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Optical Studies of Amino acids doped Ammonium Dihydrogen Phosphate (ADP) crystals for NLO Applications

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Abstract: Amino acids glycine, $_L$-alanine and $_L$-lysine doped ADP crystals were grown by slow evaporation method at room temperature. The vibrational frequencies of the grown crystals were identified using FT-IR spectral analysis. Second harmonic generation (SHG) studies were performed by classical Kurtz powder technique using Nd: YAG laser operating at 1064 nm. The SHG efficiency of glycine doped ADP is found to be higher among other grown crystals. The UV-visible study confirms the wide optical transmittance window for all doped crystals imperative for optoelectronics applications. The transmission data has been used to evaluate the optical band gap and optical conductivity. The optical band gap of $_L$-alanine doped ADP crystal is found to be 5.2 eV which is higher among the studied crystals.
Keywords: Amino acid; Growth from solution; Non linear optical; FT-IR; SHG efficiency.

1. Introduction and Experimental:

ADP is a vital nonlinear optical (NLO) material realizes the never ending applications in the field of photonics, optoelectronics, and electro-optic modulation, second harmonic and parametric generators [1]. Amino acids offers the delocalization of π electrons easily owing to the presence of proton donor carboxyl acid (-COO) group and the proton acceptor amino (NH_2) group [2]. The effect of doping of various amino acids like, $_L$-arginine, glycine, $_L$-alanine, $_L$-lysine on different properties of ADP have been reported [3-5]. In the present communication the effect of amino acids viz. glycine, $_L$-alanine and $_L$-lysine on ADP has been studied by subjecting the grown crystals to FT-IR, SHG test and UV- visible studies for their impactful suitability for NLO applications.

In the supersaturated solution of ADP three amino acids viz. glycine, $_L$- alanine and $_L$-lysine were doped as one mole percent and evaporated at room temperature. Good quality transparent seed crystals were harvested within 6-7 days for three amino acids.

2. Results and Discussion:

2.1 NLO Studies

The salts of one mole percent glycine, $_L$- alanine and $_L$-lysine doped with ADP were subjected to SHG test at IISC, Bangalore using the Q-switched Nd: YAG laser delivering energy 2.8 mJ/pulse at fundamental wavelength of 1064 nm, repetition rate of 10 Hz and pulse width of 8 ns. The collected green emission from the powdered sample at the output confirmed the nonlinear behavior of the doped ADP crystals. It was observed that the amino acids doped ADP has highest SHG efficiency than KDP and among these the SHG efficiency of glycine doped ADP is observed to be highest as **1.88** times that of KDP.

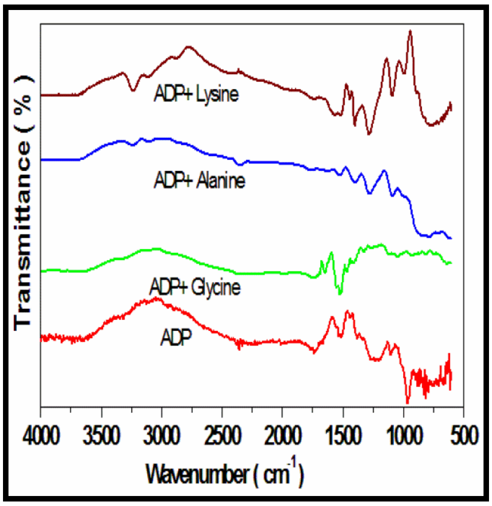

Fig.1 FT-IR spectra

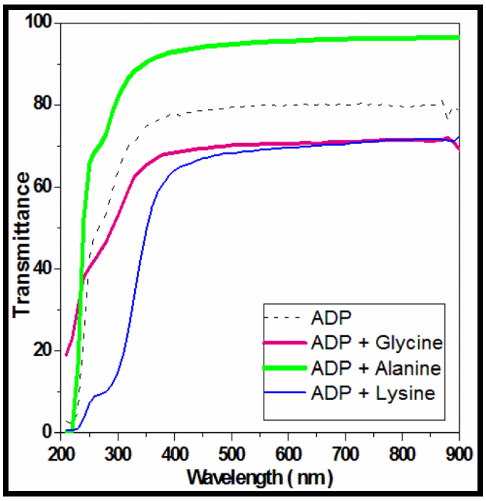

Fig.2 UV-visible spectrum

2.2 FT-IR analysis

In order to identify the different functional groups of doped ADP crystals FT-IR vibrational spectra was recorder using Bruker α-ATR spectrometer in the region 600-4000 cm^{-1} and shown in Fig. 1. The influence of amino acids on ADP is evident as the absorption peaks of P-O-H and PO bonds ascertained to be shifted [6]. The detailed analysis of the FT-IR spectrum revealed that, the P-O-H vibrations at 1105 and 964 cm^{-1} of the pure ADP are shifted to 1042 and 912 $cm^{-1}$for glycine, 1090 and 975 $cm^{-1}$for $_L$-alanine and1092 and 986 $cm^{-1}$for $_L$-lysine [3-5].

2.3 UV-vis. spectral studies

The UV-Visible spectral study of pure and doped ADP crystals was carried using Shimadzu UV-2450 spectrophotometer in the range 200-900 nm. The recorded transmittance spectrum is shown in Fig. 2. The lower cutoff wavelength is found to be 335 nm for glycine, 253 nm for $_L$-alanine and 360 nm for $_L$- lysine, indicating the wide optical transmission window favorable for second harmonic generation [7]. The optical absorption coefficient (α) was calculated using the relation $\alpha = (1/t)\ln(1/T)$. The energy dependence of the absorption coefficient suggests the occurrence of direct band gap and hence it obeys the relation for high photon energy, $\alpha = A\sqrt{h\nu - E_g}$

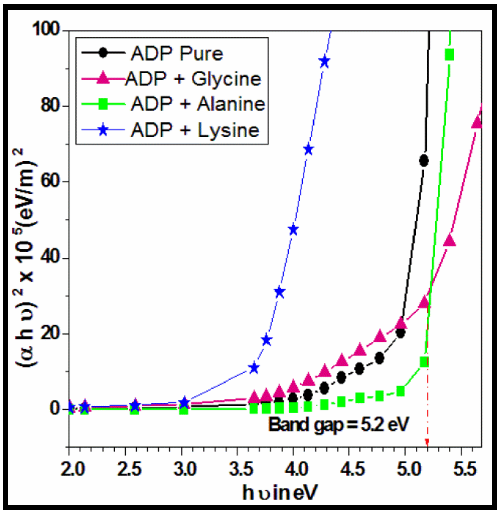

Fig.3 $(\alpha h\upsilon)^2$ vs. hυ in eV

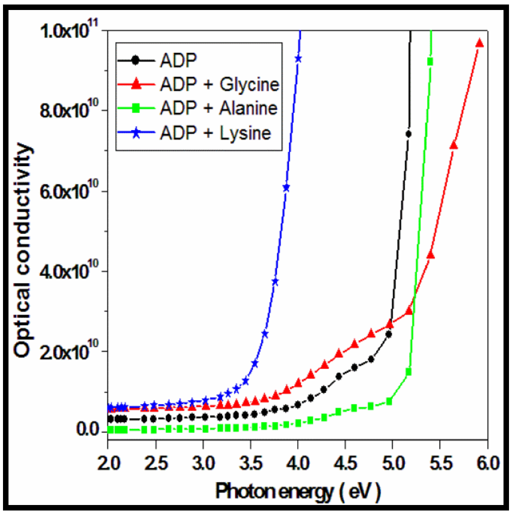

Fig.4 Optical conductivity vs. hυ in eV

The variation of $(\alpha h\nu)^2$ vs. photon energy (hν) is plotted in Fig. 3 and Eg is evaluated by the extrapolation of the linear part. The wide optical band gap of $_L$-alanine doped crystal is 5.2 eV which is highest among all grown crystals suggesting its prominence for optoelectronics applications [8].

The optical conductivity ($\sigma = \frac{\alpha nc}{4\pi}$) is a measure of the frequency response of the material when irradiated with light. The optical conductivity of the grown crystals is shown in Fig. 4. The high magnitude of optical conductivity ($10^{10}S^{-1}$) confirms the presence of very high photo response nature of the material entices the suitability for information processing and computing [9].

Conclusion

The respective shifts in the FT-IR spectra of P-O-H bond confirmed the incorporation of amino acids in ADP crystals. The SHG studies confirmed the NLO behaviour of the grown crystals. The SHG efficiency of glycine doped ADP is found to be higher among grown crystals. The UV-visible studies confirmed the wide optical transparency window and lower cutoff wavelengths of the doped crystals. The optical band gap of alanine doped ADP is found to be 5.2 eV.

Acknowledgment

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