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Study of Optical Properties of Doped Nonlinear Optical Materials

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ABSTRACT

Single crystals of p-Toluidine p-Toluenesulfonate (PTPT), an organic nonlinear optical (NLO) material, have been grown by slow evaporation method at room temperature using ethanol as solvent. The crystal system was confirmed from the single crystal XRD analysis. UV-Vis-NIR spectrum showed that the UV cut-off wavelength of PTPT occurs at 200-400 nm and it has insignificant absorption in the wavelength region of 550–750 nm. The SHG efficiency of PTPT was measured.

Keywords: Nonlinear optics, XRD, Fourier transform infrared spectroscopy, etc.

INTRODUCTION

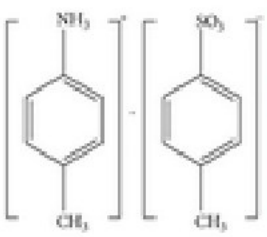
Single crystals form an indispensable part of the rapidly advancing technology which is dependent upon materials such as semiconductor, super conductors, super ionic conductors, polarizers, transducers, radiation detectors, ultra-sonic amplifiers, magnetic garnets, Solid-state lasers, Non-linear optics, piezoelectric, electro optic, photosensitive, refractories of different grades, crystalline film for micro-electronics and computer industry [1-3]. All these aspects of modern science and technology involve research in the field of crystal growth. The art of growing crystals has turned into a new direction of science with the discovery of wide spectrum of applications of single crystals and they have become one of the most the fundamental building blocks

for modern technology. A crystal is a three dimensional periodic array of atoms. Crystals are classified in two categories, single crystals and poly crystals. An ideal single crystal is constructed by infinite repetition of identical structural units in space [9]. Real crystals are finite and contain defects. The properties of material can be extensively studied when material is prepared in single crystal form. The uniformity of single crystal allows transmission of electromagnetic waves without scattering. Hence in the past few decades one could see that there is a lot of development in science and technology of crystals, especially in the field of electronics, fiber optics and lasers. The tunable lasers have been realized because of invention of nonlinear optical properties in some single crystal. Since solid state devices are being widely used in the field of computers, telecommunication etc, efforts are being made for producing larger single crystal. Nonlinear optical crystals are very important for laser frequency conversion. In recent years there has been considerable progress in the development of coherent UV sources based on nonlinear optical process in borate crystals. The success of these crystals can be attributed to the unique structural characteristics of boron-oxygen groups that confer these compounds with enhanced UV transparency, good nonlinearity and high resistance to laser damage. β-Barium Borate, Lithium Borate, Potassium beryllium boro-fluoride, Strontium beryllium borate, Cesium borate and Cesium lithium borate are promising for UV generation because of its wide band gap and adequate optical nonlinearity. YCa4O (BO3)3 (YCOB) and GdxY1-xCa4O (BO3)3 crystals are suitable for second and third harmonic generation of Nd:YAG laser radiation. Various kinds of NLO crystals have been developed because of possibility of extreme high optical nonlinearity [4,5]. The consistency of the characteristics of device fabricated from a crystal depends on the homogeneity and defect contents of the crystals. Hence, the process of producing single crystals which offer homogeneous media in the atomic level with directional properties, attract more attention than any other process involved. The procedure of growing crystals varies widely; it is mainly dictated by the characteristics of the material and its size. Day by day the demand for nonlinear optical crystals with superior properties is mounting due to quantum leap in the design of nonlinear optical devices with high performance. With progress in crystal growth technology, materials having attractive nonlinear properties are being discovered at rapid pace. To enable a material to be potentially useful for NLO applications, the material should be in bulk single crystal form. So the growth of new nonlinear optical material crystals and their investigation have become most indispensable and efficacious disciplines in the field of material science and engineering [11,12]

METHODOLOGY

Crystal Growth:

The resultant compound is obtained by the adding of p-toluenesulfonic acid (0.02 mol) with a solution of p-Toluidine (0.02 mol) in ethanol, in the stoichiometric ratio 1:1. Within 7 days, tiny crystals were formed due to the spontaneous nucleation. Optically transparent good quality crystals were used as seeds for further growth experiments. For growth, seed crystals were just immersed into the prepared solution. Good quality crystals with characteristic shape and size of mm^3 were obtained for 8 days. Figure 1 shows molecular structure of PTPT. Figure2 shows the growth of crystals.,



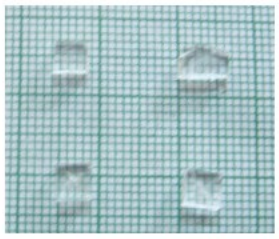


Figure 1: Figure 2:

Figure 1: Molecular Structure of PTPT

Figure 2: Grown Crystal of PTPT

which was sintered at 600^0C.from VSM the magnetic properties of the samples show remarkable changes with change of Pb percentage.

RESULTS AND DISCUSSION

XRD Studies:

The XRD pattern of PTPT is shown in Figure 3. Using the single crystal -ray diffraction analysis, the cell

parameters of PTPT were obtained from least-squares refinement of the setting angles of 25 reflections. The XRD study reveals that the crystal belongs to monoclinic system with lattice parameters of a = 5.8780 Å, b = 9.1152 Å and

c = 13.2312Å, Z = 2, and space group is $P2_1$.

UV-Vis-NIR Studies: The recorded UV-Vis-NIR spectrum of PTPT is shown in Figure 4. UV-Vis transmittance was recorded to analyze the optical properties of growth PTPT crystal. Therefore, well-polished sample of 1 mm thick from the grown crystal was used. The optical absorption study shows that the UV cut-off wavelength of PTPT occurs at 295 nm. It is well known that the efficient NLO crystal has an optical transparency at lower cut-off wavelength between 200 and 400 nm. There is no significant absorption in the entire visible region which reveals that it can find applications in the optoelectronic devices. The very low absorption around 550–750 nm signifies the resistance of the grown crystal to laser induced damage.

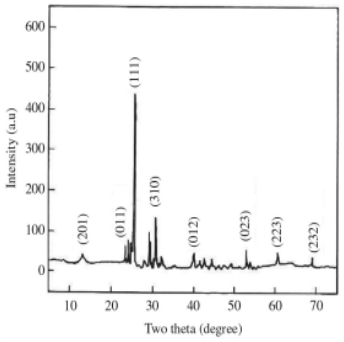


Fig. 3: XRD pattern of PTPT.

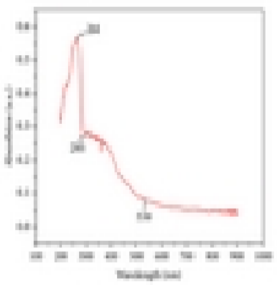


Fig. 4: UV-Vis-NIR spectrum of PTPT

CONCLUSION

Single crystals of p-Toluidine p-Toluenesulfonate (PTPT) were grown from ethanol solution by slow evaporation of the solvent at room temperature. The crystal system was confirmed from the single crystal XRD analysis. Optical absorption studies show that the sample has minimum absorption in the entire visible region. The SHG efficiency of PTPT was found to be 0.52 times than that of standard KDP.

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