Investigation on optical behavior of L-cystine dihydrobromide for optoelectronic Applications

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Abstract:
In present investigation L-cystine dihydrobromide (LCD) crystal has been grown by slow evaporation technique at room temperature. The optical studies were carried to examine optical transparency and determine the optical constants of the grown crystal quenching the optoelectronics applications. The optical studies ascertained high optical transparency and cut off wavelength was found to be 265 nm imperative for nonlinear applications. The optical band gap of grown crystal was found to be 5.16 eV. The optical constants, extinction coefficient, nonlinear index of refraction, optical conductivity, complex dielectric, optical band gap, reflectance were determined to scrutinize the electronic band structure highly demanded for optoelectronics applications.

Keywords:
Growth from solution; UV-Vis; Optical properties.

Academic Discipline
Physics

SUBJECT CLASSIFICATION
Physics – Crystal growth and characterization

TYPE
NLO crystals

1. INTRODUCTION
Nonlinear optical frequency conversion materials have a significant impact on laser technology, optical communication and optical storage technology. Sodium nitrate was a potential inorganic material having wide range of applications such as electro-optic modulator, harmonic generators and parametric generators [1-2]. The literature survey confirmed the studies on improved second harmonic generation, thermal and opto-electric properties of crystals grown by mixing Equimolar ratios of amino acids L-alanine, L-arginine with malic acid, oxalic acid, and nitric acid acetic acid [3-5]. The amino acids were organic materials for NLO application as they have donor carboxylic (COOH) group and the proton acceptor (NH2) amino group, known as zwitter-ions. Therefore, amino acids show high NLO activity due to chirality and donor-acceptor group [6]. L-cysteine posses a side chain with hydrogen atom which offers to charge transfer to form semi-organic crystals for nonlinear optical applications [7]. Thus present study reports detailed evaluation of optical properties like optical band gap, extinction coefficient, refractive index and optical conductivity of L-cystine dihydrobromide (LCD) crystal for possible application in optical limiting devices.

2. MATERIALS AND METHODS
The AR grade L-cysteine was dissolved in deionized water with continuous stirring to attain the supersaturation solution at room temperature. Hydrobromic acid had been introduced to supersaturated solution and stirred with constant speed for five hours to achieve the homogeneity throughout the volume. The filtered solution was kept for evaporation at room temperature. The purity was achieved by successive recrystallisation. The photograph shows good quality transparent crystals of L-cystine dihydrobromide cited in figure. 1. The reaction was as follows

\[ 2C_3H_7NO_2S + 2HBr \rightarrow C_6H_14N_2Br_2O_2S_2 \]  

(1)
3. RESULTS AND DISCUSSION

3.1. Optical Studies

The optical studies were studied using Shimadzu UV-2450 spectrophotometer within the range of 200-1400 nm. The recorded transmittance spectrum of LCD was shown in figure 2. The grown crystal exhibits transmittance in entire visible region with upper cutoff wavelength found to be 265 nm. The high transmittance and lower cutoff were imperative parameters for NLO applications [8].

\[ \alpha = \frac{2.302 \log(1/T)}{d} \]  

(2)

Where \( T \) is the transmittance, \( \alpha \) is the absorption coefficient; \( d \) is the thickness of the crystal optical band gap (Eg) depicted in fig. 3 was calculated by

\[ \alpha = A (h\nu - E_g)^{\frac{1}{2}} \]  

(3)

Fig 1: Photograph of LCD

Fig 2: UV Transmittance spectrum of LCD

Fig 3: \((\alpha h\nu)^2\) Vs Photon energy of LCD
Extinction coefficient can be obtained by the following relation,

\[ k = \frac{\lambda \alpha}{4\pi} \]  

(4)

Reflectance in terms of refractive index (n) is given by relations respectively,

\[ R = \frac{(n-1)^2}{(n+1)^2} \]  

(5)

The Band gap of the grown crystal was wide up to 5.16 eV which is calculated from the Tauck’s plot shown in figure 2. The wide optical band gap indicates its suitability for optical device fabrication. The lower values of reflectance and extinction coefficient in entire visible region are shown in figure 4 & 5 which substantiates the grown crystal for antireflection coating in solar thermal devices [9]. The lower value of complex dielectric shown in figure 6 indicates the high crystal perfection. The relation between band gap and refractive index [10] is given as

\[ E_g n^4 = 20.97 \text{eV} \]  

(6)

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Fig 4: Reflectance Vs Wavelength of LCD

Fig 5: Extinction Coefficient Vs Wavelength of LCD

Fig 6: Complex Dielectric Vs Wavelength of LCD
CONCLUSION

The L-cysteine dihydrobromide (LCD) crystal was grown by slow evaporation technique. The optical studies confirmed grown crystal is transparent in entire visible region. The cut off wavelength was ascertained to be 265 nm. The SHCM crystal has wide optical band gap of 5.16 eV which makes it suitable for optoelectronic device fabrications. The lower refractive index, extinction coefficient, low complex dielectric confirm good optical quality and low defect concentration of the grown crystal. All above studies revealed that the grown crystal is suitable for optoelectronics device fabrication, solar thermal devices, second harmonic generation and NLO applications.

REFERENCES


