International Journal of Interdisciplinary Innovative Research &Development (IJIIRD)
ISSN: 2456-236X
Vol. 05 Special Issue 01 | 2020

Thermal and Mechanical Study of Zn^{2+} doped Potassium Dihydogen Phosphate Crystal For NLO Applications

M. I. Baig[1], Mohd.Anis[2], M.D. Shirsat[3], S. S. Hussaini[4*]

[1] *Assistant Professor, Department of Physics, Prof Ram Meghe College of Engineering and Management, Amravati-444701, Maharashtra, India*
[2] *Assistant Professor, Department of Physics and Electronics, Maulana Azad College of Arts, Science and Commerce, Dr. Rafiq Zakaria Campus, Aurangabad-431001, Maharashtra, India*
[3] *Professor, RUSA Centre for Advanced Sensor Technology Department of Physics Dr. Babasaheb Ambedkar Marathwada University, Aurangabad-431004, Maharashtra, India*
[4] *Assistant Professor, Crystal Growth Laboratory, Department of Physics, Milliya Arts, Science and Management Science College, Beed-431122, Maharashtra, India*

ABSTRACT

The present investigation explores the influence of metallic impurity on characteristic properties of Potassium dihydrogen phosphate (KH2PO4, KDP) crystal to emphasize its utmost liability for futuristic nonlinear optical device applications. The most commercially viable slow solvent evaporation method has been employed to grow the undoped and Zn^{2+} doped KDP (Zn-KDP) single crystals. Vickers micro hardness study has been imposed to evaluate the role of metal in uplifting the hardness parameters of KDP crystal. The thermo gravimetric and differential scanning calorimetric study of Zn-KDP crystal has been comparatively investigated within the temperature range of 30–780 ºC.

Keywords: ***- Nonlinear optical crystal, Crystal growth, Microhardness study, Thermogravimetric analysis***

1. INTRODUCTION

Nonlinear Optical (NLO) crystals play a vital role in nonlinear optics. The Nonlinear optical crystal with good optical, electrical, thermal and Mechanical properties have a great impetus towards device fabrication in the domain of frequency conversion, frequency mixing, optical data storage etc. devises [1]. The attributes like easy growth, a broad transparency range, a high optical laser damage threshold and a relatively low production cost makes KDP crystal more competitive among the different nonlinear optical crystal. Furthermore, KDP is hydrogen bonded matrix which exhibit piezoelectric, ferroelectric, electro-optic and nonlinear optical properties. To tailor the properties of KDP material, an attempt in the form of additive in the host KDP has been explored by prominent research group of Anis et[2, 3], Boopathi et.al[4].

One of the prominent reported additive in the KDP system is the metal ions like Fe and Cr and cesium etc[5]. In present investigation effect of metallic dopant Zn^{2+} has been explored for thermal and mechanical properties.

2. EXPERIMENTAL PROCEDURE

The Merck make KDP salt was dissolved in double distilled water and the homogeneous solution of KDP was taken in separate beakers. The beakers were then added by 1wt% of Zinc chloride ($ZnCl_2$). The mixture was then stirred well for six hours in order to achieve homogeneous doping in KDP. The solutions were then filtered using the No.1 membrane filter paper and the filtered solution was taken in a beaker. The beakers were kept in a constant water bath maintained at 34 ^{o} C with accuracy ±0.01 ^{0}C. The single crystals have been harvested in the period of 18 to 20 days.

3. RESULTS AND DISCUSSION

3.1 Thermal Analysis

The physical and chemical material response to the temperature has been explored by the thermogravimetric (TG) and differential scanning analyses (DSC). The TG and DSC analysis of the Zn-KDP sample has been carried out using Perkin Elmer Diamond thermal analyzer. Powder samples were prepared by crushing single crystal using mortar. The sample was placed in platinum crucible and sample was heated in a nitrogen atmosphere implementing the heating rate of 10 ºC/min within 30-780 ºC. The TG curve reveals that the sample is thermally stable up to 219 ºC, after that sample undergoes gradual decomposition reflected by the appreciable weight loss. The trace of TG-DSC thermogram of Zn-KDP sample is shown in the Fig.1. It is noteworthy that incorporation of Zinc has significantly increased the decomposition temperature in contrast to the various impurity doping in the KDP as reported in literature[6]. Heat flow in the material is evident by DSC. In DSC curve, the exothermic peak appears at 231 ºC, 287 ºC and 334 ºC corresponding to various weight losses in TG thermogram.

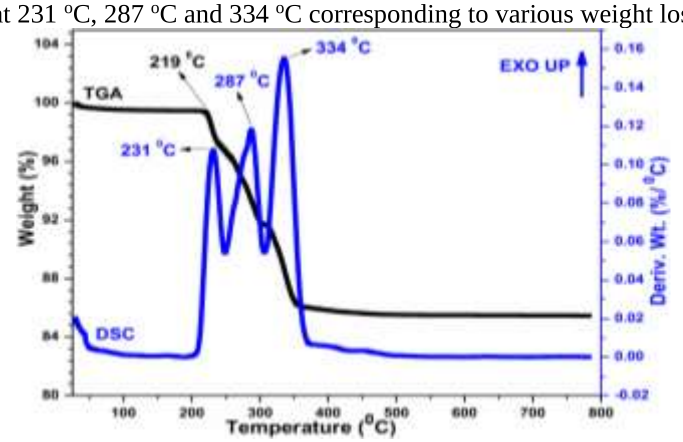

Fig -1: TG-DSC curve of ZN -KDP

3.2 Vicker's microhardness measurements

Mechanical behavior of the materials plays decisive role in the device fabrication. The smooth surface of the KDP and Zn-KDP crystals were subjected to Vicker's static indentation test at room temperature (303 K). Leitz Weit-zler hardness tester with loads of different magnitude was employed for the study. The indentation time was kept as 10 s for all the loads. Using the relation, $H_v = (1.8544 \times P)/d^2$ kg/mm^2 Vicker's hardness number was calculated, where H_v is Vicker's hardness number in kg/mm^2, P is the applied load in kg, d is the average diagonal length of the indentation mark in mm. A graph was plotted between load and Vicker's hardness number. The plot of load (P) vs. Vicker's hardness (Hv) for undoped KDP and Zn-KDP crystals are shown in Fig. 2.From the graph it is evident that the hardness of the Zn-KDP crystals is higher that the undoped KDP crystals. The increasing hardness number profile with indented load realizes the behavior as that of reverse indentation size effect (RISE). The release of internal stresses generated locally by indentation is decisive for crack formation at indent site [7].

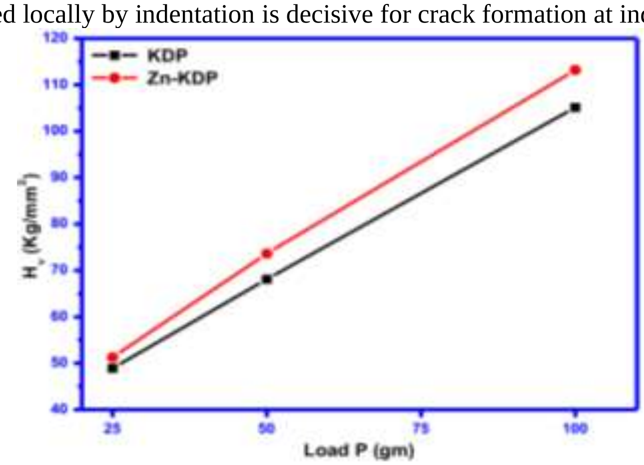

Fig -2: Vickers hardness of Zn -KDP

4. CONCLUSIONS

The single crystals of undoped KDP and Zn-KDP have been grown by slow solvent evaporation method. The TGA and DSC analysis confirmed the improvement in the thermal stability of Zn-KDP crystal. The Vicker's microhardness study confirmed the enhancement of mechanical strength of host KDP crystal. Hence Zn-KDP crystal with superior properties could be decisive in designing various NLO device applications.

5. REFERENCES

[1] M. Baig, M. Anis, H. Algarni, M. Shirsat, and S. Hussaini, "Customizing optical and dielectric traits of ammonium dihydrogen phosphate (ADP) crystal exploiting Zn2+ ion for photonic device applications," *Chinese Journal of Physics*, vol. 63, pp. 70-77, 2020.

[2] M. Anis, G. Muley, A. Hakeem, M. Shirsat, and S. Hussaini, "Exploring the influence of carboxylic acids on nonlinear optical (NLO) and dielectric properties of KDP crystal for applications of NLO facilitated photonic devices," *Optical Materials,* vol. 46, pp. 517-521, 2015.

[3] M. Anis, M. Shirsat, G. Muley, and S. Hussaini, "Influence of formic acid on electrical, linear and nonlinear optical properties of potassium dihydrogen phosphate (KDP) crystals," *Physica B: Condensed Matter,* vol. 449, pp. 61-66, 2014.

[4] K. Boopathi, P. Rajesh, P. Ramasamy, and P. Manyum, "Comparative studies of glycine added potassium dihydrogen phosphate single crystals grown by conventional and Sankaranaryanan–Ramasamy methods," *Optical materials*, vol. 35, pp. 954-961, 2013.

[5] S. Ekadevasena, J. T. J. Prakash, and J. M. S. Gnanaraj, "Modification of structural, optical, thermal and mechanical properties of KDP crystals on the addition of Ni2+," *Optik,* vol. 125, pp. 2620-2624, 2014/06/01/ 2014.

[6] V. D. Maske, N. S. Meshram, and K. G. Rewatkar, "A Study on FTIR, THERMAL, XRD, Dielectric Studies of Pure & Alanine Doped KDP Crystal as A NLO Material," *Materials Today: Proceedings,* vol. 4, pp. 11984-11990, 2017/01/01/ 2017.

[7] G. Pabitha and R. Dhanasekaran, "Investigation on the crystal growth and characterisation of an organometallic non linear optical crystal – Tetrathiourea mercury tetrathiocyanato manganate," *Materials Science and Engineering: B,* vol. 177, pp. 1149-1155, 2012/08/01/ 2012.