Optical Properties of L-Serine Hydrochloride monohydrate single crystal

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Abstract : A new organic L-serine Hydrochloride single crystal was grown by solvent evaporation technique using water. The optical transparency range has been studied through UV–Vis–NIR spectroscopy. The laser induced surface damage threshold value 13.64 GW/cm^2 indicates that this material can be used for high-power laser applications.

***IndexTerms* –LDT, Optical studies, Hydrochloride.**

I. INTRODUCTION

The organic nonlinear optical materials have attracted by many scientists due to their frequency conversion efficiency, piezoelectric, pyroelectric properties and their wide applications in the recent technologies like lasers, optical communications and data storage [1]. Organic materials show prominent properties due to their fast and large nonlinear response over a broad frequency range, inherent synthetic flexibility and large optical damage threshold for laser power and low frequency dispersion [2, 3].

Among the various types of crystals amino acid family crystals play most important role in the organic NLO crystals. Many natural amino acids exhibit the nonlinear optical properties [4] because they have a donor NH_2 and acceptor COOH and also due to the intermolecular charge transfer. L-serine is an organic compound under amino acid category. It is one of the naturally occurring protenogenic amino acids [5, 6]. L-serine exists in zwitterionic form; the molecule can combine with anionic, cationic and overall neutral constituents. The present investigation is involved in the growth of L-Serine hydrochloride monohydrate (LSHCL) single crystal and it's subjected for various characterizations.

II. Crystal growth

The analytical grade L-Serine and hydrochloric acid were taken in stoichiometric ratio. The calculated amount of L-Serine was first dissolved in Millipore water and then hydrochloric acid was added to the solution slowly with continuous stirring at room temperature. The saturated solution was filtered using Whatman filter paper and the filtered solution was kept in dust free environment and optimally closed for controlled evaporation. Over the period of 20 days, well grown transparent crystal was harvested. The photograph of grown crystal is shown in Fig.1.

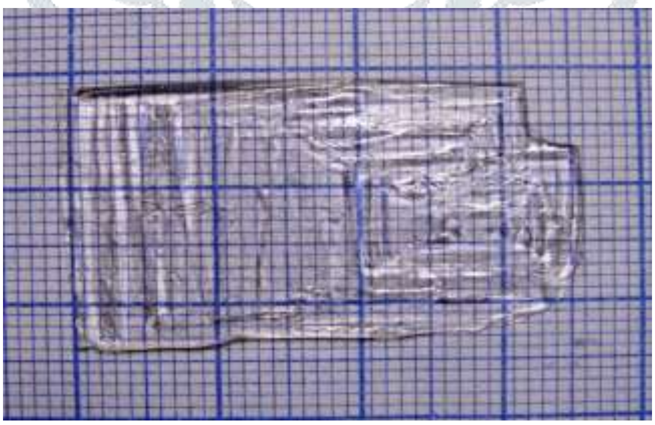

Figure 1: Asgrown crystal of LSHCL

III. UV-Vis-NIR spectral studies

The optical absorption spectrum of a LSHCL crystal was recorded in the wavelength range 190–1100 nm using a Perkin Elmer Lamda 935 UV-Vis-NIR spectrometer. The absorption spectrum shown in Fig.3a, has lower cut off wavelength of 229 nm. From the absorption spectrum, it is evident that the grown crystal is transparent in the entire visible region without any absorption peak, which is the key requirement for any nonlinear optical crystal having applications in second harmonic generation (SHG)[7].The band gap energy (E_g) can be calculated directly from the UV-cut off wavelength using the relation

$$E_g = h(c/ \lambda_c)\ \text{eV} \tag{1}$$

Where E_g is the band gap energy, h = 6.626×10^{-34} Js, C = 3×10^{8} m/s, λ_c is the UV cut-off wavelength, which is equal to 229 nm. On substituting these values in the above equation, the band gap energy is found to be $E_g = 5.42$ eV. The straightline nature of $(\alpha h\upsilon)^2$ versus hυ plot (Fig.2) reveals that nature of transition is directly allowed (i.e. m = ½ in our case). Intercept of the linear portion of the plot on the hυ axis gives the value of direct optical band gap energy E_{op} of the crystal and band gap energy is found to be 5.16 eV. As a consequence of this wide band gap, the grown crystal has a large transmittance in the visible region [8].

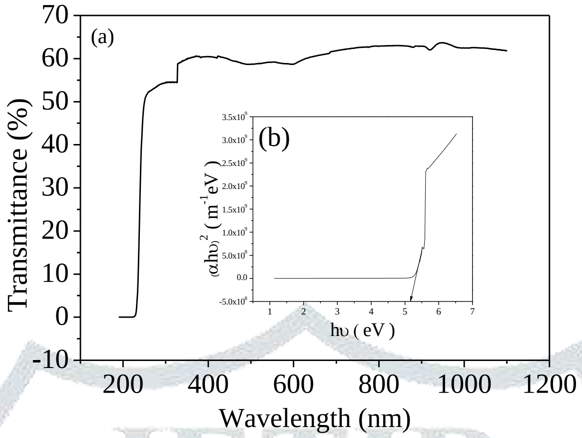

Fig.2.UV-Visible spectrum of LSHCL

IV. Laser damage threshold and nonlinear optical studies

The utility of NLO crystal depends not only on the linear and nonlinear optical properties but also largely on its ability to withstand high power lasers. Laser damage threshold (LDT) value of grown LSF crystal has been measured using Q-switched Nd:YAG laser Pulse width of 6 ns with a repetition rate of 10Hz and fundamental wavelength of 534 nm has been used for this study. The measured LDT value for LSHCL crystal (13.64 GW/cm^2) is higher than that of KDP (0.2GW/cm^2) and urea (1.5GW/cm^2). The grown LSHCL crystal can be used for high-power laser applications because of its high damage threshold.

V. Conclusion

Good quality organic NLO crystals of LSHCL have been successfully grown by slow evaporation technique. The absence of absorption in the entire visible region in UV–Vis–NIR spectrum of LSHCL makes the crystal in to a suitable material for optoelectronics applications. Laser Damage threshold of the LSHCL crystal was calculated using a highpower laser, and it is found that the LDT value of the crystals is high than that of the other Serine based crystal. Calculated surface damage threshold values of LSHCL is 13.64 GW/cm^2. From the LDT and results we conclude the crystal LSHCL can be a better candidate in opto electronics, low power laser and as well as high laser device applications and it can be a perfect replacement of same kind of organic crystals.

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