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Growth, photoconductivity and dielectric properties of triglycine sulfate (TGS) single crystals

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Single crystals of Triglycine Sulfate (TGS) were grown in water by solution method with slow evaporation technique at room temperature. The grown crystals were characterized by XRD technique. The dielectric studies show that the dielectric constant and dielectric loss decrease exponentially with frequency at room temperature. Photoconductivity study confirms the negative photoconducting nature of the crystal which confirms the high degree of transparency of the material.

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1. Introduction

The ferroelectric crystals find important applications in optoelectronics such as capacitors, nonvolatile memory devices, actuators, high-performance gate insulators, etc. All ferroelectric materials are pyroelectric, however, not all pyroelectric materials are ferroelectric. Below Curie temperature, ferroelectric and pyroelectric materials are polar and possess a spontaneous Polarization or electric dipole moment. However, this polarity can be reoriented or reversed fully or partially through the application of an electric field with ferroelectric materials. The nonpolar phase encountered above the Curie temperature is known as the paraelectric phase. The direction of the spontaneous polarization confirms towards the crystal symmetry of the material. The reorientation of the spontaneous polarization is a result of atomic displacements. The magnitude of the spontaneous polarization is highest at temperatures well below the Curie temperature and approaches zero as the Curie temperature is neared. In recent times, the trend is to design organoelectronics for which the development of organic ferroelectrics is mandatory [1–4]. In the present work, growth has been carried out by slow evaporation technique. The dielectric property was also studied at different frequencies and temperatures to find out the different kinds of polarization mechanism. The photoconductivity reveals the negative nature of the photocurrent in these crystals.

2. Experimental

TGS salt was synthesized by taking Analar Grade (AR) glycine (NH_2CH_2COOH) and concentrated sulphuric acid (H_2SO_4) in the ratio 3:1. The reactants were thoroughly dissolved in double distilled water and stirred well using a temperature controlled magnetic stirrer to yield a homogeneous mixture of solution. Then the solution was allowed to evaporate at room temperature, which yield colourless crystalline salt of TGS due to supersaturation. The seed crystals were harvested from the solution after eight days and a suitable seed was selected. The selected seed was suspended in the freshly prepared solution. After a period of three weeks, optically transparent defect free crystals were obtained from the mother solution. Fig. 1 shows as grown crystal of TGS single crystal.

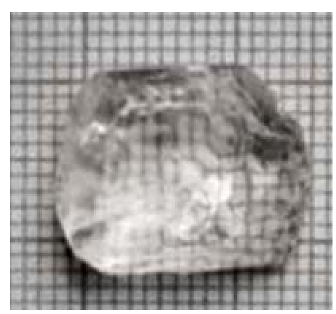

Fig. 1.The grown single crystal of TGS.

3. Single XRD analysis

Single crystal X-ray analysis was carried out for the grown crystals using ENRAF NONIUS CAD 4 automatic X-ray diffractometer. The lattice parameter values are found to be a=9.293(2) Å, b= 12.713(1) Å, c= 5.732(2) Å, α = 90 °, β= 110.45 (2), γ= 90 °. The XRD data prove that the crystal is monoclinic structure with the space group $P2_1$. The results are found to be in good agreement with the results predicted by Fleck et al [5].

4. Refractive index measurement

The refractive index of the TGS crystal was determined by Brewster's angle method using He-Ne laser of wavelength 632.8 nm. A polished flattened single crystal of TGS was mounted on a rotating mount at an angle varied from 0 to 90 degrees. The angular reading on the rotary stage was observed, when the crystal is perfectly perpendicular to the intra-cavity beam. The crystal was rotated until the laser oscillates and the angle has been set for maximum power output. Brewster's angle (θp) for TGS is measured to be 56.9 ± 0.5 degree. The refractive index has been calculated using the equation n = tan θp; where θp is the polarizing angle and it is found to be 1.534.

5. Photoconductivity

Photoconductivity measurements were carried out on a polished portion of the grown single crystal by fixing it onto a microscopic slide. Two electrodes of thin copper wire of 0.3 mm thickness were fixed using silver paint and the sample was connected in series with a DC power supply and KEITHLEY 485 picoammeter. The sample was covered with a black cloth and the dark current (Id) of the crystal was recorded with respect to the different applied voltage. Then sample was illuminated by the radiation from 100 W halogen lamp containing iodine vapour and tungsten filament and the corresponding photocurrent (Ip) is recorded for the same values of the applied voltage. The field dependent photoconductivity of the crystal was shown in Fig. 2. From the figure, photocurrent is found to be less than that of the dark current for all ranges of applied field enunciates negative photoconductivity.

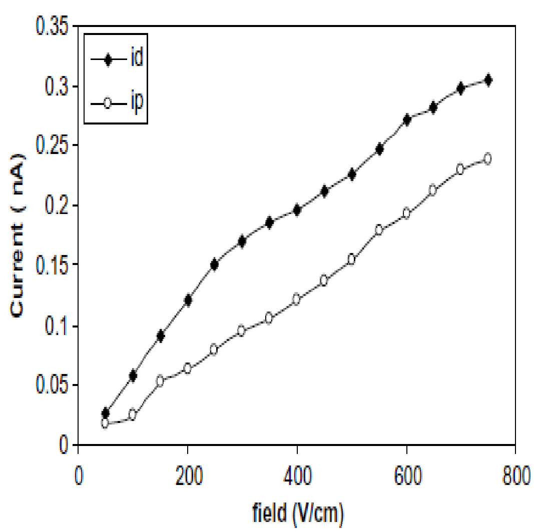

Fig. 2. Plot of field dependent photoconductivity of the title crystal.

The negative photoconductivity in this case may be due to the reduction in the number of charge carriers or their lifetime in the presence of radiation. Decrease in lifetime with illumination, could be due to the trapping process and increase in carrier velocity [6]. In Stockmann's model, a two level scheme is proposed to explain negative photoconductivity [7]. The upper energy level is situated between the Fermi level and the conduction band, whereas the other one is located in the neighborhood of the valence band. The lower level has high capture cross section for electrons from the conduction band and holes from the valence band. As a result, sooner the sample is kept under exposed light, the recombination of electrons and holes take place, resulting in decrease in the number of mobile charge carriers, giving rise to negative photoconductivity

6. Dielectric property

The dielectric studies were carried out using silver coated samples placed between the two copper electrodes which form a parallel plate capacitor. The capacitance of the sample was noted for the applied frequency that varies from 50 Hz to 5 MHz at different temperatures (35˚C, 65˚C, 95˚C and 125˚C). Fig. 3 shows the plot of dielectric constant (ε_r) versus applied frequency for different temperatures. The applied frequency is represented by logarithmic values in the plot.

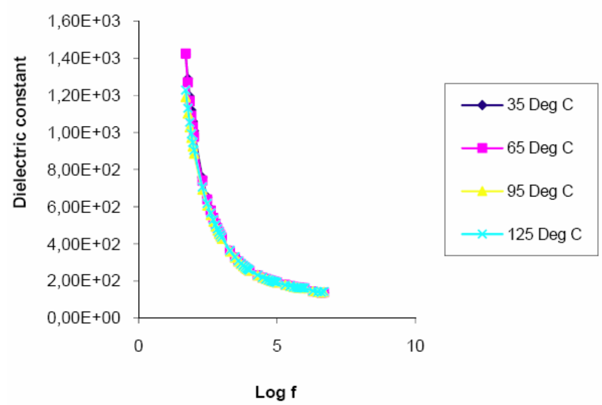

Fig. 3. Frequency vs dielectric constant.

The dielectric constant decreases with the applied frequency and it is also observed that ε_r increases with increasing temperature. The very high value of ε_r at low frequencies may be due to the presence of all the four polarizations namely: space charge, orientation, electronic and ionic polarization and its low value at higher frequencies may be due to the loss of significance of these polarizations gradually. The high value of dielectric constant at lower frequencies may be attributed to space charge and ionic polarizations. The low value of dielectric loss at high frequencies suggests that the sample possesses enhanced optical quality with lesser defects and this parameter is of vital importance for NLO applications [8].

Fig. 4 represents the dielectric loss versus frequency at different temperatures. It is observed that the dielectric loss decreases with increase of frequency.

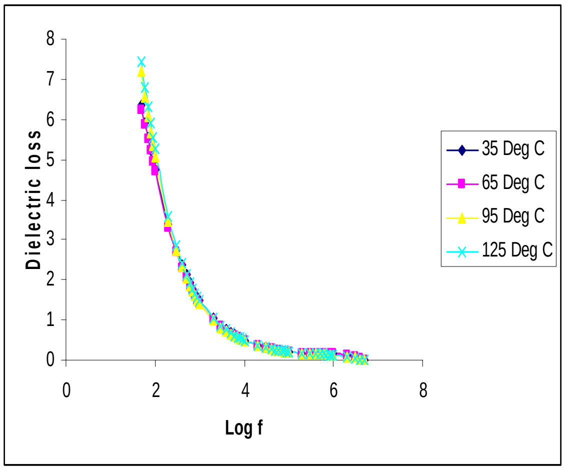

Fig. 4. Frequency vs dielectric loss.

7. Conclusion

Transparent single crystals of TGS have been grown successfully using slow solvent evaporation technique. X-ray analysis reveals that TGS crystal belongs to monoclinic structure with space group $P2_1$. The dielectric constant and dielectric loss were studied as a function of frequency at room temperature**.** Photoconductivity studies confirm that the crystal possesses a negative photoconductivity.

References

[1] K. Vinod Wadhawan, Introduction to Ferroic Materials, Gordon & Breach Publishers, London (New York), 2000.
[2] O. Auciello, J.F. Scott, R. Ramesh, Phys. Today **51**, 22 (1998).
[3] J. Dolinsek, D. Arcon, Hae Jin Kim, J. Seliger, V. Zagar, P. Vanek, J. Kroupa, Z. Zikmund, J. Petzelt, Phys. Rev. B **57** R8063 (1998).
[4] Sachio Horiuchi, Reiji Kumai, Yoshinori Tokura, J. Am. Chem. Soc. 127 (2005).
[5] R. Muralidharan, R. Mohankumar, P. M. Ushasree, R. Jayavel, P. Ramasamy, J. Crystal Growth. **234**, 545 (2002).
[6] R. H. Bube, Photoconductivity of Solids, Wiley, New York, 1981.
[7] V. N. Joshi, Photoconductivity, Marcel Dekker, New York, 1990.
[8] C. Balarew, R. Duhlew, J. Solid State Chem. **55,** 1 (1984).

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