

## On the iridescence of potassium chlorate crystals— Part III. Some general observations

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Received November 3, 1952

### 1. Introduction

In the two preceding parts we have discussed the optical behaviour of a few selected crystals which could be regarded as ideal or nearly ideal specimens exhibiting highly monochromatic iridescence. It is not without interest however to consider the subject from a wider standpoint. It is proposed in the present part to report briefly on the optical phenomena observed by us in our studies with a rather extensive collection of specimens. The availability of the material was due to the circumstance that some years ago a chemical manufacturing concern at Bangalore was engaged in the large-scale production of potassium chlorate. Arrangements were made with them for a systematic collection of the iridescent crystals that occasionally formed in the crystallising vats.

A good way of exhibiting a collection of the iridescent crystals is to place the same on a flat circular disc of black glass held horizontally and which could be rotated about a vertical axis. The reflected colours can be viewed under the diffuse illumination provided by a large window. The variety and brilliance of the tints and their rapid change with the obliquity of observation then become strikingly evident; and the disappearance and the reappearance of the iridescence of each specimen twice in each revolution of the disc can also be exhibited. This arrangement, however, does not eliminate the dilution of the iridescence by the reflection of white light from the two surfaces of the crystal. This can only be secured by mounting the plates in Canada balsam between two prisms of glass. The liveliness of the colours is thereby vastly improved and the arrangement is also suitable for exhibiting the transmission colours in a very striking manner. It is also the most suitable arrangement for a critical spectroscopic study of the reflected or transmitted light. The simple technique of immersing the specimen in a watch glass containing xylene, the outside of which has been dead-blackened, however suffices for a rapid visual examination of numerous specimens. Indeed it may be used also for obtaining a photographic record of their spectra.

## 2. Characters of the iridescence

The majority of the specimens are rhombus-shaped tablets, but hexagonal-shaped plates are also not infrequently met with. An impressive feature is the fact that though the individual crystals exhibit the widest diversity of colours by reflection, such colour is usually quite uniform over the area of a particular crystal. Occasionally however, one finds plates which exhibit iridescence of one colour over part of the area and either no iridescence at all or else an iridescence of a different colour or intensity over the rest of it; the dividing line between the two parts in such cases is usually sharp but rather wavy. Straight boundaries are however occasionally observed.

It is possible at first sight to believe that a particular specimen is non-iridescent and yet to discover on closer examination that it exhibits the characteristic reflections. This can happen, for instance, when the reflection is at the violet end of the spectrum at nearly normal incidence and moves out of the visible with oblique observation. It may also happen that the crystal has a series of monochromatic reflections in the visible spectrum the integrated effect of which is merely white light. There are cases also where the characteristic reflection moves into the visible spectrum and results in visible colour only when the crystal is viewed obliquely.

A systematic examination of the specimens was made to find whether any of the tablets have stratifications so fine that the first order reflection appears only in the ultra-violet. These were looked for by photographing a continuous spectrum of white light transmitted obliquely through the specimen. Though many crystals were examined, no such case was met with. *Prima facie* there seems to be no reason why such fine stratifications cannot appear, and it is possible they were not found merely because they had been passed over when the material was collected. On the other hand, crystals were forthcoming with stratifications so widely spaced that thirteen successive orders of reflections are observed between  $\lambda$  6600 and  $\lambda$  3200. This would mean that the order actually observed at the red end would be the twelfth, the first order being far out in the infra-red and that the actual spacing of the stratifications would be about  $2.7 \mu$ . On the other hand, a crystal showing a first order in the violet say at  $\lambda$  4200 would have a spacing of  $0.14 \mu$ .

## 3. Variations of its spectral nature

In plate I, figures 1 to 8 are illustrated the reflection spectra taken at nearly normal incidence of a series of eight crystals, beginning with a specimen which shows a single reflection (probably a first order) at  $\lambda$  4275, followed by others showing a large number of reflection maxima up to thirteen. It is generally the case that if a crystal exhibits a series of monochromatic reflections, the

monochromatism becomes sensibly more perfect in the higher order reflections seen in the ultra-violet. This feature is readily noticeable in several of the spectra reproduced in plate I. It is also generally characteristic of monochromatic reflections that their intensity is far larger than that of the subsidiary maxima accompanying them, so much so that the latter are recorded only with prolonged exposures. We have however come across several cases in which a crystal gives a series of reflection maxima forming a regular sequence, but in which we do not observe the regularities referred to above. Some examples of this kind are reproduced as figures 6, 7 and 8 in plate I. It will be seen in these three pictures that the reflection maxima are rather diffuse, each of them visibly exhibiting several components distinctly resolved from each other and that the structure of the individual reflections is not always the same. Further, the subsidiary maxima may often attain a notable intensity and show a lack of regularity in their distribution. This feature is very conspicuous in figure 8, plate I. A natural explanation of the facts observed is that the stratifications are not perfectly equidistant in these cases but are subject to errors in spacing which may be either random or periodic.

Another interesting feature which is occasionally noticed is that some of the orders are unusually strong and others unusually weak in comparison with their neighbours, e.g., the reflection at  $\lambda$  5800 appearing in figure 6 in plate I is very strong, whereas the order at  $\lambda$  4850 is weaker than the orders on either side of it. Similarly in figure 4, plate I, the orders appearing at  $\lambda$  4350 and at  $\lambda$  4900 are far stronger than the orders appearing on either side at  $\lambda$  3950 and  $\lambda$  5600 respectively. The latter is so weak that the principal maximum and the subsidiary maxima on either side are of nearly comparable intensity. Another example of the same kind is the reflection appearing at  $\lambda$  4130 in figure 5, plate I, which is much weaker than the orders at  $\lambda$  3920 and  $\lambda$  4380 respectively on either side. One more illustration is furnished by figure 7 in plate I in which the reflection appearing at  $\lambda$  4475 is far stronger than the orders at  $\lambda$  4050 and  $\lambda$  5000 respectively on either side, the latter being extremely weak. A natural explanation for these facts is to be found in the different thicknesses of the alternate layers of the polysynthetically twinned crystal. The ratio of these thicknesses would determine the relative intensity of the different orders of reflection.

#### 4. Multiply-periodic twinning

In the course of our studies also, several examples were met with in which instead of a single series of sharply defined reflection maxima, regularly spaced groups of such reflection maxima were obtained, the successive orders exhibiting almost identically similar features. Four such spectra are reproduced as figures 1 to 4 in plate II. The similarity of the successive groupings is particularly conspicuous in figure 4 in that plate, though it may be readily recognised in the others as well.

In figure 1 in plate II the principal feature observed is a strong band centred at  $\lambda$  6000 with other features on either side of it. The corresponding order in the violet is rather weak and exhibits a strong central band at  $\lambda$  4050 and weak bands at  $\lambda$  3820 and  $\lambda$  4350 respectively which are hardly visible in the reproduction.

Two alternative views may be put forward regarding the structures responsible for such spectra. One is that each specimen contains several separate layers of iridescent material, each of which gives its own series of monochromatic reflections of different orders. While this view cannot be summarily rejected, it is rather difficult to reconcile with all the observational facts and it would, in particular, require a considerable thickness of the crystal to contain all the separate lamellae required by such an explanation. Another view which appears to merit consideration is that the twinning in such crystals is multiply-periodic, in other words, that two or more sequences of equidistant planes exist side by side in the same layer. Such a structure would naturally give rise to complex groups of lines in the spectra instead of a single series of monochromatic reflections.

Finally, mention should also be made of cases which depart still further from the ideal structures giving monochromatic reflections. They give spectra in which the bulk of the intensity is concentrated in particular regions of the spectrum but not in the manner characteristic of regularly ordered stratifications. Examples of spectra of this type are reproduced as figures 5 to 8 in plate II.

## 5. Summary

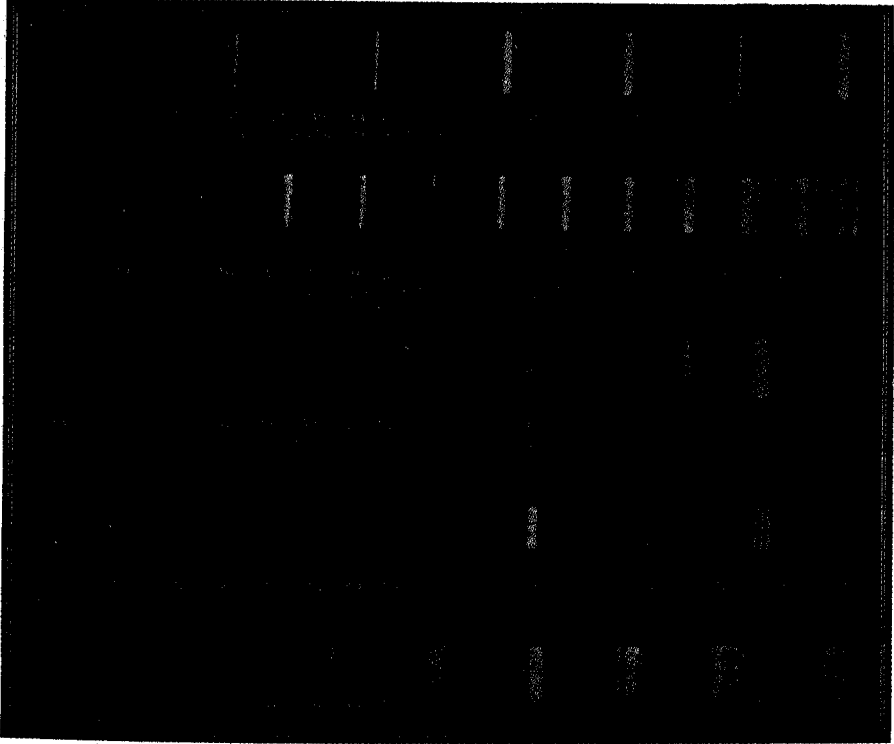
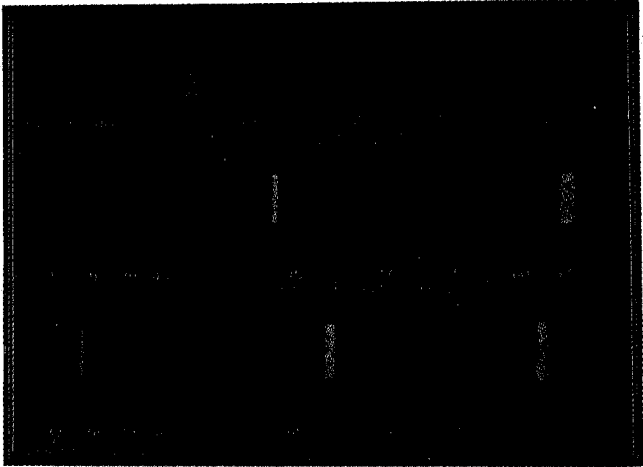
The paper describes the results of a study of an extensive collection of material. The spacing of the stratifications giving rise to monochromatic reflections has been found to range from  $2.7 \mu$  to  $0.14 \mu$ . The monochromatism becomes sensibly more perfect in the reflections of higher orders. Variations in intensity from order to order are also noticeable and these are ascribed to the alternate lamellae in the twinning being of different thickness. Instead of a single series of monochromatic reflections, regularly spaced groups of reflection maxima are also observed in some cases. The components in each group of such reflections may be wide apart or else may be closely spaced. The nature of the stratifications in these cases is discussed.

## References

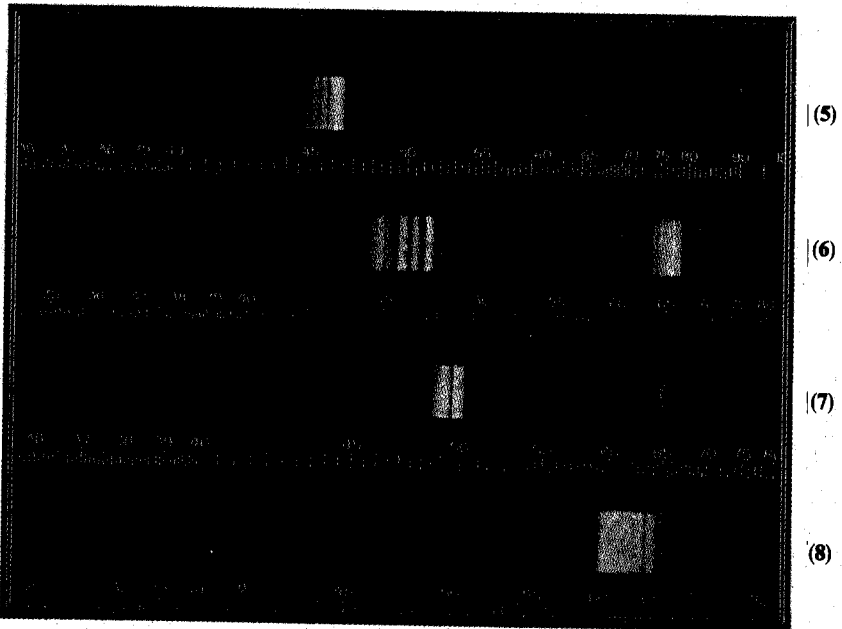
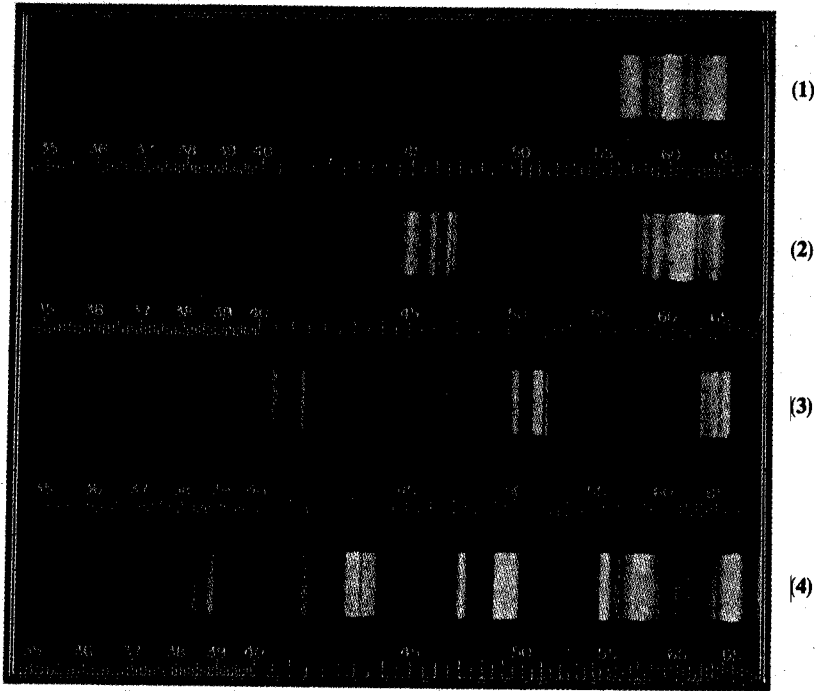
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Figures 1-8  
Plate I



Figures 1-8

Plate II