of 8.854 × 10^{-12} Fm^{-1}.

The dielectric constantobtained for LCNM is higher at lower frequencies and then it is found to decrease with the increasing frequencies and saturated for further increase in the frequency which could be attributed to space charge polarization mechanism of molecular dipoles [8]. It is important to note that the temperature has not influenced much on the dielectric behaviour of the LCNM crystal. The electronic exchange of a number of ions in the crystals gives local displacement of electrons in the direction of the applied field, which in turn gives rise to polarization. Crystals with high dielectric constant lead to more power dissipation and hence at higher frequencies, the power dissipation in the crystal may have lower value.

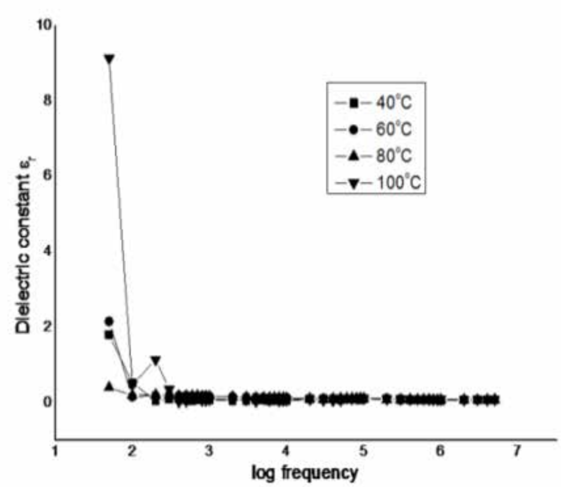

Fig.1. log frequency Vs Dielectric constant of LCNM crystal

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Fig. 2. shows the variation of dielectric loss with log frequency. From the figure it is observed that the dielectric loss decreases with increase in frequency at different temperature.As the frequency increases, the dielectric constant decreases. Thus, LCNM crystal having low value of dielectric constant is suitable for the enhancement of SHG coefficient [9].

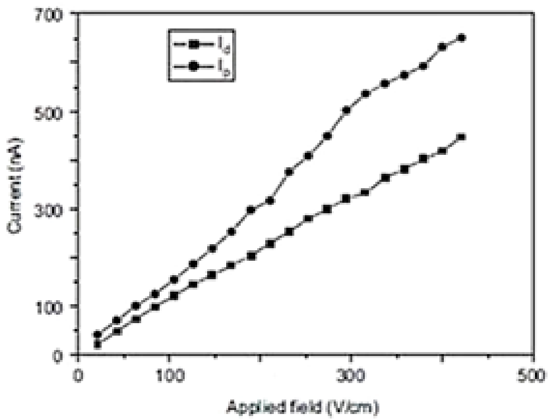

Fig.2. log frequency Vs Dielectric loss of LCNM crystal

2.2. Photoconductivity studies

Photo detection in photo-sensitive materials have become technologically very important in military applications, particularly in guided weapons, in communication through fibre optics [10]. A polished sample of LCNM crystal is attached to a microscopic slide. Thin copper wires (0.14cm diameter) are fixed at a distance of 0.1cm on the sample by silver paint. The sample is then connected in series to a DC power supply and a pico-ammeter (keithley 480). After shielding the sample from all radiations, the applied field has been increased from 50 to 2200 Volts/cm and corresponding current values shown by the pico-ammeter is noted.

The current obtained in the present condition is known as dark current (I_d). On keeping the sample in the same experimental setup, the sample is illuminated with the radiation from a halogen lamp (100w) containing iodine vapour and tungsten filament, by focusing a spot of light on it with the help of a convex lens. The photo current (I_p) in NPN is recorded for the same range of applied field used for dark current measurement. The variation of dark current and photo currents as a function of the applied electric field is shown in Fig.3. It is observed from the figure that the dark current and photo current increases with increase in the applied field, which is a prominent photoconduction. This is due to the presence of trap energy levels formed by the presence of Na^+ ion under excitation [11]. The photocurrent of any instant of the crystal is found to be less than the dark current for the same range of applied field. Hence, it can be concluded that LCNM crystals exhibits negative photoconductivity nature.

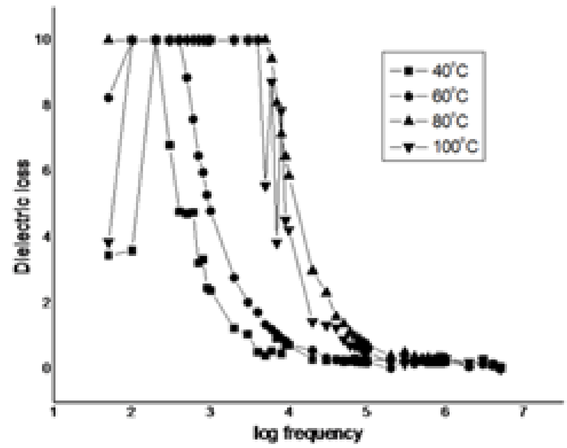

Fig.3. Field dependent photoconductivity of LCNM crystal

3. Conclusion

Dielectric constant and dielectric loss of the crystal is found to decrease with increase in frequency, higher values of dielectric constant occurs at higher temperature.It is concluded from the photoconductivity studies that LCNM crystal has negative photoconductivity with large value of photocurrent. From all these analysis, it can be concluded that the material is a promising lowvalue dielectric material, expected to be useful in the microelectronics industry. The encouraging dielectric properties of the crystal indicate the suitability of this crystal for photonics device fabrication.

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