

## **Temperature Dependences Dielectric Studies of Nickel Nitrate\***

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**Abstract** The ferroelectric behavior of nickel nitrate in compressed pellet form has been studied using capacity measuring unit (Zenith M 92A). The heating cycle of  $\epsilon$  variation with temperature, shows a increasing value of dielectric constant with rise of temperature and has a sudden jump at 46 °C ( $\epsilon = 52,80.000$ ). This transition is assigned of  $\lambda$  type. A hysteresis is found in the cooling cycle.

### **1. Introduction**

Valasek an American an American Investigator discovered anomalous dielectric properties in crystals of Rochelle Salt (sodium potassium tartrate tetrahydrate) in the vicinity of 24°C which were correctly interpreted as analogous to those accompanying a ferromagnetic transition. Some years later Sawver and Tower (1930) in the United States of America observed for the first time hysteresis lops in the P (electric polarization) versus E (electric – field) dependence for Rochelle salt. This confirmed the analogy with ferromagnetic transitions. Busch and Scherrer (1943) (working in Switzerland) discovered peaks in the dielectric constant of KDP (Potassium dihydrogen phosphate) and several isomorphs at temperatures below room temperature. During the second world war, Wainer and Salomon (1933) (in the United States), Ogawa (in Japan) and Whul and Goldman (in Russia) found anomalous dielectric properties in ceramic samples of barium titanate, which were similar in many respects to the anomalous properties previously found in Rochelle salt and KDP. After the war, several investigators, especially Mathias at Bell Labs and Pepinski at the University of Pennsylvania and their co-workers, discovered a

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multitude of new materials with phase transitions accompanied by dielectric anomalies. The use of the term “ferroelectrics”, instead of the original term “seignetteelectrics” became wide spread for these materials and their number has kept growing. At present, the number of known ferroelectrics is in several hundreds and new ferroelectrics are often added to the list. In part, the initial drive to find new ferroelectrics was prompted by the excellent piezoelectric properties of these materials, which make them useful in “sonar” devices for submarine detection.

A ferroelectric crystal can be defined as a piezoelectric possessing a spontaneous electric polarization which is reversible under the action of an external electric field. Out of the thirty two existing crystal classes, twenty are piezoelectric (i.e. non-centrosymmetric). Twenty out of these thirty two are pyroelectric (i.e. they possess a temperature dependent spontaneous polarization). Our group has measured and have investigated ferroelectric behavior in a large number of new compounds in single crystal form<sup>2</sup>.

We have studied ferroelectric behavior of disodium hydrogen phosphate pellet form. The heating cycle of  $\epsilon$  variation with temperature shows a increasing value of dielectric constant with rise of temperature and has a sudden jump at 74 C ( $\epsilon = 51,000$ ). This transition is assigned of  $\lambda$  type. A hysteresis is found in the cooling cycle.

## 2. Experimental

The compound has been procured from Fluka chemical Switzerland chemical was grinded into the fine powders in agate mortar, avoiding direct sunlight and preferably the most of the sample preparation work was done night. The pellets preparation was done at night. The pellets were prepared with the compression machine (Flextural Testing Machine CAT No. AIM – 313, S. No. 91070 AIMIL Associated, India), having pressure range 0 tonne wt/cm. a suitable die was used having rectangular cross-section 2.33 cm of the piston.

The polishing of the pellets (or material) is done to obtain smooth parallel surfaces to be used for electrodes formation. Initially the pellets are worked out with a smooth razor blade of stainless steel. Later abrasive paper is used for smoothening of the faces of the pellets. Due to grinding of chemical its fine particles attain some charges on its crystallites. Further the polishing of pellets also introduces such unavoidable strains. To get the exact behavior of materials these charges and strains are to be removed which we done by the process of annealing of the samples. In this process the pellets

are kept in a suitable furnace at nearly  $2/3$  of their melting points for sufficient times (generally 8-10 hours). The most of the irreproducibility are removed by annealing and therefore for all the samples the process was necessarily done. The electrodes were formed using Acheson's silver point. The usual substitution method i.e. with and without the specimens in suitable sample holder is used. The sample holder was directly fastened to the capacity measuring unit (Zenith M92A).

### 3. Result and Discussion

The chemical formula of the compound is  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , having molecular weight 290.79. It has very low MP (equal to  $56.7^\circ\text{C}$ ) therefore we could measure the  $\epsilon$  values only upto  $53^\circ\text{C}$ . The solid was green, monoclinic, deliquescent crystals. The specific density of the solid was 2.05. The compound was very soluble in cold water (Solubility = 238.5 gm/100 cc). Due to high solubility of the solid in water, instead of colloidal water solution of graphite, we preferred to use silver paint as electrodes.

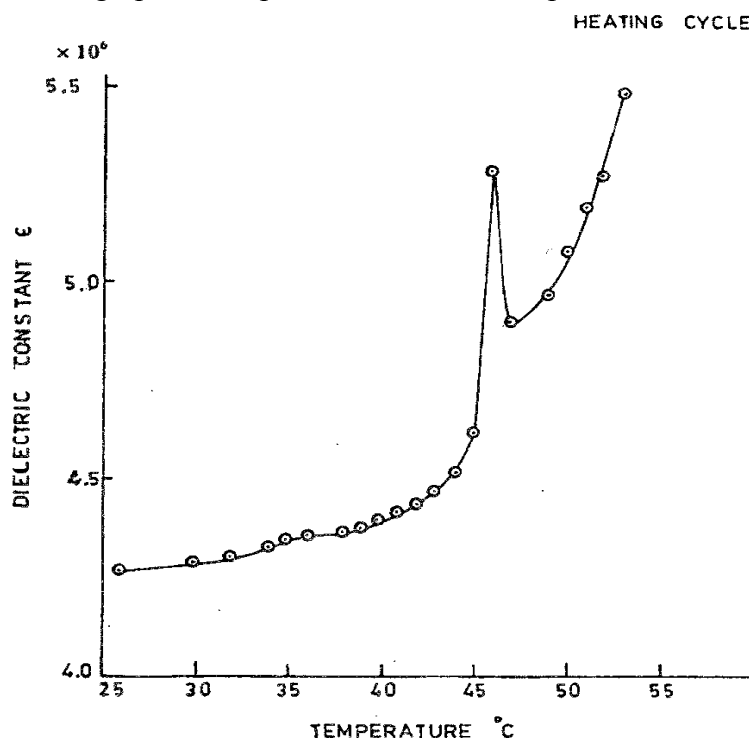


Figure - 1 : Variation of dielectric constant of  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  pellet with temperature,  $p = 5 \text{ tonne}/2.33 \text{ cm}^2$ .

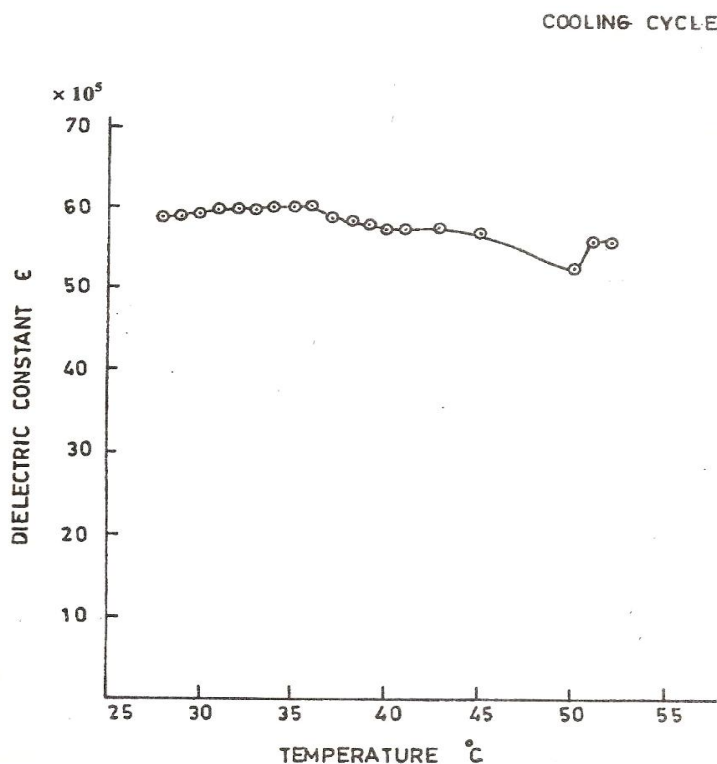


Figure - 2 : Variation of dielectric constant of  $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  pellet with temperature,  $p = 5 \text{ tonne}/2.33 \text{ cm}^2$ .

The variation of dielectric constant with temperature is shown in the Fig.1 and Fig.2 and heating cycle of  $\epsilon$  with rise of temperature upto  $46^\circ\text{C}$  accompanied with a jump in  $\epsilon$  (to very high value) at this transition temperature ( $\epsilon \approx 52,80,00$ ). The transition is of  $\lambda$  type. However, in the cooling cycle the dielectric constant remained to its high value of  $\epsilon$  throughout the temperature range is perhaps due to high polling of nickel ions. The transitions at  $46^\circ\text{C}$  is of  $\lambda$  type which satisfies Curie-Weiss law.

### References

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