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Linear Optical Constants of Succinic Acid Single crystals (SA)

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Abstract:-- **Single crystals of organic optical material of succinic acid has been grown by slow evoporation growth technique using water as a solvent. The single crystal X-ray diffraction technique reveals that the grown material crystallizes in monoclinic crystal system. The optical properties such as the transmittance, absorpsion, opticalband gap, extinction coefficient (k), reflectance, refractive index (n) and optical conductivity (σ) were calculated. Large transmittance in the visible region and the wider optical band gap of the material depicts its excellency for optical applications.**

Key words : solution growth; XRD; Uv; optical conductivity;

I. INTRODUCTION

In recent years there has been considerable interest in growing organic materials for optical storage and optical processing applications. An Organic material possess good optical transmission characteristics, ultra fast linear response time and high optical damage threshold, they attracted chemists and material scientists. Today, organic optical materials are widely used for a variety of photonic technologies and they have been identified as potential candidates in optical and electro-optical devices. They have acquired new significance with the large number of devices utilizing solid-state laser sources. The low temperature solution growth technique is widely used for the growth of organic compounds to get quality single crystals [1-2].

Growth According to the solubility data, calculated amount of succinic acid sample was mixed in double distilled water and stirred well using magnetic stirrer to get homogeneous Solution about 3 hours. And the solution was filtered using filter paper and kept for slow evaporation growth process. After few days transparent and colourless crystals were harvested.Grown crystal of succinic acid is depicted in figure (1). The size of the crystal is 8x3x4 mm.

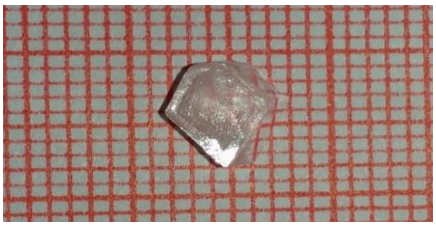

Figure: 1. As grown crystal of SA single crystals

2. SINGLE CRYSTAL X- RAY DIFFRACTION ANALYSIS

Single crystal XRD analysis confirmed that the succinic acid crystallizes in monoclinic crystal system and the space group is P21/c.The lattice constants are a=5.453 Å, b=6.11.300Å, c=5.136 Å, α=γ=90° , β = 91.49°and V = 263.9Å3. The obtained structural data for the above succinic acid grown crystals are found to be in good agreement with the data reported in the literature [3].

2. LINEAR OPTICAL ANALYSIS

Optical window width is an important characteristic of an optical material. Hence the study of the transmission of electromagnetic waves of the UV–visible–NIR range through the optic material is necessary. The optical transmission spectrum of SA sample was recorded by Uv-Visible spectrophotometer in the range of 190nm – 1100nm. Linear optical parameters viz. the optical transmission spectrum, absorption spectrum, Taue's plot, reflectance, refractive index, extinction coeffieint and optical conductivity of SA sample are shown in Figures (2-8) respectively.

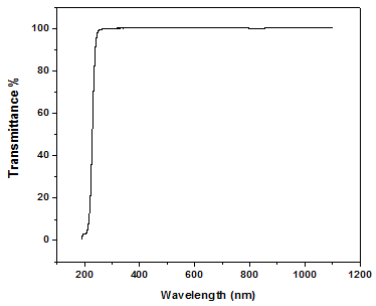

Figure : 2. Transmittance spectrum of SA sample

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Which (fig 2-3) show that SA is optically transparent in the UV–Vis–NIR region with almost 95% transmission intensity and Low absorption in the entire visible and near infrared region with the low cut-off wavelength at 230 nm. Forbidden energy band gap of the sample is 5.40 eV (figure.4).

2.1 Reflectance (R) and Refractive index (n)

The reflectance (R) in terms of absorption coefficient and refractive index (n) of the grown crystals were determined using the formula [3].

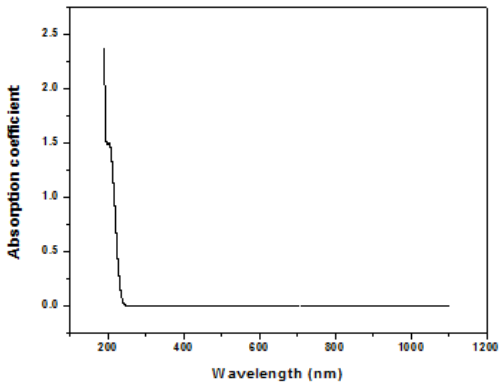

Figure : 3. Absorption spectrum of SA sample

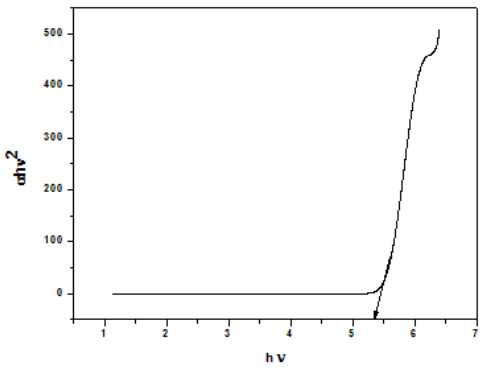

Figure : 4. Tauc's plot of SA sample

The reflectance (R) values depends on the applied wavelength and using R values the refractive index (n) values for the grown samples were determined. It is observed from the figures 5-6 that the reflectance and refractive index of grown samples decrease with increase of wavelength.

$$R = \frac{1 \pm \sqrt{1 - e^{(-\alpha d)} + e^{(\alpha d)}}}{1 + e^{(-\alpha d)}}$$

$$n = \frac{-(R+1) \pm \sqrt{3R^2 + 10R - 3}}{2(R-1)}$$

2.2 Extinction coefficient (k) and Optical conductivity (σ)

The extinction coefficient (k) gives the fraction of the light lost due to the scattering and absorption per unit distance of the penetration medium which is calculated in terms of absorption coefficient (α) using the following relation k= $\alpha\lambda / 4\pi$ [4].where λ is the wavelength. The optical and frequency response of a material is mainly studied in terms of the optical conductivity (σ) which can be calculated using the following relation $\sigma = \alpha nc / 4\pi$ [5].

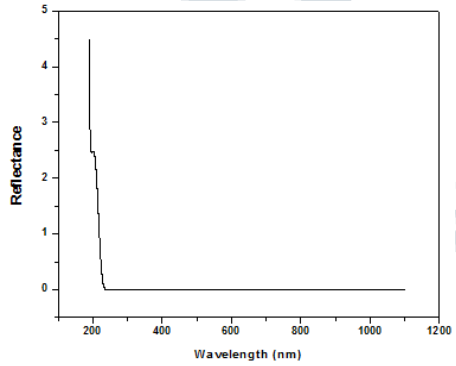

Figure : 5. Variation of Reflectance with Wavelength of SA sample

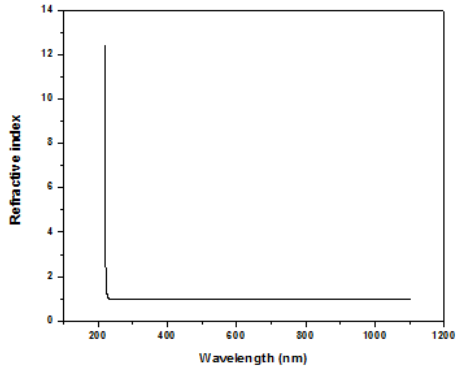

Figure : 6. Variation of Refractive index with Wavelength of SA sample

where c is the velocity of light and n is refractive index. Optical conductivity is directly proportional to absorption coefficient and refractive index of the material. The figures 7-8 show that the values of k and optical conductivity

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decrease with increase of wavelength and it is observed that at cut-off wavelength, the values are found to be high. The grown samples have high and good magnitude of optical conductivity and it confirms that the grown materials have high photo response nature and also it suggests that the grown crystals are suitable for optoelectronic device applications and they are more prominent for device applications in information processing and optical computing [6].

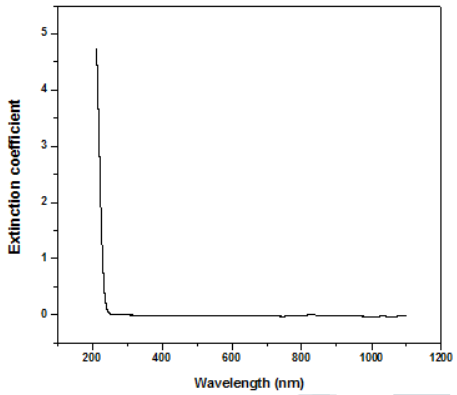

Figure : 7. Variation of Extinction coefficient with λ of SA sample

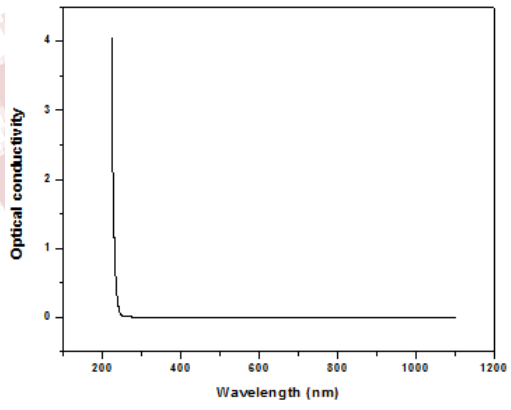

Figure : 8. Variation of Optical conductivity with λ of SA sample

2.3 CONCLUSION

The transparent succinic acid single crystals grown by solution method are found to be better optical material for various optical applications. The optical constants such as absorption coefficient, band gap energy, reflectance, refractive index, extinction coefficient and optical conductivity of the grown samples were estimated from the transmittance values. Low absorbance, low reflectance, low refractive index, low extinction coefficient, high transmittance and better magnitude of optical conductivity values of grown crystals are important parameters for optoelectronic device applications.

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