

**Growth, Structural and Optical studies of KDP crystal with various
Organic additives**

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Project work Submitted by

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INTRODUCTION

Potassium dihydrogen phosphate (KDP) is a widely studied nonlinear optical (NLO) material known for its excellent electro-optic properties, wide transparency range, and high damage threshold, making it suitable for applications in laser systems, optical modulators, and frequency conversion devices. However, the performance of KDP crystals is often limited by defects, inclusions, and poor growth morphology, which can significantly impact their optical quality and efficiency in device applications.

Organic additives, even in trace amounts, can selectively adsorb onto specific crystal planes, influence the growth rate, suppress defect formation, and enhance transparency and mechanical stability. Their presence can also induce subtle changes in the internal structure, which can lead to improved nonlinear optical responses.

This project focuses on the growth of KDP crystals in the presence of various organic additives, aiming to investigate how these modifiers affect the crystal's structural, morphological, and optical properties. By employing standard slow evaporation techniques, followed by structural characterization (XRD, FTIR), optical analysis (PL spectroscopy), and potentially nonlinear optical studies (e.g., Z-scan), this study seeks to identify optimal additives that enhance the material's properties for NLO applications.

The insights gained from this research could contribute significantly to the development of improved KDP-based materials for advanced photonic and optoelectronic devices.

OBJECTIVES

- To grow pure KDP Crystals by slow evaporation method.
- To grow doped KDP Crystals by slow evaporation method.
- To analyze the structural modifications due to the additives.
- To study the optical properties and NLO efficiency.

LITERATURE REVIEW

Nonlinear optical (NLO) materials play a crucial role in photonic and optoelectronic devices, particularly in frequency conversion, optical switching, and laser technology. The search for new NLO crystals with high efficiency, optical transparency, and good thermal stability has led to the exploration of both organic and inorganic materials, as well as their combinations. Organic compounds typically offer high nonlinearities but suffer from poor mechanical strength, whereas inorganic crystals like KDP offer excellent physical stability with moderate nonlinear properties.

The single crystals with advanced properties play a significant role in the growth of modern scientific world of advanced technology. Crystal growth is one of the significant fields with controlled phase transformation. The interest in crystal growth process has been increased particularly in the field of technological application [1-3]. Recent research is focused on the search for suitable materials displaying excellent second order nonlinear optical properties for potential application in optoelectronics, telecommunication, and optical storage device [4]. Materials can be classified as single crystals, polycrystals and amorphous materials depending upon the arrangement of constituent molecules, atoms or ions. The single crystals are solids in the most uniform condition that forms the basis for most of the applications of crystals [5].

The Literature review showed that the advanced laser imaging, optical communication and data storage systems require improved nonlinear optical materials of KDP which was achieved by doping amino acid as dopant in mother solution of KDP. This in turn improves the optical, thermal etc. properties of KDP. Organic impurities enhance the NLO properties and hence in this work we have presented the 2-amino-3-methylbutanoic amino acids (valine) doped Potassium dihydrogen phosphate (KDP) crystal. And confirmed the strong interaction of L-valine with the $-OH$ group of KDP. A comparative study was carried out on L-valine amino acid doped potassium dihydrogen phosphates (KDP). Pure and doped transparent bulk single crystals were successfully grown by above mentioned methods.[6]

ABSTRACT

Potassium dihydrogen phosphate (KDP) single crystals were successfully grown using the slow evaporation technique by incorporating various organic additives including valine, succinic acid, maleic acid, and a novel combination of valine succinate. The objective was to investigate the influence of these organic dopants on the structural, optical, and nonlinear optical (NLO) properties of KDP crystals. Powder X-ray diffraction (XRD) confirmed the tetragonal structure of the pure and doped KDP crystals, with slight shifts in diffraction angles indicating lattice distortion due to doping. FTIR spectral analysis revealed the presence of functional groups corresponding to both the host lattice and organic dopants, confirming successful incorporation into the crystal matrix. Photoluminescence (PL) studies showed a strong emission peak around 403 nm for valine succinate-doped KDP, highlighting its potential in optoelectronic applications. Furthermore, the Z-scan technique was employed to evaluate the third-order nonlinear optical properties, showing notable improvement in the nonlinear refractive index and absorption coefficient for valine succinate-doped KDP. These results demonstrate that the incorporation of organic additives not only improves the crystalline quality but also significantly enhances the optical and NLO behaviour of KDP crystals.

Keywords: KDP, Organic additives, NLO properties, XRD, FTIR, PL, Z-scan.

METHODOLOGY

Chemicals And Apparatus Used

- KDP (Potassium dihydrogen phosphate) of Molar mass 136.08g/mol
- L-Valine of Molar mass 117.15g/mol
- Succinic acid of Molar mass 118.09g/mol
- Maleic acid of Molar mass 116.07g/mol
- Distilled water
- Magnetic stirrer
- Beakers
- Petri dish
- Filter paper

Crystal Growth by Slow Evaporation Technique

- A supersaturated solution of KDP was prepared by dissolving the salt in distilled water at room temperature.
- Various Organic additives were added to separate batches of the KDP solution.
- Solutions were stirred continuously for uniform mixing and then filtered.
- The solutions were left undisturbed in clean Petri dish at a constant temperature (~30 °C) to allow slow evaporation and crystal growth.
- Crystals were harvested after a growth period of **10–15 days**, washed with distilled water, and dried.

Characterization Techniques

a) X-ray Diffraction (XRD)

- Powder XRD was performed to confirm the crystalline phase and to identify any structural changes due to additive incorporation.

b) Fourier Transform Infrared Spectroscopy (FTIR)

- Used to confirm the presence of organic additives and detect bonding interactions between KDP and the dopants.

c)Photoluminescence

- To investigate changes in the emission behaviour due to doping.

d) Z-Scan Technique

- To analyze the third-order nonlinear optical properties, including nonlinear refractive index and absorption coefficient.

Comparison and Analysis

- The results from pure KDP were compared with those of the additive-doped crystals.
- Structural, optical, and morphological variations were systematically analyzed with respect to the type and concentration of additives.

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