International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.6, pp 3237-3240, Aug-Sep 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

Optical and Dielectric Characterization of a new Non linear Optical Urea Sodium Chloride single crystal by slow evaporation technique

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Abstract: Single crystals of Urea Sodium Chloride a novel semi organic non linear optical crystal has been synthesized using slow evaporation technique at room temperature. The lattice parameters for the grown crystals were determined using single crystal XRD. The functional groups of the grown crystal were found by using Fourier Transform Infrared spectroscopy. The UV cut-off wavelength is found to be at 210 nm. TG / DTA studies show thermal properties. The dielectric constant and dielectric loss of the crystal were measured as a function of frequency and temperatures. The second harmonic generations was confirmed by the emission of green radiation.
Keywords: Growth from solution, Optical properties, Dielectric constant.

Introduction

In recent years many significant achievements have been occurred in the field of nonlinear optics because of semi organic materials. Nonlinear optical (NLO) materials plays a vital role in the field of optical computing, optical communication, optical switching, electro-optic shutters, optical modulations, optical logic, frequency shifting, optical data storage for developing technologies in telecommunication, signal processing, optical parallel information processing, laser fusion reaction and medical diagnostics [1-7]. In the present study, urea is combined with sodium chloride to form a new semi organic nonlinear optical material and its properties like optical and dielectrics studies.

1. Experiment

The starting material was synthesized by taking Urea (AR grade) and sodium chloride (AR grade) in 1:1 molar ratio and it was dissolved in millipore water of resistivity 18.2 MΩ cm. The solutions were thoroughly mixed for about 12 hours using a magnetic stirrer to ensure homogeneous concentration over entire volume of the solution. The solution was left undisturbed for slow evaporation. After 25 days, optically good quality single crystal USC of size 11mm x 9mm x 5mm were grown and are shown in Fig.1.

Fig.1.Single crystal of USC

2. Result and discussions

2.1 Single crystal X-ray diffraction

The grown crystals were subjected to single crystal X-ray diffraction analysis using ENRAF-NONIUS CAD-4 automatic X-ray diffractometer to determine the cell parameters and it reveals that the USC crystal crystallizes in monoclinic system having non- centro symmetric space group I_2. The lattice parameters were found to be a = 6.44 Å, b = 5.245Å, c = 17.312 Å, and α=90°, β=90.15°, γ=90°, V=588.76 Å^3.

2.2. FTIR analysis

The FT-IR spectrum was recorded using BRUKER IFS 66V spectrophotometer by KBr pellet technique in the range 4000-450 cm^{-1}.The Fourier transform infrared (FTIR) spectrum of USC are shown in Fig.2. The broad band at 3446 cm^{-1} is due to asymmetric stretching of NH_2 vibration of USC. The band at1631cm^{-1} are due to asymmetric bending modes. The weak band appearing at 1458 cm^{-1} is due to δ symmetric stretching vibration. The band at 1010 cm^{-1} is due to symmetric or asymmetric mode of vibration of N –C –N.

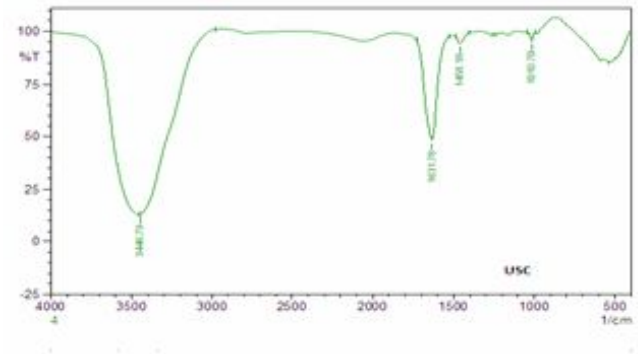

Fig.2. FTIR Spectrum of Urea Sodium Chloride

2.3 Optical absorption studies

The optical absorption spectral analysis of the grown crystal was carried out between 200-2000 nm using VARIAN CARY 5E spectrophotometer and is shown in the Fig.3. There is a very low absorbance in the entire visible region. This is one of the most desirable properties of the crystals for the device fabrication. The UV cut off wavelength of the crystal was found to be at 210 nm.

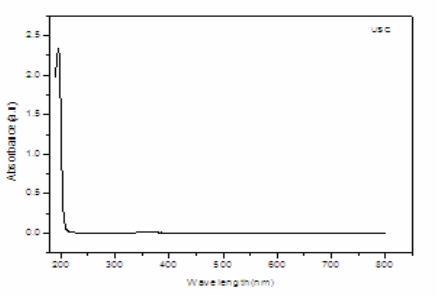

Fig.3. UV – Visible spectrum of USC

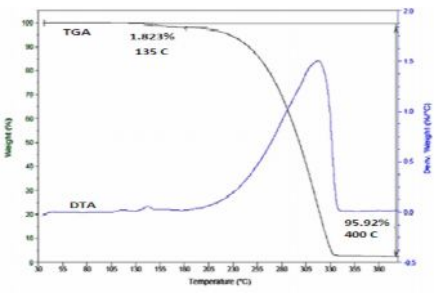

Fig .4. TG / DTA Curve of USC

2.4. Thermal studies

The thermo gravimetric analysis of urea sodium chloride crystals was carried out for the temperature between 30 to 300˚ C at a heating rate of 20˚ C min^{-1} in nitrogen atmosphere using alumina thermal analyzer and the obtained thermogram is shown in the Fig. 4. The TGA curve indicates a small weight loss from 135°C to 200°C indicates the evaporation of adsorbed water vapour. The drastic weight loss at 200°C to 310°C is assigned for decompose of the sample. The material is moisture free and stable upto 135°C so the compound could be used for device fabrication below its melting point of the crystal. The DTA thermo gram confirms that the exothermic peaks coincide with that of TGA. It confirms the thermal stability of the crystal.

2.5. Dielectric studies

Dielectric properties are correlated with electro – optic property of the crystal. The studies were carried out from 40°C to 80°C for frequencies varying from 50Hz to 5 MHz. The frequency dependence of the dielectric constant at different temperature is shown in Fig.5. At low frequencies, the dielectric constant is found to be a maximum and it decreases with increasing frequency. Higher value of dielectric constant at low frequency may be attributed to space charge polarization. The dielectric loss as a function of frequency suggests that dielectric loss strongly depends on the frequency of the applied field. The low value of dielectric loss reveals the very high purity of the USC crystal.

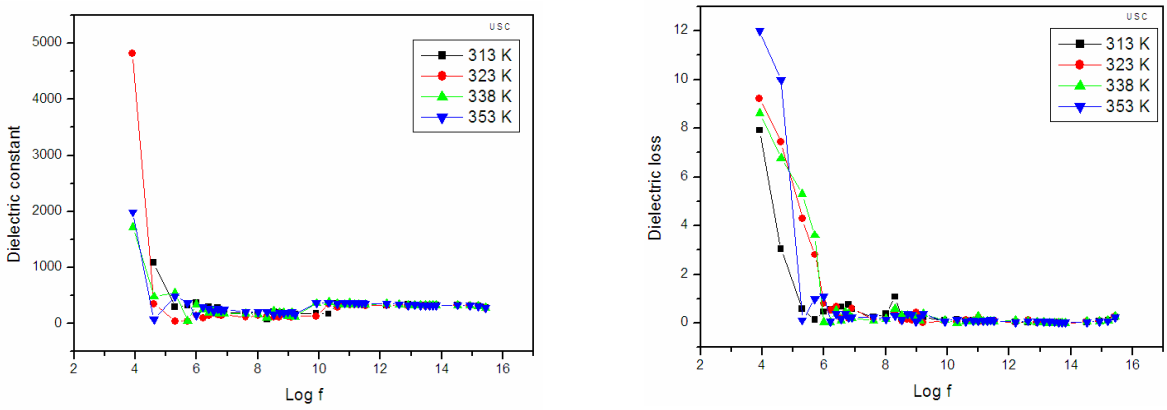

Fig.5. Dielectric constant vs frequency and Dielectric loss vs frequency of USC

2.6. Nonlinear optical studies

The Second Harmonic Generation of USC was studied using a Q-switched Nd : YAG laser by employing Kurtz- perry(8) powder test. The fundamental beam of an Nd: YAG laser with 1064 nm wavelength is focused on to the powdered sample. The SHG was confirmed by the emission of green radiation signal at 532 nm is recorded at various points on the sample using a photomultiplier tube and boxcar average. The intensity of the incident power was 6.9 mJ pulse and the intensity of output power was 10.5 mV with reference to KDP (7.5 mV). The SHG efficiency of USC crystal is found to be 1.5 times greater than that of KDP.

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