Development of Nonlinear Optical (NLO) Crystal L-Phenylalanine Doped Ammonium Dihydrogen Ortho Phosphate (ADOP)

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Abstract : The Amino acid L-Phenylalanine doped with Ammonium Dihydrogen Ortho Phosphate crystal was grown by the slow evaporation method using water as a solvent has been synthesized. The grown crystals were subjected to powder XRD analysis, the peaks confirm the crystalline nature. And the crystal XRD analysis determines the structure and lattice parameters of the crystal. The FTIR analysis shows the functional group of the material components. The AC impedance spectroscopy studies are carried out and the conductivity is measured. The NLO Property of grown L-Phenylalanine doped with Ammonium Dihydrogen Ortho Phosphate was carried out by Nd: YAG Laser.

Keywords: **Crystal growth, NLO, XRD, FT-IR spectrum, AC impedance studies.**

I. INTRODUCTION

Nonlinear optical materials play a vital role in the field of optics, these NLO material application areas are telecommunications optical signal processing, optical switching, photonics and optoelectronic technology [1-4], because of their applications lots of NLO crystals were grown[5-8]. Already NLO crystals such as L-Phenylalanine Nitrate [5], L-Phenylalanine fumaric acid [10], L-Phenylalanine nitric acid [9], L-Phenylalanine maleate [10], L-Phenylalanine perchlorate [11], L-Phenylalanine [12], and L-Phenylalanine potassium hydrogen phthalate [3] were grown by the researchers.

Phenylalanine is naturally available amino acids in protein; it is an important amino acid. The L-Phenylalanine amino acid is important for the body to create neurotransmitters [5]. The biological importance and naturally occurring properties of L-Phenylalanine have motivated to grow the NLO crystal with L-Phenylalanine. Generally, L-Phenylalanine is soluble in aqueous solution and the molecular formula is C 9H 11NO2 [13]. From the literature, there are no studies on L-Phenylalanine doped with Ammonium dihydrogen orthophosphate. The main purpose of this present work is to grow the NLO crystals based on L-Phenylalanine doped with Ammonium dihydrogen phosphate and characterized by single crystal XRD, Powder XRD, FTIR, and NLO studies by using Nd: YAG Laser.

II. EXPERIMENTAL DETAILS

Analytical reagent grade [14] of Amino acid L-Phenylalanine and Ammonium salt Ammonium Dihydrogen Ortho Phosphate were mixed in a stoichiometric ratio [5] in distilled water. The resultant solution was filtered and transferred to the crystal growth vessels. Crystallization was allowed to take place by slow evaporation at room temperature [8, 15] for a weak in a dust free place. After a weak, well defined transparent crystals were obtained in the size of 8mm length. The obtained crystal was carefully removed from the solution. The crystals were allowed to dry for sometime in dust free place. After those colorless transparent crystals were collected and stored in a clean and airtight container. L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystals the morphology is shown in figure 1.

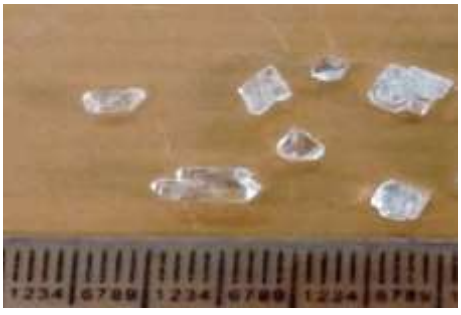

Fig. 1 Morphology L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate single crystals

III. CHARACTERIZATION STUDIES AND DISCUSSION

Single Crystal X-ray Diffraction (XRD) Study:

The single crystal X-ray diffraction has been carried out using a diffractometer to determine the unit cell dimensions [14]. From the XRD measurement of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate, we found that the lattice parameters are a=7.494Å, b=7.465 Å, c=7.541 Å with angles α=β=γ=90°and the cell volume is V=421.86 Å^3. The three different values of cell parameters with the same angle 90° conform the grown crystals belong to the **orthorhombic system.** The lattice parameter values are very well agreement with the reported values [6]. XRD data are given in table 1.

Table 1: Single crystal XRD system for L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate

Sample	a (Å)	b (Å)	c (Å)	$\alpha = \beta = \gamma$ (degree)	Cell volume(Å^3)	Crystal system
L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate	7.494	7.465	7.541	90°	421.86	**orthorhombic**

Powder X-ray Diffraction (XRD) Study:

The grown crystals were characterized by the Powder XRD technique to confirm the crystalline nature of crystals. The grown crystals were subjected to Powder XRD analysis using an X-ray diffractometer with Cu [K-Alpha (λ = 1.5406Å)] radiation. The samples were scanned for 2θ values from 10^0 to 80^0 at a rate of 2^0/min. The sharp peaks (002), (202),(110),(211), observed in the Powder XRD technique, these diffraction patterns confirm the crystalline nature of the L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystals [14]. The peaks are indexed in figure 2.

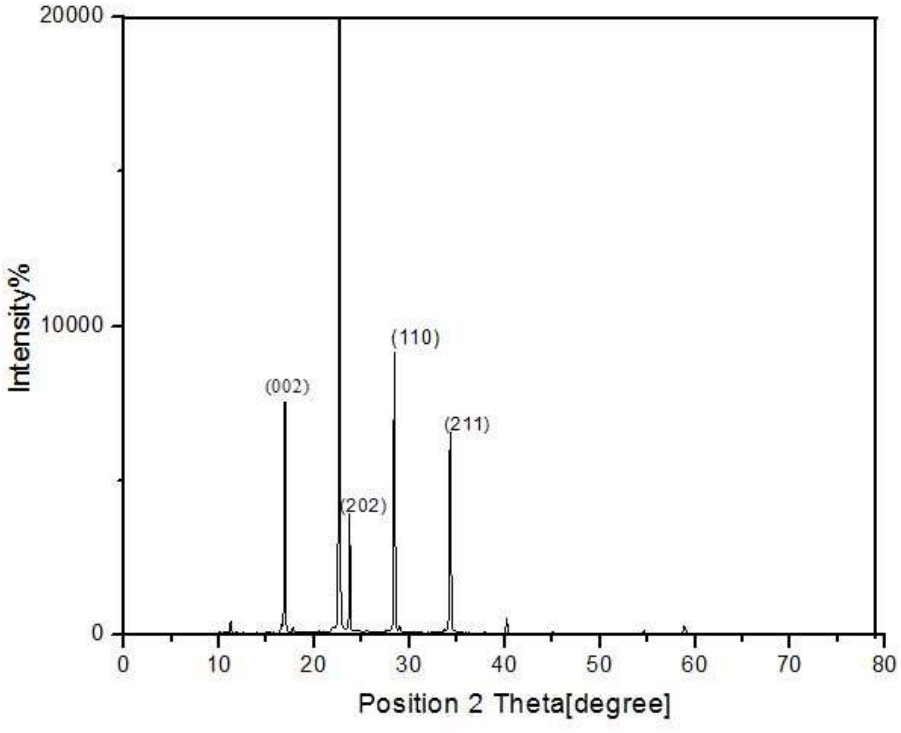

Fig. 2 Powder X-ray diffraction pattern of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal

Fourier Transform Infrared Spectroscopy (FTIR):

In FTIR studies we can find the Vibrational modes for various frequencies. The FTIR analysis of the crystals of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate was performed by employing a 66V model spectrophotometer by the KBr pellet method in the wave-number range 4000-450 cm^{-1}. The recorded FTIR spectrum is given figure 3. The FTIR spectrum of the Amino acid doped with Ammonium salt crystal is analyzed. The inclusion of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate has been strongly verified. The NH_3^+ symmetric vibration gives a strong band at 2413.75cm^{-1} in Amino acid doped with Ammonium salt crystal. The absorption band at 544.85 cm^{-1} is due to O-N=O bending vibration in the doped crystal.

At a frequency of 1744.49cm^{-1} and 1815.86 cm^{-1}, C=O stretching vibration occurs in L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal. Thus, the presence of all the functional groups was confirmed and it is tabulated in table 2.

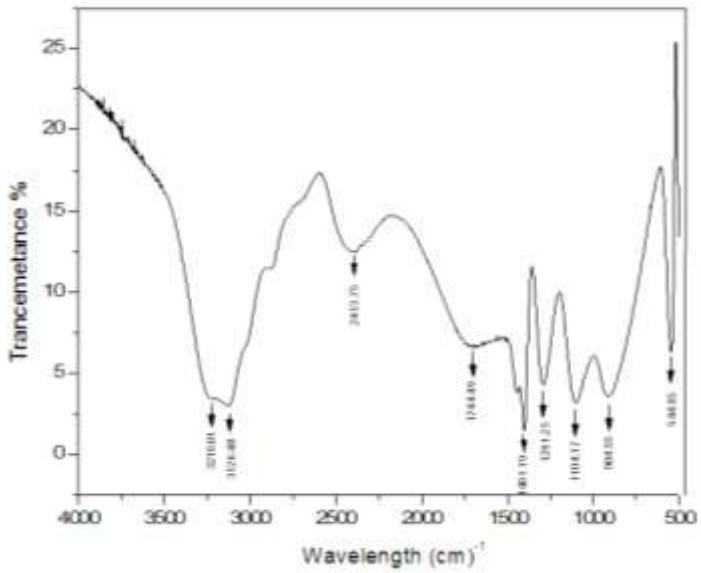

Fig. 3 FTIR Spectrum of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal

Table 2: Functional groups of-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal

Wave number (cm^{-1})	**Assignments**
544.85	$O-N=O$ bending
904.55	$N-H$ Wagging
1104.17	Symmetric $C-O-C$ Stretching
1291.25	CH_2 Out of plane stretching
1401.19	$N=O$ Stretching
1744.49	$C=O$ Stretching
2413.75	NH_3^+ Stretching
3126.4	$N-H$ Stretching (bonded)
3218.01	$N-H$ Stretching (bonded) symmetric

NLO Test:

Second Harmonic Generation (SHG) efficiency of grown crystal conforms by the Nonlinear Optical (NLO) test. Kurtz powder technique [16, 17] is the best technique to find this NLO property. The grown crystal is crushed well and makes a powder form and allowed it for the NLO test. The wavelength of light 1064nm is focused on the incident powdered sample [5]. The SHG efficiency of grown crystal is 2.02 times greater than the comparative material KDP [14]. From the NLO test result our grown

crystal SHG efficiency is greater than as L-Phenylalanine Nitrate [5], L-Phenylalanine trichloroacetate [13], L-Phenylalanine KNO3 [15].

IV. CONCLUSION

Optically transparent NLO L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal was grown by a slow evaporation method using water as a solvent. The crystalline nature was confined by powder XRD analysis. From the crystal XRD study, cell parameters and orthorhombic structure of L-Phenylalanine doped Ammonium Dihydrogen Ortho Phosphate crystal were confirmed and the FTIR trace reveals the presence of functional groups. NLO test proved grown crystal obey high SHG efficiency that is 2.02 times greater than KDP crystal and it is suitable for photonics device application [13] and it can be used as a promising NLO material.

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