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Dielectric and Photoconductivity Studies on L-Valine Zinc Sulphate NLO Single Crystal

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Abstract: Single crystal of L-Valine zinc sulphate has been grown by slow evaporation technique. The lattice parameters and crystal structure of the grown crystal were confirmed using single crystal X-ray diffraction studies. The dielectric studies show that the dielectric constant and dielectric loss decrease exponentially with frequency at different temperatures. The photoconductivity studies reveal that the crystal exhibits negative photoconductivity nature of the grown single crystal.
Key Words: Crystal growth, NLO, Single crystal X-ray diffraction, Dielectric Studies and Photoconductivity studies.

1. INTRODUCTION

Nonlinear optical (NLO) materials which can generate highly efficient second harmonic blue-violet light are of great interest for various applications including optical, optical computing, optical information processing, optical disk data storage, laser remote sensing, colour display, etc [1,2]. Inorganic NLO materials have large mechanical strength, thermal stability and good transmittance, but modest optical nonlinearity due to the lack of extended π-electron dislocation [3].Current research on crystal growth is focused on semiorganic NLO crystals for producing better nonlinear properties and having good properties crystal by combining the advantages of inorganic and organic materials. The semi-organic NLO materials have been attracting much attention due to high non-linearity, good mechanical strength, thermal strength and transmittance [4]. Many optically active organic amino acids are mixed with the inorganic salts in order to enhance their physical and chemical properties [5]. Present paper reports the studies of Single XRD, dielectric properties and photoconductivity of solution grown L-Valine zinc sulphate single crystal.

2. EXPERIMENTAL PROCEDURE

Analytical grade of L-Valine and Zinc sulphate heptahydrate were taken as the starting materials for synthesizing L-Valine zinc sulphate. A solution was dissolved in the double distilled water and stirred continuously using magnetic stirrer for homogenization and tiny seed crystals were obtained by spontaneous nucleation. Recrystallisation process was carried out two times and finally the crystals were obtained over a period of 35 days.

3. RESULTS AND DISCUSSION

3.1 Single-crystal X-ray Diffraction

A selected transparent grown crystal was subjected to single crystal X-ray diffractometer to determine crystal structure and lattice parameters. Single crystal XRD analysis reveals that the grown crystal belongs to monoclinic structure. The lattice parameters were found to be a = 9.97 Å, b = 7.24 Å, c = 24.34 (6) Ǻ; with unit cell volume V = 1736 $Ǻ^3$.

3.2Dielectric studies

The dielectric constant is one of the basic electrical properties of solids. The measurement of dielectric constant and loss as a function of frequency ranges from 50 Hz to 5 MHz at different temperatures using HIOKI 3532-50 LCR HITESTER. Essentially, dielectric constant is the measure of how easily a material is polarized in the presence of external electric field [6]. Good quality crystals were polished and electronic grade silver paste was applied on either side of the sample, which acts as an electrode. Frequency dependant dielectric constant of the grown crystal was studied for various temperatures. The following formula was used to calculate dielectric constant (εr) for studies

$$£_r = \frac{C_p d}{£_0 A} \qquad (1)$$

where '*Cp*' is the capacitance of parallel plate capacitor, '*A*' is the area of overlap of the two plates and'*d*' is the separation between the plates. The variation of dielectric constant with frequency for L-Valine and Zinc sulphate single crystal is shown in Fig.1. It is observed from the studies that dielectric constant decreases with increase in frequency and reaches a constant value, depending on a fact that beyond a certain frequency of the electric field, the dipole does not follow the alternating field. At all temperatures dielectric constant shows high values in the low frequency region and then it decreases with increase of frequency. The high value of dielectric constant at low frequencies may be due to the presence of all the polarizations such as space charge, orientation, ionic and electronic polarization [7]. Hence the large value of dielectric constant at low frequencies can be attributed to the lower electrostatic binding strength which arises due to space charge polarization near the grain boundary interfaces. From dielectric loss plots Fig.2, the curves suggest that the dielectric loss strongly depends on the frequency of the applied field similar to that happens with the dielectric constant in the ionic system [8]. The dielectric loss decreases with increase in frequency at different temperatures. The characteristic of low dielectric loss with high frequency for L-Valine zinc sulphate possess good optical quality with lesser defects and this parameter is of vital importance for non-linear optical materials.

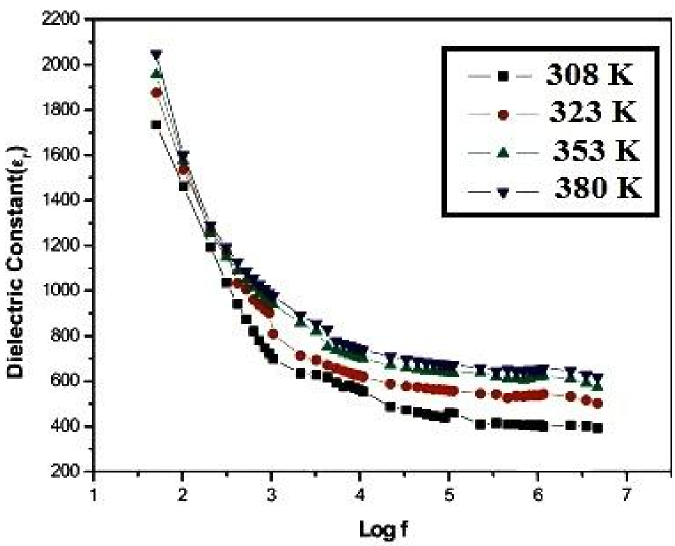

Fig.1. Variation of dielectric constant with frequency

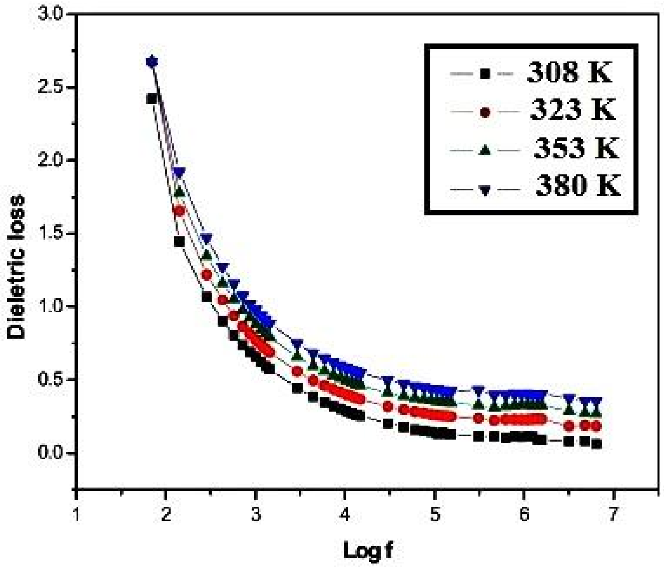

Fig.2. Variation of dielectric loss with frequency

3.3 Photoconductivity Property

Field dependence of dark and photo currents of L-Valine zinc sulphate single crystals is shown in Fig.4 using Keithley 485 picoammeter. The photocurrent is found to be less than the dark current at every applied electric field. This phenomenon is known as negative photoconductivity which in this case may be due to the reduction in the number of charge carriers or their lifetime in the presence of radiation. Decrease in lifetime with illumination, could be due to the trapping process and increase in carrier velocity according to the relation:

$$\tau = (vsN)^{-1} \qquad (2)$$

Where *v* is the thermal velocity of the carriers, *s* is the capture cross section of the recombination centers and N is the carrier concentration. As intense light falls on the sample, the lifetime decreases [9]. In Stockmann model, a two level scheme is proposed to explain negative photoconductivity [10]. Fig.3. shows the variation of both dark current (I_d) and photocurrent (I_p) with applied field. It is seen from the plots that both I_d and I_p of the sample increase linearly with applied field. It is observed from the plot that the dark current is always higher than the photo current, thus confirming the negative photoconductivity nature of the single crystal.

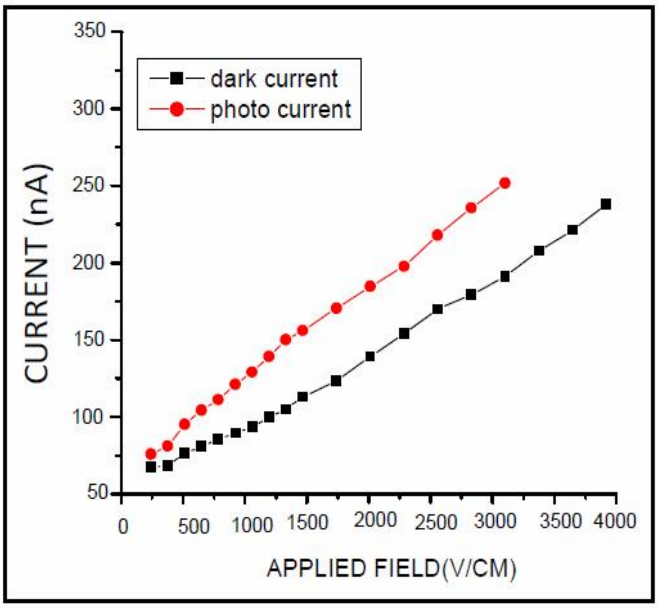

Fig.3. Photoconductivity of grown single crystal

4. CONCLUSION

Single crystals of L-Valine zinc sulphate were grown from aqueous solution by slow evaporation technique. The grown crystals were characterized by single crystal XRD and it is confirmed that the crystal belongs to the monoclinic system. Dielectric measurements were carried to analyse the dielectric constant and dielectric loss at different frequencies and different temperatures. The photocurrent was less than the dark current, signifying negative photoconducting nature.

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