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Thermal, magnetic, dielectric and anti microbial properties of solution-grown pure and doped sodium potassium tartrate crystals

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ABSTRACT

Crystals of pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt (sodium potassium tartrate) crystals are grown from solution at room temperature. The thermal studies such as TGA (thermo gravimetric analysis) shows that there are four stages of decomposition which is confirmed through the four endothermic peaks found in the DSC (differential scanning calorimetry) curve for both pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals. The magnetic susceptibility of the pure and doped crystals were found out to be 42.483×10^{-6} and 40.29×10^{-6} emu, respectively. Similarly, the magnetic moment of pure and doped crystals have been found out to be 3.19 BM and 3.10 BM, respectively. The antimicrobial activity of Pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals for various concentrations are explained in detail. The dielectric constant of pure and doped crystal decreases as the frequency of applied field increases at the end it gives diminishing value of dielectric constant. The dielectric nature of pure and doped crystals have been compared. The antimicrobial activity of pure and doped crystals shows the inhibition zone diameter for various concentrations with respect to *E. coli* and *Staphylococcus aureus*.

1. Introduction

The electrical properties of some of the tartrate crystals have attracted many of the crystal growth researchers. Some of these crystals are ferroelectric or piezoelectric in nature. Most of them are used in linear and nonlinear mechanical devices, fabrication of crystal oscillators and in transducers. The calorimetric, phase transition mechanism and electric behavior of metal tartrate crystals has been reviewed recently. These metal tartrate compounds have many applications in various fields [1–9]. Many authors have reported the vibrational studies of Rochelle salt and other metal tartrate crystals [10–12]. Taylor et al. have studied the Raman spectra and dielectric constant of ferroelectric Rochelle salt and calcium tartrate tetrahydrate crystals [13]. Kaneko et al. have reported the Raman and IR spectra and performed normal co-ordinate calculations of some metal tartrate crystals [14]. Bhattacharjee et al. has given a detail report about the Raman and FT-IR spectra of $K_2C_4H_4O_6{\cdot}1/2H_2O$ and $NaKC_4H_4O_6{\cdot}4H_2O$ crystals [15].

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2. Materials and method

The Sel de Seignette or Rochelle salt (sodium potassium tartrate tetrahydrate, $NaKC_4H_4O_6{\cdot}4H_2O$) is ferroelectric highly soluble in water and can be easily grown as large and colorless single crystal. Although it is a crystal in which ferroelectricity was earliest discovered but compared to other H-bounded crystals, little theoretical work has been done on this classic salt. It is ferroelectric between 255 K and 297 K showing orthorhombic structures in paraelectric phases and monoclinic in the ferroelectric phase. On duteration, lower and upper transition temperatures shift to 251 K and 306 K, respectively. The growth procedure, characterization such as Laser Raman, FTIR and XRD of pure and doped sodium potassium tartrate crystals have been dealt in detail by the same author already [16]. In the present work, the grown crystals were characterized by thermo gravimetric (TG) and differential scanning calorimetry (DSC) analysis, magnetic properties, dielectric studies and antimicrobial activity. A detail comparative study has been made.

3. Results and discussion

3.1. Thermal analysis

TG curves represent the variation of mass (m) of the sample with respect to temperature (T). Differential scanning calorimetry,

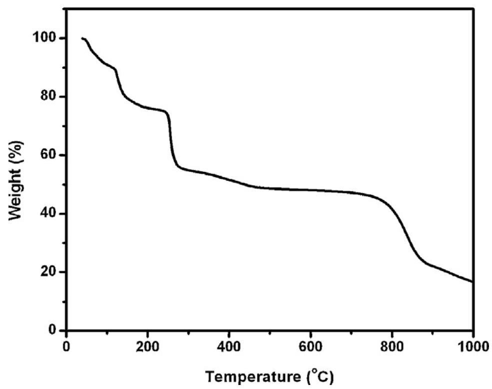

Fig. 1. TGA of pure Rochelle salt crystal.

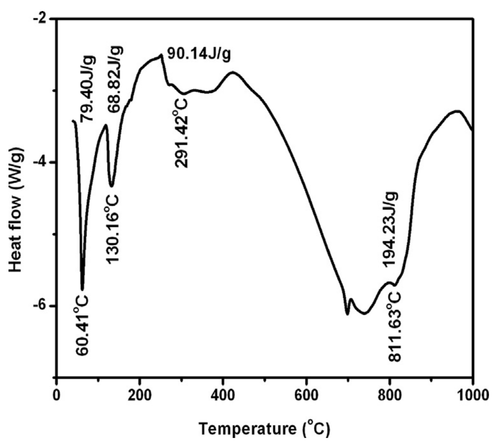

Fig. 2. DSC of pure Rochelle salt crystal.

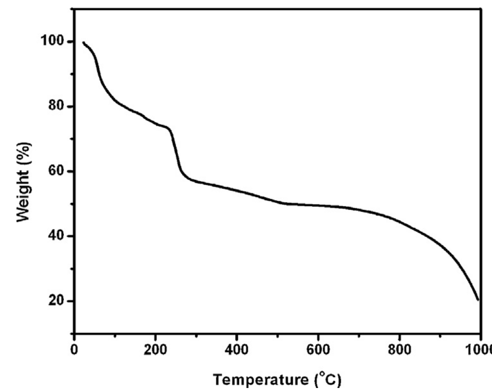

Fig. 3. TGA of $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystal.

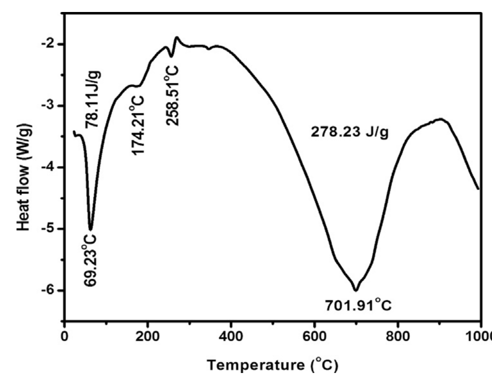

Fig. 4. DSC of $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystal.

or DSC, is a thermal analysis technique that looks at how a material's heat capacity (C_p) changes with respect to temperature. A sample of known mass is heated or cooled and the changes in its heat capacity are found out when there is change in heat flow. The transitions like melts, glass transitions, phase changes, and curing can be detected in this way.

The TGA analysis of pure sodium potassium tartrate crystal is shown in Fig. 1. The TGA analysis is done between 40 °C and 1000 °C at a heating rate of $20^\circ\,min^{-1}$ in nitrogen atmosphere. The first stage of decomposition starts from 50 °C and continues up to 120 °C resulting in a weight loss of about 14%. The second stage of decomposition starts from 125 °C and continues up to 200 °C resulting in a weight loss of about 10.9%. The third stage of decomposition starts from 205 °C and continues up to 500 °C resulting in a weight loss of about 6%. The fourth stage of decomposition starts from 505 °C and continues up to 1000 °C resulting in a weight loss of about 30%.

The DSC curves pure sodium potassium tartrate crystals show four endothermic peaks. This is shown in Fig. 2. The peaks at 60.41 °C, 130.16 °C, 291.42 °C and 811.63 °C show the first, second, third and fourth stage of decomposition, respectively [17].

The TGA of $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt ($NaKC_4H_4O_6{\cdot}4H_2O$) is shown in Fig. 3. There are four stages of decomposition of the sample. The first stage of decomposition starts from 50 °C and continues up to 120 °C resulting in a weight loss of about 15%. The second stage of decomposition starts from 125 °C and continues up to 210 °C resulting in a weight loss of about 11.2%. The third stage of decomposition starts from 215 °C and continues up to 500 °C resulting in a weight loss of about 7.8%. The fourth stage of decomposition starts from 505 °C and continues up to 1000 °C resulting in a weight loss of about 31%. The DSC curves of $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals show three endothermic peaks. This is shown in Fig. 4. The peaks at 69.23 °C, 174.21 °C, 258.51 °C, and 701.91 °C show the first, second, third and fourth stage of decomposition, respectively.

The decomposition process for pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals are shown in Table 1.

3.2. Magnetic properties

The magnetic properties of the pure and doped Rochelle salt crystals are found out by using Gouy balance. The measurements using Gouy balance is discussed in detail by the same author [18]. The details of magnetic properties of pure and doped crystals are given in Tables 2 and 3, respectively. A graph 'm' vs 'H^2' for pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals are given in Fig. 5.

3.3. Dielectric study

HIOKI 3532-50 LCR hitestester instrument and a conventional sample holder (westphal) were used to take the dielectric study of pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals. Silver paint has been applied to the sample and electrodes to ensure good electrical contact between the sample and the electrodes [19]. Dielectric measurements were made in the frequency range 50 Hz–5 MHz at room temperature (305 K).

Fig. 6 indicates the plots of dielectric constant vs frequency for pure and $Cu(NO_3)_2{\cdot}3H_2O$ doped Rochelle salt crystals. From the plots it can be seen that the dielectric constant decreases as the frequency of applied field increases. As the frequency is still increased, a point will be reached where the space charge polarization gets diminished, which gives rise to a very small and almost constant values of dielectric constant. Thus the crystal exhibit smooth