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DC electrical conductivity measurements for pure and titanium oxide doped KDP Crystals grown by gel medium

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Abstract

Now a day's crystals are the pillars of current technology. Crystals are applied in various fields like fiber optic communications, electronic industry, photonic industry, etc. Crystal growth is an interesting and innovative field in the subject of physics, chemistry, material science, metallurgy, chemical engineering, mineralogy and crystallography. In recent decades optically good quality of pure and metal doped KDP crystals have been grown by gel growth method in room temperature and its characterizations were studied. Gel method is a very simple and one of the easiest methods among the various crystal growth methods. Potassium dihydrogen phosphate KH2PO4 (KDP) continues to be an interesting material both academically and technologically. KDP is a delegate of hydrogen bonded materials which possess very good electrical and nonlinear optical properties in addition to interesting electro – optic properties. We made an attempt to grow pure and titanium oxide doped KDP crystals with various doping concentrations (0.002, 0.004, 0.006, 0.008 and 0.010) using gel method. The grown crystals were collected after 20 days. We get crystals with good quality and shaped crystals. The dc electrical conductivity (resistance, capacitance and dielectric constant) values of the above grown crystals were measured at two different frequencies (1KHz and 100 Hz) with a temperature range of 50^0C to 120^0C using simple two probe setup with Q band digital LCR meter present in our lab. The electrical conductivity increases with the increase of temperature. Dielectric constants value of titanium oxide doped KDP crystal was slightly decreased compared with pure KDP crystals. Results were discussed in details.

I. Introduction

KH_2PO_4 (Potassium dihydrogen phosphate, KDP) is an interesting material in academically and industrially. KDP is a main hydrogen bonded materials. It possesses very good electro – optic and nonlinear optical properties and also the interesting electrical properties. The demand for high quality large single crystals of KDP increase because of the application as frequency conversion crystal in inertial confinement fusion [1-2].The piezo – electric property makes useful the KDP crystal for the construction of crystal filters and frequency stabilizers in electronic circuits.

The best properties of KDP include transparency in a wide region of optical spectrum, resistance to damage by relatively high non- linear efficiency and also the laser radiation, in combination with reproducible growth to large size. Therefore, it mostly used in various applications such as frequency conversion, laser fusion and electro-optical modulation. Lot of studies on the crystal growth and properties of KDP crystals in the presence of impurities have been reported [3 - 4]. Potassium dihydrogen phosphate (KDP) crystal attracts persistent attention of scientists due to its supreme quality and growing as large- size crystal possibility [5 - 6]. Microscopically, crystal growth includes growth rate, crystal morphology and crystal defects which are all related to the constituent growth units and their chemical bonding process [7 - 8].DKDP, KDP and ADP are the only nonlinear crystal which are recently used for these applications because of its exclusive properties. The grown crystals were characterized using dielectric constant, electrical properties, and optical transmittance.

II. Materials and Methods

Pure and TiO_2 doped KDP single crystals are grown in gel medium using analytical grade KDP and TiO2. Sodium meta silicate of 1.08 g/cm^3 of 50 cc equally poured in a wide mouth test tube. KDP of 2.5 M of 50cc was prepared and 25 cc of above prepared KDP solution was mixed with sodium meta silicate. During the process pH was maintained at 5-6. Ethyl alcohol of equal volume is added over the cell surface without damaging the set of gel .When the alcohol diffuses into the set gel, it reduces the solubility. This single crystal used to induce the nucleation and the nuclei process. The crystal growth was carried out at room temperature.

III. Doping

Doping means adding impurity to the known pure crystal .To prepare a doped crystal a required amount of dopant solute is also mixed along with the pure solute.

Table 1: Doping concentrations of impurities

Doping ratio	Mass of TiO_2 added(in mg)
1 : 0.002	0.0715
1 : 0.004	0.1431
1 : 0.006	0.2147
1 : 0.008	0.2863
1 : 0.010	0.3579

An impurity can suppress, enhance or stop the growth of crystal completely. Usually it acts assure crystallographic faces. The effects depend on the pH, super saturation, impurity centralization, heat of the solution.The growth period was about 20 days. The photograph of the grown pure and TiO_2 doped KDP crystals were shown in the figs 1 and 2.

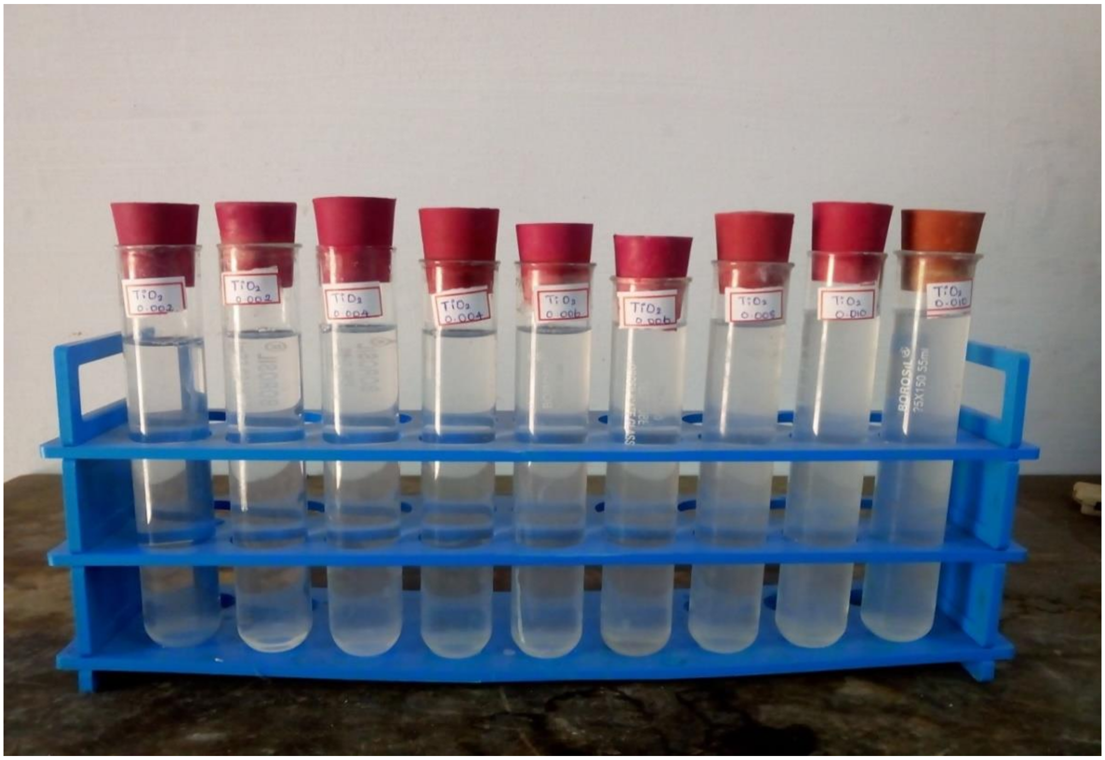

Figure.1

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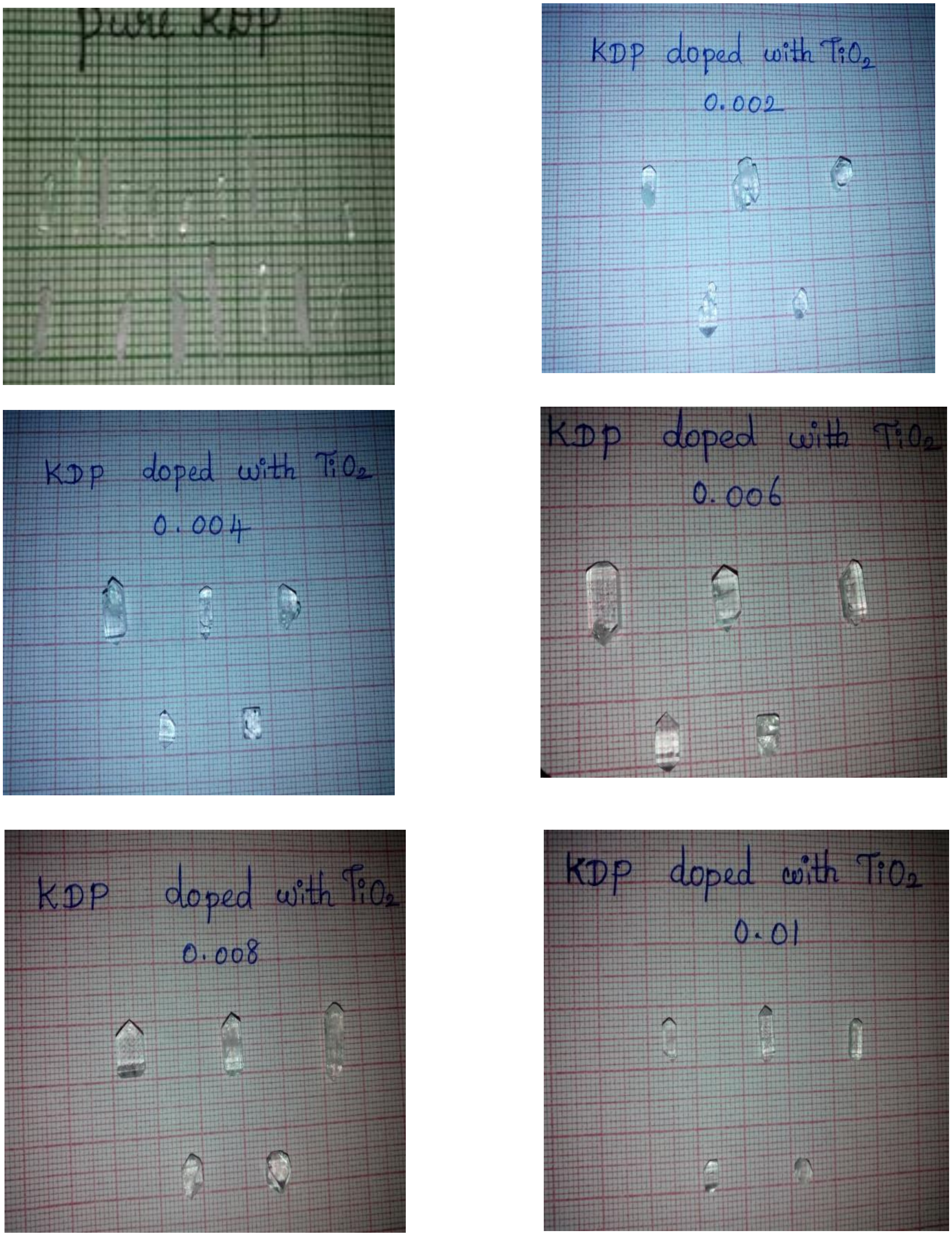
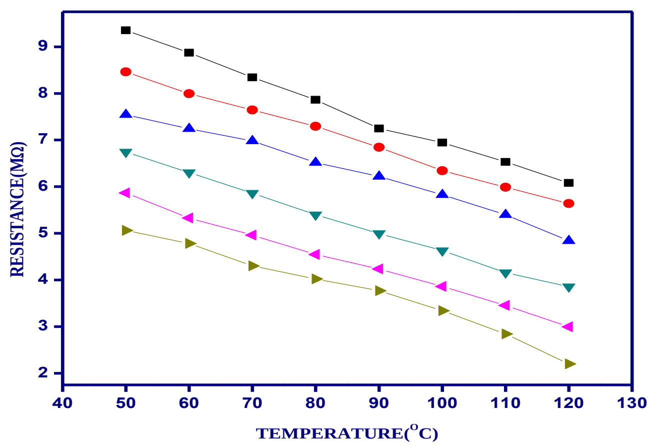


Figure .2.Photograh shown the grown pure KDP and TiO2 doped KDP crystals

IV. Results and Discussions

Dielectric properties are correlated with electro-optic properties of the crystals specifically when the crystals are non- conducting materials. Metal electrical conductivity increases because of the incorporation of metal ions polarization increases. The magnitude of dielectric constant depends on the charge displacement in the crystal and the degree of polarization. The dielectric constant of materials is due to the contribution of dipolar and space charge polarizations, electronic, ionic which depends on the frequencies [5]. At low frequencies, all these polarization are active [6]. In KDP crystals, many records are available about this crystal's dielectric behavior and in our present work the measured dielectric constant values are exactly close agreement with the reported results [7-8]. The temperature dependence of dielectric constant at frequency 100Hz to 1 KHz is shown in fig. (9 and 10). Even though KDP has many reports on dielectric constant it is observed that the dielectric constant decreases with increasing frequency and poor dielectric losses were observed.

Fig .3. Variation of resistance with temperature at frequency of 1KHz for pure and TiO_2 doped KDP crystals



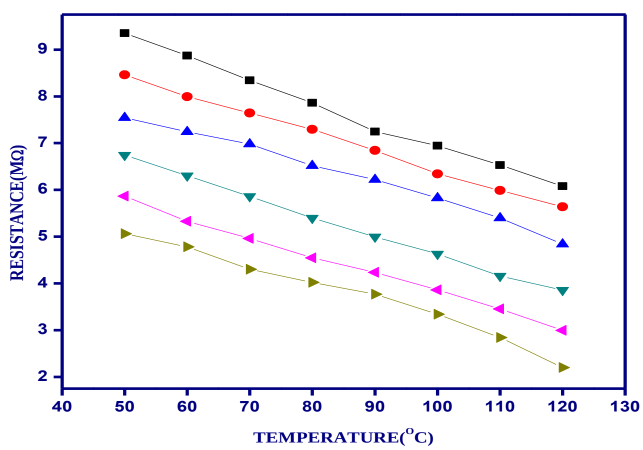


Fig .4. Variation of resistance with temperature at frequency of 100KHz for pure and TiO_2 doped KDP crystals

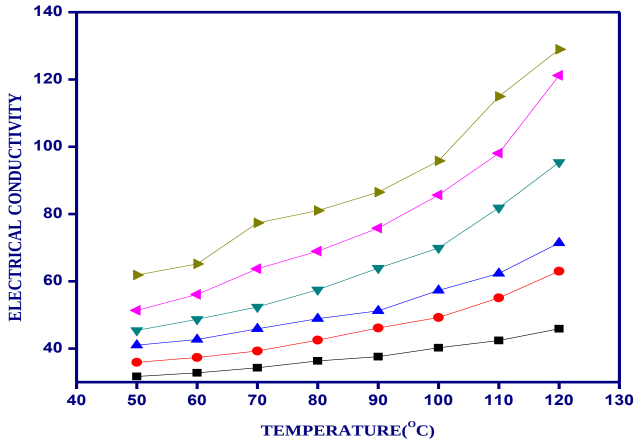


Fig.5. Variation of electrical conductivity with temperature at frequency of 1KHz for pure and TiO_2 doped KDP crystals

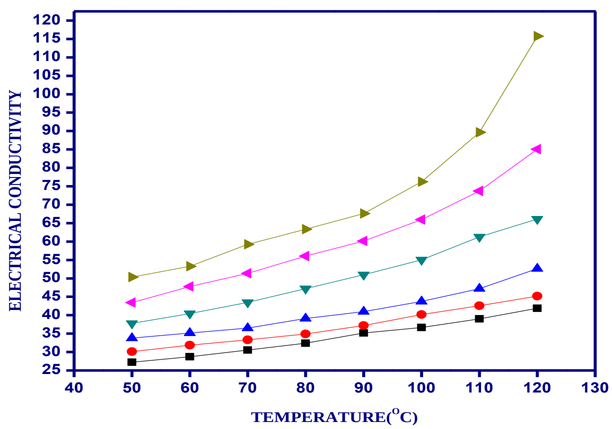


Fig .6. Variation of electrical conductivity with temperature at frequency of 100KHz for pure and TiO_2 doped KDP crystals

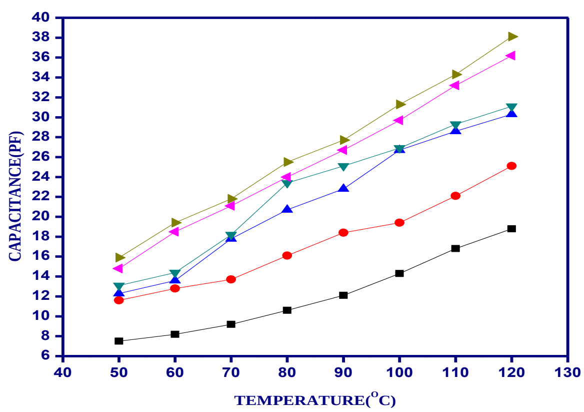


Fig.7. Variation of capacitance with temperature at frequency of 1KHz for pure and TiO_2 doped KDP crystals

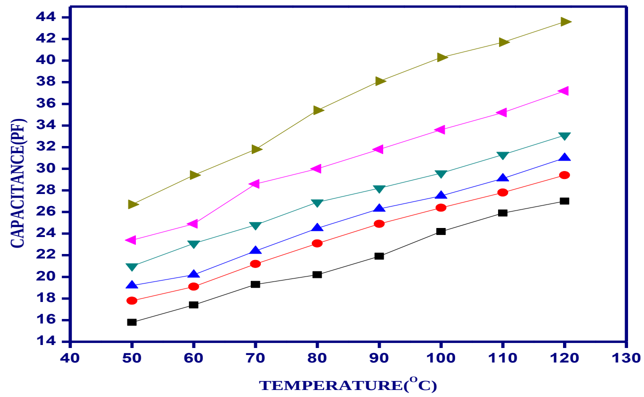


Fig .8. Variation of capacitance with temperature at frequency of 100KHz for pure and TiO_2 doped KDP crystals

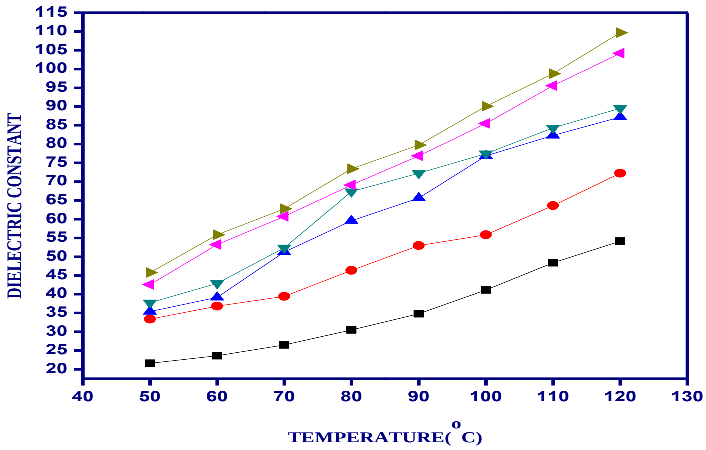


Fig .9. Variation of dielectric constant with temperature at frequency of 1KHZ for pure and TiO_2 doped KDP crystals

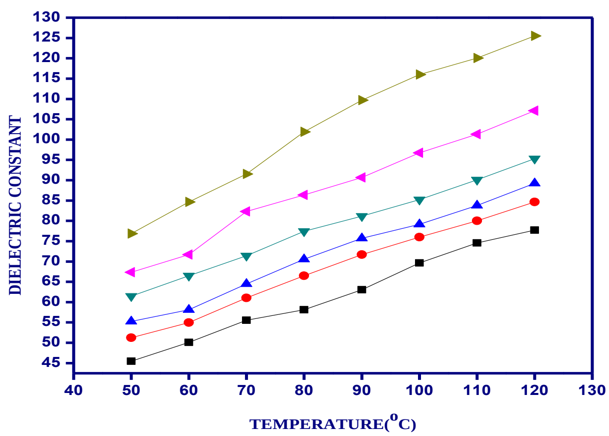


Fig.10. Variation of dielectric constant with temperature at frequency of 100KHZ for pure and TiO_2 doped KDP crystals

V. Conclusion

Gel method is used to grow the pure and TiO_2 doped KDP crystals. In gel growth, due to the three dimensional structures, the crystals are free from microbes. The capacitance , dielectric constant and electrical conductivity were measured at various frequencies (1 KHZ and 100 HZ) with a temperature range of 50^0C to 120^0C using simple two probe setup with Q band digital LCR meter present in our lab. The capacitance and dielectric constants value of titanium oxide doped KDP crystals were slightly fall off in size when compared with pure KDP crystals. Lower value of dielectric constant is more in the enhancement of SHG signals. The electrical conductivity of the pure KDP and TiO_2 doped KDP crystals were found to be increase with increase of temperature and frequencies.

REFERENCES

[1] X.Sun, X, Xu, Z.Gao, Y.Fu, S.Wahg, H.Zong, Y.Li, J.Cryst.Growth 217(2000) 404
[2] N.Zaitseva, L.Carman, I.Smolsky, J.Cryst.Growth 241(2002) 363.
[3] Bo Wang. Chang –shuiFang.Sheng –Iai Wang, Xun Sun, Quing-tianGu,Yi-ping Li, Xin-guangXu, JianqinZhang,BingLiu,with potassium carbonate as additives .J.Cryst.Growth 2008;310:5341-5346.
[4] N.Pattanaboonmee, P.Ramasamy, P.Manyumprocedia Engineering 32(2012) 1019-1025.
[5] Dongli Xu, DongfengXue. J.Cryst. Growth 310 (2008) 1385
[6] Dogli Xu, DongfengXue, J.Alloys Compd. 449 (2008) 353
[7] Dongli Xu, DongfengXue. J.Cryst. Growth 310 (2008) 1385
[8] S.Balamurugan, P.Ramasamy, Spectrochimica Acta part A 71 (2009) 1979-1983