

Growth and Spectroscopic Characterization of Cobalt Tartrate Crystals

Ariponnammal S. and Srinivasan T.

Department of Physics, Gandhigram Rural Institute, Deemed University, Gandhigram, Dindigul District, TamilNadu 624 302, INDIA

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Abstract

Cobalt tartrate single crystals have been grown by gel growth method. The x-ray powder diffraction study has shown that the Cobalt tartrate has been crystallized in orthorhombic structure. The scanning electron microscope reveals the morphology of the crystal having nearly spherical particles embedded in coral reef structure. It resembles coral flower. The particle size is determined as 80.7nm. The analysis of EDAX has shown the presence of Cobalt and oxygen. The FTIR study has shown the presence of O-H bond, C-H bond and metal –oxygen bond. The UV-Vis spectrum shows high absorption in the ultra-violet region at about 365.7nm which makes the material to be suitable for UV filters. The energy gap is determined as 1.33eV.

Keywords: Cobalt tartrate, gel growth, XRD, SEM, UV-VIS, FTIR.

Introduction

The tartrate crystals have received a considerable interest due to their interesting physical properties and technological applications. Some crystals of this family are ferroelectric, some others are piezoelectric and quite few of them have been used for controlling laser emission¹⁻⁵. Several tartrate compounds find numerous applications in medical, pharmaceutical and industrial fields. It is notable that the tartrate compound is very much used in the treatment of cognitive disorders associated with diabetes, treating the cancer with tartrate ions and using tartrates in herpes⁶⁻⁸. Iron tartrate complex ions play important role as contrast blocks of renal tissues prior to their dehydration⁹. Also, Iron tartrate is one of the prominent species in apple juice¹⁰. Certain compounds find applications in cosmetics as hair conditioner additive and tanning agent for skin¹¹⁻¹². The tartrates also find applications in science and technology such as ferroelectric applications, ferroelectric - ferroelastic applications and dielectric applications¹³⁻¹⁷. They are used for transducers and many linear and non-linear mechanical devices¹⁸⁻¹⁹. Some tartrate compounds are used as tracers for military purposes²⁰. They also find industrial applications such as corrosion inhibitive composition for coolant system, light stabilizers for plastics and so on²¹⁻²². The study on tartrate compounds seems to be an application oriented and therefore, one such compound cobalt tartrate has been chosen for the present work.

Material and Methods

The crystals of Cobalt tartrate has been grown in silica gel in pure form by gel growth method, The powder XRD has been recorded by using Richseifert diffractometer. The SEM images were taken on a JEOL JSM-6390 model (made in Japan) scanning electron microscope. The EDAX spectrum was recorded by OXFORD INCAPENTAx3 model made in

England. The UV-Visible absorption spectrum was recorded using Perkin Elmer Lamda 35 spectrophotometer in the spectral range 200 to 1100nm.

Results and Discussion

XRD: The recorded powder XRD pattern for the grown cobalt tartrate crystal is shown in figure-1 and the data is analyzed by the method of least square fitting. The crystal is found to be crystallized in orthorhombic structure with $a=7.936\pm 0.02\text{\AA}$, $b=11.152\pm 0.02\text{\AA}$, $c=18.024\pm 0.02\text{\AA}$, $V=1595.17\text{\AA}^3$ and $\alpha=\beta=\gamma=90^\circ$ which is in agreement with reported values²³.

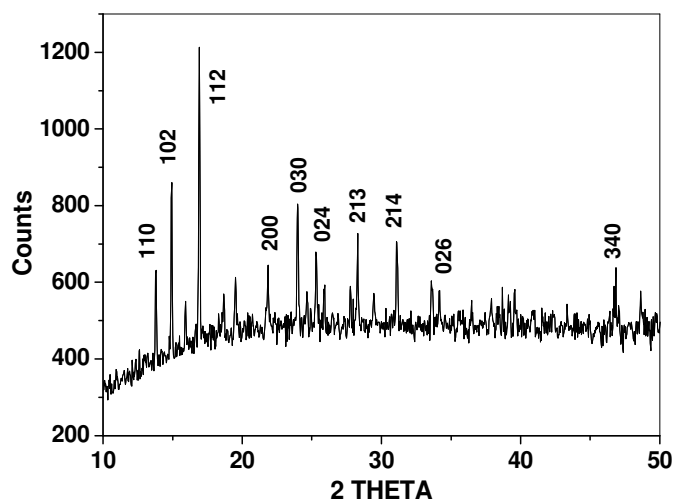


Figure-1

The X-ray powder diffraction pattern of Cobalt tartrate

SEM: The SEM images (figure-2) of cobalt tartrate ($\text{CoC}_4\text{H}_4\text{O}_6$) has shown considerable uniform distribution of spherical particles with particle size of 80.75nm. The scanning electron microscope reveals the morphology of the particles as spherical

particles embedded in rock like structure and it resembles coral reef like structure, since it has been grown by gel growth method. The expanded SEM image of magnification $\times 40,000$ shown in figure 3 has shown clearly the appearance of the spherical particles as coral flowers.

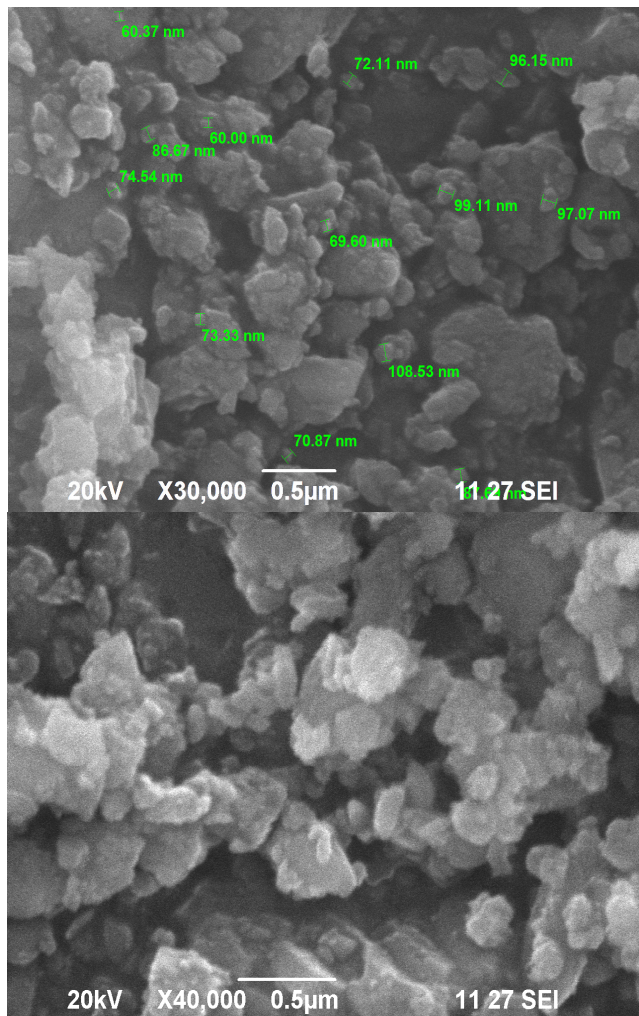


Figure-2

The SEM images of Cobalt tartrate with two different magnification

EDAX: The Cobalt tartrate is one of the more complicated systems with a number of phases and differing chemical compositions since it is grown in medium of silica gel by the diffusion of cobalt chloride into the gel. The diversity in the stoichiometry of cobalt tartrate poses a challenge for the control of size and shape. The energy dispersive x-ray spectrum (figure 4) has shown that the Co and O are present in the atomic percentage of 20.08 and 79.91 respectively and apparent concentration of 28.39 and 63.47. The analysis of EDAX has confirmed the hydrous nature of the compound. That is, cobalt tartrate with dehydrate ($\text{CoC}_4\text{H}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$) may be formed.

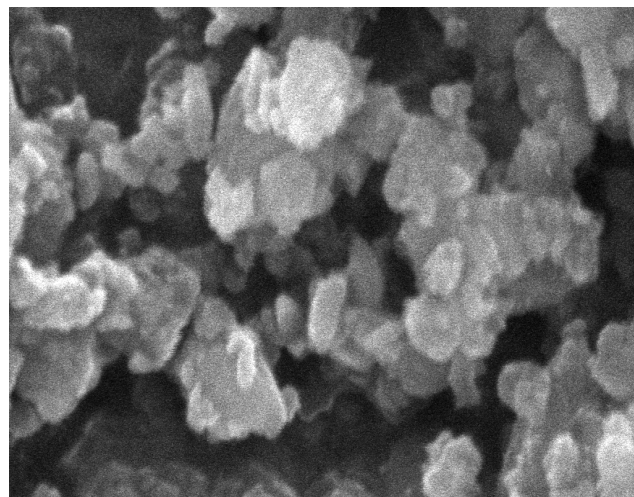


Figure-3

The Expanded SEM image of Cobalt tartrate with $\times 40,000$ magnification

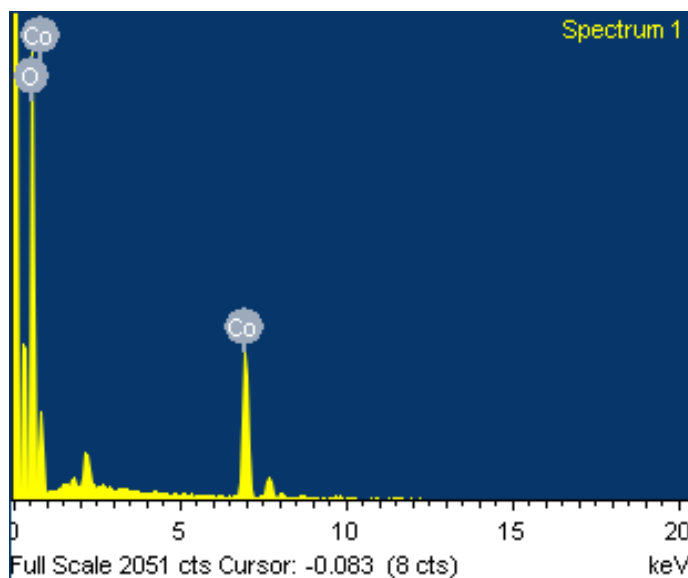


Figure-4

The EDAX pattern of Cobalt tartrate

FTIR: The figure 5 shows the FTIR spectrum of the Cobalt tartrate and table 1 presents the observed absorption frequencies and their assignments in relation to their characteristic vibrational modes. The broad trough positioned in between $3700\text{-}2700\text{ cm}^{-1}$ and the band at 1439.6 cm^{-1} corresponds to O-H bonding which confirms the hydrous nature of the compound. The band 572.2 corresponds to metal oxygen bonding and the bands observed at 628.3 , 717.9 and 931.7 cm^{-1} are the characteristic bands of C-H bending in tartrate²⁴⁻²⁶. The bands at 1047.7 , 1115.7 , 1239.2 , 1293.2 , 1381.4 and 1599.4 are the bands corresponding to C-O bonding in the tartrate of the compound²⁴⁻²⁵.

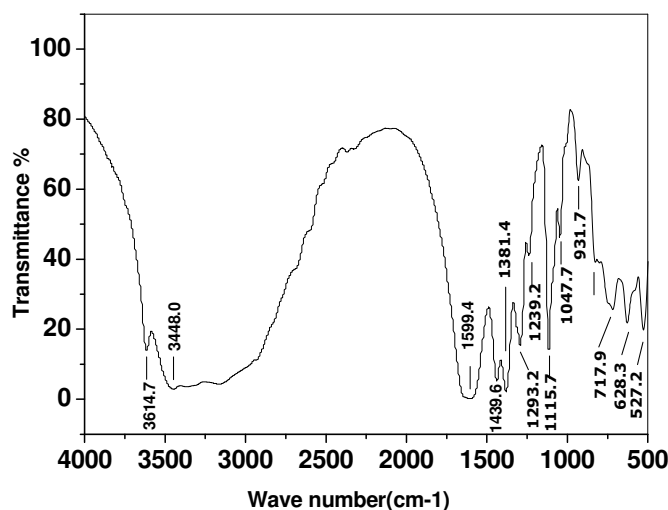


Figure-5
 The FTIR spectrum of Cobalt tartrate

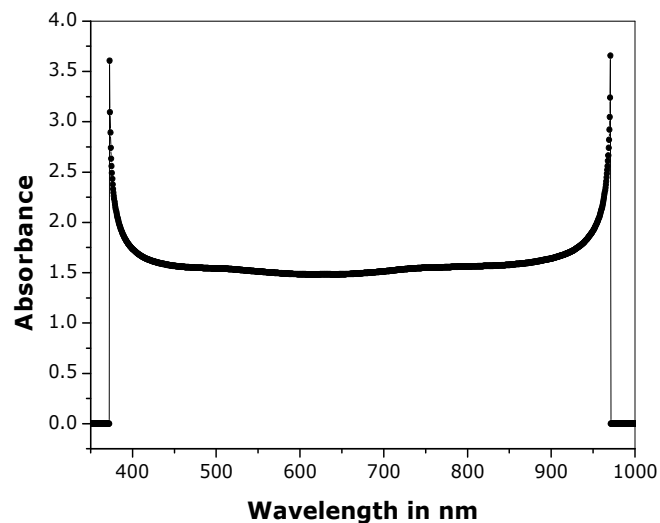


Figure-6
 The plot of absorbance versus wavelength of Cobalt tartrate

Table 1

The assignment of FTIR bands of Cobalt tartrate

Sl.NO.	Frequency of bands	Assignment
1.	3617.4	O-H stretching
2.	3448.0	O-H stretching
3.	1599.4	C=OH Stretching
4.	1439.6	OH in plane bending
5.	1381.4	C-O stretching and OH in plane bending
6.	1293.2	C-O stretching
7.	1239.2	C-O stretching
8.	1115.7	C-O stretching
9.	1047.7	C-O stretching
10.	931.7	C-H bending (out of plane) and O-H bending (out of plane)
11.	717.9	C-H bending and O-H bending
12.	628.3	C-H bending
13.	572.2	Metal oxygen bonding

UV-Visible: The transmission spectrum of Cobalt tartrate recorded in the UV-Vis region is shown in figure 6. It shows that the cobalt tartrate have high absorption in the ultra-violet region at about 365.7nm in UV region of the spectrum. This makes the material to be suitable for devices for good absorption of UV radiation that is, it can be used as a UV filters. The spectrum shows moderate transmittance in the visible region. The observed wide transmission in the entire visible region (300 to 1100 nm) enables it to be a potential candidate for optoelectronic applications. The energy gap has been deduced as 1.33eV from the plot of absorbance² versus wavelength shown in figure-7. The colour of the crystal indicates the semiconducting nature of the crystal which is confirmed by the energy gap Eg value of 1.33eV.

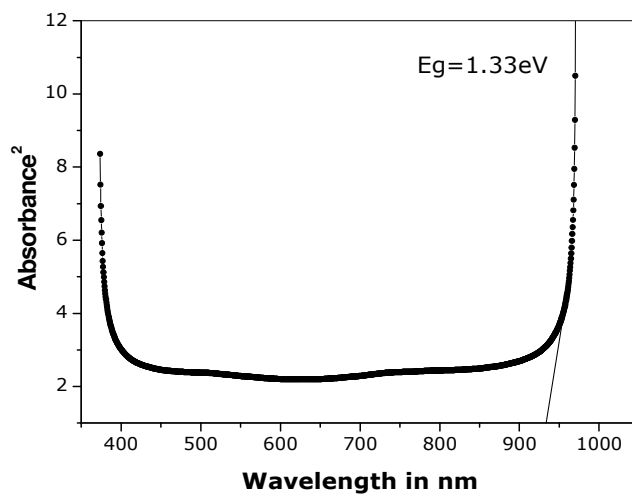


Figure-7
 The plot of absorbance² versus wavelength of Cobalt tartrate

Conclusion

The crystals of Cobalt tartrate has been grown by gel growth method. The powder XRD has confirmed the orthorhombic structure of the crystal. The SEM of cobalt tartrate ($\text{CoC}_4\text{H}_4\text{O}_6$) has shown considerable uniform distribution of spherical particles with particle size of 80.7 nm.. The morphology of the crystal has shown the spherical particles appearing as coral flowers embedded in coral reef like structure. The analysis of EDAX has shown the presence of hydrous nature of the cobalt tartrate crystal. The FTIR spectrum of the cobalt tartrate has shown the broad trough positioned in between $3700\text{-}2700\text{cm}^{-1}$ corresponds to O-H bonding confirming the hydrous nature of the tartrate compound. The spectrum has shown the presence of

metal oxygen band. The high absorption in the ultra-violet region at about 365.7nm nm makes the material to be suitable for UV filters and the wide transmission in the entire visible region enables it to be a potential candidate for optoelectronic applications. The energy gap of the crystal is deduced as 1.33eV which confirms the semiconducting nature of the crystal.

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