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Spectroscopic and Optical analysis of Eosin doped Strontium Tartrate Crystals Grown by Gel Growth Technique

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Abstract - Eosin is a molecular organic dye particular interesting for the spectroscopic applications such as photovoltaic conversion devise and also used in pharmaceutics. Compounds of tartaric acid find several practical applications in science and technology. In the present investigations eosin dye has been added to strontium chloride supernatant solution to grow strontium tartrate crystals by single diffusion reaction silica gel technique. The growth conditions were optimized by varying the parameters such as pH, concentration of gel, gel setting time and concentration of reactants. Crystals having shiny pink color and sphere-shaped morphology were grown within silica gel column. The functional group of the dye doped strontium tartrate crystals were found by FTIR analysis. The UV-Vis spectrum of strontium tartrate crystals have been revealed that by adding systematically eosin dye in strontium tartrate, optical properties of the grown crystals changed.

Keywords —Eosin dye, FTIR, Gel technique, Strontium tartrate, Single crystal growth and UV

I. INTRODUCTION

In recent years, a number of practical applications in the field of optoelectronics, a great deal of interest has been shown in the study of the optical behavior of various materials [1-3]. Tartaric acid work as an ignoble for the growth of novel materials because of the presence of two hydroxyl and carbonyl groups in tartaric acid permits the ready incorporation of monovalent, divalent or trivalent metal ions [4]. Tartrate single crystals show many interesting physical properties such as ferroelectric, piezoelectric, dielectric, optical and other pertinent characteristics. They are used for non-linear optical devices based on their optical second harmonic generation and optical transmission characteristics. They are also used for fabrication of crystal oscillators, resonators and controlled laser emission [5-9]. Among the several tartrate compounds, strontium tartrate has received greater attention on account of its ferroelectric, nonlinear optical and spectral characteristics [10-13]. A series of pure and mixed single crystals, as well as polycrystalline materials have been grown by several researchers with the aim of identifying new materials for industrial and engineering applications point of view. Currently, great attention has been developed to grow doped crystals and effects of dopants on various properties of single crystals with the aim of identifying innovative materials for application purposes [14]. Dyes are being used by a large number of industries for different purposes such as dyeing, printing, cosmetics, pharmaceuticals, leather and fluorescent pigment. These are done in order to color their products and make their appearance more attractive. Eosin Y is a pink water soluble acid dye (anionic dye) which also shows yellow-green fluorescence and with the wavelength of maximum absorbance. In the present study, single crystals of pure and eosin-Y dye doped strontium tartrate crystals were grown by the single diffusion gel technique. Optimum growth conditions were determined by varying gel concentration, pH, gel setting time and concentration of reactants. The grown crystals were characterized by FTIR spectral and UV-Vis spectrum. The results obtained are reported and discussed herein.

II. MATERIALS AND METHOD

The anionic dyes used in this study were eosin Y and eosin B. Molecule structure of the dye is shown in Fig. 1. The dye eosin yellow and eosin blue were obtained from Merck, Germany. Stock dye solutions were prepared by dissolving 1.00 g of dyes in 1 L of double distilled water. All working solutions were prepared from the stock solutions by further dilution.

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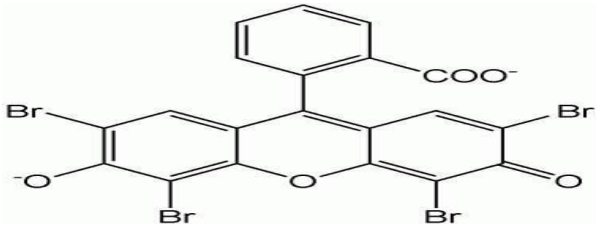

Fig. 1. Chemical structure of eosin dye

Growth of single crystals

The gel growth technique [15] has attracted the attention of many researchers as it has been proven the successful method to grow the crystals of such compounds having sparing solubility in water or decompose before melting. There are some advantages of gel technique, i.e., gel method is simple, cheap, highly economical, at every stage crystals can be practically observed, crystal can be harvested without damaging the crystal faces etc. In the present study, the first time attempt to doped eosin dye in strontium tartrate to grow the single crystals of it.

The eosin doped strontium tartrate single crystals were grown by gel technique using single diffusion reaction technique at room temperature. The glass test tubes were used as crystalline apparatus and hydro-silica gel as a growth media. Gel was prepared by mixing aqueous solution of sodium meta-silicate having specific gravity from 1.03 to 1.06. After add solution 1 M of tartaric acid into sodium meta-silicate and set pH from 4.0 to 5.5 by continuous stirring. This solution of gel was transferred to test tubes. Dimension of test tubes of 25 mm diameter and 140 mm length. After setting the gel, a supernatant solution 10 ml of 0.5 M strontium chloride containing eosin dye was poured carefully over the set gel without break gel interface. Crystals were grown within the gel and at the gel liquid interface. The crystals grown in the gel were harvested after 3 weeks. Grown crystals outside the test tubes are shown in Fig. 2 for different 0%, 0.25%, 0.50%, 0.75% and 1.0% concentration of Eosin dye. The eosin dye content existing in the crystal is nearly proportional to the concentration considered in the solution used for the growth of single crystals. It is found that the 1.0 % eosin dye content strontium tartrate crystals are having highly pink than the other eosin dye content strontium tartrate crystals.

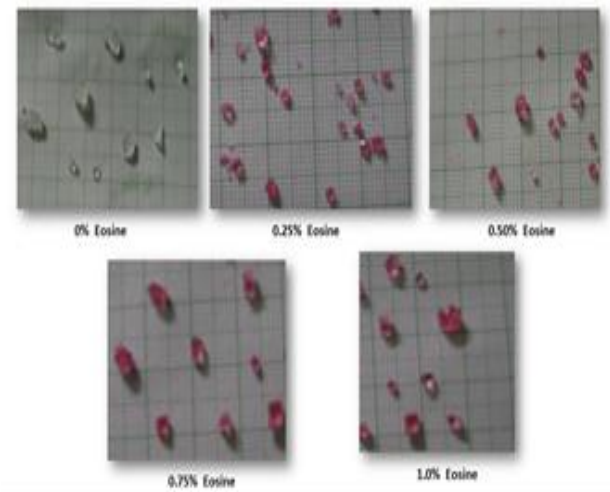

Fig. 2 Photographs of grown strontium tartrate single crystals with different concentration of Eosin dye

III. EXPERIMENTAL TECHNIQUES

FTIR Spectroscopic analysis

Infrared spectroscopic study deals with infrared region of the electromagnetic spectrum. Basically, IR Spectroscopic method covers a range of techniques, mostly based on absorption spectroscopy. FTIR is useful technique to identify organic and/or inorganic substances. It can also be useful to quantitate some components of an unknown mixture. This technique is equally applicable to the analysis of solids, liquids and gases. The FTIR spectrum of powdered sample of grown magnesium tartrate crystals was recorded in the range of 400 cm^{-1} to 4000 cm^{-1} using a Perkin Elmer Fourier transform infrared spectrometer Model: Spectrum GX.

UV- visible and florescent spectroscopic study

In order to evaluate optical effects on the absorption spectra, fundamental UV/Vis characterization has been carried out. The electronic spectra has recorded and revealed charge-transfer absorption band in the UV-visible region. Most of the absorption spectroscopy has been based on the transitions of n or π electrons to the π^* exited states which take place in the range of 200–1000 nm. UV-visible absorption measurements over a wavelength ranges 200–1000 nm were recorded on a Shimadzu, Japan (UV-160) spectrometer.

IV. RESULTS AND DISCUSSION

The spectra observed in the present study for the eosin dye doped 0.25%, 0.50%, 0.75% and 1.0% of strontium tartrate crystals are presented in Fig. 3(a), 3(b), 3(c) and 3(d) respectively. The Fig. 3(e) displays comparison of the all combined four FTIR data. The functional groups identified from the FTIR spectra confirm the material of the grown crystals as strontium tartrate. In the Fig 3(a), the stretching frequency 3408.4 cm^{-1} shows OH group presence in the

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0.25% doped strontium tartrate crystal. When dye doping increased more percentage like 0.50, 0.75 and 1.0 % the stretching frequencies shifted towards the higher frequency range. The OH stretching frequency appears at around 3400 cm^{-1} indicating the presence of water in the all crystals reflected. C=O stretching vibration frequency seems at 1591.4, 1590.7, 1588.2 and 1589.9 cm^{-1} of eosin dye doped 0.25%, 0.50%, 0.75% and 1.0% respectively, show that carbonyl group present in every doped strontium tartrate crystals. The bands at 3200 cm^{-1} are assigned to C-H stretching vibrations [16-17]. This indicates the presence of water and it belongs to free water symmetry stretch. The strong C-O stretch has been found around 1399 cm^{-1}. C-O-C asymmetric strong stretching has been observed in the range 1300-1270cm^{-1}. The single bond C-O stretch frequency is present at around 1390 cm^{-1} and observed in all four spectra about at 1389.3, 1390.1, 1384.4 and 1388.8 cm^{-1} of eosin dye doped 0.25%, 0.50%, 0.75% and 1.0% respectively. The metal-oxygen (Sr-O) stretching frequency has been observed in the range 700-950 cm^{-1} in all four FTIR spectra. The observed peak of vibrational data with corresponding assignments are given in Table 1.

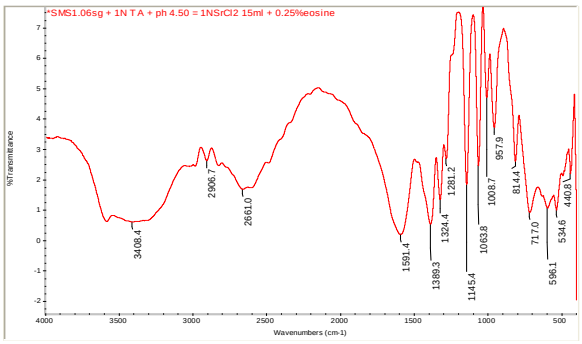
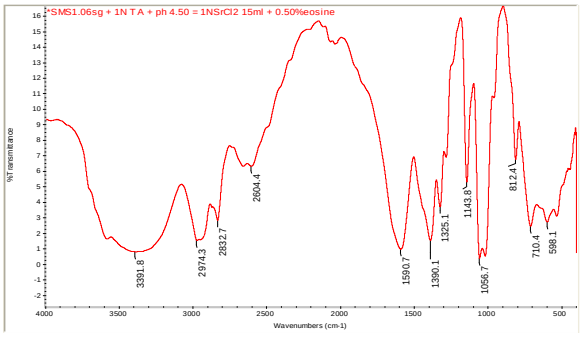


Fig. 3(a)



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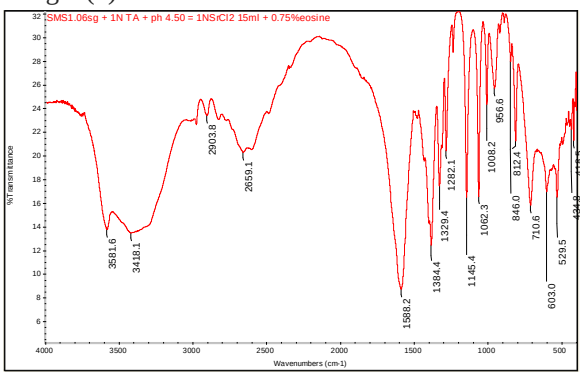

Fig. 3(c)

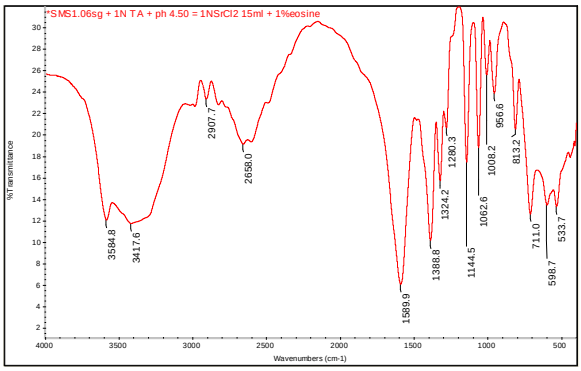

Fig. 3(d)

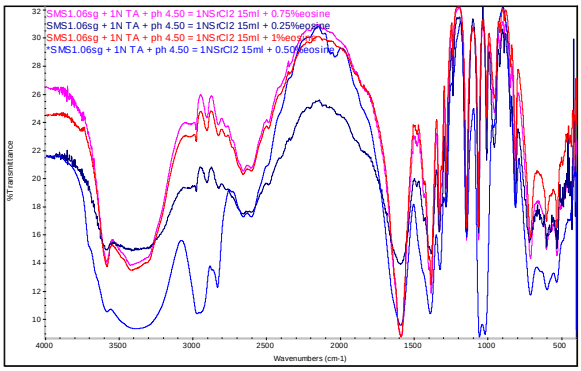

Fig. 3(e)

Fig. 3 FTIR spectrums of the (a) 0.25% (b) 0.50% (c) 0.75% (d) 1.0 % and (e) Comparison all four FTIR spectra of eosin doped strontium tartrate single crystals

Table 1 Peak assignments for FT-IR spectrum for Eosin doped $SrCl_2$

Assignment of absorption peaks	Peak positions in cm^{-1} (1M $SrCl_2$+ %Eosin)			
	0.25%	0.50%	0.75%	1.00%
O-H stretching vibrations	3408.4 2906.7 2661.0	3391.8 2974.3 2832.7 2604.4	3581.6 3418.1 2903.8 2659.1	3584.8 3417.6 2907.7 2658.0
C=O stretching vibrations	1591.4	1590.7	1588.2	1589.9
C-O stretching vibrations	1389.3 1324.4 1281.2	1390.1 1325.1	1384.4 1329.4 1282.1	1388.8 1324.2 1280.3
C-H stretching vibrations	1145.4 1063.8 1008.7	1143.8 1056.7	1145.4 1062.3 1008.2	1144.5 1062.6 1008.2
Metal - Oxygen (Sr-O) stretching vibrations	957.9 814.4 717.0 596.1 534.6 440.8	812.4 710.4 598.1	956.6 846.0 812.4 710.6 603.0 529.5 434.8	956.6 813.2 711.0 598.7 533.7

Dielectric crystals are mainly used in opto-electronic and photonic applications. So, the optical transmission wavelength range and cut-off wavelength are needed. Fig. 4 shows the UV-Vis spectra in the wavelength range 200-1000 nm of the eosin dye doped 0.25%, 0.50%, 0.75% and 1.0% of strontium tartrate crystals. From the spectra it can be seen that these crystals have sufficient transmission in the entire visible and most of the UV regions. When only strontium tartrate crystal, i.e. 0% eosin dye doped, no peak

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observed at 500-550 nm, and when added eosin dye doping by 0.25%, 0.50%, 0.75% and 1.0%, observed peak at 534, 535, 533 and 530 nm respectively. This indicating presence of eosin dye in the strontium tartrate crystals.

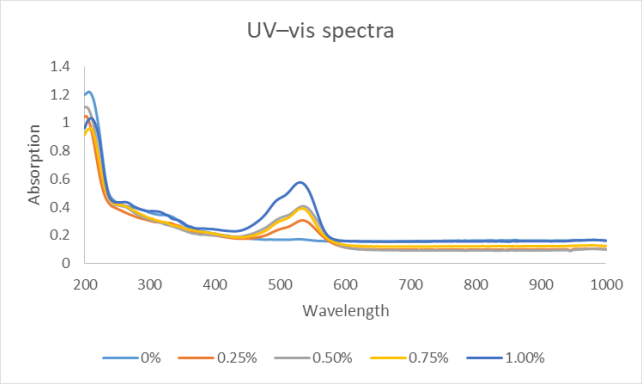

Fig.4 The UV-Vis spectra of all 0.0%, 0.25%, 0.50%, 0.75% and 1.0 % of eosin doped strontium tartrate single crystals

V. CONCLUSION

Pure and eosin doped (0.25%, 0.50%, 0.75% and 1.0 %) of strontium tartrate single crystals were grown by single diffusion reaction technique in silica gel medium. Various growth conditions were maintained to study the best growing environment for the growth of good quality crystals. The color of pure strontium tartrate single crystal is white and when doped eosin dye in strontium tartrate, the color of crystals are found to be pale pink and transparent quality crystals. The FTIR spectra have been recorded at room temperature to elucidate the various functional groups present in the crystal compounds of doped dye crystals. UV-Vis spectroscopy analyzed the optical property of the pure strontium tartrate crystals and eosin doped 0.25%, 0.50%, 0.75% and 1.0 % of strontium tartrate crystals. The results representing presence of eosin dye in the strontium tartrate crystals.

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