L - arginine acetate single crystals for NLO applications

P. Gnanasekaran[a], and J. Madhavan[b*]
[a]Department of Physics, C. Kandaswami Naidu College, Chennai – 600 102, India
[b]Department of Physics, Loyola College, Chennai – 600 034
jmadhavang@yahoo.com

Abstract: Single crystals of pure and Lanthanum doped L- arginine acetate (LAA) were grown successfully by slow evaporation technique. The grown crystals were confirmed by X-ray powder diffraction studies. The pure and doped crystals were characterized by Fourier Transform Infrared (FT-IR) and UV-Vis-NIR studies. It was found that the optical properties were enhanced by the incorporation of the dopant. Nonlinear optical studies reveal that the dopant has increased the efficiency of the LAA crystal.

Keywords: L-arginine acetate crystal, dopant, lanthanum, NLO.

Introduction

L-arginine acetate (LAA) is one of the prominent members of the L-arginine phosphate (LAP) family (Monaco *et al*., 1987) identified as the most promising organic nonlinear material. Recent studies reveal that LAA possess excellent optical, thermal, mechanical properties which make it a strong candidate for photonic devices (Pal & Kar, 2005). The present work deals with the influence of rare earth dopant (Lanthanum) on the growth and characterization of LAA single crystals.

Experimental procedures

From aqueous solution with equimolar proportion of L-arginine (kemphasol 98%) and acetic acid (AR grade) $LACH_3COOH$ is formed by slow evaporation technique. The pH values of LAA and La-LAA were 6.0, 6.5 respectively. The concentration of the dopant was maintained at 2%. Optically clear LAA and La-LAA were harvested after a period of 35 days. The grown crystals were subjected to powder X-ray diffraction to confirm the crystallinity and also to estimate the lattice parameters. The FT-IR spectra were taken using the KBr pellet technique to confirm the presence of functional groups. UV-Vis-NIR absorption studies were also done and the spectrums were recorded. The SHG efficiencies were studied using a Q-switched, mode locked Nd:YAG laser.

Results and discussion

Powder X-ray diffraction analysis

Fig.1 and Fig. 2 show the powder X-ray diffraction pattern of pure and doped crystals respectively. From the X-ray diffraction data, it is observed that both pure and doped crystals crystallize in the monoclinic system with space group $P2_1$ (Muralidharan *et al*., 2003). The crystal data of LAA and La-LAA are presented in Table.1

Table1. Crystal data for LAA and La-LAA

Sample	a(Å)	b(Å)	c(Å)	β°	Volume Å^3
LAA	9.221	5.184	13.090	109.61	586.20
La-LAA	9.114	5.232	12.794	107.66	581.38

Inductively coupled plasma analysis

The exact percentages of dopants present in the crystal lattice were determined by Inductive Coupled Plasma (ICP) analysis. The result shows that 15 ppm of Lanthanum entered into the crystal lattice of the crystal. It is seen that the amount of dopant incorporated in to the doped crystal is less than the concentration of the dopant in the corresponding solution.

FT-IR analysis

The middle infrared spectrum of pure and doped LAA is shown in Fig. 3 and Fig. 4 respectively. The spectra show a broad envelope between 2100 and 3500 cm^{-1}. It is due to overlapping of peaks of NH(NH_3^+) vibrations, OH(COOH) and CH(CH_2 & CH_3). The C=O stretch of COO^- gives its peak at 1689 cm^{-1} whereas the asymmetric NH bend of NH_3^+ shows its peak at 1639 cm^{-1}. The corresponding symmetrical NH bend is assigned to the peak at 1532 cm^{-1}. All these peaks overlap and produce broad intense envelope. In this envelope, the peak due to asymmetric CO_2 stretch is observed at 1400 cm^{-1}. All the other peaks below 1400 cm^{-1} are due to COO^- and other bending modes. The torsional NH oscillation of NH_3^+ gives its peak at 543 cm^{-1}. From the results obtained form FT-IR spectrum it is concluded that the acetic acid proton is not transformed –COO^- group of L-arginine, but it its one of the unprotanated amino group.

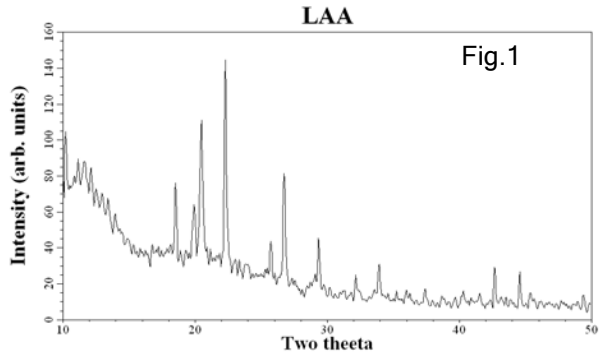
UV-Vis-NIR absorption studies

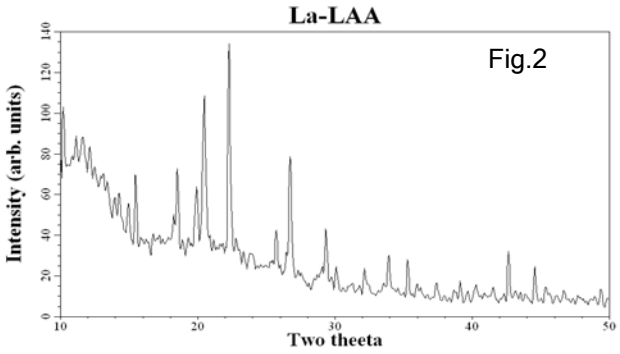
The absorption spectra are shown in Fig. 4. From the absorption spectra it was seen that the absorption is minimum in the entire visible region for both pure and doped crystals. Though the lower cut-off for both pure and doped crystals were found to be around 240nm, the lower percentage of absorption for doped one in comparison to pure LAA is likely to improve the nonlinear optical (NLO) property.

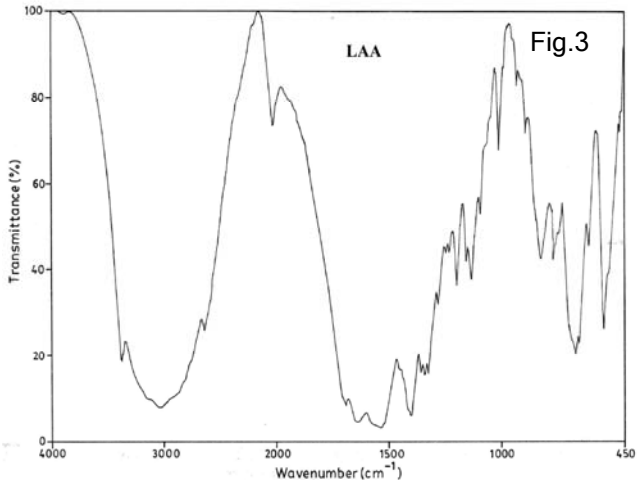
Second Harmonic Generation studies

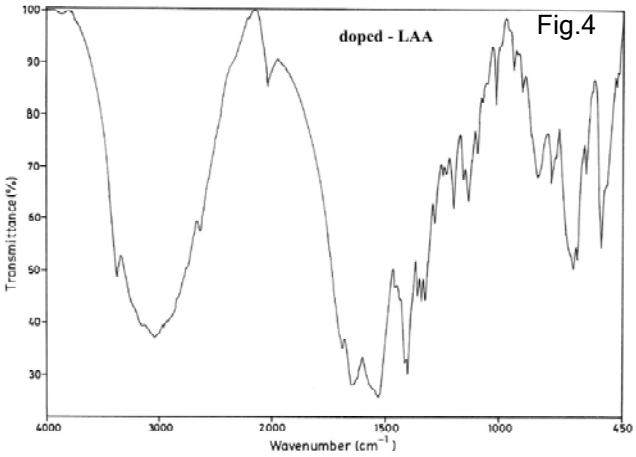
The results obtained from SHG studies (Kurtz & Perry, 1968) reveal that the efficiency of frequency doubling in LAA (24.6%) and Mg-LAA (33.8%) were better than KDP (08%). It was

Fig.1. Powder X-ray diffraction pattern of LAA; Fig.2. Powder X-ray diffraction pattern of La - LAA; Fig.3. FT-IR spectrum of pure LAA; Fig. 4. FT-IR spectrum of La - LAA.

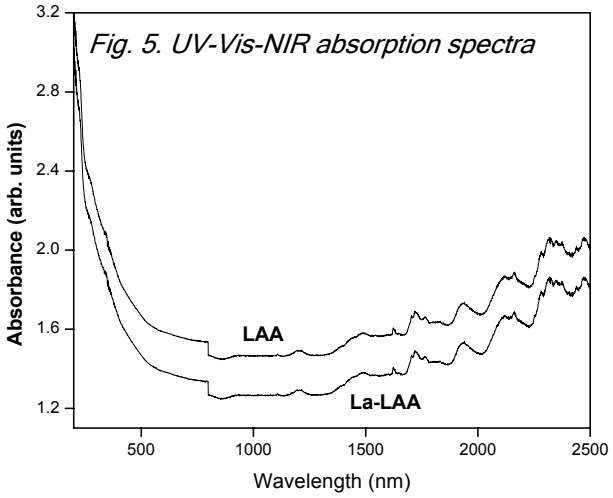








also found that La doped crystal has an efficiency equivalent to that of LAP (33%) for the same input power.



Conclusion

The studies confirm that the grown crystals were non-linear in nature and the metal substitution has enhanced the non-linearity of the crystals.

Reference

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