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Growth and Studies of Cadmium Chloride Doped L-Asparagine Single Crystal

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Abstract

Cadmium Chloride doped L-Asparagine single crystal was grown by solvent evaporation technique at room temperature. The presence of functional groups and modes of vibration of the sample was identified by FT-IR studies. The estimated band gap is 5.096 eV. The dielectric loss is low at high frequency was confirmed by dielectric studies. Microhardness studies reveal that the grown crystal is belonging to soft materials in nature.

Keywords: Crystal growth; Optical properties; Dielectric properties; Mechanical Properties; FTIR

1. INTRODUCTION

Amino acid based nonlinear optical single crystals have been attracted many researchers and industry people due to their unique properties like high transparency, fast nonlinear optical response, high laser damage threshold and large electro optic coefficient [1-3]. Due to unique properties, they can be applied in various fields of applications such as electro optic modulator, optical phase conjugation, parametric oscillator, frequency doubling, telecommunication, optical disc data storage and optical information process [4-5]. Amino acids complex materials have been proved and attracted in nonlinear optical applications because they contain a proton donating carboxyl group and proton accepting amino group [6]. Asparagine is an α – amino acid that contains an α – amino group, an α – carboxylic acid group and a side chain carboxamide and its molecular formula is $C_4H_8N_2O_3$. The crystal system and non centrosymmetric space group of the L-Asparagine is Orthorhombic and $P2_12_12_1$. L-Asparagine and its complex is an important nonlinear optical materials, which were reported by many researchers, such as Mn^{2+} doped L-Asparagine monohydrate [7], L-Asparagine picrate [8] and L-Asparagine L-tartaric acid [9]. In this present work, the author has grown Cadmium Chloride doped L-Asparagine single crystal from low temperature solution growth slow evaporation technique at room temperature and grown crystal was subjected to various characterization studies, like UV-visible, dielectric, microhardness and FTIR studies. The detailed results of work were reported in this article.

2. EXPERIMENTAL WORK

The calculated amount of L-Asparagine (Analar grade) was dissolved in double distilled water and stirrered continuously for 2 hours with the help of magnetic stirrer to get saturated homogeneous solution. Then 0.1 mol % of Cadmium Chloride was added in L-Asparagine, immediately the white precipitation was occurred. To avoid the precipitation, the solution was slowly heated till 60°C and stirrer about 2 hours. After 2 hours stirrering, the clear solution was obtained and doubly filtered with Whattman filter paper to remove the unwanted impurities. Then the solution was covered with perforated polythene paper and kept unperturbed place for evaporation at room temperature. After 28 days, the colourless well transparent quality Cadmium Chloride doped L-Asparagine single crystal was harvested. The as grown crystal is shown in fig.1.

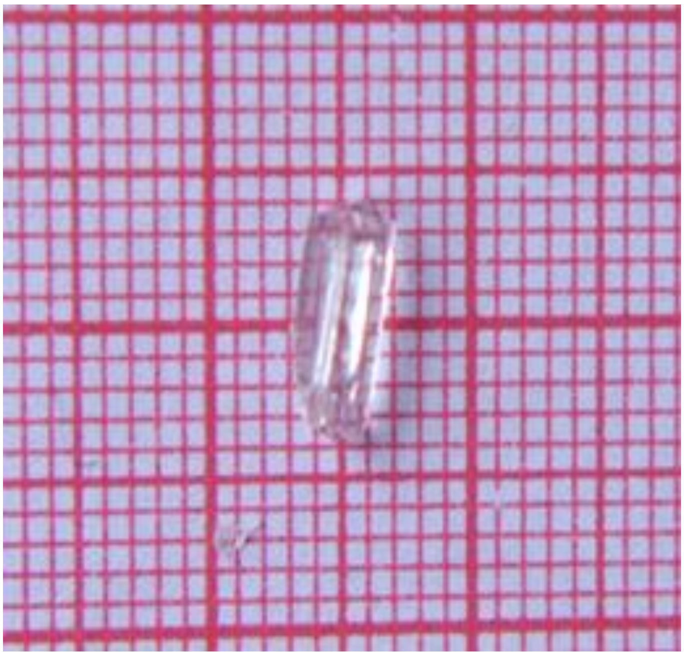

Fig. 1 As grown Cadmium Chloride doped L-Asparagine crystal

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3. RESULTS AND DISCUSSION

3.1. UV Visible Studies

An ultra violet visible study of the grown crystal was carried out using LS45 model UV-visible spectrophotometer in the range of 190 - 800 nm. The absorption spectrum of Cadmium Chloride doped L-Asparagine crystal is shown in fig. 2. The observed lower cut off wavelength of the Cadmium Chloride doped L-Asparagine crystal is 243.75 nm. The observed lower cutoff wavelength value is good agreement with literature value [3]. The forbidden band gap of the grown crystal was calculated by using the relation, $E_g = hc/\lambda$, where, h is the Planck's constant, c is the velocity of the light and λ is the cutoff wave length. The calculated forbidden energy band gap of Cadmium Chloride doped L-Asparagine crystal is 5.096 eV. The obtained band gap value suggests that the grown material belong to the typical insulating material and is essential for nonlinear optical applications.

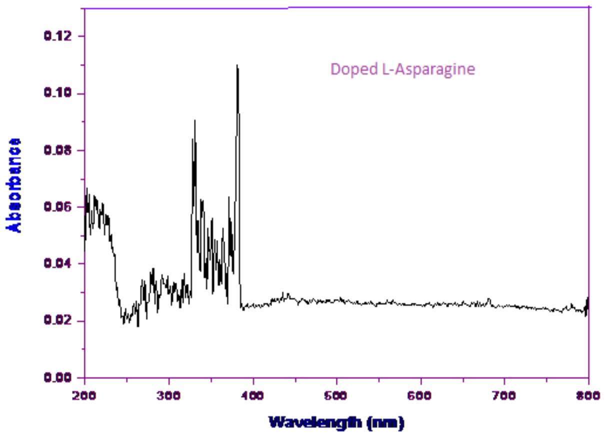

Fig. 2 Absorption spectrum of Cadmium Chloride doped L-Asparagine single crystal

3.2 Microhardness Studies

The Vicker's Microhardness studies of the grown Cadmium Chloride doped L-Asparagine single crystal was carried out on selected face of the crystal using HMT-2T microhardness tester in air at room temperature. Hardness number was measured by changing the load as 25 gram, 50 gram and 100 gram. The graph was drawn between load (P) and Hardness number (Fig.3), which was a straight line. Also, the graph was plotted between Log P and Log d (Fig.4) for obtaining the work hardening coefficient (n). The obtained value of work hardening coefficient of the grown material is 1.8. The n value reveals that the grown material belongs to the class of soft material in nature. Below 100 gram of applied load, the grown material is well appropriate one for nonlinear optical applications.

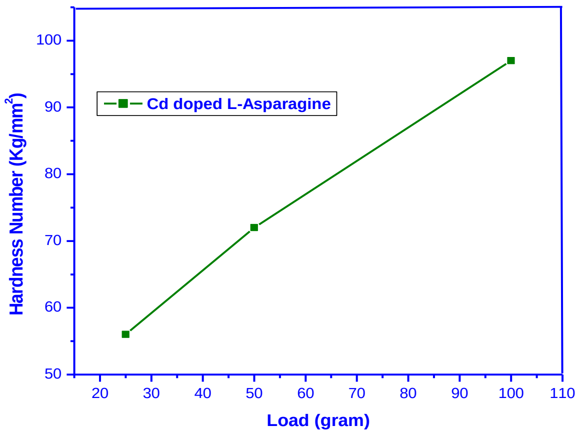

Fig. 3 Load Vs Hardness number

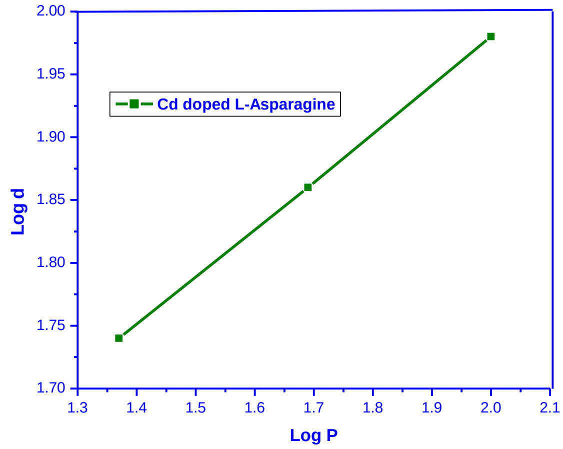

Fig. 4 Log P Vs Log d

3.3 Dielectric Studies

Cadmium Chloride doped L-Asparagine single crystals was subjected to dielectric studies using LCR HIOKI 3532 HI tester with the frequency range between 50 Hz to 5 MHz at the temperature 323 K and 373 K. The dielectric loss was calculated by varying the frequency. The graph plotted between log f and dielectric loss, which is shown in fig. 5. The dielectric loss of the material decreases with increasing of frequencies. The dielectric loss of material decreases with increasing of frequency. This variation of dielectric loss is due to attribution of electronic, ionic and orientation polarization. The low dielectric loss at high frequencies suggested that the gown Cadmium Chloride doped L-Asparagine single crystal is well apt applicant to use in nonlinear optical device applications.

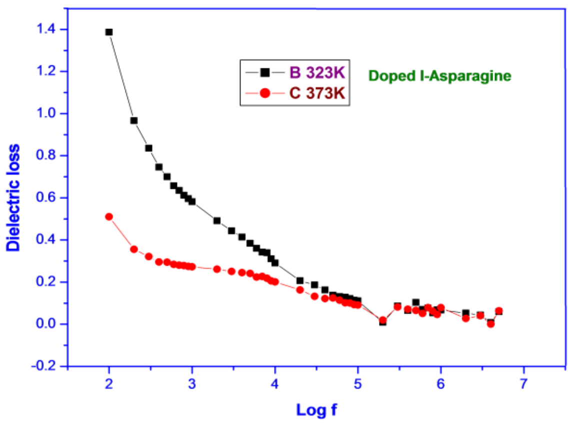

Fig. 5 log f Vs dielectric loss of Cadmium Chloride doped L-Asparagine

3.4 FTIR Analysis

Fourier transform infrared spectral analysis of grown Cadmium doped L-Asparagine single crystal was carried out using Perkin Elmer spectrometer in the range of 4000 cm^{-1} to 450 $cm^{-1}$to find the presence of functional groups and modes of vibrations. The recorded FTIR spectrum is shown in fig.6. The absorption band at 3380 cm^{-1} is attributed due to N-H symmetric stretching vibrations. NH_3^+ rocking vibration is assigned to the wavenumber at 1074 cm^{-1}. The peak at 665 cm^{-1} and 681 cm^{-1} are assigned to COO^- bending vibration and NH_3^+ torsion vibration. The band located at 2916 cm^{-1} is due to CH_2 stretching vibration. The peak at 1527 cm^{-1} and 889 cm^{-1} are attributed due to asymmetric mode of COO^- and C-C stretching vibration [11].

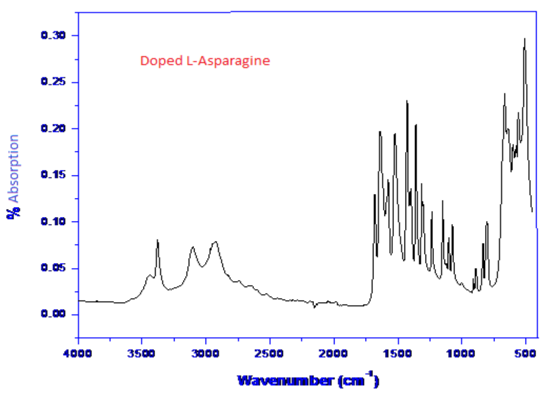

Fig. 6 FTIR spectrum of Cadmium Chloride doped L-Asparagine

4. CONCLUSION

Cadmium Chloride doped L-Asparagine single crystal was successfully grown by solvent evaporation technique at room temperature. The lower cutoff wavelength was obtained at 243.75 nm in UV-visible absorption spectrum. The low dielectric loss at high frequencies confirms that the grown Cadmium Chloride doped L-Asparagine crystal is apt one for optical applications. The presence of functional groups and modes of vibration in grown material was revealed by FTIR studies. Microhardness studies disclose that the grown material has soft in nature.

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