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Investigation on the Growth and Characterization of Silver Nitrate Doped Zinc Pottasium Phosphate Hexahydrate NLO Single Crystal

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ABSTRACT

Single crystal of silver nitrate doped pottasium zinc phosphate hexahydrate was grown from slow evaporation technique. The grown crystal was subjected to single crystal X-ray diffraction and powder X- ray diffraction. It was confirmed that doped silver nitrate changed the structure and cell parameter of the as grown crystal. Functional groups of grown crystal was recorded using FTIR spectrometer

Keywords : Zinc Pottasium Phosphate Hexahydrate, Monoclinic, Optical Properties, FTIR, NLO

I. INTRODUCTION

The importance of the nonlinear optical interaction imposes severe demand on potential nonlinear applications. Extensive studies have been made on the growth of the nonlinear optical materials over the past few decades because of their potential applications in the field of telecommunication and optical signal processing[1-2]. The unique property of perfect single crystals was employed in the development of device fabrications in semiconductors, optics, photonics, nonlinear optics, light-emitting diodes, faster processors, high- resolution detectors, ferroelectric and piezoelectric applications[3-5]. The numerous applications of the nonlinear optical (NLO) crystals in the vast field of science and technology made the process of search of the new NLO crystals and improvements in the properties of the known crystals a never stopping process. Purely inorganic NLO materials typically have excellent mechanical and thermal properties but often posses relatively modest optical nonlinearities due to their lack of extended π- electrons delocalization. Furthermore inorganic crystals grown from high temperature melts typically have lower damage thresholds and more optical inhomogeneties throughout their bulk due to impurities internal stress and defect resulting from the extremely nonequilibrium growth conditions [6-11]. Zinc potassium phosphate hexahydrate is a molecular ionic crystal. KDP based single crystals have a high laser damage threshold and a large nonlinear optical coefficient besides the advantages of good structural quality and mechanical properties. By linking un symmetrical, bifunctional or multifunctional ligands with transparent d10 metals, non centrosymmetric metal coordination compounds can be successfully synthesized. Thus the impurity ions such as transition metal ions are responsible for the modification of many physical properties in the crystals and play a crucial role in fabrication of nonlinear optical devices. In these crystals, acentric frame works are obtained without calling on

polarizable chiral entities, while the shielding effect from adequate inorganic anions such as PO_4 group favours the expected polar packing. Recently, development of UV-Vis wavelength technologies has attracted much attention[12-15]. Therefore, we consider these materials as promising candidate for nonlinear optical devices. In this research article, a detailed study about silver nitrate doped Zinc potassium phosphate hexahydrate is presented.

II. Experiment

2.1 Crystal growth

Good quality of pottasium zinc phosphate hexahydrate was grown from slow evaporation method. Zinc sulfate and pottasium dihydrogen phosphate was added in 1:1 equimolar ratio to dissolve in distilled water. The solution was stirred well to get homogeneous solution. Silver nitrate of 70 mg was added into the homogeneous mixture while stirring. The Silver nitrate doped solution was stirred for 6-8 hours and filtered using whatman filter paper. The solution was allowed to evaporate at room temperature. A good transparent crystal of 11 x8 x 5 mm^3 was harvested after two weeks. Single crystal of Silver nitrate doped pottasium zinc phosphate hexahydrate from slow evaporation method is shown in fig.1.

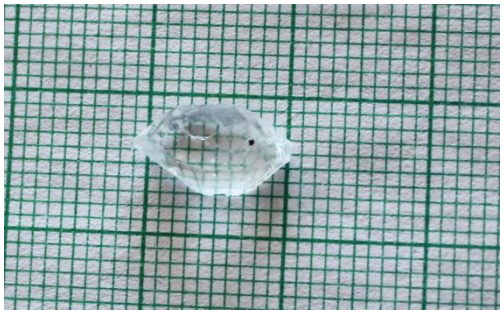

Figure 1 : As grown crystal of silver nitrate doped pottasium zinc phosphate hexahy- drate single crystal

III. Results and discussion

3.1 Single crystal X- diffraction

In order to check the structure and quality of as grown crystal was subjected to single crystal X-ray diffraction. It was confirmed from the result that due to the doped silver nitrate structure, cell parameters and volume have been changed. The as grown crystal from slow evaporation belongs to monoclinic crystal system with space group P2. The cell parameters are a= 6.16 Å, b= 12.20 Å, c= 9.03Å, α= 90°, β= 104.73°, and γ= 90°. The volume of crystal is 655 $Å^3$ .The cell parameter of pure pottasium zinc phosphate hexahydrate [16] is listed in the Tab 1.

	Reported	Experiment
Crystal structure	Orthorhombic	Monoclinic
Space group	Pm21	P2
Cell parameters	a= 5.564 Å b= 5.808 Å c= 12.495 Å α= 90° β= 90° γ=90°	a= 6.16 Å b= 12.20 Å c= 9.03 Å α= 90° β= 104.73° γ= 90°
Volume	432 $Å^3$	655 $Å^3$

Table 1. cell parameter of pure and silver nitrate doped pottasium zinc phosphate hexahydrate

3.2 Powder X-ray diffraction

Fig.2 shows powder X-ray diffraction pattern of silver nitrate doped zinc pottasium phosphate hexahydrate. The data was collected using PW 1830 Philips analytical powder X-ray diffractometer with nickel filtered, Cu K_α radiation (35 KU, 30 mA).The specimen was scanned for the angular range of 10–80° of 2θ with the scan rate of 0.05°/s. From the powder samples the various planes of reflections were indexed using refinement software. It is revealed from the sharp diffraction pattern that the grown crystal is optically good.

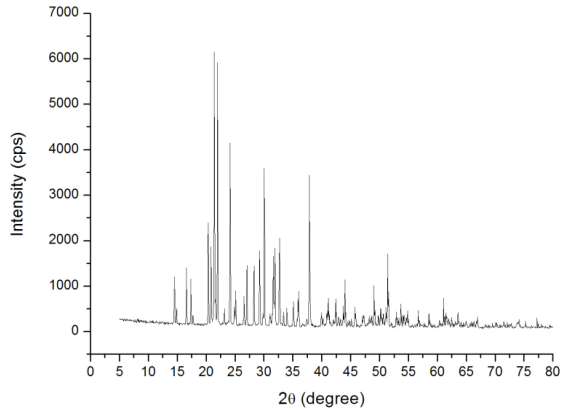

Figure 2 : Powder X-ray diffraction of silver nitrate doped pottasium zinc phosphate hexahydrate single crystal

3.3 FTIR

Fourier transform infrared (FTIR) spectra of Silver nitrate doped pottasium zinc phosphate hexahydrate was recorded using FTIR spectrometer (model: Brukker IFS 66 FT-IR) in the region 4000– 400 cm^{-1}at a resolution of ±4 cm^{-1} using KBr pellet containing a fine Silver nitrate doped pottasium zinc phosphate hexahydrate. The recorded spectrum is shown in fig.3. It is noted from the FTIR spectra that peaks at 3758 cm^{-1} and 3466 cm^{-1} indicates OH symmetric stretching, H_2O asymmetric stretching respectively. Peak at 2431 cm^{-1} represented overtones and combinations. The bond observed at 1648 cm^{-1} is due to OH asymmetric stretching. SO_2 out of plane wagging is noted at 1111 cm^{-1}. PO symmetric stretching is noted at 971 cm^{-1}. Peaks observed at 747 cm^{-1} and 492 cm^{-1} are due to Hydrogen bonding of water.

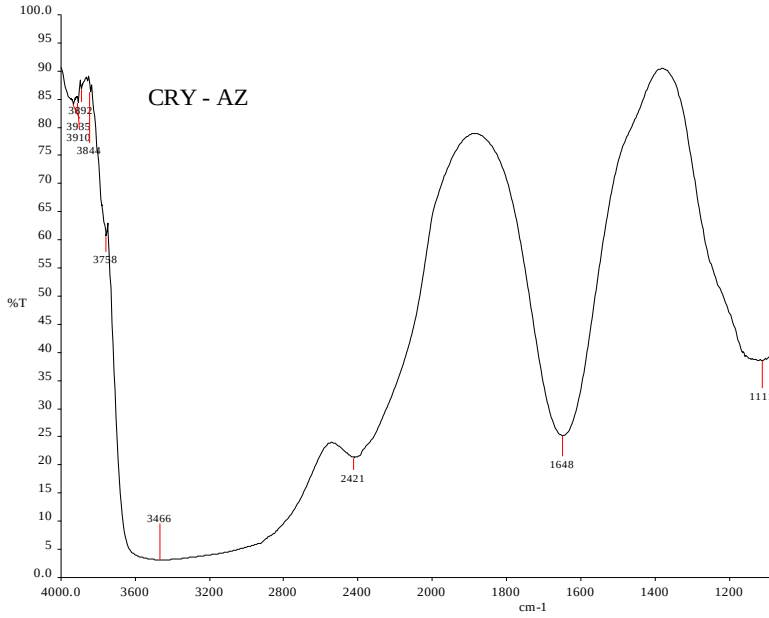

Figure 3 : Fourier transform infrared (FTIR) spectra of Silver nitrate doped pottasium zinc phosphate hexahydrate

3.4 Optical properties

Optical properties of silver nitrate doped zinc pottasium phosphate hexahydrate single was studied using Perkin Elmer lambda 35 UV–Vis–NIR spectrometer in the spectral region 190–1100 nmwith spectral resolution 2 nm as shown in Figs. 4 and 5. It is evidence from the absorption spectra that lower cut off value is 203 nm. The as grown crystal has wide transparent window which is suitable material for device fabrication. It is revealed from the transmittance spectra that as grown crystal almost transparent up to 99%. This uniform transparency throughout the visible region which is assertive quality of material to inherit the NLO behaviour. It is also noted from the transmittance spectra that as grown has high optical homogenity and less crystalline defects. The wide transparency is one of the additional key requirements for having efficient NLO character[17]. The energy band of the as grown crystal is 6.11 eV.

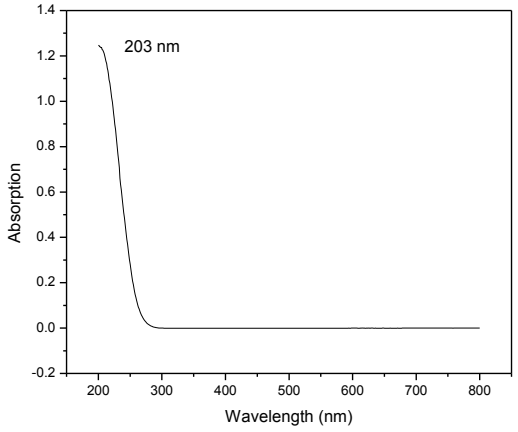

Figure 4 : UV absorption of silver nitrate doped Zinc pottasium phosphate hexahydrate single crystal

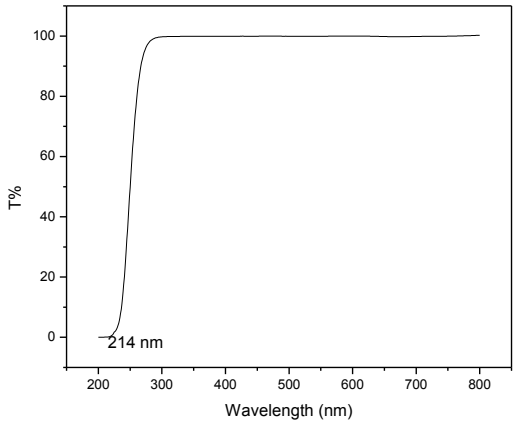

Figure 5 : UV Transmittance of silver nitrate doped Zinc pottasium phosphate hexahydrate

IV. Conclusion

Monoclinic crystal system of silver nitrate doped Zinc pottasium phosphate hexahydrate was grown from slow evaporation method. A good transparent crystal of 11 x8 x 5 mm^3 was harvested for fourteen days. It was confirmed from the result that due to the doped silver nitrate structure, cell parameters and volume have been changed. The cell parameters are a= 6.16 Å, b= 12.20 Å, c= 9.03Å, α= 90°, β= 104.73°, and γ= 90°. The grown crystal was subjected to powder X-ray diffraction and revealed from the sharp diffraction pattern that the grown crystal is optically good. Functional group of silver nitrate doped Zinc pottasium phosphate hexahydrate was confirmed using FTIR spectrometer. It was understood from optical properties that the as grown crystal lower cut off value is 203 nm and it has wide transparency window which is suitable property for NLO device fabrications. Photoluminescence, photoconductivity, Dielectric and microhardness of the as grown crystal will be reported.

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VI. REFERENCES

[1]. P. N. Prasad and D. J. Williams, introduction ton nonlinear optical effects on molecular and polymers, Wiley, New York, 1991.

[2]. D.S. Chemla and J. Zyss introduction to nonlinear optical properties of organic molecules and crystasl, Vol. 1and 2, Academic press, Orlando, 1987.

[3]. Sajan. D, Vijayan. N, Safakath. K, et al Intra molecular charge transfer and z-scan studies of a semi- organic nnonlinear optical material sodium acid phthalate hemihydrate: a vibrational spectroscopic study J.Phy.Chem.; 115; 8216-8226, 2011.

[4]. Sun.Z, Zhang. G, Wang. X et al , Groeth, morphology, thermal, spectral, linear, and nonlinear optical properties of L- Arginine bis (trifluoroacetate) crystal, Cyrst.Growth Des, 9, 3251-3259, 2009.

[5]. Soma Adhikari, Seth Sk, Kar T. Structural studies and physicochemical properties of L- Valine hydrochloride monohydrate, Cryst. Eng. Comm.; 15, 7372-7379, 2013.

[6]. R. Masse, J. Zyss, A new approach in the design of polar crystals for quardraticnonlinear optics exemplified by the synthesis and crystal structure of 2-Amino5-Nitropyridinium Dihydrogen Monophosphate, J. Mol. Eng. 1, 141–152, 1991.

[7]. Z. Kotler, R. Hierle, D. Josse, J. Zyss, R. Masse, Quadratic nonlinear opticalproperties of new transparent and highly efficient organic–inorganic crystal:Amino 5-Nitropyridinium Dihydrogen Phosphate (2A5NPDP), J. Opt. Soc. Am.B 9, 534–547, 1992.
[8]. D. Eimerl, IEEE J. Quantum Electron. 23, 575, 1987.
[9]. M.Ambrose Rajkumar, S.Stanly John Xavier, S.Anbarasu, D. Prem Anand,Growth and characterization studies of an efficient semiorganic NLO single crystal: 2-Amino 5-nitropyridinium sulfamate (2A5NPS) by assembled temperature reduction (ATR) method, Optical Materials 55, 153-159, 2016.
[10]. M.Ambrose Rajkumar, S.Stanly John Xavier, S.Anbarasu, D. Prem Anand,Growth and characterization studies of an efficient semiorganic NLO single crystal: 2-Amino 5-nitropyridinium dihydrogen phosphate (2A5NPDP) by Sankaranarayanan-Ramasamy (S-R) method, Optik 127, 2187-2192, 2016.
[11]. M.Ambrose Rajkumar, S.Stanly John Xavier, S.Anbarasu, D. Prem Anand,Growth and characterization studies of an efficient semiorganic NLO single crystal: 2-Amino 5-nitropyridinium chloride (2A5NPCl) by assembled temperature reduction (ATR) method, Materials research innovations, 2017.
[12]. W. B. Lin, O. R. Evans, R. G. Xiong, Z. Y. Wang, J. Am. Chem. Soc. 120, 13272, 1998.
[13]. W.B. Lin, Z.y. Wang, L. Ma, J. Am. Chem. Soc. 121, 11249,1999.
[14]. O.R. Evans, R.G. Xiong, Z.Y. Wang, G.K. Wong, W.B. lin, Angew.chem. Int. Engl. 38, 536, 1999.
[15]. O.R. Evans , W. B. Lin, Chem. Mate. 13, 2705,2001.
[16]. V. Krishnakumar, S. Manohar, R. Nagalakshmi, M. Piasecki, I.V. Kityk, and P.Bragiel, Zinc pottasium phosphate hexahydrate crystals for nonlinear optics, Eur. Phys. J. Appl. Phys, 47, 3071, 2009.
[17]. S. C. Kurtz, T.T. Perry, J. Appl. Phys. 39,, 3798-3813, 1968