Analyzing the Ferroelectric Properties of Amateur Grown Rochelle Salt

QiLin Xue

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In this experiment, Rochelle salt was grown in an amateur lab and was tested for ferroelectric properties. Ferroelectric materials, similar to ferromagnetic, can generate a spontaneous polarization at certain temperatures, which can be reversed. There are two key signatures which we checked for:

(A) A critical temperature T_c at which a phase transition occurs, where at temperatures below this critical point, spontaneous polarization can occur. This is reflected in the electric susceptibility, which for $T > T_C$, Mean Field Theory suggests that

$$\chi \propto (T - T_C)^{-1}.$$

Literature shows that Rochelle salts actually have two critical temperatures, one at around 24° C and another at −18° C.[1]

(B) A hysteresis loop when an applied electric field is applied. Since it is energetically favorable for electric dipoles to align, increasing the electric field and then decreasing it does not reset the polarization.

In this experiment, we were able to find evidence for behavior (A)

- Page 12 contains an annotated image of the experimental set-up. The data is recorded on pages 18-20. Data on previous pages (13-17) were faulty due to poor connections and uncontrolled variables.
- Graph shown on page (30) shows the electric susceptibility of the Rochelle salt at various temperatures, with the theoretical model for the phase transition fitted. The temperature scale was renormalized through a discussion on page (24) and uncertainties are discussed in pages (26,27).
- There are two critical points, and the nature of the graph can be compared to literature[1], and discussed, on page (30).

However, we were unable to find evidence for behavior (B)

- To test for Hysteresis, a Sawyer-Tower circuit was built, as shown on page (4), in which the capacitance of the sample can be derived (page 6). Page 25 shows an annotated photo of the circuit setup. The capacitance is related to the electric susceptibility χ_e through $C = \frac{\kappa\epsilon_0 A}{d}$ and $\chi_e = \kappa - 1$, as shown on page (4).
- If there was a hysteresis curve, we were still in the linear domain. Plots are on pages (32-34). No significant deviation can be seen. The deviation, which represents the voltage across the reference capacitor were also plotted (pages 36-38). This deviation plot has some troubling characteristics, which are discussed in more detail on page (38).
- The hysteresis curve often found in literature is given in page (40)[2]. The maximum electric field that is applied is over 4000 V/cm, which translates to 800 V for a 2 mm thick sample. This is both unattainable by the equipment on hand, and can potentially be unsafe.

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[1] Kwan Chi Kao. Ferroelectrics, piezoelectrics, and pyroelectrics. In *Dielectric Phenomena in Solids*, pages 213–282. Elsevier, 2004.

[2] J. Valasek. Piezo-electric and allied phenomena in rochelle salt. *Physical Review*, 17(4):475–481, April 1921.