2. CALCIUM TARTRATE SINGLE CRYSTALS

Tartrate crystals are of considerably interest, particularly for the basic studies of some of their interesting physical properties. Some crystals of this family are ferroelectric [1-3], some others are piezoelectric [4] and quite a few of them have been extensively used for controlling laser emission [5].

Calcium tartrate is, in fact, a remarkably an unexciting material but precisely because it grows so well in gels it lends itself to a variety of studies on the behaviour of gel systems. Henisch [6] has described calcium tartrate as follows:

"Calcium tartrate crystals are beautiful and the fact that they appear to be totally useless has always been a matter of profound regret within the crystal growing community"

Most of the early works on calcium tartrate crystals were done to understand the basic principles and the nature of crystal growth phenomenon; especially those involved in simple, yet versatile technique of growing crystals at room temperature, namely the gel method [7-13]. However a ray of hope appeared, when it was reported that d.c.conductivity measurements on these crystals indicated a peak at 140°C, a possible ferroelectric transition [14].

2.1 Structure of Calcium Tartrate Tetrahydrate

Calcium tartrate tetrahydrate is found to be orthorhombic [15,16] with space group P2₁2₁2₁ with the following crystal data.

<table>
<thead>
<tr>
<th>Molecular formula</th>
<th>CaC₄H₄O₆.4H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular weight</td>
<td>260.1</td>
</tr>
<tr>
<td>Lattice parameters</td>
<td>a = 9.24 ± 0.02 Å⁺</td>
</tr>
<tr>
<td></td>
<td>b = 10.63 ± 0.02 Å⁺</td>
</tr>
</tbody>
</table>
The tartrate ion consists of two planar halves, each containing a carboxyl group, a tetrahedral carbon atom and hydroxyl oxygen atoms. The chain of the carbon atoms is almost planar. The planes of two CO\(_2\) groups are inclined nearly at 60° to the plane. Hence C\(_{2v}\) symmetry is assumed for the tartrate ion. The structure of the tartrate ion is shown in Figure 2.1.

The crystal structure of calcium tartrate tetrahydrate viewed down the c-axis is shown in Figure 2.2. The co-ordinates of the atoms in calcium tartrate tetrahydrate are given in Table 2.1. The intermolecular bond distances are given in Table 2.2 and intermolecular bond angles are given in Table 2.3. The intermolecular features of the tartrate ion in calcium tartrate tetrahydrate are given in Figure 2.3 [17].

2.2 Growth of Calcium Tartrate Single Crystals

If the reagent in the gel is tartaric acid and the supernatant reagent is an approximately 1M solution of calcium chloride then, in due course, crystals of calcium tartrate tetrahydrate are formed in the gel as a result of the exchange reaction, which yields hydrochloric acid as the by-product. The crystals are sparingly soluble in water. They can usually be seen near the gel surface within an hour or so. Good crystals appear further down the column within about a week and grow to about 8 mm average size. Occasionally they are larger but then usually less perfect. The speed of formation depends on the concentrations involved and the time taken before crystals
Figure 2.1: Structure of tartrate ion
Figure 2.2: The crystal structure of calcium tartrate viewed down the c-axis
Table 2.1:

Co-ordinates (fractional) of atoms in calcium tartrate tetrahydrate, with mean standard deviations ($\sigma$)

<table>
<thead>
<tr>
<th>Atom</th>
<th>x</th>
<th>y</th>
<th>z</th>
<th>B(Å²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>0.4363</td>
<td>0.4265</td>
<td>0.4328</td>
<td>0.95</td>
</tr>
<tr>
<td>O(1)</td>
<td>0.2661</td>
<td>0.2588</td>
<td>0.4805</td>
<td>1.94</td>
</tr>
<tr>
<td>O(2)</td>
<td>0.2023</td>
<td>0.0593</td>
<td>0.5139</td>
<td>2.15</td>
</tr>
<tr>
<td>O(3)</td>
<td>0.5251</td>
<td>0.2051</td>
<td>0.3904</td>
<td>1.65</td>
</tr>
<tr>
<td>O(4)</td>
<td>0.4112</td>
<td>-0.0346</td>
<td>0.2778</td>
<td>1.41</td>
</tr>
<tr>
<td>O(5)</td>
<td>0.7131</td>
<td>-0.0332</td>
<td>0.5079</td>
<td>1.67</td>
</tr>
<tr>
<td>O(6)</td>
<td>0.6939</td>
<td>-0.0780</td>
<td>0.2810</td>
<td>2.00</td>
</tr>
<tr>
<td>O(7)W</td>
<td>0.1784</td>
<td>0.1762</td>
<td>0.1659</td>
<td>3.30</td>
</tr>
<tr>
<td>O(8)W</td>
<td>0.9524</td>
<td>0.0805</td>
<td>0.3126</td>
<td>3.74</td>
</tr>
<tr>
<td>O(9)W</td>
<td>0.8168</td>
<td>0.3099</td>
<td>0.1749</td>
<td>4.37</td>
</tr>
<tr>
<td>O(10)W</td>
<td>0.5242</td>
<td>0.1576</td>
<td>0.0856</td>
<td>2.05</td>
</tr>
<tr>
<td>C(1)</td>
<td>0.2962</td>
<td>0.1422</td>
<td>0.4879</td>
<td>1.38</td>
</tr>
<tr>
<td>C(2)</td>
<td>0.4528</td>
<td>0.1094</td>
<td>0.4705</td>
<td>1.08</td>
</tr>
<tr>
<td>C(3)</td>
<td>0.4804</td>
<td>-0.0201</td>
<td>0.4091</td>
<td>2.05</td>
</tr>
<tr>
<td>C(4)</td>
<td>0.6401</td>
<td>-0.0449</td>
<td>0.4011</td>
<td>1.56</td>
</tr>
</tbody>
</table>

$\sigma(x) = \sigma(y) = \sigma(z)$ for Ca, 0.002 Å; for other atoms, 0.01 Å
Table 2.2: Intramolecular bond distances in calcium tartrate tetrahydrate (in Angstrom units)

<table>
<thead>
<tr>
<th>Bond</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)-O(1)</td>
<td>1.27</td>
</tr>
<tr>
<td>C(1)-O(2)</td>
<td>1.26</td>
</tr>
<tr>
<td>C(4)-O(2)</td>
<td>1.24</td>
</tr>
<tr>
<td>C(4)-O(6)</td>
<td>1.31</td>
</tr>
<tr>
<td>C(2)-O(3)</td>
<td>1.44</td>
</tr>
<tr>
<td>C(3)-O(4)</td>
<td>1.40</td>
</tr>
<tr>
<td>C(1)-C(2)</td>
<td>1.50</td>
</tr>
<tr>
<td>C(2)-C(3)</td>
<td>1.52</td>
</tr>
<tr>
<td>C(3)-C(4)</td>
<td>1.50</td>
</tr>
</tbody>
</table>
Table 2.3: Intramolecular bond angle in calcium tartrate tetrahydrate (in degrees)

<table>
<thead>
<tr>
<th>Bond Sequence</th>
<th>Angle (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O(1) - C(1) - O(2)</td>
<td>123</td>
</tr>
<tr>
<td>O(1) - C(1) - C(2)</td>
<td>116</td>
</tr>
<tr>
<td>O(2) - C(1) - C(2)</td>
<td>122</td>
</tr>
<tr>
<td>C(1) - C(2) - O(3)</td>
<td>110</td>
</tr>
<tr>
<td>C(1) - C(2) - C(3)</td>
<td>115</td>
</tr>
<tr>
<td>C(3) - C(2) - O(3)</td>
<td>111</td>
</tr>
<tr>
<td>C(2) - O(3) - C(4)</td>
<td>112</td>
</tr>
<tr>
<td>C(2) - C(3) - C(4)</td>
<td>110</td>
</tr>
<tr>
<td>O(4) - C(3) - C(2)</td>
<td>112</td>
</tr>
<tr>
<td>C(3) - C(4) - O(6)</td>
<td>118</td>
</tr>
<tr>
<td>O(5) - C(4) - O(6)</td>
<td>124</td>
</tr>
</tbody>
</table>
Figure 2.3: The intermolecular features of the tartrate ion in calcium tartrate tetrahydrate
are seen with the naked eye may vary from few hours to few days. When much higher concentrations are used sodium tartrate tends to grow [6].

Armington and his co-workers [18] have grown calcium tartrate crystals with the aim to investigate in a semiquantitative manner several parameters of gel growth, in order to determine their effect both on the rate of crystal growth and on the crystalline product. They have grown calcium tartrate since it appeared to be the easiest crystal to be grown in this method. They have prepared the gel solution by titrating 0.5 M tartaric acid with 0.5 M sodium silicate to the desired pH. After the gel is set 0.5 M CaCl$_2$ solution was added to it. They have varied the pH from 3.5 to 4.5. The entire experiment was done at 40°C. They have used 50 ml test tubes as well as 500 ml graduated cylinders. The maximum size of the crystal obtained in a 50 ml test tube was 9.4 mm and in that of a 500 ml cylinder it was 1 inch in length and ½ inch in diameter.

Most of the calcium tartrate crystals exhibit growth veils near their geometrical centre [6]. These veils evidently formed during the initial stages of growth and may be well associated with the non-linearities near the origin. Such features are not actually peculiar to crystal growth in gels. They are frequently observed in the course of growth from solution. Egli and Johnson [11] have ascribed them to a growth rate temporarily greater than the crystal can tolerate.

Calcium tartrate tetrahydrate crystals occurred in three typical habits. Two of them showed only pyramidal faces (101), (001) and the other one showed (110) faces. It was observed that the average crystal growth rate was the highest near the top of the diffusion column where the concentration gradients were high; and small near the bottom where the gradients were small. Corresponding to the distribution of growth rates there was also distribution in the number of etch pits on any crystal face. The average etch pit densities observed on gel grown calcium tartrate crystals are of the order of $10^3$ - $10^4$ pits/cm$^2$ [6].
Hanoka [19] observed the formation of gel cusps in calcium tartrate. Cipanov et al [20] have shown that the variation of the acidity of the crystallogenetic media strongly influenced the depth of the first crystal arising in the gel.

Vimal S.Joshi and Mihir S. Joshi [21] have grown calcium tartrate trihydrate crystals using a gel containing sodium metasilicate and ortho phosphoric acid. Calcium chloride and tartaric acid were mixed together and was taken as the supernatant solution. The largest crystal was having the dimensions 8 mm x 7 mm x 3 mm. The growth is successful only in the presence of the gel medium.

2.3 Growth of Doped Calcium Tartrate Single Crystals

Doped calcium tartrate tetrahydrate crystals have also been grown. Armington et al [18] had grown Nd$^{3+}$ doped calcium tartrate crystals. A variety of studies had been done on these crystals by them. It was observed that, as the Nd$^{3+}$ content in the crystal was increased the colour of the calcium tartrate crystals were changed from very faint blue to purple showing to some extent that the colour is a function of the doping level. They also observed that those crystals that were grown in dark were more perfect and transparent and those grown under fluorescent light were not good. Emission spectroscopic analysis on these crystals showed only <10 ppm of sodium in the crystal. Though neodymium is reported to fluoresce in the infrared at about 1μm, Nd$^{3+}$ doped calcium tartrate crystals do not exhibit any visible fluorescence. The micro hardness measurements showed that the hardness for 100 g load was 111.2 kg/mm$^2$. The density of the crystal was found to be 1.836 g/cc. They have also concluded that crystals which grow rapidly take more impurities than those growing slowly.
Studying the optical absorption spectrum of single crystals of calcium tartrate tetrahydrate doped with Ni$^{2+}$ ions, Reddy et al [22] attributed the site symmetry of Ni$^{2+}$ ions to an elongated octahedron with a small tetragonal distortion.

Basha et al [23] investigating the electronic absorption spectra of calcium tartrate single crystals doped with Fe$^{3+}$ ion showed that site symmetry of the Fe$^{3+}$ ions in the calcium tartrate tetrahydrate was predominantly octahedral with a small tetragonal distortion.

Capobianco et al [7] on doing laser excited site selective spectroscopic studies of Eu$^{3+}$ doped calcium tartrate tetrahydrate showed that Eu$^{3+}$ occupied atleast three different types of sites and crystal field strength of the three sites increased with increasing excitation energy.

Sperka et al [24] on studying the site selection spectroscopy of UO$^{2+}$ doped calcium tartrate tetrahydrate crystals reported the presence of a large number of both discrete and disordered sites.

Medrano et al [25] reported the polar character and the non-centro symmetric structure of calcium tartrate tetrahydrate by means of second harmonic generation.

Nakatani and Noriyuki [26] studying the etch figures of orthorhombic calcium tartrate tetrahydrate concluded that the point group of calcium tartrate tetrahydrate was non-polar and expressed doubt regarding the polar characters observed by Medrano.

On studying the optical and structural characterization of Sr$^{2+}$ doped calcium tartrate tetrahydrate crystals, Suryanarayana et al [27] reported no dispersion of the birefringence and also the packing of tartrate ions remained unaltered even after 12 % of strontium doping.
Suryanarayana and Dharmaprakash [28] on studying the defect characterization of Sr$^{2+}$ doped calcium tartrate tetrahydrate crystals, have reported the existence of dislocation network in the body of the crystal.

Gon [29] reported ferroelectricity with calcium tartrate tetrahydrate crystals. The ferroelectric transition temperature being 123°C. He observed abrupt changes in the dielectric constant and thermal co-efficient of the crystal at 123°C.

Torres et al [30] have studied the thermal and electromagnetic behaviour of gadolinium doped calcium tartrate tetrahydrate crystals by solution technique. The crystals were obtained by diffusing calcium ions and gadolinium through silica gel impregnated with tartaric acid and grown by means of slow cooling between 72°C and 40°C. The thermal analysis showed that these crystals are thermally unstable. Dielectric and magnetic measurements were also carried out.

Selvarajan et al [31] have studied the infrared spectroscopic and thermal studies of calcium tartrate tetrahydrate crystals. From thermal studies they have concluded that calcium tartrate tetrahydrate are thermally unstable and there is no physical (crystallographic) transformation independent of mass change or decomposition of calcium tartrate crystals. The presence of carbon, oxygen and water of crystallization in calcium tartrate crystals was established from IR spectrum.

Torres et al [32] have studied the electrical conductivity of polycrystalline samples of calcium tartrate tetrahydrate in pure form and doped with barium and strontium in the temperature range 65°C to 95°C. It seems that these crystals exhibit two types of conduction, one at low temperature and the other at higher temperature, by the way of extrinsic and intrinsic conduction respectively. This behaviour is attributed to the rotation of the tartrate ions by thermal energy.
FT-IR and thermal studies on calcium tartrate trihydrate crystals [21] revealed the presence of O-H bond, C-O and carbonyl C=O bond. They have also detected the presence of water molecules. Thermal studies showed that these crystals are thermally unstable and decompose into calcium oxide through many stages.

Torres et al [33] had doped calcium tartrate tetrahydrate crystals with Ba, Sr, Co, Ni, Mn, Zn and Cd and have done structural characterization on the doped crystals. It was reported that some of the doping atoms are located in the host lattice and others are distributed at random positions especially on the surface of the crystals. In the host lattice the doping atom replaces calcium when an alkaline earth atom was used but occupies the interstitial site when transition metal atom was used. The dielectric permittivity was found to be higher in doped compounds.

2.4 Growth of Calcium-Strontium Mixed Crystals

Some studies have also been carried out on the mixed crystals of calcium and strontium tartrate tetrahydrate. Patel and Arora [34] reported for the first time the growth of mixed crystals of calcium and strontium tartrate (the two tartrates have similar chemical constitution and crystalline structure). The crystals were grown for 5 different compositions of calcium and strontium. Wiktorowska et al [35] have reported the successful growth of calcium strontium mixed crystal employing neutral gel.

Suryanarayana and Dharmaprakash [36,37] have grown calcium-strontium mixed crystals from light irradiated sodium metasilicate gel medium at ambient temperature. The TGA showed that the crystals are thermally unstable.

ESR studies of X-irradiated strontium mixed calcium tartrate crystals have been done by Suryanarayana et al [38]. The ESR spectrum showed only one species of free radical but with two magnetically non-equivalent sites were observed at room
temperature. The free radical was found to be the result of the splitting of a C-H bond adjacent to both hydroxyl and carboxyl groups. The radical was found to be very stable.

2.5 Growth of Calcium Tartrate in Gels: The Comforts and Constraints

For any beginner in crystal growth in gels, calcium tartrate tetrahydrate crystals appear to be the best crystal to learn with. It is the easiest crystal that can be grown by the gel method. In that way it gives you a comfort. But as we proceed our process of growing calcium tartrate tetrahydrate crystals we would come across with so many constraints. The most important of it is the size of the crystal. Three main reasons can be said for the reduction in size of this crystal.

1. In the gel region close to the supernatant liquid, the original tartaric acid content of the gel is completely exhausted partly through the formation of calcium tartrate crystals and partly through the demonstrable loss of tarataric acid to the solution at the top.

2. As the diffusion process continues and the reaction boundary moves down the column the diffusion gradient generally diminishes. This tendency is enhanced when the growth tubes are of finite length. Both factors can reduce the speed of growth to levels which amounts to zero growth for practical purposes.

3. In case of involving weak acids, of which calcium tartrate is an example, there is a major change towards lower pH values in the course of crystal growth, since the reaction yields rapidly diffusing hydrogen ions. In the increasingly acid environment (pH = 1) calcium tartrate is increasingly soluble and a steady state may be eventually reached in which without any shortage of reagents, growth and solution are in balance.
Calcium tartrate crystals do not nucleate at pH values below 3. Also, high perfection at increasing depths would be the natural outcome of diminished competition [39].

In most of the cases to improve the size of the crystal growing in the gel, nucleation control techniques like concentration programming or neutral gel technique is used. These methods successfully control the nucleation and also yield crystals of larger size and higher degree of perfection. It was reported that [6,13] the size of calcium tartrate crystals growing in the gel was not improved even after applying these methods. The improvement in size of some crystals under concentration programming is compared with that of calcium tartrate in Table 2.4 [6]. The increase in size amounts to approximately a factor of 3 for all the crystals, except for calcium tartrate.

Calcium tartrate crystals often grow more prolifically under or after irradiation of the gel system than in darkness, usually refered to as "Photonucleation". This effect was traced to the light stimulated development of small CO₂ bubbles, either by dissociation of some tartaric acid or by the release of some CO₂ previously dissolved.

Light can alter the distribution of impurities between the growing crystal and the surrounding gel and may well be a surface barrier effect as suggested above. This is easily demonstrated with calcium tartrate system in the presence of iron contamination. Under irradiation by UV or visible light the iron uptake is inhibited and the resulting crystals are almost colourless and those grown in darkness are yellowish.
Table 2.4: Concentration programming - a comparison on crystal size

<table>
<thead>
<tr>
<th>Crystal</th>
<th>Largest linear dimension (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>without programming</td>
</tr>
<tr>
<td>Calcium tartrate</td>
<td>12</td>
</tr>
<tr>
<td>Cuprous tartrate</td>
<td>1</td>
</tr>
<tr>
<td>Lead iodide</td>
<td>3</td>
</tr>
<tr>
<td>Thallium iodide</td>
<td>0.5</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.5</td>
</tr>
<tr>
<td>Cadmium oxalate</td>
<td>2</td>
</tr>
</tbody>
</table>
2.6 A Brief Review of the Studies on Other Tartrate Crystals

2.6.1 Strontium tartrate

Strontium tartrate is isomorphic with calcium tartrate, usually called as "sister crystals". Henisch et al [6] were the first to grow strontium tartrate crystals in gels. But a considerable work has been done on this crystal by Patel et al [40]. They have succeeded in growing strontium tartrate crystals of size 2 inches; claimed to be the largest ever grown crystal by the gel method.

Studying the electronic absorption spectrum of single crystals of strontium tartrate tetrahydrate doped with Co$^{2+}$ ions, Reddy et al [41] concluded that the site symmetry of the Co$^{2+}$ ion in strontium tartrate tetrahydrate is predominantly octahedral. From electron paramagnetic resonance spectra of Mn$^{2+}$ doped strontium trihydrate, Korkmaz et al [42] concluded that Mn$^{2+}$ entered the lattice substitutionally and was trapped at two crystallographically unequivalent sites. Optical absorption spectrum of Ni$^{2+}$ doped strontium tartrate tetrahydrate [43] showed the characteristic features of Ni$^{2+}$ in a distorted octahedral field.

Rethinam et al [44-46] have doped strontium tartrate with various dopants (Cd$^{2+}$, Fe$^{3+}$, Co$^{2+}$, Ni$^{2+}$, Cr$^{2+}$) and have studied their mechanical and thermal properties. It was observed that as the dopant concentration was increased, the hardness also increases. The TGA studies of these doped crystals showed no difference in their behaviour with that of the pure strontium tartrate at lower temperatures. However at higher temperatures there was a difference between pure and doped strontium tartrate crystals.

---

1 Literatures are not updated
Vivekanandan et al [47] have studied the dielectric properties of strontium tartrate tetrahydrate crystals. They have reported ferroelectric transitions. Selvasekarapandian et al [48] have recently studied the vibrational studies on rubidium tartrate and strontium tartrate tetrahydrate crystals. The laser Raman and Fourier transform IR spectra of these crystals were recorded in the frequency range 100-4000 cm\(^{-1}\) and the presence of tartrate ion, monohydrogen tartrate ion, water molecules and external mode vibrational frequencies were identified.

2.6.2 Lead tartrate and cadmium tartrate

By the reaction between lead nitrate solution and tartaric acid, Abdul Kadhar et al were able to grow lead tartrate crystals [49]. The crystals were found to form in three different stages. Good dendrites were formed at the first stage. These dendrites were thickened at the second stage and at the third stage single crystals were formed. Hopwood and Nicol [50] were able to grow colourless cadmium tartrate pentahydrate single crystals in silica gel. The crystals grew either as elongated parallelopipeds bound by (100), (010) and (001) faces or as lathe-like fibre bundles. Crystals having the later morphology were found to grow when the gel density was excessively high.

2.6.3 Manganese, sodium and ammonium tartrates

Manganese tartrate trihydrate crystals were grown in silica gel [51] using manganese chloride/manganese sulphate as the supernatent solution. A number of dendrites were found to grow in the case of manganese chloride. In the case of manganese sulphate, less dendrites were formed at the interface and this facilitated the diffusion of manganese sulphate into the gel medium and platelets were found to grow in addition to dendrites.

Abdel Kader et al [1] were able to grow ammonium tartrate from aqueous solution of ammonium tartrate at room temperature. They studied the thermal and
electrical properties of these crystals. The specific heat was observed to have a sudden rise with a peak at about 92°C. This peak was followed by a sharp decrease in the dielectric constant as the temperature was increased. Similarly, the pyroelectric current also had a prominent peak at about 92°C. They observed similar behaviour in the case of sodium tartrate crystals also.

2.6.4 Rare earth tartrates

Yttrium and samarium tartrate crystals were grown by the reaction between rare earth nitrate and tartaric acid in sodium metasilicate gel. The crystals were spherulites with an average diameter of about 3.5 mm. A few spikes were found to develop over the spherulitic surface. Involving the use of gadolinium chloride or gadolinium nitrate as the outer reactant and sodium metasilicate gel impregnated with tartaric acid, Kotru et al [52] successfully grew gadolinium tartrate dihydrate crystals. Growth of praseodymium tartrate crystals was accomplished by allowing diffusion of praseodymium nitrate through silica gel impregnated with tartaric acid. The crystals exhibited spherulitic morphology [53].

2.6.5 Growth of mixed tartrates

On studying the dielectric and pyroelectric behaviour of antimony-sodium tartrate crystals from room temperature to 123°C, Abdel-Kader et al [54] ruled out the possibility of the existence of a ferroelectric phase transition as the Sawyer-Tower test was negative. However, Zhu et al [55], on studying the optical and electro-optical properties of lithium-thallium tartrate monohydrate, concluded that lithium-thallium tartrate underwent a phase transition. Wlodarz et al [56] measured the temperature dependence of thermal expansion coefficients of sodium-potassium tartrate (rochelle salt) crystals for the basic crystallographic directions in the temperature range from 173° to 27°C. They observed anomalies of thermal expansion coefficients at about
73° to -120°C besides those corresponding to known ferroelectric phase transition at temperatures of -18° and 24°C.

Aleksandryzk et al [57] have reported the growth of potassium-hydrogen tartrate in an ion exchanged silica gel. They observed that, for pH values below 2, crystals grew in platelet form with well defined (010) faces and for pH values between 2 and 3 the crystals were found to grow in the form of a nearly regular tetrahedron with maximum edges of about 4 mm. Veintemillas and Dodriguez [58] could successfully grow crystals from aqueous solutions at 50°C and 100°C and studied their growth kinetics and morphology.

Rubidium hydrogen tartrate crystals were grown by Desai and Patel [3] by employing the gel technique. Colourless and transparent crystals upto 16 x 5x 4 mm³ were grown in about 2 to 3 weeks. They examined the crystals by SEM, XRD, EDAX and thermal analysis. The crystals were not found to contain any water molecule. Studying the nature of the variation of the dielectric constant with temperature, Desai and Patel [59] identified the different polarizations that contributed to the dielectric constant of rubidium hydrogen tartrate crystals. The efficiency of rubidium hydrogen tartrate crystals in different modulation and defocussing systems were characterized by their electro optical coefficients [5].

Ammonium hydrogen tartrate crystals were also grown by Desai and Patel [59] using controlled reaction between ammonium chloride and tartaric acid by diffusion process in silica gels. The magnetic susceptibility of ammonium hydrogen tartrate was found to be more than that of rubidium hydrogen tartrate. Ammonium hydrogen tartrate and rubidium hydrogen tartrate have been used for controlling laser emission [5].
References


