ISSN: 0974-5823 Vol. 6 No. 3 December, 2021

International Journal of Mechanical Engineering

STUDY OF THERMAL & DIELECTRIC PROPERTIES OF METAL SULFATE CONTAINING NLO SEMIORGANIC CRYSTALS

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Abstract:

A nonlinear optical material crystals LM+CS and LV+LS are of semiorganic type. It has been grown using slow evaporation solution technique, from L-Methionine and Copper Sulfate Pentahydrate and L- Valine mixed with Lithium Sulfate. To get high optical perfection, they were crystalized and recrystallized by SEST at elevated temperature (40°C) from a supersaturated solution by stirring it for several hours. Their thermogram indicates that LM+CS and LV+LS are thermally stable up to 100 ºC and 130 ºC respectively, the dielectric constant has higher value at lower frequencies, and it gradually decreases with increase in frequency. These materials show exceedingly small optical nonlinearity.

Keywords: *Thermal Stability, Dielectric Constant, Nonlinearity.*

Introduction:

Researchers shown much interest in synthesizing NLO materials, in integrated optical devices all optical or hybrid effects are especially important. All optical nonlinearities are resulted from valence electron motion and is weak as compare with the hybrid one. Hybrid effects arrived due to the ionic motion, vibrational, orientational or translational and results into large nonlinearities, and faster electronic polarization. The speed of nonlinearities and magnitude are the main features of the NLO materials [1]. The NLO materials which are complexes of organic amino acids with metal (inorganic) salts are used for optical applications, such as optical communication, optical computing, optical information processing, optical disk data storage, laser fusion reactions and laser remote sensing [2-3].

Rresearch Methodology:

Material synthesis and crystal growth:

Analytical grade of L-Methionine and copper sulphate pentahydrates, also L-Valine and lithium sulfate (Loba Chemie) were taken as per there solubilities measured in double distilled water to grow crystals. The solution was stirred continuously for several hours, and the solution was vacuum filtered by Whatman's filter paper. The solution was kept undisturbed at 40 ºC in PID controlled constant temperature bath. Fig. 1 shows, the good quality crystals of LM+CS and LV+LS were grown within 3 weeks by allowing slow evaporation of supersaturated solution at constant temperature. Fig.-1 & Fig.-2 shows grown crystals of LM+CS & LV+LS.

Fig.-1 Grown crystal of LM+CS.

Fig.-1 Grown crystal of LV+LS.

Analysis and Discussion

Thermal analysis of LM+CS & LV+LS:

The thermal stability of the crystals was analyzed from the TGA/DTA data in the air as an atmosphere at the heating rate of 10 ºC/min using Perkin Elmer simultaneous TGA/DTA analyzer in air as an atmosphere in the temperature range between from 25 to 400 ºC and the resultant thermogram is shown in the Fig. (3) & (4).

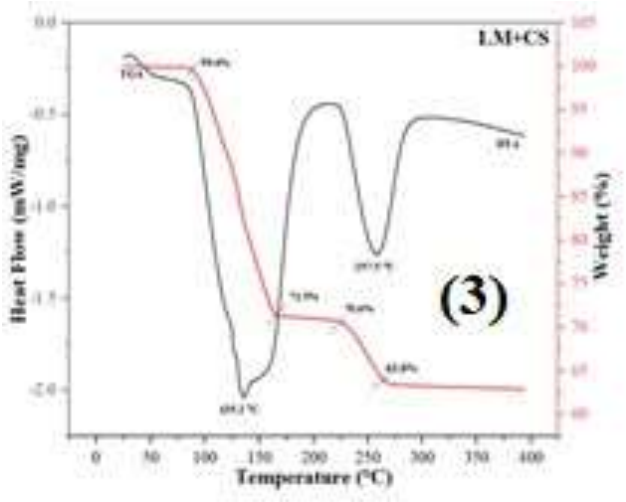

Fig.-3: TGA/DTA of crystal LM+CS

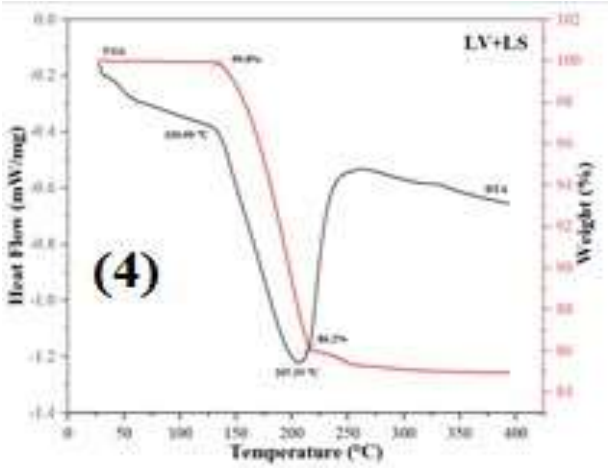

Fig.-4: TGA/DTA of crystal LV+LS

The TGA curve of LM+CS shows that there is a loss of weight in two stages of thermal decomposition, in the range between 88.5-164.3 ºC and 225.8-265.6 ºC in association with a sharp endothermic peak at 135.2 ºC and 257.5 ºC in DTA, which shows the absorption of energy for disappearing of bonds at the initial and final stage of decomposition. From TGA graph there is negligible loss below 135.2 ºC, which is the melting point of the crystal. From the results of DTA, it is observed that before melting point there is no transformation inside the structure. The crystal can retain its texture up to 135.2 ºC.

The TGA curve of LV+LS shows that there is no weight loss traced up to the 130 ºC, which shows that there is no decomposition up to this point and this will be insured thermal stability of material for possible application in lasers. Without any intermediate stages, there is 13.3% loss of weight in the temperature range 130-215 ºC in association with a sharp endothermic peak at 207.35 ºC in DTA. The TGA/DTA curves may be ascribed the absorption of energy for breaking of bonds at the initial and final stage of decomposition of weight beyond 400 ºC, as both L-Valine (298 ºC) and Lithium Sulfate (859 ºC) have remarkably high melting point.

Dielectric studies of LM+CS & LV+LS:

Dielectric study of crystals was carried out to investigate the response of the crystal to an applied electric field. The capacitance was measured as a function of frequency in the range 1KHz – 6MHz at a constant temperature of room temperature using a two-probe setup. LM+CS crystal of dimension $10 \times 10 \times 5$ mm^3 was cut parallel to (1 1 0) plane and LV+LS crystal of dimension $15 \times 15 \times 3$ mm^3 was cut parallel to (1 1 1) plane and polished. Silver paste was pasted on two opposite faces of the crystal to make a parallel plate capacitor and used in the measurement.

The variation of dielectric constant with frequency is shown by Fig. (5) & (6). The dielectric constant and dielectric loss are higher in the region from 1KHz - 1MHz Hz and gradually decreases with increase in frequency and continues up to 6MHz. After this, it almost remains constant at all other higher frequencies. The high value of dielectric constant at low frequency may be due to electronic, ionic, dipolar and space charge polarizations in the material [4]. Whereas the lower value of dielectric constant at higher frequency improves SHG efficiency [5].

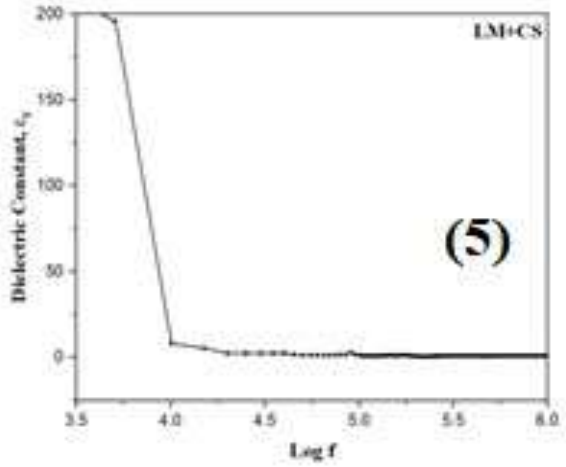

Fig.-5 : Dielectric constant vs Logf of LM+CS crystal.

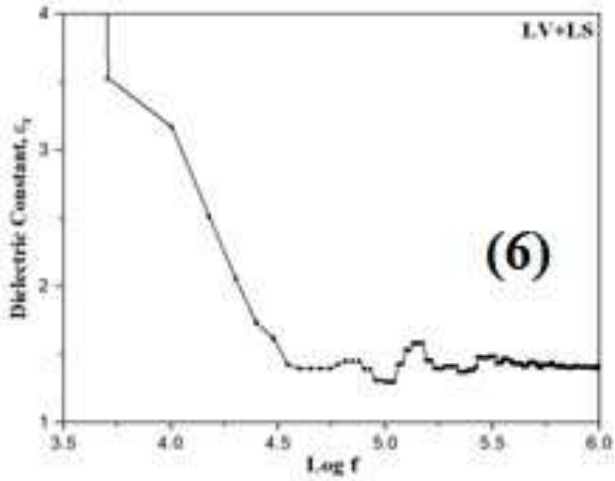

Fig.-6 : Dielectric constant vs Logf of LV+LS crystal.

Conclusion:

The thermal analysis shows that LM+CS & LV+LS crystals are thermally stable only up to 100 ºC & 130.09 ºC respectively. Dielectric measurements indicate that both the grown crystal has low values of dielectric constant at high frequency. Kurtz- Perry test confirms that LM+CS & LV+LS has exceedingly small SHG efficiency in comparison with Urea and KDP.

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