Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 05, pp.16448-16451, May, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

DIELECTRIC AND AC CONDUCTIVITY STUDIES OF SOME INORGANIC CRYSTALLINE COMPOUNDS

*,[1]Indira, S., [2]Ramesh, K. and [3]Viruthagiri, G.

[1]Research Scholar, Karpagam University, Coimbatore
[2]Vidyaa Vikas College of Engineering and Technology, Tiruchengode
[3]Department of Physics, Annamalai University, Annamalainagar

ARTICLE INFO

Article History:
Received 07th February, 2015
Received in revised form
23rd March, 2015
Accepted 18th April, 2015
Published online 31st May, 2015

Key words:
Crystal growth, Crystals of various sulphate compounds, Dielectric and AC conductivity studies.

ABSTRACT

The spectacular advances made in the growth of single crystals with or without suitable addition of impurities have facilitated the fabrication of transistor, IC's, piezoelectric filters, solid-state lasers and so on. The crystal growth technology directly used for the growth and development in the field of electronics, fibre-optics communication and laser. The pure crystals of copper sulphate, nickel sulphate, nickel sulphate doped with zinc sulphate, zinc sulphate and magnesium sulphate were grown by slow evaporation method at room temperature. The grown crystals were subjected to dielectric and AC conductivity studies and the results are discussed.

Citation: Indira, S. Ramesh, K and Viruthagiri, G., 2015. "Dielectric and AC conductivity studies of some inorganic crystalline compounds", *International Journal of Current Research,* 7, (5), 16448-16451.

INTRODUCTION

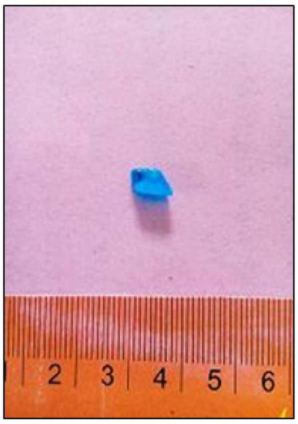
Pure nickel sulphate is reported to be orthorhombic in the literature. The crystals of nickel sulphate can be easily grown by solution method. The crystal structure of magnesium sulphate is also reported to be orthombic. Many research workers have reported the growth and characterization of nickel sulphate and magnesium sulphate in the literature (Ikeya, 2000). Epsomite ($MgSO_4$. 7H $_2$O), magnesium sulphate heptahydrate is a hydrogen bonded crystal belonging to the orthorhombic crystal system with a tetra molecular unit cell . It is isomorphous with NiSO $_4$. 7H $_2$O and $ZnSO_4$. $7H_2O$. Crystal growth and characterization of magnesium sulphate, nickel sulphate, copper sulphate and zinc sulphate are of great importance as these materials are important inorganic substances having wide applications in the fields of agriculture, medical, dosimetric and luminescence studies (Mahadevan, 1998 and Lal *et al.,* 1969). In this article, the grown crystals are subjected to dielectric and AC conductivity studies. The results are reported for the effect of dielectric constant, dielectric loss and AC conductivity of the grown crystal with temperature.

MATERIALS AND METHODS

Slow evaporation technique is the simplest way to grow crystals and works best for compounds, which are not sensitive to ambient conditions in the laboratory. A solution of the compound is prepared in a suitable solvent. The solution is saturated or nearly saturated. The solution is transferred to a clean crystal growing dish and it is covered. The covering for the container should not be airtight. The container is placed in a quiet dust free and thermally stable environment. The controlled evaporation of solvent leads to crystallization. The samples grown in this work were pure crystals of copper sulphate, nickel sulphate, nickel sulphate doped with zinc sulphate, zinc sulphate and magnesium sulphate. The crystals were grown by solution method with slow evaporation technique. To grow crystals, Analytical Reagent grade (AR) chemicals were used. The solvent used to grow crystals was deionised water. The salt of nickel sulphate was used to prepare the saturated solution and it was filtered and kept in a beaker. The beaker was covered with perforated paper for slow evaporation. After 20 to 25 days, crystals were harvested. Similarly crystals of copper sulphate, zinc sulphate and magnesium sulphate were grown. To grow mixed crystals of nickel sulphate and zinc sulphate, the salts were taken in the molar ratio of 1:1 and the saturated solution was prepared. The solution was kept in a separate beaker and it was allowed to evaporate at room temperature. It took about 20 days to obtain mixed crystals zinc sulphate and nickel sulphate. The photographs of the grown crystals are displayed below.

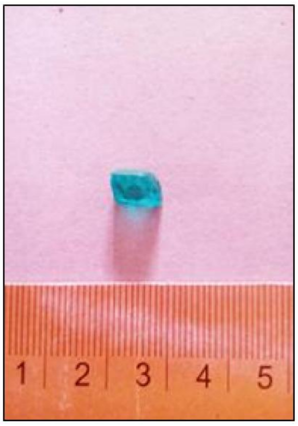
***Corresponding author: Indira, S.**
Research scholar, Karpagam University, Coimbatore

Figure. 1.1: Photograph of $CuSO_4.7H_2O$ crystal



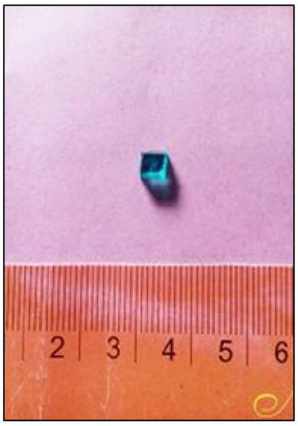
Size: 5mmx4mmx3mm

Figure. 1.2: Photograph of $NiSO_4.7H_2O$ crystal



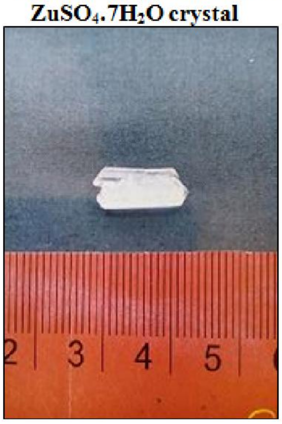
Size: 5mmx4mmx3mm

Figure. 1.3: Photograph of $NiSO_4$ and $ZnSO_4$ crystal



Size: 3mmx3mmx3mm

Figure. 1.4: Photograph of $ZuSO_4.7H_2O$ crystal



Size: 13mx6mmx3.5mm

Figure. 1.5: Photograph of $MgSO_4.7H_2O$ crystal

Size: 15mmx6mmx3.5mm

RESULTS AND DISCUSSION

Dielectric constant and dielectric loss

One of the widely used parameters is the dielectric constant of a material which gives an insight in to the nature of bonding (Suresh sagadevan *et al.,* 2014). A good quality crystal was selected from the grown crystals and its faces were polished. Graphite paint was coated on the faces of the crystal to obtain a good ohmic contact. The capacitance with crystal and dielectric loss were measured using an LCR meter shown in figure 2.1 and a two-probe arrangement with fixed frequency 1 kHz at temperature ranging from room temperature 30°C to 70°C. Temperature of the crystal was measured using a sensitive digital thermometer.

By varying the temperature, the capacitance for the respective temperature is noted. The dielectric constant (ε_r) was determined with the formula $\varepsilon_r = \frac{c}{Co}$

Where, c is the capacitance of condenser with crystal,

c_o is the capacitance of condenser without crystal. At the same time the equivalent series resistance is measured with the same LCR meter.

The dielectric loss is determined by the formula tanδ = (ESR/X_C)

Where, ESR is the equivalent series resistance,
X_C is the capacitive reactance ($1/\omega_c$).

Figure 2.1. Digital LCR- meter

The low dielectric loss value of the grown crystals at room temperature indicates that the crystals are of high quality

(Hatton, 2006). For a particular temperature the dielectric constant and dielectric loss were noted. A graph is plotted between dielectric constant with temperature and dielectric loss with temperature. The variation of dielectric constant with temperature and dielectric loss with temperature is shown by Figure 3.1(a), 3.1(b), 3.2(a), 3.2(b), 3.3(a), 3.3(b), 3.4(a), 3.4(b), 3.5(a), 3.5(b).

(30°C to 70°C). The AC conductivity of the crystalsincreases at high frequencies (Bala subramania, 2010).The AC conductivity is calculated by using the formula $\sigma_{ac} = 2\pi \upsilon \, \varepsilon_o \, \varepsilon_r \tan\delta$.

Where, υ - is the frequency of ac given to LCR meter.
ε_O - is the permittivity of free space
ε_r - is the dielectric constant for a given temperature
$\tan\delta$ - is the dielectric loss for a given temperature

Dielectric studies and AC conductivity of $CuSO_4.7H_2O$ crystal

Figure: 3.1(a)

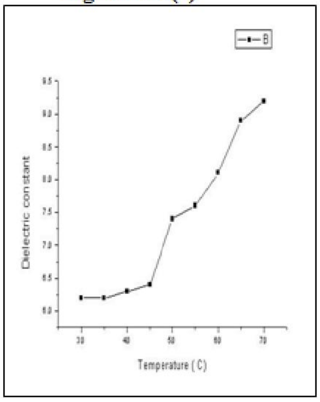


Figure: 3.1(b)

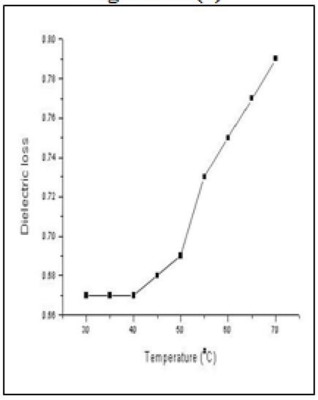
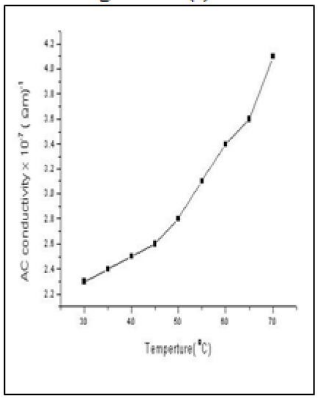


Figure: 3.1(c)



Dielectric studies and AC conductivity of $NiSO_4.7H_2O$ crystal

Figure: 3.2(a)

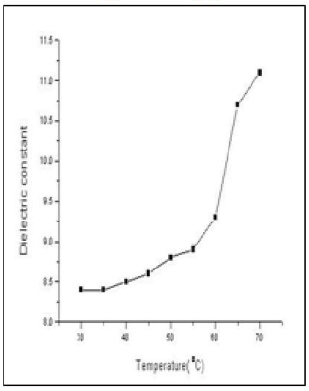


Figure: 3.2(b)

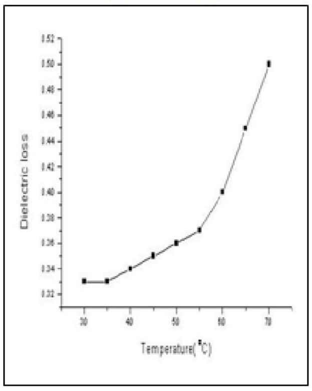
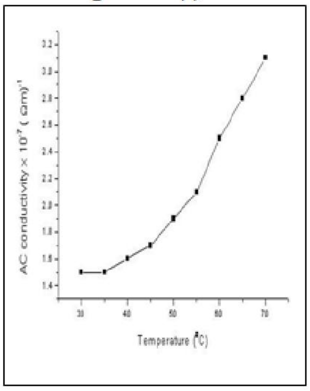


Figure: 3.2(c)



Dielectric studies and AC conductivity of $NiSO_4$ and $ZnSO_4$ crystal

Figure: 3.3(a)

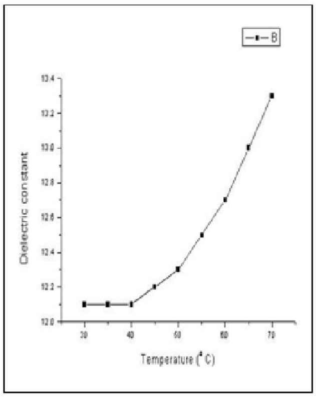


Figure: 3.3(b)

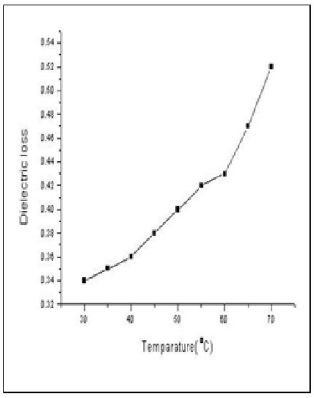
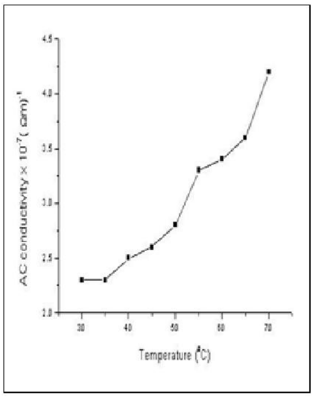


Figure: 3.3(c)



AC conductivity

For the calculated values of dielectric constant and dielectric loss, the AC conductivity is calculated for different temperature

A graph is plotted between temperature and AC conductivity. The variation of AC conductivity with temperature is shown by the figure 3.1(c), 3.2(c), 3.3(c), 3.4(c), 3.5(c).

Dielectric studies and AC conductivity of $ZnSO_4.7H_2O$ crystal

Figure: 3.4(a)

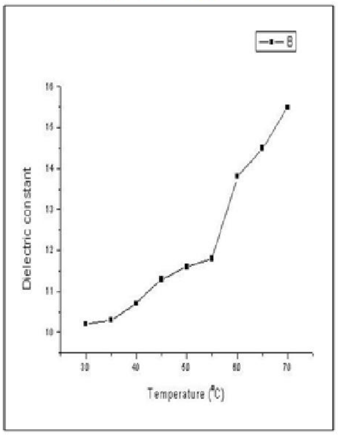


Figure: 3.4(b)

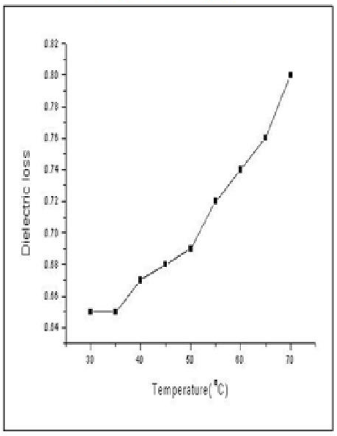
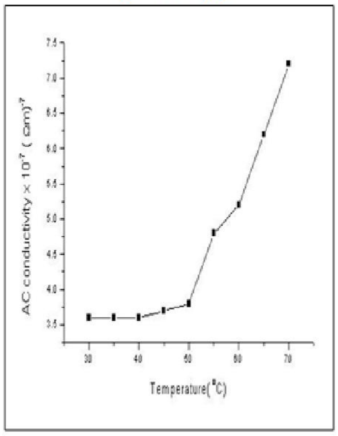


Figure: 3.4(c)



Dielectric studies and AC conductivity of $MgSO_4.7H_2O$ crystal

Figure: 3.5(a)

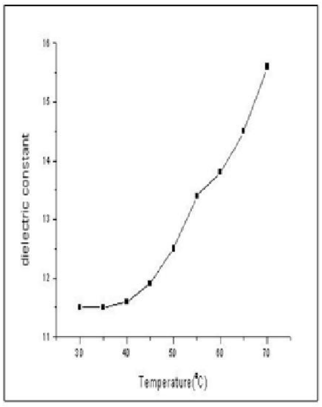


Figure: 3.5(b)

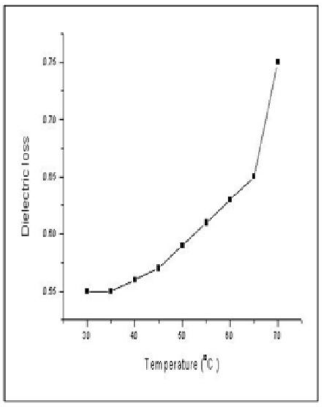
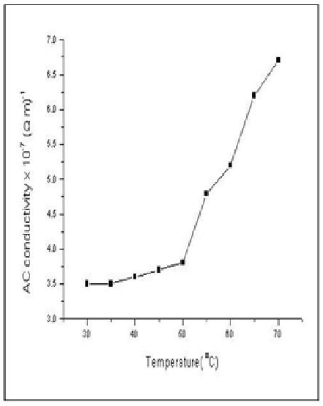


Figure: 3.5(c)



It is observed from the studies that AC conductivity of the grown crystals increases with temperature and it shows that the grown crystals are insulating in nature (Boomadevi *et al.,* 2004). This increase in AC conductivity is due to transition of charge carriers from valence band to conduction band when temperature of crystals increases (Selvarajan *et al.,* 1994 and Joseph John *et al.*, 2007). Generally, the increase in ionic distance due to the temperature influences the electronic and ionic polarizations. Due to increase in the values of polarizations, the dielectric constant increases with temperature (Rajesh *et al.,* 2009).

Conclusion

A good quality of copper sulphate, nickel sulphate, mixed crystals of nickel sulphate and zinc sulphate, zinc sulphate and magnesium sulphate crystals are grown by slow evaporation method. Dielectric constant and dielectric loss have been measured using two probe arrangement and LCR meter as a function of temperature at higher frequencies. The temperature has some influences on the dielectric constant. It is observed that the dielectric parameters increase with temperature. Using the values of dielectric parameters, AC concudtivity is calculated. It is noticed that the AC conductivity of the grown crystals increases with temperature due to transition of charge carriers from valence band to conduction band and the crystals are insulating in nature.

REFERENCES

Bala Subramanian, D. *et al*. 2010. *J. Crystal Growth*, Vol.312, pp. 1855 – 1859.

Boomadevi, S. Mittal, H.P. Dhanasekaran, R. Crystal Growth., J. 2004. 261, 55.

D.P. Lal *et al*. J. Crystal. Growth,5 (1969),p.1.[SD – 008]. *Int.J.curr.Res.chem.pharma.Sci.,* Vol.1, Issue : 6, 2014, pages:56-63.

Hatton, B.T. *et al*. 2006. Materials Today, 9. 22 - 31.

Ikeya, M. *et al*. 2000. *Appl. Radiat. Isot.*, 52,1209.

Joseph John, N. Selvarajan, P. *et al*. 2011. *Journal of Minerals and Materials Characterization and Engineering* Vol.10, No.15, pp. 1379 – 1389, 2011.

Journal of Minerals and Materials Characterization and Engineering Vol.10, No.13, pp. 1225 - 1231, 2011.

Mahadevan, C. *Bull. Electrochem.,* 14 1998 349.

Rajesh, P. Ramasamy, P. 2009. Spectro chimica. Acta part A 74210 - 213.

Selvarajan *et al*. P. 1994 *Journal of Material Science*, 29. 4061.

Suresh sagadevan *et al*. 2014. *Int.J.chemTech* Res. 6(5),pp 2645-2649.

Wyckoff., R.W.G. Cryst Struct., 1960. Vol. 3, 2nd edition, *Interscience*, New York.

****