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Investigation of Dielectric Properties of Potassium Dihydrogen Phosphate (KDP)

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ABSTRACT

Potassium Dihydrogen Phosphate (KDP) is an excellent inorganic nonlinear optical material that is used in various instrumental applications. In the present work, Pure KDP powder is used for the characterization at room temperature by the complex relative dielectric function $\varepsilon^*(\omega) = \varepsilon' - j\varepsilon''$ of mixture of KDP dissolved in double distilled water in molar fraction have been measured using precision LCR meter in the frequency range 20Hz to 2MHz. This properties are used to measured various important dielectric parameters i.e. complex relative dielectric function $\varepsilon^*(\omega)$, conductivity $\sigma^*(\omega)$ Refractive Index, Density as well as permeability ($\varepsilon\alpha$).The obtained results are discussed in detail.

KEY WORDS:

NLO, Complex relative dielectric function, Conductivity, Aqueous solution.

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INTRODUCTION:

In the last century the various applications of the nonlinear optical (NLO) crystals have been discussed in the research field of science and technology. In last few year non linear optical materials have found increasingimportance in the research as well as in industrial application because of carrying unlimited information, storage capacity, process capacity and cost effectiveness, etc. in all the research and application requires single crystals with nonlinear optical (NLO) properties in which crystallineperfection plays an important role in device performance depending on the growth technique and conditions [1, 7]. Potassium dihydrogen phosphate (KDP), Ammonium dihydrogen phosphate (ADP), potassium dihydrogen arsenate (KH_2AsO_4) and ammonium dihydrogen arsenate ($NH_4H_2AsO_4$) are an isomorphous saltas well as nonlinear optical materials. These materials exhibits phase changes at low temperature as well as solid solution of the ferroelectric potassium dihydrogen phosphate and anti ferroelectric ammonium dihydrogen phosphate have large important, ferro electric phase transition in KDP occurs at 150 °C and anti ferroelectric phase transition in ADP occurs at 125 °C [8].

The importance for high quality KDP and ADP single crystals increases due to their application as frequency conversion crystal in inertial confinement fusion [9-10]. In this paper we have study the dielectric spectroscopy of binary mixture of KDP crystal and double distilled water. In present there is a large interest on the molecular interaction in the liquid materials and it will provides information to make a comparative dielectric study of the liquid samples KDP-double distilled water mixtures in the frequency range 20Hz to 2MHz and data obtained from the LCR meter will be accurately measured dielectric constant and other evaluated dielectric parameter at room temperature. The properties of liquid mixture is represented in terms of intensive quantities i.e. complex relative dielectric function $\varepsilon^*(\omega)$, conductivity $\sigma^*(\omega)$, refractive index, permeability and density.

EXPERIMENTAL PROCEDURE:

KDP materials were of AR grade have been taken and the growth process was carried out in aqueous solution. According to molar fraction the calculated amount of KDP is dissolve in the double distilled water in the range of 0.1 to 0.4 different molar fractions. This solution is used for the study of dielectric spectroscopy in the frequency range 20Hz to 2MHz using the LCR meter.

RESULT & DISCUSSION:

The complex dielectric function ε*(ω) of liquid samples were determined by using precision LCR meter with four terminal liquid dielectric test fixture for the measurement of capacitance and resistance in the frequency range 20Hz to 2MHz. The capacitance and parallel resistance of the dielectric liquid test fixture without samples and with samples were measured to compensate for a short. The test fixture correction coefficient was also considered to cancel the effect of stray capacitance during the calculation of the complex relative dielectric function ε*(ω). The complex relative dielectric function contains two terms in which first term gives the dielectric constant and it is an important property of the dielectric materials. Complex relative dielectric function depends on the frequency of the chemical structure imperfection of the material, alternating field fixed in LCR meter, temperature which can be vary from the room temperature to the higher temperature and pressure [11].

Complex Relative Dielectric Function

Complex relative dielectric function can be obtained from the equation 1.

$$\varepsilon * (\omega) = \varepsilon' - \varepsilon'' = \alpha \left[\frac{C_P}{C_0} - j \frac{1}{\omega C_0 R_P} \right] \quad (1)$$

Where C_0=Capacitance of air, C_P=parallel capacitance with sample, R_P=Parallel resistance with sample, ω=2πf and is the angular frequency, α=correction coefficient of the cell.

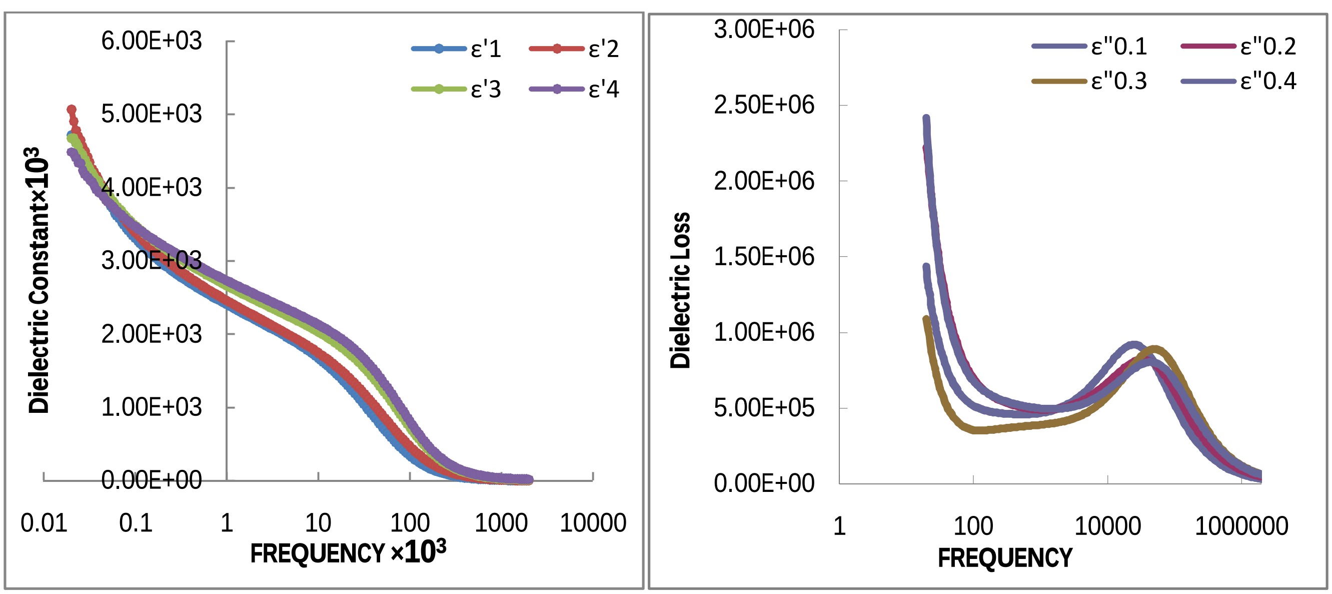

Figure 1 (a) Dielectric Constant as a function of logf. (b) Dielectric Loss as a function of logf.

The dielectric constant is shown in figure 1(a), all mixtures samples decreases as the frequency increasing from 20Hz to 2MHz. From the figure 1(a), dielectric constant of different molar fraction of KDP in water over an entire frequency range is high in the low frequency region and decreases as the frequency increases. This effect of high dielectric constant at low frequency is due to electrode polarization and ionic conduction. As the frequency increases the vibration of molecules increases result decreases in dielectric constant. Figure 1(b) shows the dielectric loss spectra in which it shows the peak at low frequency and is due to the polarization which is used to separate the bulk material properties.

Conductivity

$\sigma = \sigma' - j\sigma = \omega\varepsilon_0\varepsilon'' - \omega\varepsilon_0\varepsilon'$ (2)

Real part σ′ and the imaginary part σ′′ are the two part of the complex conductivity σ*(ω) and its values can be obtained from the equation 2. Where ε_0 (8.854×10^{-11} F·m^{-1}) is free space dielectric constant.

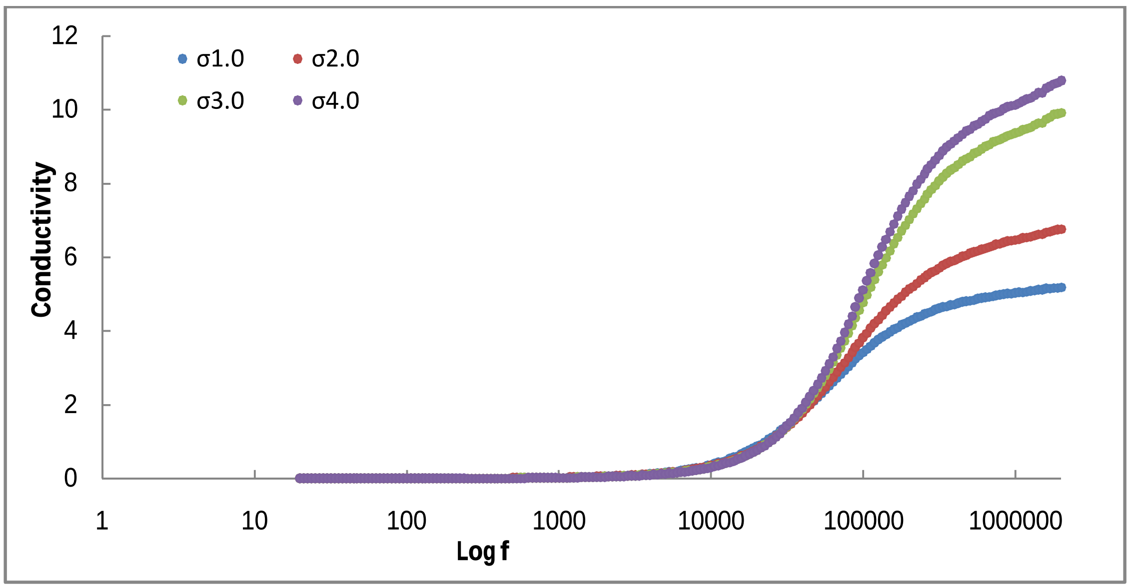

Figure 2: Conductivity vs. Logf

Figure 2 shows the σ′ spectra of the liquid mixture of KDP with different molar fraction.This figure 2 shows the linearly increment in conductivity upto certain limit in low frequency region and this is due to the increment of number of mobile charge carrier as the molar fraction of the KDP in distilled water increases.

Refractive Index, Permeability & Density

The Abbe refractometer is a classic optical instrument which is used to measure the refractive index of liquids. In order to measure the refractive index, a filtered yellow sodium source of D line of 589 nm is used. The refractive index (η) can be calculated using the equation (3).

$$\eta = \frac{c}{v} \quad (3)$$

Table 1: Properties of KDP at different molar fraction.

Molar Fraction(%)	Refractive Index	Permeability (ε_{α})	Density (Kg/m^3)
0.1	1.339	1.793	1.76
0.2	1.348	1.817	1.80
0.3	1.354	1.834	1.84
0.4	1.367	1.870	1.87

Table 1 show the refractive indices increases as the molar fraction of the KDP increases due to increasing the number of ions in the liquid mixtures. Permeability obtained from the square of refractive index which ranging from 1.8 to 1.9. Density can be found from the pycnometer and obtained data displayed in the table 1.

CONCLUSION:

This paper gives the data for complex relative dielectric function and conductivity of mixture samples of different molar fraction of KDP. Dielectric constant and dielectric loss for the KDP decreases as the frequency increases and as the fraction of KDP increases the dielectric constant and dielectric loss also decreases Where Conductivity increases as the frequency increases as well as the concentration of KDP increases. Refractive index, permeability and density increases as the molar fraction of KDP increases.

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REFERENCES:

1. Muncheryan HM, Lasers and Opto-Electronics Devices. Hemisphere Pub Co. New York 1991.
2. Shen YR, The Principles of the Nonlinear Optics. Wiley. New York 1984.
3. Sethuraman K, Babu RR, GopalakrishnanR et al. Unidirectional Growth of (1 10) Ammonium Dihydrogen Orthophosphate Single Crystal by Sankaranarayanan-RamasamyMethod. Journal of Crystal Growth. 2006; 294:349-52.
4. MeystreyP and Sargent M. Elements of Quantum Optics. Springe-Verlag. Berlin, 1991.
5. BalamuruganN andRamasamy P. Investigation of the Growth Rate Formula and Bulk Laser DamageThreshold KDP Crystal Growth from Aqueous Solution by theSankaranarayanan-Ramasamy (SR) Method. crystalGrowth& design.2006; 6: 1642-44.
6. Sakai RI. Phase Conjugate Optics. McGraw Hill, Inc., New York, London, 1992.
7. Ramasamy P and SanthanaRaghavan P. Crystal Growth Processes and Methods. KRU Publications. Kumbako-nam, 1999.
8. P. SanthanaRaghavan and P. Ramasamy. Recent Trends in Cyrstal Growth. Pinsa 68. New Delhi, 2002; 235.
9. Ravi U, Srinivasan K, Anbukumar S, Ramasamy P. Growth and characterization of sulphatemixed L-argininephosphate and ammonium dihydrogen phosphate/potassiumdihydrogen phosphate mixed crystals. Journal of Crystal Growth. 1994; 137:596-04.
10. Xiue Ren, Dongli Xu, DongfengXue.Crystal growth of KDP, ADP, and KADP. Journal of Crystal Growth.2000; 310: 2005-09.
11. Anee, TK.Meenakshisundaram et al. Crystal growth of ADP. J. Cryst. Growth, 2005; 285:380-87.
12. Arunmozhi, G, Gomes et al. S. Cryst. Res. Technol, 2004; 39:408-13.
13. Zaitseva N, Atherton J, Rozsa R, et al. Design and benefits of continuous filteration in rapid growthof large KDP and DKDP crystal. J. CrystalGrowth. 1999; 197: 911.