

CXLI.—*The Effect of Asymmetry. A Study in  
Crystal Structure.*

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COMPARATIVE studies of more or less closely related organic compounds abound in the literature of crystallography; in fact, the attempt to trace so-called "morphotropic resemblances" may be regarded as one of the distinctive features of crystallographic investigation during the last fifty years. Whilst such investigations have added extensively to the general stock of knowledge, they cannot, unfortunately, be said to have led to the formula-

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tion of any general laws correlating chemical composition and crystalline form. At least one of the causes of this general failure has been recently revealed as the result of the investigation of crystal structure by means of *X*-rays. It is now clear that the Bravais space-lattices do not always represent completely the structure of a crystal, for something like 70 per cent. of the structures already elucidated by *X*-ray methods consist of several interpenetrating space-lattices, that is, of "point systems" in the sense of Sohncke, Fedorov, and Schönflies. Crystal structure is thereby proved to be a subject of great complexity, and much further investigation is evidently needed before general laws can be formulated.

The object of the present research was to ascertain whether a definite similarity may exist between the crystalline forms of two closely related organic substances, one of which differs from the other in possessing an asymmetric atom. The kind of similarity sought was of that definite degree which exists between isomorphous substances rather than that vaguely implied by a "morphotropic resemblance."

In selecting materials for examination, it was necessary to find a series of compounds in which the replacement of one radicle by another is not incompatible with an isomorphous relationship (at least so long as the molecule remains symmetrical) before proceeding to inquire whether a further replacement of radicles, by which the molecule becomes asymmetric, is compatible with the survival of isomorphism. Now, experience shows that in series involving the replacement of organic radicles, isomorphism is only to be found where the molecule is relatively large in proportion to the change of composition, and it therefore seemed probable that compounds of the type  $R_4NHgI_3$  (that is, "double compounds" of a quaternary ammonium iodide with mercuric iodide in the ratio 1:1), in which *R* may represent either identical or different organic radicles, should be suitable for the end in view. Such compounds, having a pale to deep lemon-yellow colour, are known to crystallise well from acetone solutions. A commencement was therefore made with a series of compounds in which  $R_4$  is wholly represented by alkyl groups (compare table I), but no definite cases of isomorphism were encountered. This is a fact of some significance, as illustrating the highly sensitive character of the relationship between form and composition: in spite of the high molecular weight, the replacement of even a single methyl by an ethyl radicle brings about a fundamental change of crystalline form and structure.

The investigation of a still more complex group then became necessary. The phenylalkylammonium compounds, of the general

TABLE I.  
*The Alkylammonium Group of Compounds.\**

No	Substance.	System.	Crystallographic constants.		Prism angle.	Cleavage.
			$a : b : c$ .	Axial angles.		
1	$\text{Me}_4\text{NHgI}_3$	Rhombic	0.5777 : 1 : 0.5199	—	60° 2'	001) imperfect.
2	$\text{MeEt}_3\text{NHgI}_3$	Anorthic	1.1202 : 1 : 0.5578	$\alpha = 102^\circ 55'$ $\beta = 93^\circ 56'$ $\gamma = 108^\circ 25'$	98° 18'	(110) good. ( $\bar{1}\bar{1}0$ ) good.
3	$\text{Et}_4\text{NHgI}_3$	Monoclinic	1.4826 : 1 : 0.8192	$\beta = 107^\circ 55'$	109° 20'	(100) perfect. (001) imperfect. (110) perfect.
4	$\text{PrEt}_3\text{NHgI}_3$	"	1.1350 : 1 : 0.7359	$\beta = 97^\circ 11'$	96° 48'	(011) perfect. (110) imperfect.
5	$\text{MePr}_3\text{NHgI}_3$	"	1.0749 : 1 : 0.6542	$\beta = 93^\circ 22'$	94° 2'	(011) fair. (110) imperfect.
6	$\text{EtPr}_3\text{NHgI}_3$	Rhombic	0.6890 : 1 : 0.5106	—	69° 8'	(011) perfect. (110) imperfect.
7	$\text{Pr}_4\text{NHgI}_3$	Monoclinic	1.4965 : 1 : 0.7328	$\beta = 113^\circ 16'$	107° 56'	( $\bar{2}01$ ) good.

\* The corresponding trimethylethyl and trimethylpropyl compounds were also prepared, but the crystals could not be obtained in a form suitable for measurement. In addition to the 1 : 1-compound, tetraethylammonium iodide also forms an orange-coloured substance with mercuric iodide in the molecular proportions 2 : 3. A description of this compound is included in the experimental part (p. 1314).

formula  $R_3\text{PhNHgI}_3$ , furnished clear cases of isomorphism. In the annexed table, the first member is not isomorphous with the succeeding compounds. The next three compounds, however, are clearly isomorphous, and, moreover, exhibit the following peculiarity. Although the compound  $\text{Me}_3\text{EtPhNHgI}_3$  (No. 9) differs from the compound  $\text{MeEt}_2\text{PhNHgI}_3$  (No. 11) by an amount expressible by  $\text{CH}_2$ , it is much more closely isomorphous with it than is the compound  $\text{Me}_2\text{PrPhNHgI}_3$  (No. 10), in spite of the fact that the last two compounds are isomerides. The similarity of angles between the first two mentioned compounds is, indeed, comparable with the close isomorphism met with in the sulphates of potassium, rubidium, caesium, and ammonium. The isomorphism of the three compounds numbered 9—11 was confirmed by a method which has been especially developed by one of us (T., 1906, 89, 1120). Crystal fragments of any one of the three substances continue to grow when placed in a saturated solution of either of the others, and thus satisfy one of the most rigid tests for isomorphism. Proceeding with the table, it is seen that there is a marked change of form in passing from No. 11 to No. 12, differing in composition by  $\text{CH}_2$ , but that the two compounds  $\text{Et}_3\text{PhNHgI}_3$  (No. 12) and  $\text{Et}_2\text{PrPhNHgI}_3$  (No. 13), also differing by  $\text{CH}_2$ , are closely isomorphous—a conclusion which was confirmed by the formation of regular growths when a crystal of one is immersed in a saturated solution of the other.

The choice of the final materials was, of course, dictated by practical considerations. Asymmetry of molecular configuration is most easily produced by the inclusion of a benzyl radicle, and the phenylbenzylalkylammonium group of compounds, represented by the general formula  $R_2(\text{CH}_2\text{Ph})\text{PhNHgI}_3$ , in which asymmetry is involved by the selection of different R-groups, was therefore examined. The results of the crystallographic examination are summarised in table III.

A glance at the values of the axial ratios is sufficient to show that the first substance has no really close relationship to the second and third compounds; moreover, the large discrepancy in the axial ratio  $b:c$  of the fourth substance shows that it also stands alone. The relationships of the second and third compounds (No. 15 and No. 16 of the table) deserve further notice. The axial ratios and angle  $\beta$  differ by relatively small amounts, thus indicating the possibility that the two substances are isomorphous. A comparison of the form-development points the same way. In the methylethyl derivative we have  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $q\{011\}$ , and  $r\{201\}$ , with the forms  $b$  and  $a$  developed as small facets, whilst in the diethyl derivative we have

TABLE II.

*The Phenylalkylammonium Group of Compounds.\**

No.	Substance.	System.	Crystallographic constants.		Prism angle.	Cleavage.
			$a : b : c.$	$\beta.$		
8	$\text{Me}_3\text{PhNHgI}_3$	Monoclinic	1.2400 : 1 : 0.6783	104°54'	100°18'	(100) good.
9	$\text{Me}_2\text{EtPhNHgI}_3$	"	0.7391 : 1 : 0.6783	94° 6'	72°48'	(001) perfect.
10	$\text{Me}_2\text{PrPhNHgI}_3$	"	0.7775 : 1 : 0.6711	96°34'	75°22'	(001) perfect.
11	$\text{MeEt}_2\text{PhNHgI}_3$	"	0.7319 : 1 : 0.6976	93°24'	72°18'	(001) perfect. (110) imperfect.
12	$\text{Et}_3\text{PhNHgI}_3$	"	1.1250 : 1 : 1.3490	101°21'	95°36'	(100) perfect.
13	$\text{Et}_2\text{PrPhNHgI}_3$	"	1.1185 : 1 : 1.3440	100°57'	95°22'	(100) perfect. (110) imperfect.

\* Phenyltriethylammonium iodide also forms a second type of compound with mercuric iodide in the molecular proportions 2 : 1. A description of this substance is included in the experimental part (p. 1318).

TABLE III.

*The Phenylbenzylalkylammonium Group of Compounds.*

No.	Substance.	System.	Crystallographic constants.		Prism angle.	Cleavage.
			$a : b : c.$	$\beta.$		
14	$\text{Me}_2(\text{CH}_2\text{Ph})\text{PhNHgI}_3$	Monoclinic	0.7386 : 1 : 0.5105	92°26'	72°52'	(100) fair.
15	$\text{MeEt}(\text{CH}_2\text{Ph})\text{PhNHgI}_3$	"	0.9878 : 1 : 0.5797	106° 9'	87° 0'	(110) good.
16	$\text{Et}_2(\text{CH}_2\text{Ph})\text{PhNHgI}_3$	"	1.0301 : 1 : 0.6354	108° 7'	88°48'	(001) imperfect. (201) perfect.
17	$\text{MePr}(\text{CH}_2\text{Ph})\text{PhNHgI}_3$	"	1.1060 : 1 : 0.7766	102°55'	94°18'	(100).

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the same forms, but without  $b\{010\}$  and  $a\{100\}$ . Since in the former compound these two forms were but slightly developed, their absence in the latter has no particular significance, merely indicating that one compound tends to present a richer form-development than the other. The coincidence of all the remaining forms, and, more especially, the occurrence in common of the form  $\{201\}$ , point to an identical space-lattice, and prove the substances to be isomorphous, in so far as purely geometrical characters can do so. This conclusion is strengthened by the observation that a broken fragment of the diethyl compound, when placed in a saturated solution of the methylethyl derivative, immediately begins to grow, and eventually becomes a perfect crystal.

The sole remaining question relates to the special chemical nature of phenylbenzylmethylethylammonium mercuri-iodide: whether the crystals are dextro- and lævo-enantiomorphs, or are racemic or pseudo-racemic. As no trace of optical inhomogeneity was ever observed in crystals selected from various crops, and as the measurements gave no indications of the wide variations of angle characteristic of pseudo-racemic crystals, it follows that the crystals are either truly racemic or, on the other hand, a conglomerate of the two enantiomorphs. In order to decide this question, three of the largest crystals, weighing approximately 2, 1.5, and 1 gram respectively, were powdered, and as rapidly as possible dissolved separately in about 20 c.c. of acetone, and the solutions immediately examined in the polarimeter. In no case was an appreciable rotation observed; the crystals therefore presumably represent a true racemate. This conclusion was supported by etch-figures on the crystal faces, for they were in accordance with holohedral symmetry.

The main result of this investigation is to prove that racemic crystals of phenylbenzylmethylethylammonium mercuri-iodide are isomorphous with the corresponding diethyl derivative, although the racemic crystals contain two kinds of asymmetric molecules, whilst in the diethyl derivative all the molecules are necessarily identically similar and symmetrical.

## EXPERIMENTAL.

*Preparation of Compounds.*

The general method of preparing the compounds was as follows. The proper molecular proportions of the tertiary amine, alkyl iodide, and mercuric iodide were warmed together with acetone until the whole was dissolved, and the solution allowed to remain overnight. Crystals were usually obtained the following day,

although two or three recrystallisations were sometimes necessary before really good crystals were formed.

Some of the compounds prepared were found to be unsuitable for crystallographic investigation; the trimethylethyl and trimethylpropyl compounds, for example, crystallise in needles. On the other hand, in some cases more than one compound is formed; thus, tetraethylammonium iodide unites with mercuric iodide in the proportions 1:1 and 2:3. With regard to the phenylalkyl group, it was observed that increase of molecular weight lowered the crystallisability of the compounds; sometimes five or six recrystallisations were necessary before sufficiently good crystals were obtained. The phenyldimethylpropyl and phenyldimethylethyl compounds have a strong tendency to form needles, but after repeated recrystallisations they finally yielded some measurable crystals. In one and the same solution, phenyltriethylammonium iodide forms with mercuric iodide two compounds, which on analysis proved to be the 2:1- and 1:1-compounds respectively; these were separated by hand. In the phenylbenzylalkyl group, the chemical combination of the various components was relatively slow; several attempts to prepare phenylbenzylethylpropylammonium mercuri-iodide were made, but a pure product could not be isolated.

#### *Method of Analysis.*

The method employed for the quantitative estimation of the mercury was that described by Marsh and Lye (*Analyst*, 1917, **42**, 84). The process is a modification of the method of estimating mercury by combustion with quicklime. Calcium oxalate is placed at the closed end of the tube, and after this a few grams of dry calcium sulphate and quicklime; next comes about 1 gram of the substance ground up with about the same weight of potassium cyanide and a few grams of calcium sulphate and quicklime.\* After this, 5 or 6 grams of a mixture of calcium sulphate and quicklime are packed in, and the remainder of the tube is filled with quicklime. The vaporised mercury is collected in a small flask of water. No calcium sulphate was used with the tetramethyl, phenyldimethylpropyl, and phenyldiethylpropyl compounds. It may be noted that more satisfactory results were obtained with a tube longer than that recommended by Marsh and Lye; the length of the tube before drawing out should be about 50 cm.

\* In the case of the phenylbenzylalkylammonium group about a gram of black copper oxide was mixed with the substance and the potassium cyanide was placed nearer the drawn-out end of the tube.

*Method of Crystallographic Examination.*

A Fedorov two-circle goniometer was exclusively employed in the measurement of the crystals. Apart from its other advantages, a two-circle instrument is especially useful for the measurement of laboratory products, the crystals of which are frequently of microscopic dimensions, since it necessitates only one adjustment of the crystal. The results were plotted on a Fedorov stereographic net, and the crystal system, if not immediately obvious, was deduced from zonal angles, graphically determined by the help of the three-point compass and stereographic net, and later confirmed by an examination of the optical properties. The crystallographic indices were determined graphically in every case by the help of the gnomonic projection. In order to avoid possible errors, the axial ratios have been calculated in two independent ways for every compound. First, by the method in common use, depending on the solution of spherical triangles, and, secondly, by Goldschmidt's method (*Zeitsch. Kryst. Min.*, 1893, **21**, 210), based on the gnomonic projection. The crystal drawings were made directly from the gnomonic projection by the method devised by Goldschmidt (*Zeitsch. Kryst. Min.*, 1891, **19**, 352). Attention is especially called to this point, because the method does not appear to have come into general use, although experience proves it to be superior to all the other methods of drawing crystals.

In the descriptions of the crystals, the conventional rules have been adopted [in the monoclinic system, for instance, the indices (010) have been uniformly assigned to the plane of symmetry]; but, in addition, the "correct setting" of the crystal according to Fedorov's methods, and his "complex-symbol," have been worked out in every case, and the "transformation equations," by which the indices corresponding with Fedorov's theoretical ideas may be obtained from the conventional indices, are also given. The descriptions consequently contain everything necessary for an absolute identification of any of the compounds on any future occasion by the method now generally known as "crystallo-chemical analysis," a descriptive outline of which has already been given elsewhere (*Ann. Reports*, 1913, **10**, 245; 1914, **11**, 248; 1917, **14**, 227). An explanation of the meaning of the terms "transformation equations" and "complex-symbol" may well be appended here, as not having been previously given.

The connexion between the indices representing any face of a crystal when referred to two different sets of axes is most conveniently expressed by means of "transformation equations," by which one set of indices can be immediately deduced from the



other. Thus, in the case of the anorthic methyltriethylammonium mercuri-iodide (p. 1313), the new indices ( $pqr$ ) of any face referred to the axes chosen by Fedorov on structural grounds can be obtained from its indices ( $hkl$ ) when referred to the conventional axes by the equations:  $p = -1h + 0k + 2l$ ,  $q = 1h + 0k + 2l$ ,  $r = 1h + 2k + 0l$ . The numerical coefficients of  $hkl$  in these equations are  $\bar{1}02$ ,  $102$ , and  $120$  respectively, and the equations can be abbreviated to "trans.  $\bar{1}02/102/120$ "—a form which is adopted in this paper.

The Fedorov "complex-symbol" is an expression which indicates simultaneously both the type of structural arrangement and the characteristic angles of the crystal (if necessary, after a suitable homogeneous deformation or shear). The initial term of the symbol is the number 6, 4, or 3, according as the crystal is held to approximate most closely to a hexagonal, tetragonal, or trigonal (rhombohedral) form respectively. When necessary, this number is immediately followed by a letter,  $h$ ,  $o$ , or  $d$ , respectively indicating, in Fedorov's phraseology, that the arrangement is "hexahedral" (that is, that of a simple space-lattice), "octahedral" (that of a centred lattice), or "dodecahedral" (that of a face-centred lattice). Thus  $4h$  signified that the type of the structural arrangement is that of a simple tetragonal space-lattice, whilst  $3d$  indicates the face-centred trigonal lattice as being the structural type. All remaining terms of the complex-symbol are numerical constants, representing degrees of arc, which serve to characterise each crystal species. As described below, one of these numerical terms, expressing in general the value of the angle (after a shear) between the correct basal plane and primary pyramid, is especially important in Fedorov's classification, so by way of contrast he encloses in brackets all other terms as are necessary to express the angular deviations of the lattice from an ideal hexagonal, tetragonal, or trigonal form. Thus, in the symbol " $(6)37\frac{1}{2}(+3)$ ," the first term means that the crystal approaches ideal hexagonal symmetry, the second that the principal angle is  $37\frac{1}{2}^\circ$ , and the third that the prism angle has the value  $60^\circ + 3^\circ$  instead of the value  $60^\circ$  proper to an ideal hexagonal lattice. The absence of any further term indicates that the system is orthorhombic. On the other hand, in the symbol " $(3h; +2)58(0)$ " we have a new kind of numerical term, namely,  $+2$ , immediately following the structural term  $3h$ . This means that the angle between two of the structural planes is not  $90^\circ$ , but  $90^\circ + 2^\circ$ , in other words, that the crystal is monoclinic with a value  $\beta = 92^\circ$ . The last term, " $(0)$ ," refers, as before, to the prism angle, and means that the deviation (from the ideal value of  $60^\circ$ ) is nearer

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$0^\circ$  than  $\frac{1}{2}^\circ$ . The angles in the complex-symbols are only given to the nearest half degree, since this is the limit of accuracy of the graphical methods employed.

The Fedorov complex-symbol derives its immense importance from two facts: first, unlike axial ratios, it is an unambiguous constant for each crystal-species, and, secondly, such symbols can be readily classified in ordered form. In his "Dictionary of the Crystal-Kingdom," the publication of which by the Petrograd Academy of Science has been delayed by circumstances beyond its control, the late Professor Fedorov has classified all the existing data. All crystals belonging to the same type (say  $4h$  or  $3d$ , and so on) are first brought together, and then arranged in order according to the value of the principal angle mentioned above. Any well-developed crystalline substance which has once been measured, and placed in the dictionary in the place required by its complex-symbol, can be identified on any future occasion, for it is only necessary to measure the crystal to be identified, deduce its complex-symbol from the form-development, and refer to the dictionary for a statement of the chemical composition.

*Analytical and Crystallographic Details.*

Following is a detailed summary of the results of chemical analysis and crystallographic measurement of the various substances prepared. Although measured angles only are reproduced in this paper (the angles which served as a basis for calculation being marked with an asterisk), it may be mentioned that the correctness of the various indices was checked by the logarithmic computation of the angular values demanded by the law of simple, rational indices, and that these computed angles were in every case satisfactorily close to the measured angles. The omission of these computed angles results in a great saving of space and does not seem to us to involve the loss of anything essential to the future usefulness of the crystallographic descriptions.

*Tetramethylammonium Mercuri-iodide*,  $\text{Me}_4\text{NHgI}_3$ .—M. p. above  $200^\circ$  (Found:  $\text{Hg}=30.43$ . Calc.:  $\text{Hg}=30.53$  per cent.). Orthorhombic,  $a:b:c=0.5777:1:0.5199$ . Forms:  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $n\{120\}$ ,  $c\{001\}$ ,  $e\{101\}$ ,  $p\{111\}$ ,  $t\{121\}$ . Two distinct habits were observed on crystals from acetone. The more usual habit is shown in Fig. 1. The second habit is bipyramidal and tabular parallel to  $b\{010\}$ . Following are the mean angular values obtained from five crystals:

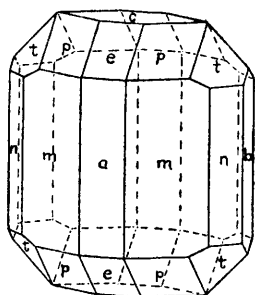
	$b\{010\}$ .	$a\{100\}$ .	$m\{110\}$ .	$n\{120\}$ .	$e\{101\}$ .	$p\{111\}$ .	$t\{121\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$90^\circ 4'$	$*59^\circ 59'$	$40^\circ 50'$	$89^\circ 53'$	$59^\circ 59'$	$40^\circ 54'$
Polar distance ( $\rho$ )	$89^\circ 59'$	$89^\circ 59'$	$90^\circ 0'$	$90^\circ 2'$	$*41^\circ 59'$	$46^\circ 3'$	$53^\circ 57'$

Cleavages:  $a\{100\}$ , fair;  $c\{001\}$ , imperfect. Optic axial plane,  $a\{100\}$ ; acute bisectrix, perpendicular to  $\{001\}$ ; wide axial angle; birefringence, strong; dispersion  $\rho > v$ .

Trans.: 100/001/010. Complex-symbol,  $(4d)69(+3)$ .

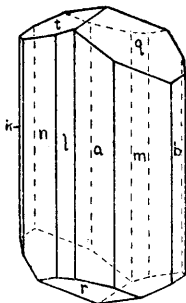
*Methyltriethylammonium Mercuri-iodide*,  $\text{MeEt}_3\text{NHgI}_3$ .—M. p.  $104^\circ$  (Found:  $\text{Hg}=28.67$ .  $\text{C}_7\text{H}_{18}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=28.73$  per cent.). Anorthic,  $a:b:c=1.1202:1:0.5578$ ;  $\alpha=102^\circ 55'$ ,  $\beta=93^\circ 56'$ ,  $\gamma=108^\circ 25'$ . Forms:  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $n\{1\bar{1}0\}$ ,  $k\{1\bar{2}0\}$ ,  $l\{2\bar{1}0\}$ ,  $q\{011\}$ ,  $t\{0\bar{1}1\}$ ,  $r\{1\bar{0}1\}$ . The common habit is

FIG. 1.



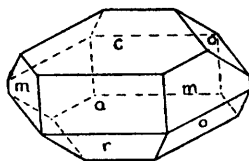
*Tetramethylammonium mercuri-iodide.*

FIG. 2.



*Methyltriethylammonium mercuri-iodide.*

FIG. 3.



*Tetraethylammonium mercuri-iodide.*

slender prismatic, as shown in Fig. 2. Following are the mean angular values obtained from nine crystals:

	$b\{010\}$ .	$a\{100\}$ .	$m\{110\}$ .	$n\{1\bar{1}0\}$ .	$k\{1\bar{2}0\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$*70^\circ 5'$	$*32^\circ 18'$	$130^\circ 40'$	$154^\circ 17'$
Polar distance ( $\rho$ ) ...	$90^\circ 0'$	$90^\circ 0'$	$90^\circ 0'$	$90^\circ 0'$	$90^\circ 0'$
	$l\{2\bar{1}0\}$ .	$q\{011\}$ .	$t\{0\bar{1}1\}$ .	$r\{1\bar{0}1\}$ .	
Azimuth ( $\phi$ ) .....	$104^\circ 5'$	$*4^\circ 29'$	$168^\circ 32'$	$281^\circ 43'$	
Polar distance ( $\rho$ ) ...	$90^\circ 0'$	$*41^\circ 21'$	$*19^\circ 3'$	$23^\circ 41'$	

Cleavages:  $m\{110\}$  and  $n\{1\bar{1}0\}$ , good. Optics: All the prism faces give oblique extinction.

Trans.:  $\bar{1}02/102/120$ . Complex-symbol,  $(4d; \pm 21)62(0; 0, ?)$ .

*Tetraethylammonium Mercuri-iodide*,  $\text{Et}_4\text{NHgI}_3$ .—M. p.  $110^\circ$  (Found:  $\text{Hg}=27.95$ . Calc.:  $\text{Hg}=28.13$  per cent.). Monoclinic,  $a:b:c=1.4826:1:0.8192$ ;  $\beta=107^\circ 55'$ . Forms.  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $r\{201\}$ ,  $o\{111\}$ . The common habit is stout prismatic, as shown in Fig. 3. Following are the mean angular values obtained from five crystals:

	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$r\{201\}$ .	$o\{111\}$ .
Azimuth ( $\phi$ ) .....	$90^\circ 0'$	$*35^\circ 20'$	$89^\circ 46'$	$269^\circ 58'$	$*342^\circ 34'$
Polar distance ( $\rho$ ) ...	$90^\circ 0'$	$90^\circ 0'$	$17^\circ 54'$	$39^\circ 56'$	$*40^\circ 39'$

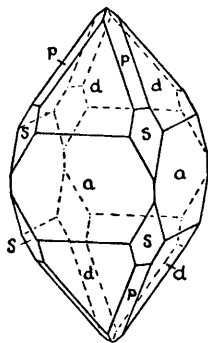
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Cleavages:  $a\{100\}$ , perfect;  $c\{001\}$ , imperfect. Optic axial plane,  $b(010)$ . An optic axis emerges nearly perpendicular to  $c\{001\}$ .

Trans.:  $011/01\bar{1}/101$ . Complex-symbol,  $(4d; -14\frac{1}{2})55(-6\frac{1}{2})$ .

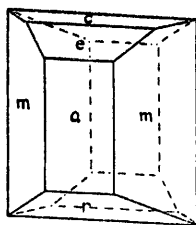
*Tetraethylammonium Mercuri-iodide*,  $2\text{Et}_4\text{NI}\cdot 3\text{HgI}_2$ .—M. p.  $154^\circ$  (Found:  $\text{Hg}=31.94$ . Calc.:  $\text{Hg}=31.98$  per cent.). Tetragonal,  $c:a=0.8186:1$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $e\{101\}$ ,  $d\{201\}$ ,  $p\{111\}$ ,  $s\{221\}$ . The common habit of the crystals is shown in Fig. 4. Following are the mean angular values obtained from four crystals:

FIG. 4.



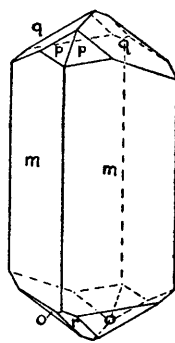
*Tetraethylammonium mercuri-iodide.*

FIG. 5.



*Triethylpropylammonium mercuri-iodide.*

FIG. 6.



*Methyltripropylammonium mercuri-iodide.*

	$a\{100\}$ .	$m\{110\}$ .	$e\{101\}$ .	$d\{201\}$ .	$p\{111\}$ .	$s\{221\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$45^\circ 0'$	$0^\circ 3'$	$0^\circ 3'$	$45^\circ 3'$	$45^\circ 2'$
Polar distance ( $\rho$ ) .....	$90^\circ 0'$	$90^\circ 8'$	$39^\circ 13'$	$*58^\circ 35'$	$49^\circ 9'$	$66^\circ 35'$

Cleavage:  $a\{100\}$ , good. Double refraction, very strong; positive. Complex-symbol,  $(4h)49^\circ 9'$ .

*Triethyl- $\alpha$ -propylammonium Mercuri-iodide*,  $\text{Et}_3\text{Pr}^\alpha\text{NHgI}_3$ .—M. p.  $85^\circ$  (Found:  $\text{Hg}=27.33$ .  $\text{C}_9\text{H}_{22}\text{NI}\cdot\text{HgI}_2$  requires  $\text{Hg}=27.58$  per cent.). Monoclinic,  $a:b:c=1.1350:1:0.7359$ ,  $\beta=97^\circ 11'$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $e\{101\}$ ,  $r\{\bar{1}01\}$ ,  $p\{111\}$ . Two habits were observed, one of which is shown in Fig. 5. The second habit shows the pyramid  $p\{111\}$ , and  $a\{100\}$  is much narrower. Following are the mean angular values obtained from six crystals:

	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$e\{101\}$ .	$r\{\bar{1}01\}$ .	$p\{111\}$ .
Azimuth ( $\phi$ ) .....	$90^\circ 0'$	$*41^\circ 36'$	$89^\circ 58'$	$89^\circ 59'$	$270^\circ 4'$	$46^\circ 39'$
Polar distance ( $\rho$ ) .....	$90^\circ 0'$	$90^\circ 0'$	$7^\circ 5'$	$*37^\circ 51'$	$27^\circ 58'$	$*46^\circ 59'$

Cleavage:  $m\{110\}$ , perfect. Optic axial plane,  $b(010)$ . An optic axis is visible through  $a\{100\}$  on the extreme edge of the field.

Trans.:  $\bar{1}10/\bar{1}\bar{1}0/002$ . Complex-symbol,  $(3h; +2)58(0)$ .

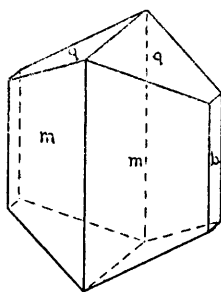
*Methyltri- $\alpha$ -propylammonium Mercuri-iodide*,  $\text{MePr}_3\text{NHgI}_3$ .—M. p.  $123^\circ$  (Found:  $\text{Hg}=26.55$ .  $\text{C}_{10}\text{H}_{24}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=27.06$  per cent.). Monoclinic,  $a:b:c=1.0749:1:0.6542$ ;  $\beta=93^\circ 22'$ . Forms:  $m\{110\}$ ,  $q\{011\}$ ,  $r\{\bar{1}01\}$ ,  $p\{111\}$ ,  $o\{\bar{1}11\}$ . Two distinct habits were observed, one of which is shown by Fig. 6. The second habit is stout prismatic with large pyramidal faces. Following are the mean angular values obtained from five crystals:

	$m\{110\}$ .	$q\{011\}$ .	$r\{\bar{1}01\}$ .	$p\{111\}$ .	$o\{\bar{1}11\}$ .
Azimuth ( $\phi$ ) .....	$42^\circ 59'$	$4^\circ 59'$	$269^\circ 53'$	$45^\circ 37'$	$319^\circ 50'$
Polar distance ( $\rho$ ) ...	$90^\circ 1'$	$33^\circ 24'$	$28^\circ 56'$	$43^\circ 5'$	$40^\circ 26'$

Cleavages:  $q\{011\}$ , fair;  $m\{110\}$ , imperfect. Optic axial plane,  $b(010)$ , and an optic axis is visible through  $a(100)$  on the edge of the field.

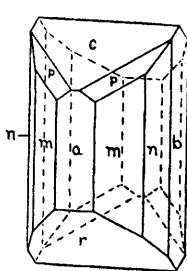
Trans.:  $\bar{1}10/\bar{1}\bar{1}0/002$ . Complex-symbol,  $(4o; +3\frac{1}{2})50(-2)$ .

FIG. 7.



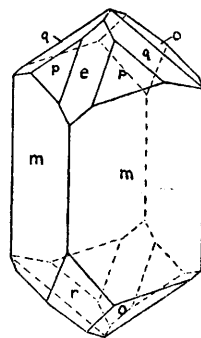
*Ethyltri- $\alpha$ -propylammonium mercuri-iodide.*

FIG. 8.



*Tetrapropylammonium mercuri-iodide.*

FIG. 9.



*Phenyltrimethylammonium mercuri-iodide.*

*Ethyltri- $\alpha$ -propylammonium Mercuri-iodide*,  $\text{EtPr}_3\text{NHgI}_3$ .—M. p.  $135^\circ$  (Found:  $\text{Hg}=26.43$ .  $\text{C}_{11}\text{H}_{26}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=26.56$  per cent.). Orthorhombic,  $a:b:c=0.6890:1:0.5106$ . Forms:  $b\{010\}$ ,  $m\{110\}$ ,  $q\{011\}$ . The common habit is shown in Fig. 7. A second habit was observed much shortened along the vertical axis. Following are the mean angular values obtained from six crystals:

	$b\{010\}$ .	$m\{110\}$ .	$q\{011\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$55^\circ 26'$	$0^\circ 0'$
Polar distance ( $\rho$ ) ...	$89^\circ 58'$	$90^\circ 0'$	$27^\circ 3'$

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Cleavages:  $q\{011\}$ , perfect;  $c\{001\}$ , imperfect. Optic axial plane,  $a\{100\}$ , and the  $c$ -axis is the negative acute bisectrix.

Trans.:  $100/011/00\bar{2}$  Complex-symbol,  $(6)37\frac{1}{2}(+3)$ .

*Tetra- $\alpha$ -propylammonium Mercuri-iodide*,  $\text{Pr}_4\text{NHgI}_3$ .—M. p.  $178^\circ$  (Found:  $\text{Hg}=25.75$ .  $\text{C}_{12}\text{H}_{28}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=26.07$  per cent.). Monoclinic,  $a:b:c=1.4965:1.07328$ ;  $\beta=113^\circ 16'$ . Forms:  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $n\{120\}$ ,  $c\{001\}$ ,  $r\{\bar{2}01\}$ ,  $p\{111\}$ . The habit is prismatic, as shown in Fig. 8. Following are the mean angular values obtained from five crystals:

	$b\{010\}$ .	$a\{100\}$ .	$m\{110\}$ .	$n\{120\}$ .	$c\{001\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$90^\circ 0'$	$*36^\circ 2'$	$20^\circ 1'$	$89^\circ 58'$
Polar distance ( $\rho$ ) ...	$90^\circ 0'$	$90^\circ 2'$	$90^\circ 2'$	$90^\circ 0'$	$*23^\circ 16'$

	$r\{\bar{2}01\}$ .	$p\{111\}$ .
Azimuth ( $\phi$ ) .....	$270^\circ 0'$	$52^\circ 45'$
Polar distance ( $\rho$ ) ...	$32^\circ 19'$	$*50^\circ 26'$

Cleavages:  $m\{110\}$  and  $r\{\bar{2}01\}$ , good. Optic axial plane,  $b(010)$ . An optic axis emerges nearly perpendicular to  $r\{\bar{2}01\}$  and the acute negative bisectrix nearly coincides with the  $c$ -axis. Dispersion, moderate,  $\rho > v$ .

Trans.:  $0\bar{1}1/011/\bar{1}0\bar{1}$ . Complex-symbol,  $(3d; -14)50(+1\frac{1}{2})$ .

*Phenyltrimethylammonium Mercuri-iodide*,  $\text{PhMe}_3\text{NHgI}_3$ .—M. p.  $135^\circ$  (Found:  $\text{Hg}=27.80$ .  $\text{C}_9\text{H}_{14}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=27.89$  per cent.). Monoclinic,  $a:b:c=1.2400:1.06783$ ;  $\beta=104^\circ 54'$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $n\{210\}$ ,  $q\{011\}$ ,  $e\{101\}$ ,  $r\{\bar{3}01\}$ ,  $p\{111\}$ ,  $o\{\bar{1}11\}$ . The habit is prismatic, as shown in Fig. 9. Following are the mean angular values as obtained from five crystals:

	$a\{100\}$ .	$m\{110\}$ .	$n\{210\}$ .	$q\{011\}$ .	$e\{101\}$ .
Azimuth ( $\phi$ ) .....	$90^\circ 0'$	$*39^\circ 51'$	$59^\circ 6'$	$21^\circ 28'$	$90^\circ 0'$
Polar distance ( $\rho$ ) ...	$90^\circ 1'$	$90^\circ 0'$	$90^\circ 0'$	$36^\circ 6'$	$*39^\circ 46'$

	$r\{\bar{3}01\}$ .	$p\{111\}$ .	$o\{\bar{1}11\}$ .
Azimuth ( $\phi$ ) .....	$269^\circ 59'$	$50^\circ 54'$	$336^\circ 4'$
Polar distance ( $\rho$ ) ...	$55^\circ 7'$	$*47^\circ 2'$	$36^\circ 34'$

Cleavage:  $a\{100\}$ , good. Optic axial plane,  $b(010)$ . Through  $a\{100\}$  an optic axis is visible on the edge of the field.

Trans.:  $\bar{1}10/\bar{1}\bar{1}0/002$ . Complex-symbol,  $(4a; +15)48\frac{1}{2}(-5)$ .

*Phenyl dimethylethylammonium Mercuri-iodide*,  $\text{PhMe}_2\text{EtNHgI}_3$ .—M. p.  $95^\circ$  (Found:  $\text{Hg}=27.21$ .  $\text{C}_{10}\text{H}_{16}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=27.36$  per cent.). Monoclinic,  $a:b:c=0.7391:1.06783$ ;  $\beta=94^\circ 6'$ . The common habit is that of unmeasurable radiating needles. A few measurable crystals were obtained of the type shown in Fig. 10.

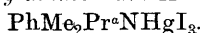
Forms:  $m\{110\}$ ,  $q\{011\}$ ,  $e\{101\}$ ,  $r\{\bar{1}01\}$ ,  $c\{001\}$ . Following are the mean angular values obtained from seven crystals (no trustworthy results were obtainable from the face  $c$ , which was always curved):

	$m\{110\}$ .	$q\{011\}$ .	$e\{101\}$ .	$r\{\bar{1}01\}$ .
Azimuth ( $\phi$ ) .....	$53^{\circ}36'$	$6^{\circ}2'$	$89^{\circ}59'$	$270^{\circ}0'$
Polar distance ( $\rho$ ) ...	$90^{\circ}1'$	$34^{\circ}18'$	$44^{\circ}43'$	$40^{\circ}22'$

Cleavage:  $c\{001\}$ , perfect. Optic axial plane,  $b(010)$ . An optic axis is visible through  $c\{001\}$  on the edge of the field. The dispersion of the optic axes is strong.

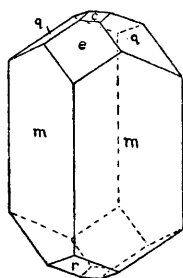
Trans.:  $\bar{1}01/\bar{1}0\bar{1}/010$ . Complex-symbol,  $(4d; 4)53(-2\frac{1}{2})$ .

*Phenyldimethyl- $\alpha$ -propylammonium Mercuri-iodide*,



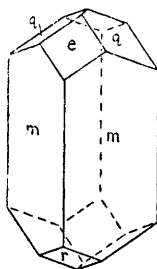
—M. p.  $88^{\circ}$  (Found:  $\text{Hg} = 26.54$ .  $\text{C}_{11}\text{H}_{18}\text{NI}, \text{HgI}_2$  requires  $\text{Hg} = 26.84$  per cent.). Monoclinic,  $a:b:c = 0.7775:1:0.6711$ ;  $\beta = 96^{\circ}34'$ . Forms:  $m\{110\}$ ,  $q\{011\}$ ,  $e\{101\}$ ,  $r\{\bar{1}01\}$ . The common

FIG. 10.



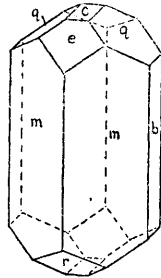
*Phenyldimethylethylammonium mercuri-iodide.*

FIG. 11.



*Phenyldimethylpropylammonium mercuri-iodide.*

FIG. 12.



*Phenylmethyldiethylammonium mercuri-iodide.*

form is that of radiating needles. A few measurable crystals were obtained of the habit shown in Fig. 11, with prism faces much curved. Following are the mean angular values obtained from seven crystals:

	$m\{110\}$ .	$q\{011\}$ .	$e\{101\}$ .	$r\{\bar{1}01\}$ .
Azimuth ( $\phi$ ) .....	$53^{\circ}19'$	$9^{\circ}44'$	$89^{\circ}52'$	$269^{\circ}57'$
Polar distance ( $\rho$ ) ...	$90^{\circ}0'$	$34^{\circ}14'$	$44^{\circ}44'$	$36^{\circ}58'$

Cleavage:  $c\{001\}$ , perfect. Optic axial plane perpendicular to  $b(010)$ . The acute negative bisectrix is nearly perpendicular to  $c\{001\}$ . Dispersion strong,  $\rho > v$ .

Trans.:  $\bar{1}01/\bar{1}0\bar{1}/010$ . Complex-symbol,  $(4d; 6\frac{1}{2})52\frac{1}{2}(-4)$ .

*Phenylmethyldiethylammonium Mercuri-iodide*,  $\text{PhMeEt}_2\text{NHgI}_3$ .

—M. p.  $96^{\circ}$  (Found:  $\text{Hg} = 26.63$ .  $\text{C}_{11}\text{H}_{18}\text{NI}, \text{HgI}_2$  requires  $\text{Hg} =$

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26.84 per cent.). Monoclinic,  $a:b:c=0.7319:1:0.6976$ ;  $\beta=93^{\circ}24'$ . Forms:  $b\{010\}$ ,  $m\{110\}$ ,  $n\{120\}$ ,  $c\{001\}$ ,  $q\{011\}$ ,  $e\{101\}$ ,  $r\{\bar{1}01\}$ . The common habit is shown by Fig. 12. Following are the mean angular values obtained from five crystals:

	$b\{010\}$ .	$m\{110\}$ .	$n\{120\}$ .	$c\{001\}$ .	$q\{011\}$ .
Azimuth ( $\phi$ ) .....	$0^{\circ} 0'$	$*53^{\circ}51'$	$34^{\circ}18'$	$89^{\circ}54'$	$*4^{\circ}52'$
Polar distance ( $\rho$ ) ...	$90^{\circ} 0'$	$90^{\circ} 0'$	$90^{\circ} 0'$	$3^{\circ}25'$	$*34^{\circ}57'$

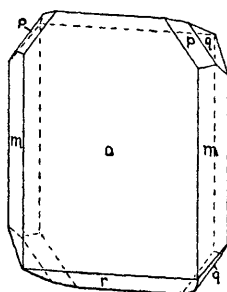
	$e\{101\}$ .	$r\{\bar{1}01\}$ .
Azimuth ( $\phi$ ) .....	$90^{\circ} 2'$	$269^{\circ} 57'$
Polar distance ( $\rho$ )	$45^{\circ}19'$	$41^{\circ}42'$

Cleavages:  $c\{001\}$ , perfect;  $m\{110\}$ , imperfect. Optic axial plane,  $b(010)$ . An optic axis is inclined at about  $20^{\circ}$  to  $c\{001\}$ . The double refraction is negative, with strong dispersion  $\rho < v$ .

Trans.:  $\bar{1}01/101/010$ . Complex-symbol,  $(4d; 3)55(+2)$ .

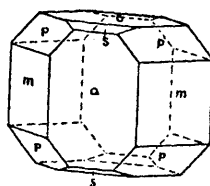
*Phenyltriethylammonium Mercuri-iodide*,  $\text{PhEt}_3\text{NHgI}_3$ .—M. p.  $98^{\circ}$  (Found:  $\text{Hg}=25.94$ .  $\text{C}_{12}\text{H}_{20}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=26.35$  per

FIG. 13.



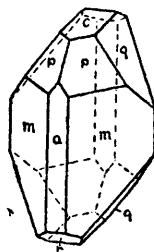
*Phenyltriethylammonium mercuri-iodide* (1:1).

FIG. 14.



*Phenyltriethylammonium mercuri-iodide* (2:1).

FIG. 15.



*Phenyl-diethylpropylammonium mercuri-iodide*.

cent.). Monoclinic,  $a:b:c=1.1250:1:1.3490$ ;  $\beta=101^{\circ}20'$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $r\{\bar{1}02\}$ ,  $q\{011\}$ ,  $p\{111\}$ . The common habit is shown by Fig. 13. Following are the mean angular values obtained from five crystals:

	$a\{100\}$ .	$m\{110\}$ .	$r\{\bar{1}02\}$ .	$q\{011\}$ .	$p\{111\}$ .
Azimuth ( $\phi$ ) .....	$90^{\circ} 0'$	$*42^{\circ}12'$	$269^{\circ}58'$	$8^{\circ} 5'$	$*46^{\circ}33'$
Polar distance ( $\rho$ ) ...	$90^{\circ} 0'$	$90^{\circ} 1'$	$22^{\circ}48'$	$53^{\circ}39'$	$*62^{\circ}59'$

Cleavage:  $a\{100\}$ , perfect. Optic axial plane is  $b(010)$ . Inclined dispersion, strong.

Trans.:  $001/\bar{1}00/010$ . Complex-symbol,  $(4h; 9\frac{1}{2})46(-5\frac{1}{2})$ .

*Phenyltriethylammonium Mercuri-iodide*,  $2\text{PhEt}_3\text{NI}, \text{HgI}_2$ .—M. p.  $144^{\circ}$  (Found:  $\text{Hg}=19.21$ .  $(\text{C}_{12}\text{H}_{20}\text{NI})_2\text{HgI}_2$  requires



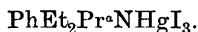
Hg=18·80 per cent.). Orthorhombic,  $a:b:c=0.8642:1:1.1605$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $s\{104\}$ ,  $p\{111\}$ . The habit is shown by Fig. 14. Following are the mean angular values obtained from five crystals:

	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$s\{104\}$ .	$p\{111\}$ .
Azimuth ( $\phi$ ) .....	90° 0'	*49°10'	—	89°58'	49°10'
Polar distance ( $\rho$ ) ...	90° 0'	90° 0'	0° 0'	18°38'	*60°36'

**Cleavage:**  $c\{001\}$ , imperfect. Optic axial plane,  $b(010)$ ; the acute bisectrix is perpendicular to  $c\{001\}$ . The optic axial angle is wide.

**Trans.:** 010/100/001. Complex-symbol,  $(4d)60\frac{1}{2}(+4)$ .

*Phenyldiethyl- $\alpha$ -propylammonium Mercuri-iodide,*



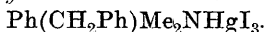
—M. p. 93° (Found: Hg=26·33.  $\text{C}_{13}\text{H}_{22}\text{NI}, \text{HgI}_2$  requires Hg=25·87 per cent.). Monoclinic,  $a:b:c=1.1185:1:1.3440$ ;  $\beta=100^\circ57'$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $q\{011\}$ ,  $r\{\bar{1}02\}$ ,  $p\{111\}$ . The common habit is shown by Fig. 15. Another habit was observed tabular to  $a\{100\}$ . Following are the mean angular values obtained from five crystals:

	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$q\{011\}$ .	$r\{\bar{1}02\}$ .	$p\{111\}$ .
Azimuth ( $\phi$ ) .....	90° 0'	*42°19'	90° 4'	8°10'	270°15'	*46°31'
Polar distance ( $\rho$ )	90° 1'	90° 1'	11° 0'	53°43'	22°45'	*62°53'

**Cleavages:**  $a\{100\}$ , perfect;  $m\{110\}$ , imperfect. Optic axial plane perpendicular to  $b(010)$ . The positive acute bisectrix is visible through  $a\{100\}$  on the edge of the field. Dispersion, strong,  $\rho < \nu$ .

**Trans.:** 001/100/010. Complex-symbol,  $(4h; 11)50(+6)$ .

*Phenylbenzyltrimethylammonium Mercuri-iodide,*

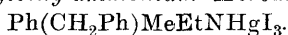


—M. p. 143° (Found: Hg=24·74.  $\text{C}_{15}\text{H}_{18}\text{NI}, \text{HgI}_2$  requires Hg=25·22 per cent.). Monoclinic,  $a:b:c=0.7386:1:0.5105$ ,  $\beta=92^\circ28'$ . Forms:  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $q\{011\}$ ,  $r\{\bar{1}01\}$ ,  $s\{121\}$ ,  $v\{\bar{1}41\}$ ,  $t\{321\}$ . The common habit is shown in Fig. 16. Following are the mean angular values obtained from five crystals:

	$b\{010\}$ .	$a\{100\}$ .	$m\{110\}$ .	$q\{011\}$ .	$r\{\bar{1}01\}$ .
Azimuth ( $\phi$ ) .....	0° 0'	89°59'	*53°34'	4°44'	270° 1'
Polar distance ( $\rho$ ) ...	90° 0'	90° 0'	90° 0'	27° 7'	32°57'
		$s\{121\}$ .	$v\{\bar{1}41\}$ .	$t\{321\}$ .	
Azimuth ( $\phi$ ) .....		*35°43'	342°24'	296°41'	
Polar distance ( $\rho$ ) ...		51°31'	65° 1'	66°15'	

**Cleavage:**  $a\{100\}$ , fair. Optic axial plane,  $b(010)$ .

**Trans.:** 0 $\bar{1}0/\bar{1}0/\bar{1}03$ . Complex-symbol,  $(4d; -7\frac{1}{2})69(+4)$ .

*Phenylbenzylmethylethylammonium Mercuri-iodide,*

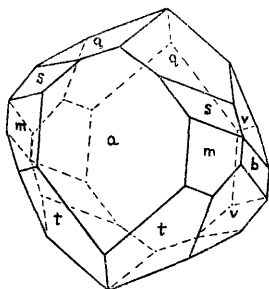
—M. p.  $127^\circ$  (Found:  $\text{Hg}=24.68$ .  $\text{C}_{16}\text{H}_{20}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=24.78$  per cent.). Monoclinic,  $a:b:c=0.9878:1:0.5797$ ,  $\beta=106^\circ 9'$ . Forms:  $b\{010\}$ ,  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $q\{011\}$ ,  $r\{201\}$ . The habit is shown in Fig. 17. Following are the mean angular values obtained from seven crystals:

	$b\{010\}$ .	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$q\{011\}$ .	$r\{201\}$ .
Azimuth ( $\phi$ ) .....	$0^\circ 0'$	$90^\circ 1'$	$*46^\circ 30'$	$90^\circ 8'$	$26^\circ 37'$	$269^\circ 58'$
Polar distance ( $\rho$ ) .....	$90^\circ 0'$	$90^\circ 0'$	$90^\circ 0'$	$16^\circ 9'$	$32^\circ 57'$	$42^\circ 51'$

Cleavage:  $m\{110\}$ , good. Optic axial plane is  $b(010)$ . An optic axis is visible through  $r\{201\}$ . The dispersion is strong.

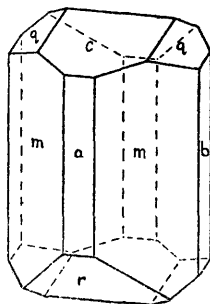
Trans.:  $010/100/001$ . Complex-symbol,  $(4h; -16)40(1\frac{1}{2})$ .

FIG. 16.

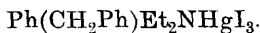


*Phenylbenzylmethylethylammonium mercuri-iodide.*

FIG. 17.



*Phenylbenzylmethylethylammonium mercuri-iodide.*

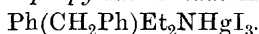
*Phenylbenzyl-diethylammonium Mercuri-iodide,*

—M. p.  $138.5^\circ$  (Found:  $\text{Hg}=23.71$ .  $\text{C}_{17}\text{H}_{22}\text{NI}, \text{HgI}_2$  requires  $\text{Hg}=24.36$  per cent.). Monoclinic,  $a:b:c=1.0301:1:0.6354$ ,  $\beta=108^\circ 7'$ . Forms:  $m\{110\}$ ,  $c\{001\}$ ,  $q\{011\}$ ,  $r\{201\}$ . The crystals are curved and distorted. The common habit is shown in Fig. 18. Following are the mean angular values obtained from seven crystals:

	$m\{110\}$ .	$c\{001\}$ .	$q\{011\}$ .	$r\{201\}$ .
Azimuth ( $\phi$ ) .....	$*45^\circ 36'$	$90^\circ 0'$	$*27^\circ 14'$	$270^\circ 0'$
Polar distance ( $\rho$ ) ...	$90^\circ 0'$	$18^\circ 25'$	$35^\circ 33'$	$43^\circ 49'$

Cleavages:  $c\{001\}$ , imperfect;  $r\{201\}$ , perfect. Optic axial plane,  $b(010)$ , and there is an optic axis visible through  $r\{201\}$  on the edge of the field. There is strong dispersion.

Trans.:  $010/100/001$ . Complex-symbol,  $(4h; -18)42(\frac{1}{2})$ .

*Phenylbenzylmethyl- $\alpha$ -propylammonium Mercuri-iodide,*

—M. p.  $134^\circ$  (Found:  $\text{Hg} = 24.34$ .  $\text{C}_{17}\text{H}_{22}\text{NI}, \text{HgI}_2$  requires  $\text{Hg} = 24.36$  per cent.). Monoclinic,  $a:b:c = 1.1060:1.0:0.7766$ ,  $\beta = 102^\circ 55'$ . Forms:  $a\{100\}$ ,  $m\{110\}$ ,  $c\{001\}$ ,  $r\{\bar{1}01\}$ ,  $s\{221\}$ ,  $x\{\bar{2}21\}$ . The common habit is shown by Fig. 19. Following are the mean angular values obtained from seven crystals:

	$a\{100\}$ .	$m\{110\}$ .	$c\{001\}$ .	$r\{\bar{1}01\}$ .	$s\{221\}$ .	$x\{\bar{2}21\}$ .
Azimuth ( $\phi$ )	..... $90^\circ 0'$	$42^\circ 51'$	$89^\circ 52'$	$270^\circ 0'$	$47^\circ 4'$	$321^\circ 45'$
Polar distance ( $\rho$ )	$90^\circ 0'$	$90^\circ 0'$	$12^\circ 36'$	$26^\circ 45'$	$66^\circ 19'$	$63^\circ 1'$

FIG. 18.

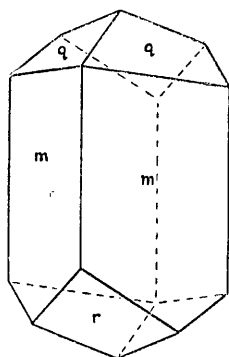
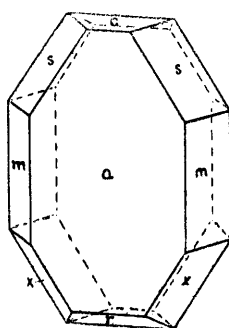
*Phenylbenzylmethylpropylammonium mercuri-iodide.*

FIG. 19.

*Phenylbenzylmethylpropylammonium mercuri-iodide.*

Cleavage:  $a\{100\}$ . The optic axial plane is perpendicular to the plane of symmetry, and an optic axis is visible through  $m\{110\}$ .

Trans.:  $100/010/002$ . Complex-symbol,  $(4d; +13)64\frac{1}{2}(+2)$ .

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