Research Paper

# Synthesis, Growth and XRD Studies of New Nonlinear Optical L-tyrosine Hydrochloride Single Crystals

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## Abstract

Nonlinear optics deals with the study of phenomena that take place due to the modication of the optical properties of a material in the presence of intense laser light. Most of the organic and inorganic crystals inves-tigated so far have failed to meet the standards set by device applications used in the eld of telecommunica-tions and Optoelectronics. Hence, there is a need to synthesize various new materials and to grow good qual-ity single crystals for NLO applications. In this context, a new class of materials called semiorganics have come into existence. L-tyrosine hydrochloride, a new semiorganic material was synthesized and bulk single crystals of this material have been grown by solution growth method. Grown crystals were characterized by Powder XRD and Single Crystal XRD techniques. Second harmonic conver-sion e-ciency of the synthesized material was measured in powder form and compared with that of KDP.

Keywords: Nonlinear optics, second harmonic gen-eration, bulk crystals.

## 1 Introduction

With unprecedented developments that are taking place in the eld of telecommunications and data processing, photonics which employs the 'photon' to acquire, store, process and transmit data has become a potent eld of re-search. The design of devices that utilize photons instead of electrons in the transmission of information has created a need for new materials with unique optical properties [1]. Materials possessing nonlinear optical (NLO) suscep-tibility are of particular interest [2]. Second Harmonic Generation (SHG) is the conversion of coherent light of frequency ! into light of frequency 2 !. One practical ap-plication of second harmonic generation is the conversion of relatively inexpensive (yet powerful) infrared laser light into visible laser light. Self-focusing eect allows one to change the refractive index of a material by applying a DC electric eld to the material; thus, one can utilize the modulation of an electrical signal to activate an optical switch [3]. Since, it is impossible to get a crystal which satises, the standards set by device applications for the fabrication of nonlinear optical devices, the search for new materi-als satisfying most of those conditions is still continuing.

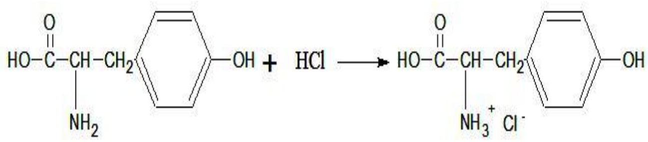
The inherent limitations of the maximum attainable non-linearity in inorganic materials and the moderate success in growing device grade organic single crystals have made scientists to adopt alternate strategies. The obvious one was to develop hybrid organic-inorganic materials with some tradeo in their respective advantages. This new class of materials has come to be known as semiorganics. One approach to high e-ciency optical quality organic based NLO materials in this class is to form compounds in which a polarizable organic molecule is stochiometri-cally bonded to an inorganic host. They have better me-chanical properties as compared to organic molecules, like wide transparency range, higher laser damage threshold; and at the same time, like organic crystals, their proper-ties can be controlled by the wide variation of chemical composition. Keeping this in view, experiments were car-ried out so as to develop new salts of amino acids. Some representative amino acids are selected and made to react with inorganic acids. The resulting materials were inves-tigated for their NLO properties since; they will have the properties of ionic as well as, hydrogen bond and Vander walls force. L-tyrosine hydrochloride (L-THCl), a salt of amino acid L-tyrosine is synthesized, characterized and bulk single crystals are grown, and presented in this pa-per.

## 2 Experimental

### 2.1 Synthesis

A saturated solution of L-tyrosine prepared in 4N HCl (pH<1) was heated for 12 hrs at 40 C to evaporate. The

resulting pale yellow solid was dried and puried by re-peated crystallization in concentrated HCl. The mate-rial thus prepared was analyzed by physical and chemical methods and conrmed to be L-THCl. This compound was used to grow bulk crystals. Following chemical reac-tion yields L-THCl:




### 2.2 Crystal Growth

A saturated solution of L-THCl at 40 C was prepared

and subjected to slow vaporization by cooling at a rate of 0.5 C per day. Optically transparent seed crystals were suspended in the supersaturated solution when the temperature reached 32 C. The growth temperature was maintained at 32 C in the crystal growth apparatus. Bulk crystals of maximum size 30mm 10mm 4mm were harvested after a month. L-THCl crystal grows in the shape of prism elongated in the c direction. L-THCl is stable at room temperature and non hygroscopic. Figure 1 is the photograph of grown crystals.

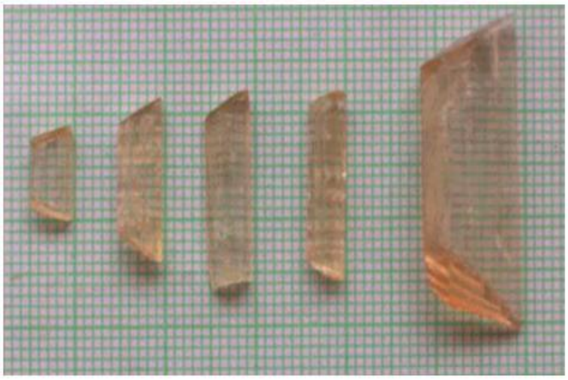


Figure 1: Single Crystals of L-THCl.

## 2.3 Powder X-Ray Diraction Studies

Powder X-ray diraction patterns of the grown L-THCl was recorded using BRUKER D8 ADVANCE powder diractometer with Cu K radiation ( =1.5406Å). The sample was scanned at a rate of 1 per minute in the range 10 to 70 . The Powder XRD diractogram of L-THCl is shown in Figure 2.

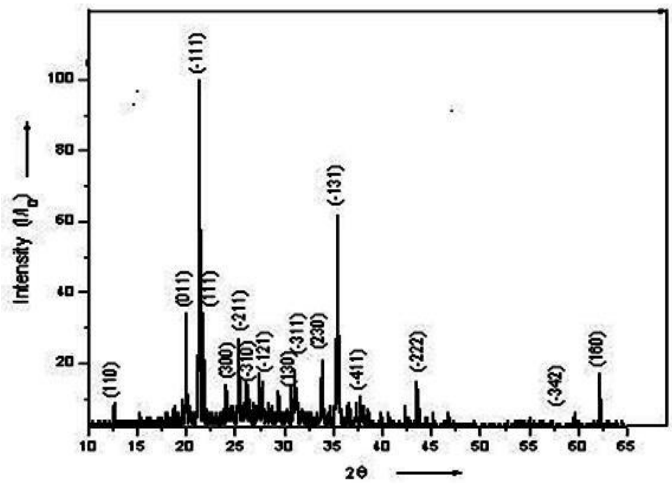



Figure 2: Powder XRD diractogram of L-THCl.

## 2.4 Unit Cell Parameters

Unit cell parameters of the grown crystals were obtained using ENRAF, NONIUS CAD-4 diractometer. The re-sults obtained are presented in Table 1. These values agree quite well with the reported values.

Table 1: Unit cell parameters of L-THCl

| Parameter | Present work Single crystal | powder | Literature [4] |
|---|---|---|---|
| Space Group | $P2_1$ | $P2_1$ | $P2_1$ |
| a(A) | 11.0704 | 11.0822 | 11.41 |
| b(B) | 9.0556 | 9.0327 | 9.11 |
| c(A) | 5.0877 | 5.0912 | 5.17 |
| B | 91.7243 | 91.7902 | 91.00 |
| V(A3) | 509.8124 | 509.3915 | 537.5 |

## 2.5 Second Harmonic Generation

The second harmonic generation (SHG) e-ciency was determined by the modied version of the powder tech-nique developed by Kurtz and Perry [5] using a Quanta Ray Spectra Physics model Prolab170 Nd: YAG 10 ns laser with a pulse repetition rate of 10Hz working at 1064 nm. The sample was ground into ne powder and tightly packed in a micro-capillary tube. It was mounted in the path of the laser beam of 9.6 mJ pulse energy obtained by splitting the original laser beam. The out-put light was passed through a monochromator (TRI-ACS 550) transmitting only the second harmonic (green) light at 532 nm. The green light intensity was registered by a photomultiplier tube (PMT-Philips Photonics XP 2020) and converted into an electrical signal. This sig-nal was displayed on the oscilloscope (Tektronics TDS 3052B) screen. Potassium dihydrogen phosphate (KDP) ground into samples of identical size was used as reference material in the SHG measurement. SHG conversion e--ciency was computed by the ratio of signal amplitude of the L-THCl sample to that of the KDP signal amplitude recorded for the same input power. The SHG e-ciency of the L-THCl was found to be 1.2 times that of KDP.

# 3 Results and Discussion

L-tyrosine hydrochloride (L-THCl) was synthesized by conducting reactions with hydrochloric acid. Single crys-tals of L-THCl of dimension up to some centimeters could be grown by slow evaporation of saturated solutions of L-THCl in 2N hydrochloric acid. These crystals grow in the shape of prisms elongated in c-direction bounded by six major planes. The crystals are yellowish and optically not very transparent.

The crystallinity of the synthesized L-THCl was con-rmed by the powder XRD pattern. The cell parameters of the grown crystals were determined using the single crystal X-ray diractometer as well as from powder data using the standard software. Close agreement of the de-termined cell parameters with the reported values con-rmed the identity of the grown crystals. L-THCl crys-tallizes in noncentrosymmetric system with space group $P2_1$ making the materials as an eligible candidates for second harmonic generation.

# 4 Conclusions

L-Tyrosine hydrochloride is synthesized and bulk single crystals are grown by slow evoporisation of solution in

2N hydrochloric acid. Crystallinity of the sample is analyzed by powder XRD and single crystal XRD experiments. Cell parameters of the grown single crystals found to agree quite well with the reported literature. Second harmonic conversion e-ciency of the crystal is measured by modied version of the powder technique developed by Kurtz and Perry, and found to be 1.2 times that of KDP.

## References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