

DIELECTRIC AND PHOTOCONDUCTIVITY PROPERTIES OF L-ARGININE DIODATE NONLINEAR OPTICAL SINGLE CRYSTAL

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Abstract. Single crystal of L-arginine diiodate was grown from aqueous solution by slow evaporation technique. The crystalline nature of the material has been confirmed by single crystal X-ray diffraction. Dielectric constant and dielectric loss measurements were carried out at different temperatures and frequencies. The photoconductivity studies reveal that the crystal exhibits negative photoconductivity.

1. Introduction

Nonlinear optical (NLO) materials play a major role in nonlinear optics and in particular they have a great impact on information technology and industrial applications. In the last decade, however, this effort has also brought its fruits in applied aspects of nonlinear optics. This can be essentially traced to the improvement of the performances of the NLO materials. The development of optical devices, such as photonic integrated circuitry, depends strongly on the design of highly efficient nonlinear optical (NLO) materials. Among such NLO materials, organic materials are shown to be superior to their inorganic counterparts in terms of synthesis, crystal fabrication, potential to create large devices and much faster optical nonlinearities [1, 2]. The design and synthesis of organic molecules exhibiting second-order nonlinear optical (NLO) properties has also been motivated by their tremendous potential for application in optical communications, optical computing, data storage, dynamic holography, harmonic generators, frequency mixing and optical switching [3, 4]. In the present investigation, deals with the growth of L-arginine diiodate single crystal by the slow evaporation technique. The grown crystal has been subjected to single crystal X-ray diffraction (XRD), dielectric and photoconductivity studies.

2. Experimental procedure

The starting material was synthesized by taking l-arginine and iodic acid in the stoichiometric ratio and dissolved in double distilled water and stirred well for about six hours. The purity of the synthesized salt was further improved by successive recrystallization process. The seed crystals were formed due to spontaneous nucleation. Then it was filtered and allowed to crystallize by slow evaporation method. Within 35 days, crystals with good transparency were produced. Transparent good quality seed crystals free from macro defects were used for growth experiments.

3. Results and discussion

Single crystal XRD analysis. In order to obtain the crystal data of L-arginine diiodate crystals, the single crystal X-ray diffraction analysis was performed using Enraf Nonius CAD4 Single Crystal X-Ray Diffractometer. The single crystal XRD data of L-arginine

diiodate crystal indicate that it crystallizes in orthorhombic system with space group $P2_12_12_1$. The calculated lattice parameter values are $a = 6.95 \text{ \AA}$, $b = 7.95 \text{ \AA}$, $c = 25.05 \text{ \AA}$, $V = 1383.04 \text{ \AA}^3$, $\alpha = \beta = \gamma = 90^\circ$, in good agreement with the reported values [5].

Dielectric studies. The temperature dependent dielectric constant and dielectric loss of L-arginine diiodate were measured using Hioki 3532 LCR Hi-Tester in the frequency range from 50 to 5 MHz. In order to ensure good electrical contact between the crystal and the electrodes, a sample was coated with silver paint and mounted between the two electrodes. The capacitance of the parallel plate capacitor formed by the electrodes, with the sample as a dielectric medium, was measured. The variation of capacitance was recorded in the frequency range 50 to 5 MHz at different temperatures. The dielectric constant of the material was calculated for different frequencies from the measured capacitance values.

The plot of dielectric constant versus applied frequency is shown in Fig. 1. It is observed that dielectric constant has high values in the low frequency region and there after decreases with the applied frequency.

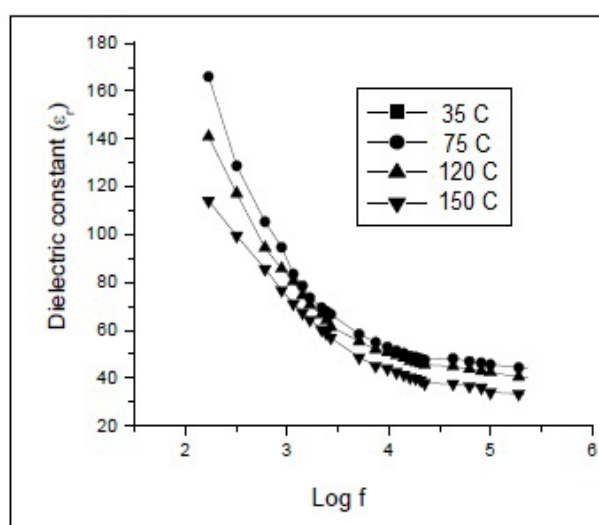


Fig. 1. Variation of dielectric constant with Log frequency.

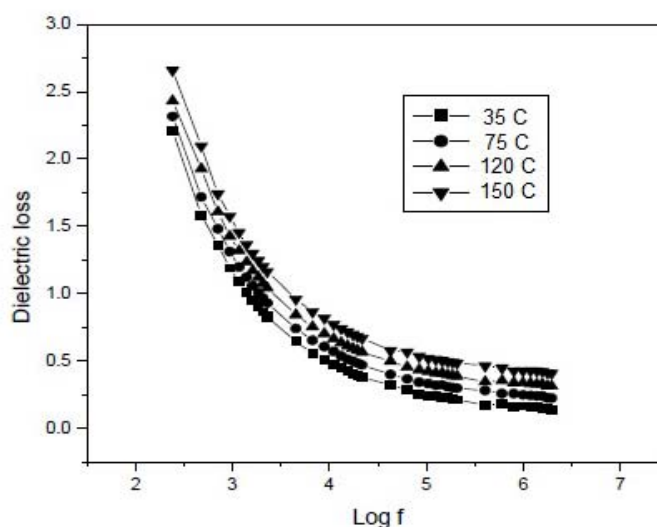


Fig. 2. Dielectric loss as a function of frequency.

The very high value of dielectric constant at low frequencies may be due to the presence of all the four polarizations namely, space charge, orientational, electronic and ionic polarization, and the low value at higher frequencies may be due to the loss of significance of these polarizations gradually. The variation of dielectric loss with frequency is shown in Fig. 2. For a given sample if there is low dielectric loss with high frequency, it suggests that the sample possess enhanced optical quality with lesser defects [6]. This is observed in the case of L-arginine diiodate single crystals.

Photoconductivity studies. Photoconductivity measurements are carried out on a polished sample of the grown single crystal by fixing it onto a microscope slide. The sample is connected in series with a DC power supply and KEITHLEY 485 picoammeter. The dark current is recorded. The sample is illuminated by the radiation from 100 W halogen lamp containing iodine vapour and tungsten filament. The photocurrent is recorded for the same values of the applied voltage. Field dependence of dark and photo currents of L-arginine diiodate crystals is shown in Fig. 3.

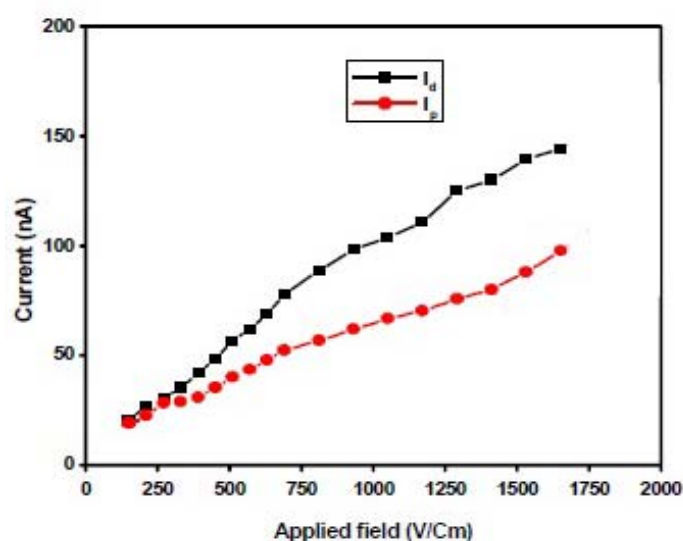


Fig. 3. Field dependent photoconductivity of grown single crystal.

The photocurrent is found to be less than the dark current at every applied electric field. This phenomenon is known as negative photoconductivity. Generally, this may be attributed to the loss of water molecules in the crystal. However, the negative photoconductivity in this case may be due to the reduction in the number of charge carriers or their lifetime in the presence of radiation [7]. Decrease in lifetime with illumination, could be due to the trapping process and increase in carrier velocity according to the relation:

$$\tau = (v s N)^{-1},$$

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 [8]. In Stockmann model, a two level scheme is proposed to explain negative photoconductivity [9]. The upper energy level is situated between the Fermi level and the conduction band, whereas the other one is located in the neighbourhood of the valence band. The lower level has high capture cross section for electrons from the conduction band and holes from the valence band. As a result, no sooner the sample is kept under exposure to

light, the recombination of electrons and holes take place, resulting in decrease in the number of mobile charge carriers, giving rise to negative photoconductivity.

4. Conclusion

Single crystals of L-arginine diiodate were grown by using the slow evaporation technique. The lattice parameters were calculated by single crystal X-ray diffraction and it was confirmed that the crystals belong to the orthorhombic system with the space group $P2_12_12_1$. The dielectric constant decreases with increasing frequency at different temperatures. The photocurrent was less than the dark current, signifying negative photoconducting nature.

References

- [1] G. Jordon, T. Kobayashi, W.J. Blau, S. Pfeiffer, H-H. Horhold // *Advanced Functional Materials* **13** (2003) 751.
- [2] Z. Yang, S. Aravazhi, A. Schneider, P. Seiler, M. Jazbisnek, P. Gunter // *Advanced Functional Materials* **15** (2005) 1072.
- [3] D.S. Chemla, J. Zyss, *Nonlinear optical properties of organic molecules and crystals* (Academic Press, Orlando, 1987).
- [4] P.N. Prasad, D.J. Williams, *Introduction to nonlinear optical effects in organic molecules and polymers* (Wiley, New York, 1991).
- [5] R. Sankar, R. Muralidharan, C.M. Raghavan, R. Jayavel // *Materials Chemistry and Physics* **107** (2008) 51.
- [6] C. Balarew, R. Duhlew // *J. Solid State Chem.* **55** (1984) 1.
- [7] R.H. Bube, *Photoconductivity of Solids* (Wiley, New York, 1981).
- [8] I.M. Ashraf, H.A. Elshaik, A.M. Badr // *Cryst. Res. Technol.* **39** (2004) 63.
- [9] V.N. Joshi, *Photoconductivity* (Marcel Dekker, New York, 1990).