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Electrical Conductivity Studies on Pure and Cobalt Added Strontium Tartarate Trihydrate Crystals

KEYWORDS

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ABSTRACT *Pure and cobalt added strontium tartrate trihydrate crystals were grown using silica gel under laboratory conditions. The D.C. conductivity measurements, IR and XRD spectrum analysis were carried out on the grown crystals.The sharp peaks during XRD analysis clearly emphasized the crystal form. A shift in the frequencies of the doped sample in comparison with the pure sample was documented. Doping influenced the properties and crystals can be designed to meet the needs. The conductivity studies show an increase in conductivity with increase in the amount of Cobalt doped. However, more detailed investigations are needed to elucidate better outcomes.*

Introduction

Currently, a mickle of interest has been noticed in the study of the dielectric behavior of various materials, as these have a myriad of practical applications in the field of micro-electronics and opto-electronics (Suresh et al., 2011). Strontium tartrate is a pivotal ferroelectric strategic material with a wide spectrum of applications (Arora et al., 2001). Electrical conductivity is an amazing experimental tool to poke into the structural defects and internal purity of crystalline solids. The growth and characterization of pure and doped tartrate crystals for describing/finding new materials for practical purposes is extremely relevant (Suresh et al., 2006) in the current era of industrialization.

The use of Strontium tartrate (STT) in ammunition units are already well proved. Strontium tartrate tetrahydrate crystals are orthorhombic and monoclinic (Ambady, 1968: Joseph et al., 2009). The crystalline material conductivity in the higher temperature region is determined by the intrinsic defects induced by the thermal variances inside the crystal. In short, the temperature increase promotes more and more defects which lead to increased conductivity. However, there exists a lacuna of study about conductivity mechanism of Cobalt added STT crystals. The present work is in this perspective.

Materials and Methods

The growth of STT was accomplished by controlled diffusion of Strontium ions through silica gel tinctured with tartaric acid. The gel solution was prepared by mixing 1 M tartaric acid with silica gel, made from sodium metasilicate of density 1.05 g/cc. The titration was continued till pH reaches 4. The gel was set in about 48 hours. After the gel aging of one day, 1 M Strontium chloride was added above it without inducing any scathe and kept undisturbed at room temperature. Crystals appeared near the gel solution within two days and at the middle of the gel column within four days.

The anticipated chemical reaction is,

$$SrCl_2 + C_4H_6O_6 \rightarrow SrC_4H_4O_6 + 2HCl$$

Cobalt added STT crystals were also grown. The maximum size of pure crystals was about 7.5 x 4.2 x 4 mm and 10.2 x 4 x4 mm in the case of doped crystals. All the crystals were harvested after 30 days and its DC conductivity, IR (Nocolet Magna 560 FTIR)) and XRD spectrum (Debye Scherrer Powder method) was canvassed.

Results

Silica gel is the most ideal medium for crystal growth. It is widely accepted that very dense gel produces pure quality crystals which are mechanically stable. In the present study, all the crystals formed are dendrite shaped and colourless. Tendency to form crystals increases as depth from the interface increases. No crystals are found at the bottom region of the gel medium. Depth from the interface size of the crystals also increases and the time for formation of crystal depends on the molarity and pH of the gel (Photo 1).

The IR spectra in the region 400-4000A^0 with KBr sample pellet was evaluated. IR spectrum of pure STT crystals and doped STT crystals are given in Figure 1 & 2. Vibrations of tartarate ion, OH, carboxylic group and C-C-H are also documented. In the spectrum of pure STT a very strong peak is obtained at 1591.27 cm^{-1}. On the other hand, doped STT has a strong peak at 1593.23 cm^{-1}. This region is corresponding to asymmetric stretching of Coo^- ion. In the spectrum of pure STT a combination band is obtained at 1369 cm^{-1} while the doped STT the combination band is obtained at 1371.39 cm^{-1}.

The XRD spectrum of pure and doped STT is given in Figures 3 & 4. The sharp peaks indicate the sample is in crystal form from 2θ and d values. The S values of the crystal and lattice parameter are calculated and Miller indices (h, k, l) are assigned to some of the d planes. The S value sequence was in the order 6, 7, 8, 10, 11, 13, 15, 17, 18, 22, 24, 27, 31, 33, 35, 36, 39, 42, 49, 51, 53, 54, 59, 61, 63, 65, 69, 74, 76, 78, 82, 85 and 88. The results of DC conductivity studies are given in Table 1.

Discussion

Crystals have unique and incredible properties like ferroelectric, piezoelectric, dielectric, optical characteristics which contribute for infinite applications in industry (Freeda et al., 2012). In the present study the electrical conductivity of STT pure and doped crystals are studied. The finding of the present study is in tune with various available reports worldwide. Krishnan et al. (2009) reported the optical and dielectric studies on succinic acid single crystals. The electrical conductivity and Hall Effect in $GaInTe_2$ single crystals

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was also documented by Orainy et al. (2012).

The DC conductivity increases with increase in impurity concentration. With the increase in the amount of Cobalt doped, increased conductivity was noted which is strictly in a non-linear manner. Similar observations were reported by Peimo et al. (1993) regarding electrical conductivity studies of a pure C_{60} single crystal.

Conclusion

The growth of pure and Cobalt doped STT crystals grown under laboratory conditions and spectra were analyzed. A shift in the frequencies of the doped sample in comparison with the pure sample was documented. Doping influenced the properties and crystals can be designed to meet the needs. The conductivity studies show an increase in conductivity with increase in the amount of Cobalt doped. Further extensive studies in this regard are recommended to cope up with egressing market demands.

Photo 1. STT crystals (Specific gravity 1.05 g/cc; pH-4)

Samples	Resistance (R) M(Ω)	Conductivity σ dc (10^{-6}) s/m
Pure STT crystals (L=1.65 X 10^{-3}m)	3.2	3.88
STT with 0.01g Cobalt doped (L=2.65 X 10^{-3}m)	4.36	4.63
STT with 0.02g Cobalt doped (L=2.06 X 10^{-3}m)	2.41	6.44
STT with 0.03g Cobalt doped (L=2.50 X 10^{-3}m)	2.42	7.79
STT with 0.04g Cobalt doped (L=2.63 X 10^{-3}m)	1.95	10.16

Table 1.DC conductivity values of pure and doped STT

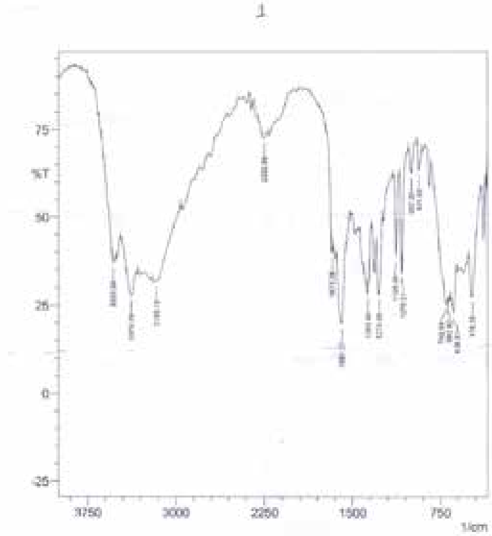

Fig. 1. Spectrum of Strontium tartarate crystals (Pure)

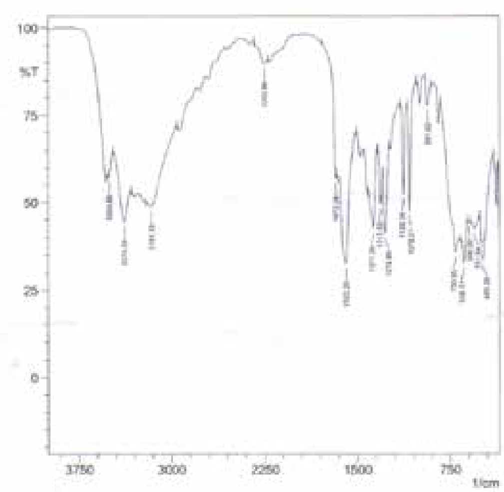

Fig. 2. Spectrum of Strontium tartarate crystals (Doped)

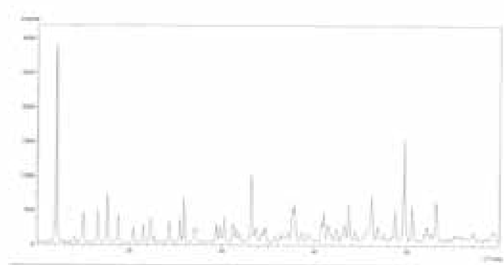

Fig. 3. XRD Spectrum of Strontium tartarate crystals (Pure)

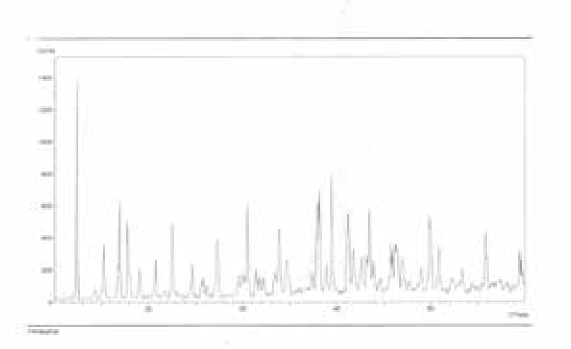

Fig. 4. XRD Spectrum of Strontium tartarate crystals (Doped)

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