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ISSN: 2278-1862

Journal of Applicable Chemistry

2019, 8 (4): 1893-1899

(International Peer Reviewed Journal)

Growth, Characterization and Nucleation Reduction Mechanism of CCT Crystals in Silica Gel Medium at Different Environments

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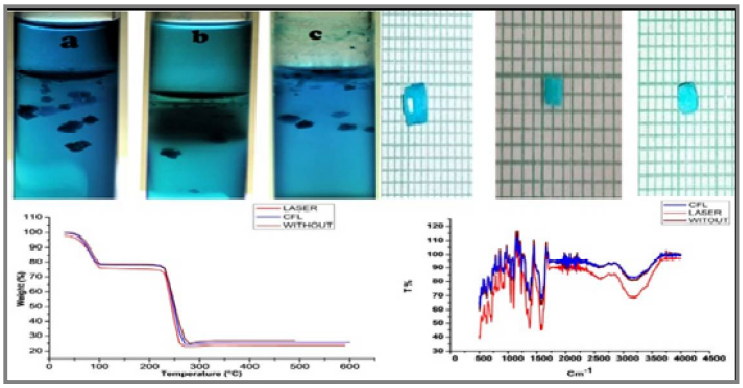
Accepted on 18th June, 2019

ABSTRACT

Cadmium doped Copper Tartrate (CCT) crystals were grown in silica gel medium using single diffusion methods at room temperature by passing semiconductor laser and other light radiations. Cadmium doped Copper Tartrate crystals were grown in three different growth faces to attain the total nucleation reduction. The metallic compositions in the crystals were estimated by Energy Dispersive X-ray Analysis (EDX). Thermo Gravimetric Analysis (TGA) of pure and Cadmium doped Copper Tartrate crystals suggest the possibility of the presence of co-ordinate water molecule in the crystalline structure. The functional groups present in the crystals were identified using Fourier transform infrared (FTIR) analysis. UV-Vis-NIR transmission spectrum was recorded to study the optical transparency of the grown crystals.

Graphical Abstract



Keywords: CCT, EDX, TGA, FTIR, UV-VIS-NIR.

INTRODUCTION

Single crystals are the backbone of the latest technology of logical innovation. In the present years crystals growth in gel medium has attracted the many investigators. Now a days great thinking has been devoted on the growth and characterization of doped crystals with the aim of determine new

materials for practical purposes. This effect single crystal is clearly visible on industries like semiconductors, optics, etc., most of the tartrate compounds are insoluble in water and molder before melting, hence single crystals of such types of compounds can't be grown by either melt techniques or slow evaporation. In this situation gel methods is the appropriate one for their growth. Many of tartrate compounds including pure and mixed tartrate deserve great attention due to its medical, pharmaceutical and industrial application, eg, injections of Na-Cr tartrate increase the susceptibility of the transplanted sarcoma to the effects of X-rays, ferrous tartrate to tan skin, Zinc tartrate with other compounds from bright coating and used as protecting powder for metals etc.,. Wide application of such compounds, many more authors also studied the growth and characterization of different compounds [**1-10**].

In the present investigation, Cadmium doped Copper Tartrate were grown in silica gel medium using single diffusion method at different environments. The next approach is to grown mixed crystal in silica gel medium at different environments, which contains two major elements Copper chloride and Cadmium chloride. These crystals are identified and characterized by Energy Dispersive X-ray analysis, FTIR, Thermogravimetry Analysis (TGA) and UV visible spectroscopy [**11-15**].

MATERIALS AND METHODS

Cadmium doped copper tartrate (CCT) crystals were grown in silica gel by employing the test tube diffusion method. Silica gel was prepared by adding sodium meta silicate solution of specific gravity 1.05 gm/cc to tartaric acid (1 M) drop by drop with continuous stirring with a view to avoid excessive local ion concentration which may cause premature local gelling and make the final solution in homogeneous and turbid. The pH of the gel was adjusted to attain the value of 3.5 to 6. This gelling mixture was allowed to set in glass tubes of 20 × 2.5 cm. The gel was found to set in about 4 days. After ensuring firm gel setting, a mixture of aqueous solutions of Cadmium chloride (0.5 M) and Copper chloride (1 M) was poured above the set gel with the help of a pipette, so as to allow the solution to fall steadily along the wall of the tube to prevent the gelled surface from cracking. The supernatant solution diffuses into the gel column and reacts with the inner reactant, giving rise to the formation of Cadmium doped Copper Tartrate crystals. The crystals were harvested after a month as shown in the figure 1 and 2.

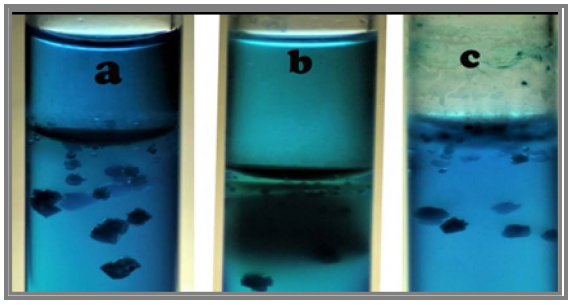


Figure 1. Growth condition in test tube

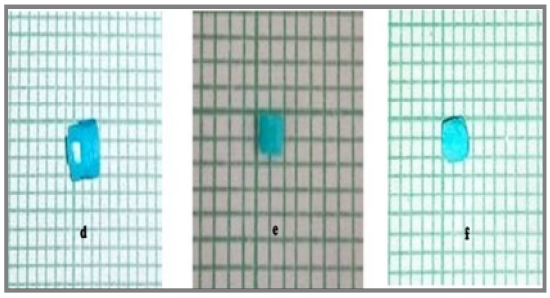


Figure 2. Harvested crystals

RESULTS AND DISCUSSION

Energy Dispersive X-ray Analysis: In order to confirm the presence of the elements in the grown CCT crystals, the sample of grown crystals were subjected to Energy Dispersive X-ray analysis. The obtained spectrum confirms the presence of cadmium and copper. The elemental analysis of cadmium doped copper tartrate crystals were shown in figure 3, 4 and 5. Table 1, gives the atomic % and weight % of cadmium doped copper tartrate crystals.

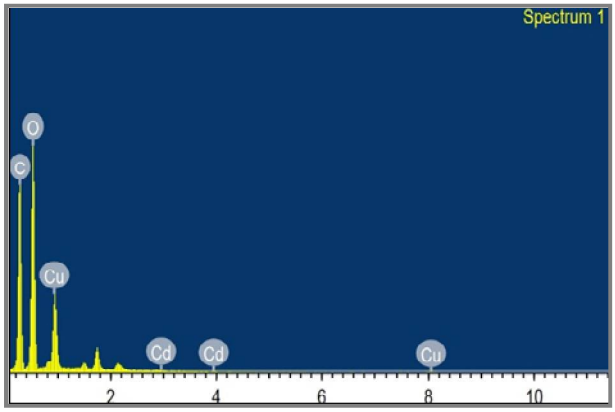


Figure 3. CFL

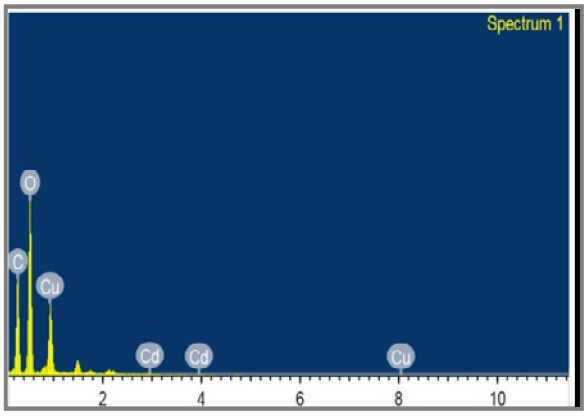


Figure 4. Laser

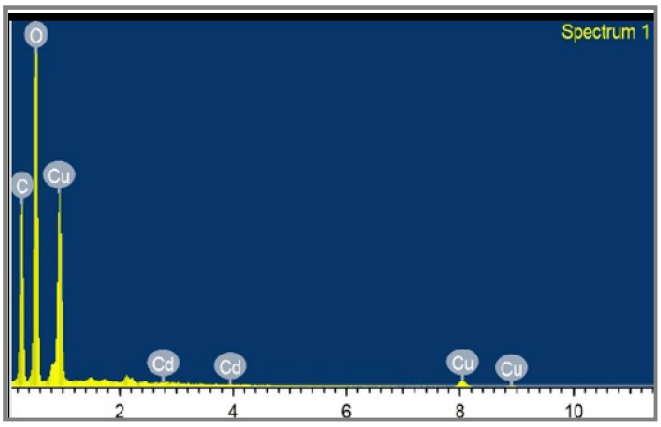


Figure 5. Without

Table.1 EDX result for CFL, Laser and Without

Crystals condition	Elements	Atomic %	Weight %	Crystals condition	Elements	Atomic %	Weight %	Crystals condition	Elements	Atomic %	Weight %
	C	60.75	51.08		C	61.60	53.63		C	60.16	49.55
CFL	Cu	8.83	19.18	Laser	Cu	7.57	26.18	Without	Cu	9.79	31.86
	Cd	0.04	0.24		Cd	0.02	0.056		Cd	0.03	0.16
	O	30.38	29.49		O	30.81	20.14		O	30.05	18.60
Total			100	Total			100	Total			100

FTIR spectral analysis: The FTIR spectrum recorded for the grown crystal of Cadmium doped Copper Tartarate at different environmental condition with observed band shown in figure 6, 7 8 and 9. The absorption peaks corresponded to the molecular group vibrations. In the FTIR spectrum, the absorption bands in the region 3190-2600 cm^{-1} are due to O-H stretching mode of water and C-H stretch. The band around 1573 to1595 cm^{-1} is attributed to the C=O stretch of carbonyl group. The strong peak 1381 cm^{-1} assigned to C=O symmetric. The C-O stretching vibration corresponded to absorption in the range 1381 to 1220 cm^{-1}. The peaks with in 1103 cm^{-1} to 1022 cm^{-1} are due to out plane O-H deformation and C-O stretching. The absorption situated below 898 cm^{-1} is due to metal oxygen vibration. It is confirmed that the water in crystallization and Cd-O, Cu-O crystals grown in different environments.

Thermo Gravimetric Analysis (TGA): The thermal behaviour of the grown crystal was studied by using TGA technique. The thermal decomposition of the crystals in different environmental condition were shown in the figure 10, 11, 12 and 13. The thermal decomposition occurs in two stages between of 25-600°C. Decomposition of the sample at 23°C and terminates at 303°C. There are two stages of

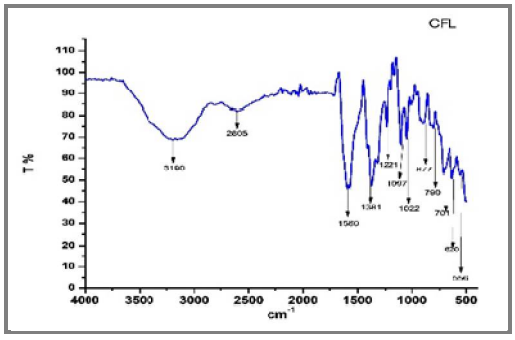


Figure 6. CFL.

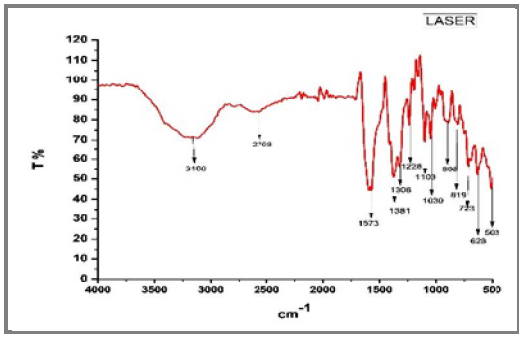


Figure 7. Laser.

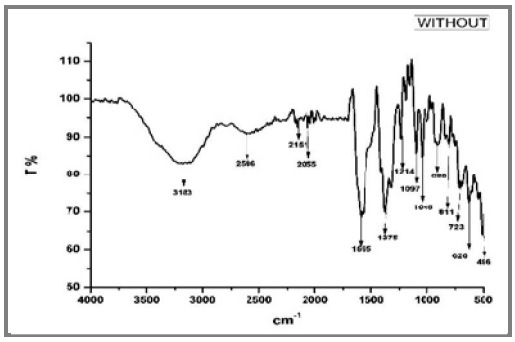


Figure 8 . Without.

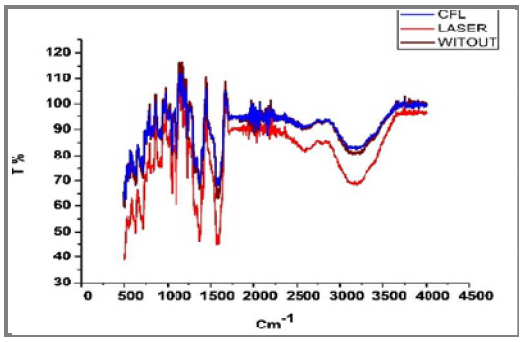


Figure 9. Variation on different environmental condition.

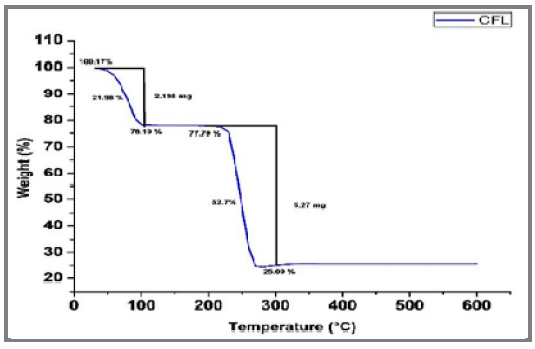


Figure 10. CFL

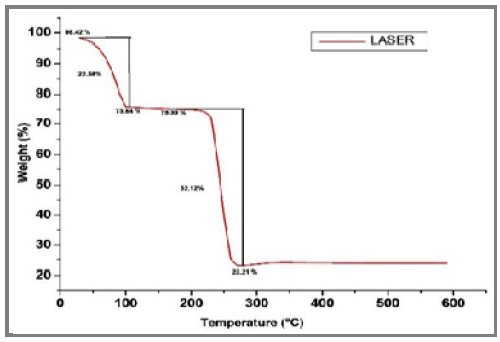


Figure 11. Laser

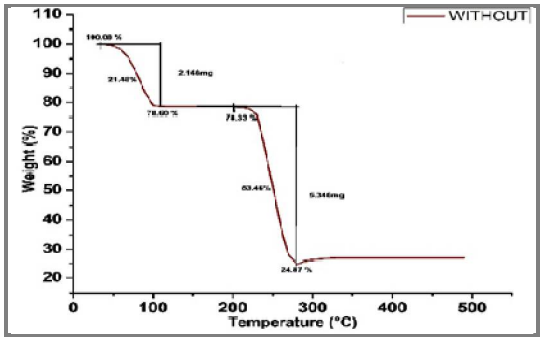


Figure 12 Without

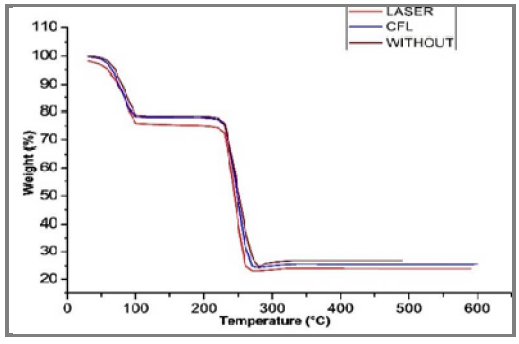


Figure 13. Variation on different environmental condition

decompositions. At first stage the crystal loss water and become anhydrous in the temperature range of 29 to 103°C. Then it decomposes into carbonate at the temperature range of 194-303°C. The weight loss of Cadmium doped copper tartrate with various radiations was tabulated table 2.

Table.2 The weight loss of cadmium doped copper tartrate with various radiations

Laser Radiation		CFL Light Radiation		Without Radiation	
Temperature (^oC)	Weight loss (%)	Temperature (^oC)	Weight loss (%)	Temperature (^oC)	Weight loss (%)
29.00 -77.93	22.58	31.73-106.29	21.98	32.83-108.37	21.48
194.70-302.13	52.12	195.53-274.48	52.7	201.77-279.57	53.45

UV-Vis absorption spectroscopy: The absorbance spectrum reveals that the sample has sufficient transmission in the entire visible and IR region. The absorption coefficient is high at lower wavelength 230 nm and the wide transparency from 290 nm suggestive their suitability for second and third harmonic generations of the 1100 nm radiation. The absorption spectra for Cadmium doped Copper Tartrate single crystals shows in the figures 14, 15, 16 and 17.

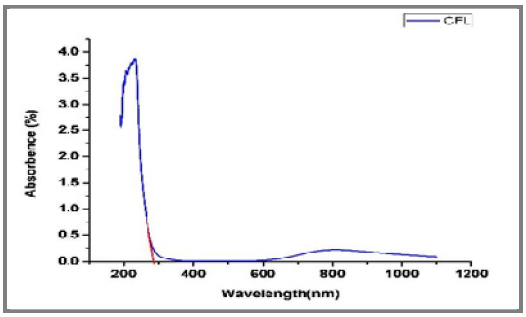


Figure 14. CFL

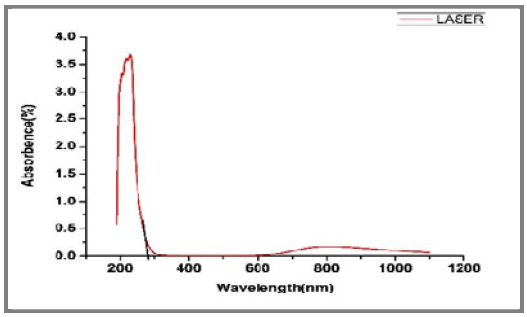


Figure 15. Laser

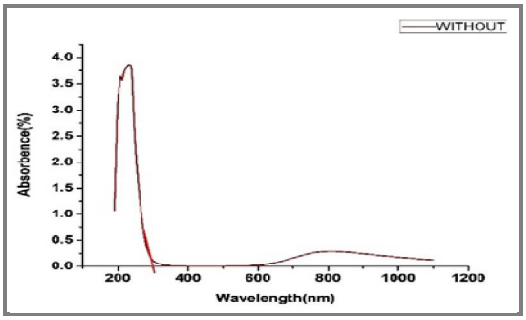


Figure 16. Without

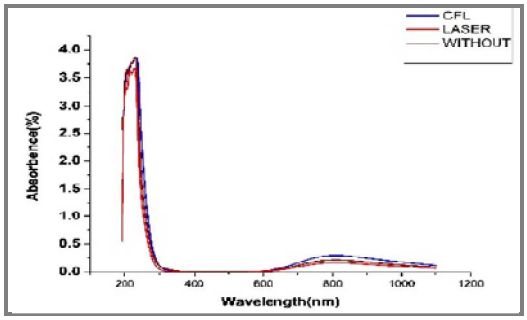


Figure 17. Variation on different environmental condition

Figures.14, 15, 16, and 17 shows the Absorbance of Cadmium doped Copper Tartrate single crystals

Tauc's plot gives the band gap energy of the CCT crystal was found to be 4.5eV and 4.7 eV, shown in the figure 18, 19 and 20. Hence by irradiating with light decrease the energy gap of the crystals.

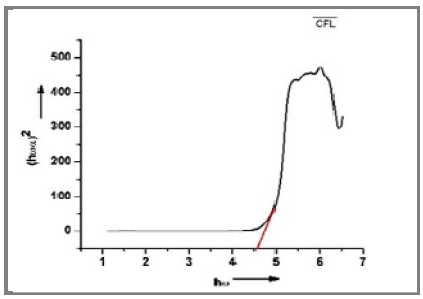


Figure 18. CFL

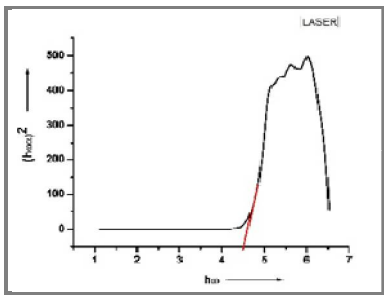


Figure 19. Laser

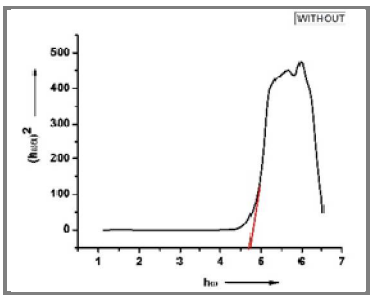


Figure 20. Without

Figures. 18, 19, and 20 shows hὼ vs $(\alpha h\grave{\omega})^3$ of Cadmium doped Copper Tartrate single crystals.

APPLICATION

CCT crystals are transparent to visible light. This allows them to be used for window applications, where the crystalline perfection and optical transparency is essential. As crystals behave as insulators and suitable for the fabrication of materials for opto-electronic devices. They can be used to develop copper clad laminates in PCBs and also various application of in the electronic industries.

CONCLUSION

Cadmium doped Copper Tartrate single crystals were successfully grown by the silica gel medium at different environment. The optimum conditions were identified by varying different parameters. FTIR and EDAX spectral studies confirm the presence of cadmium copper cation and tartrate group, bond in the CCT single crystal. The band gap energy, wide transparent nature indicates that the CCT crystals were insulators and suitable for the fabrication of materials for opto-electronic devices. The thermal stability was studied by the TGA supporting its application in the electronic industries.

ACKNOWLEDGEMENTS

The authors are thankful to the scientific officer DST-PURSE laboratory Mangalore University, Chairman Department of studies in Physics Mangalore University, Director USIC Mangalore University for providing facilities for the characterization and technical support to carry out the work.

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