very feeble piezoelectricity but also directly witness the polarity of the phenomenon. The polarity may be deduced by comparing the oscillograms obtained by pressing the crystal first on one side and then on the opposite side. We see, for example, that a phase shift of just 180° takes place in the oscillograms of tourmaline pressed in this way (Fig. 1(*a*), (*b*)). The polarity is further evidenced by the test as follows: We cut the specimen into two parts and exert the pressure on them, superimposing them so that first the same and then the different sides come into contact. Whereas with the latter arrangement we obtain an oscillogram (Fig. 1(*d*)) identical with one of the single slips, with the former we observe that the charge has vanished, the two opposing charges being compensated (Fig. 1(*c*)). This test is especially useful when the charge developed is very small and we cannot tell with certainty that it actually arises from piezoelectricity. We have determined thus that harmotome, $Ba_2Si_{12}Al_4O_{32}.12H_2O$, is definitely, though very weakly, piezoelectric.

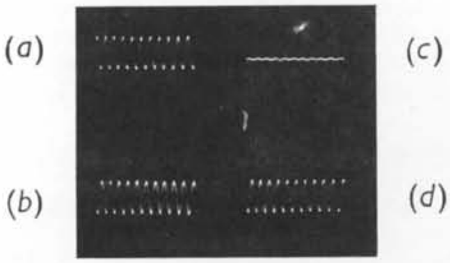

Fig. 1. Oscillograms of tourmaline (*a*) on a face (00.1); (*b*) on the face opposite to (*a*); (*c*) two slips (00.1) superimposed, the same sides of (00.1) being in contact; (*d*) two slips (00.1) superimposed, the different sides of (00.1) being in contact.

The method can be used on any tiny crystal fragment to which the pressure head (needle) of the vibrator can be applied. (This may eventually be manipulated under a microscope.) Usually crystal fragments are embedded in resin or other suitable matrix and a slip is made so that two parallel faces are cut or ground from a single fragment.

We have worked also with Cady's and Giebe & Scheibe's 'click' phenomena (Cady, 1922; see also Cady, 1946, p. 231; Giebe & Scheibe, 1925) displayed visually.* The test described above has, however, proved to be much more convenient and satisfactory.

The writer wishes to express his gratitude to Prof. Ito, who has given him guidance and encouragement throughout the present work.

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* Such a device has been developed at Prof. Hägg's laboratory in Uppsala (private communication from Prof. Ito).

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Unit cell and space group of papaverine, papaverine chlorhydrate and papaverine bromhydrate.

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1. Goniometric measurements

Papaverine or 6:7-dimethoxy-1-[3′:4′-dimethoxy-benzyl] isoquinoline ($C_{20}H_{21}O_4N$) is an alkaloid of the isoquinoline group (*Beilsteins Handbuch*, 1935). Suitable crystals for examination were obtained by slow evaporation of a solution in alcohol and water.

Some information concerning crystallographic data of the three substances cited above is to be found in Groth (1906–19); no further descriptions were found in the literature. Results of goniometric measurement are listed in the following tables.

(*a*) *Papaverine*

Needle-shaped crystals, orthorhombic system, class 222.

Forms	φ	ϱ
110	72° 18′	90° 00′
011	0° 00′	23° 11′
100	90° 00′	90° 00′
120	57° 33′	90° 00′
010	0° 00′	90° 00′
112	72° 18′	34° 45′

Forms in order of development: 110, 011, 100, 120, 010, 112.

$$a:b:c = 0\cdot3267:1:0\cdot4252\ .$$

Barker angles (Barker, 1930; Terpstra, 1946):

$$\underline{c}r = 56°\ 49',\ am = 33°\ 27',\ bq = 32°\ 27'.$$

The axial ratios, derived from the X-ray results, are:

$$a:b:c = 0\cdot3175:1:0\cdot2122.$$

The goniometric and X-ray settings are different. Transformation determinants for Groth's (G), Barker's (B) and the röntgenographic (R) settings are:

$R \rightarrow B$ 002/200/010 $R \rightarrow G$ 100/010/002
$B \rightarrow R$ 010/002/100 $G \rightarrow R$ 200/020/001
$B \rightarrow G$ 010/002/200
$G \rightarrow B$ 001/200/010

(*b*) *Papaverine chlorhydrate*

Prismatic crystals, monoclinic system, class $2/m$.

Forms	φ	ϱ
110	50° 04′	90° 00′
011	3° 31′	30° 32′
121	32° 17′	54° 03′
$\bar{1}21$	330° 22′	53° 23′
$\bar{1}11$	311° 19′	41° 29′
111	51° 37′	43° 08′
100	90° 00′	90° 00′
$\bar{2}11$	293° 07′	56° 09′
120	31° 08′	90° 00′

Forms in order of development: 110, 011, 121, $\bar{1}21$, $\bar{1}11$, 111, 100, $\bar{2}11$, 120.

$$a:b:c = 0\cdot8370:1:0\cdot5845\,.$$

$$X_0' = 0\cdot0367,\ \mu = 2°\ 06',\ \beta = 92°\ 06',\ d = 59°\ 31',\ f = 53°\ 43'.$$

The Barker setting coincides with Groth's setting and with the cell derived from röntgenographic data.

Barker angles:

$$cr = 34°\ 11',\ za = 53°\ 43',\ \underline{am} = 39°\ 56',\ bq = 59°\ 31'.$$

(c) *Papaverine bromhydrate*

Isomorphous with papaverine chlorhydrate.

Forms	φ	ϱ
110	50° 07′	90° 00′
120	31° 01′	90° 00′
100	90° 00′	90° 00′
011	3° 58′	30° 08′
111	51° 52′	43° 08′

Forms in order of development: 110, 120, 100, 011, 111.

$$a:b:c = 0\cdot8314:1:0\cdot5789$$

$$X_0' = 0\cdot0405,\ \mu = 2°\ 19',\ \beta = 92°\ 19',\ d = 59°\ 56',\ f = 53°\ 36'.$$

Here, too, the Barker setting coincides with Groth's setting and with the röntgenographic cell.

Barker angles:

$$cr = 34°\ 05',\ za = 53°\ 36',\ \underline{am} = 39°\ 53',\ bq = 59°\ 56'.$$

2. X-ray data

Laue diagrams of all three substances confirmed the symmetry as derived from the goniometric measurements.

The given values of the angle β were calculated from the goniometric measurements and from zero-layer Weissenberg diagrams, taken with the b axis as rotation axis (Cu $K\alpha$ radiation). The dimensions of the unit cell (Table 1) were determined from rotation and Weissenberg photographs about all three axes.

Table 1

	a(Å)	b(Å)	c(Å)	β	V(Å^3)	σ_c	Z
Papaverine	9·50	29·22	6·35	—	1805	1·248	4
Papaverine.HCl	13·10	15·80	9·22	92° 36′	1902	1·312	4
Papaverine.HBr	13·82	15·94	9·28	92° 36′	2042	1·350	4

σ_c = calculated density; Z = number of molecules in cell.

Papaverine gives sytematic extinctions for $h00$ with h odd, $0k0$ with k odd and $00l$ with l odd; therefore the space group is $P2_12_12_1$.

Both other isomorphous derivates give absences for $h0l$ with l odd and $0k0$ with k odd. The space group is therefore $P2_1/c$. Determination of the structure is in progress.

We thank Dr A. Van Ryssen who synthetized the substances examined.

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A nomogram for evaluating the temperature factor.*

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The nomogram evaluates the expression

$$\exp\,[(-2B\sin^2\theta)/\lambda^2] = f_t/f_0\,,$$

where the symbols have the usual significance. It has four scales, A, B, C and D. A and D are logarithmic scales with 1 cycle = 10 in.; they are equidistant from C, which is the logarithmic scale having 2 cycles = 10 in. required for multiplication. Since

$$f_t = f_0 \exp\,[(-2B\sin^2\theta)/\lambda^2]$$
$$= f_0 10^{-\frac{2B}{\log_e 10}\cdot\frac{\sin^2\theta}{\lambda^2}} = f_0 10^{-\frac{B}{1\cdot15}\cdot\frac{\sin^2\theta}{\lambda^2}}\,,$$

the D scale has its origin displaced to the left, so that the reference line carrying the origins of the A and C scales cuts the D scale at the value 1·15. Thus, if the value of $(\sin^2\theta)/\lambda^2$ is found on the A scale, and the value of $B = 8\pi^2\bar{u}^2/3$ is found on the D scale, the line joining these points will cut the C scale at the point $(B/1\cdot15)\times(\sin^2\theta)/\lambda^2$. The antilogarithm of this value is now required, and the B scale, which is a linear inch scale, performs this operation against the A scale. Note that the values on the B scale increase from right to left,

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