Study on L-Arginine Doped Triglycine Sulphate Single Crystals - Optical and Structural Properties

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INTRODUCTION

Triglycinesulphate (TGS) crystals being high melting point (233˚C) materials, makes it suitable in many scientific applications. Since the amino acids are the constituent of TGS, it is soluble in water and insoluble in non-polar organic solvents. The crystal structure of TGS crystal has been determined by Hoshino et al. [1] Researchers made several attempts to grow amino acid glycine in its polymorphic forms. Major forms of TGS are α-glycine, β- glycine and γ-glycine. [2-4] TGS is useful in pyroelectric infrared detectors and vidicon camera because of its large value of pyroelectric coefficient and low value of dielectric constant. [5]

In the pure form of TGS, quality of TGS crystals gets degraded and also get depolarized as time elapses. Doping of TGS with dopants alters the crystal structure because of the internal stress developed; however, they prevent depolarisation by inducing the internal bias field. C. Rai et al., reported improved pyroelectric and ferroelectric properties in iminodiacetic acid doped TGS. [6]

EXPERIMENT:

High purity glycine and sulphuric acid purchased from Sigma Aldrich were dissolved indistilled water in molar ratio of 3:1 at p^H 2.5. The reaction scheme is as shown below.

$$3(NH_2CH_2COOH) + H_2SO_4 \rightarrow (NH_2CH_2COOH)_3 \cdot H_2SO_4$$

The solution is maintained at a constant temperature of 50˚C with constant stirring to obtain a homogeneous solution. Then the solution is filtered using high quality filter paper and kept for evaporation at ambient temperature. Single crystals of pure TGS were grown from the solution by slow evaporation method.

Transparent single crystals were obtained in a time period of 20 days duration. The size of the crystal obtained is about 20 mm × 18 mm × 14 mm in dimensions (Fig.1).

Similar procedure was adopted using pure L-Arginine to grow L-Arginine doped TGS keeping all other parameters constant.

A weight percentage of dopants namely, 5% wt, 10% wt and 15% wt of L-Arginine is added to solution during growth and doped crystal were grown in two weeks duration.

The doped crystals were pale brownish in color. It is observed that as the percentageof the L-Arginine increases, the transparency decreased in the single crystal. A single crystal with L-Arginine as dopant with a dopant concentration of 5 % wt, 10 % wt and 15 % wt is shown in the Fig. 1a to Fig. 1c respectively. Pure TGS crystal is as shown in Fig 2.

Fig. 1a.

Fig. 1b.

Fig. 1c.

Fig. 2.

STRUCTURAL PROPERTIES

A single crystal with L-Arginine as dopant with a dopant concentration of 5 % wt, 10% wt and 15% is shown in the figure Fig. 1a to Fig 1c.

The dimension of L-Arginine 5% wt doped TGS crystal is 12 mm × 8 mm × 6 mm.
The dimension of L-Arginine 10% wt doped TGS crystal is 15 mm × 12 mm × 9 mm.
The dimension of L-Arginine 5% wt doped TGS crystal is 15 mm × 12 mm × 5 mm.

The dimension of pure TGS crystal is 8 mm × 4 mm × 2 mm.

OPTICAL PROPERTIES

To identify the functional groups present in the TGS crystals, Fourier Transfer Infrared (FTIR) spectrum was collected.

The FTIR spectrum was obtained in the spectral range of 600 - 4000 cm^{-1} using "PerkinElmer UATR Two" FTIR spectrometer. The FTIR spectrum for pure TGS shown in Fig. 3a.[11] The FTIR spectrum for L-Arginine doped TGS shown in Fig. 3b.

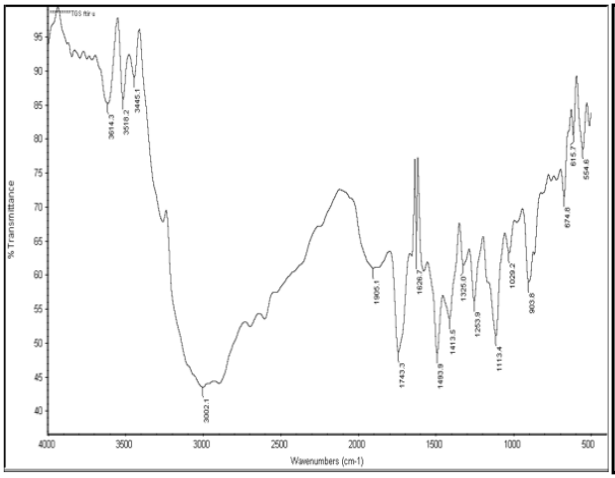


Fig. 3a

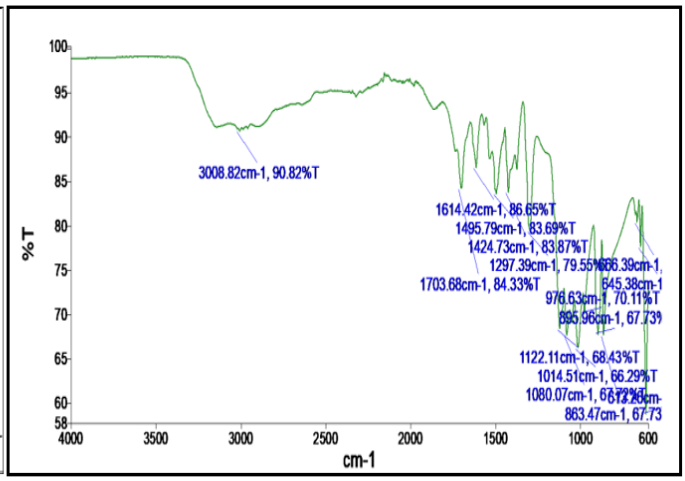


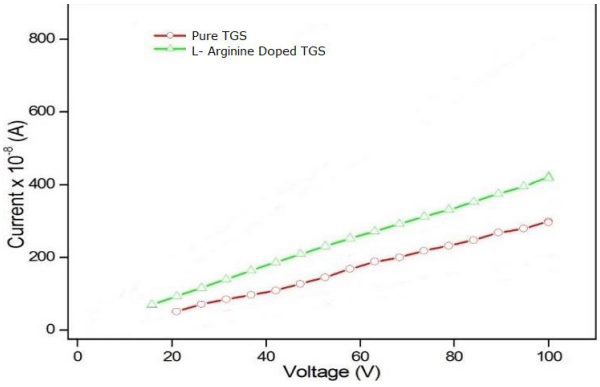
Fig. 3b

The absorption band due to C=O stretching vibration is observed around 1760-1730 cm^{-1}. The broad peak around 3008 cm^{-1} is attributed to NH_{Fe} stretching vibrations which form continuous series of overlapping bands. The absorption bands observed in the spectral range of 1660-1560 cm^{-1} and 1550-1485 cm^{-1} are attributed to NH_3^+ deformation and NH_3^+ symmetric stretching vibrations respectively. The CO_2^- symmetric stretching vibrations is observed around 1410 cm^{-1}. The L-Arginine doped TGS showed similar absorption bands with minor/negligible shift in their characteristic's absorption bands.

ELECTRICAL CONDUCTIVITY

To understand different physical phenomenon such as electric and ionic polarization, atomic polarization, polarization of lattice, orientation polarization of dipoles, space charge distribution etc., and electrical conductivity is studied.

Fig 6. I -V graph of Pure TGS and L-Arginine doped TGS single crystals



All TGS sample crystals were cleaved perpendicular to the polar b axis from clear regions far from the seeding area, polished to a 1 mm thickness and then polished. The dc conductivity measurements were carried out for all the crystals grown employing the conventional two-probe technique. A Keithley Source Measure Unit 236 was used to determine the current. Current through the sample wasmeasured for various voltages ranging from 1 to 110 Volt in steps of 5 volts. Since the crystal was cut along the b-axis, the field applied was along the c-axis i.e., perpendicular to a and c axis.

I versus V plots for various sample crystals are shown in the Fig. 6. From the linear fit of these curves' slopes are determined. [11-13]

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