THE OPTICAL PROPERTIES OF AN ISOLATED CRYSTAL OF SELENIUM.

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THE optical properties of various forms of selenium have been investigated by Meier,[1] Foersterling and Fréedericksz,[2] Gripenberg,[3] Pfund,[4] Wood[5] and others, but no results have yet been published on the optical properties of an isolated crystal of selenium. The present paper is to extend the investigations to this particular form.

The polarimetric, or Babinet compensator, method was used. The investigation was confined to a prism face of a crystal of the hexagonal prism type.[6] The reflecting surface was about 2 mm. by 5 mm., and required no polishing. A frequent cleansing in alcohol helped prevent the formation of surface films. Owing to the purity of such crystals, the surface may be taken as very probably representing the state of matter within the crystal.

The theory of metallic reflection for crystals of this type has been fully developed by Drude.[7]

Let $\bar{\phi}_1$, $\bar{\psi}_1$, be the angles of principal incidence and principal azimuth, respectively, when the crystal is in the first principal position (*i. e.*, when the principal axis of the crystal is parallel to the plane of incidence);

$\bar{\phi}_2$, $\bar{\psi}_2$, be the angles of principal incidence and principal azimuth, respectively, when the crystal is in the second principal position (*i. e.*, when the principal axis of the crystal is perpendicular to the plane of incidence);

n_1, n_2, k_1, k_2, R_1, R_2, be the indices of refraction, absorption coefficients, and coefficients of reflection, respectively, for the two principal positions:

[1] Meier, Ann. d. Phys., 31, p. 1029, 1910.

[2] Foersterling and Fréedericksz, Ann. d. Phys., 43, p. 1227, 1914.

[3] Gripenberg, Phys. Zeitschr., 14, p. 123, 1913.

[4] Pfund, Phys. Zeitschr., 10, p. 340, 1909.

[5] Wood, Phil. Mag., S. 6, Vol. 3, pp. 612–613, 1912.

[6] These crystals were obtained through the courtesy of Dr. F. C. Brown, of the physical laboratory of the State University of Iowa.

[7] P. Drude, Ann. d. Phys., 32, p. 613, 1887; 34, p. 515, 1888; 36, p. 542, 1889.

then,

$$\frac{\sqrt{\alpha}}{\cos \phi_1} - \sqrt{\beta}\cos\bar{\phi}_1 = \cos 2\bar{\psi}_1 + i \sin 2\bar{\psi}_1;$$

$$\frac{\sqrt{\beta}}{\cos \bar{\phi}_2} - \sqrt{\alpha}\cos\bar{\phi}_2 = \cos 2\bar{\psi}_2 + i \sin 2\bar{\psi}_2;$$

$$\alpha = a_{11} + ia_{12}; \qquad \beta = a_{21} + ia_{22};$$

$$\frac{a_{12}}{a_{11}} = \tan x; \qquad \frac{a_{22}}{a_{21}} = \tan \epsilon;$$

$$k_1 = \tan\frac{x}{2}; \qquad k_2 = \tan\frac{\epsilon}{2};$$

$$n_1^2 = \frac{2\sin\frac{x}{2}\cos^3\frac{x}{2}}{a_{12}}; \qquad n_2^2 = \frac{2\sin\frac{\epsilon}{2}\cos^3\frac{\epsilon}{2}}{a_{22}};$$

$$R_1 = \frac{n_1^2(1 + k_1^2) + 1 - 2n_1}{n_1^2(1 + k_1^2) + 1 + 2n_1}; \qquad R_2 = \frac{n_2^2(1 + k_2^2) + 1 - 2n_2}{n_2^2(1 + k_2^2) + 1 + 2n_2}.$$

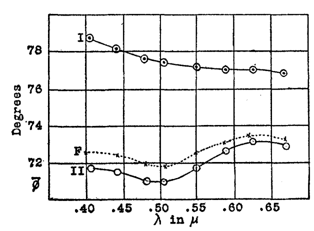

Fig. 1.

Principal Incidence.

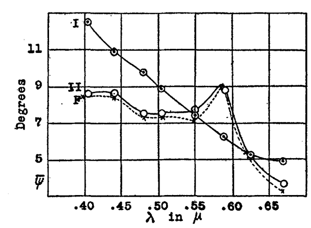

Fig. 2.

Principal Azimuth.

In the following table, the values of $\bar{\phi}$ and $\bar{\psi}$ are the means of several observations. The results are shown graphically in Figs. 1–5, where

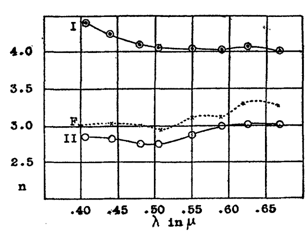

Fig. 3.

Index of Refraction.

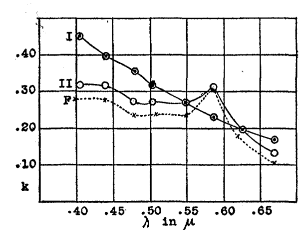

Fig. 4.

Absorption Coefficient.

$\bar{\phi}$, $\bar{\psi}$, and the calculated constants, are plotted with the wave-length. Curves marked I and II refer to the crystal in the first and second principal position, respectively.

It was found that when the crystal was placed in the second principal position, the results obtained agreed well with the best published results for crystalline selenium in mass. The curves marked F are from the results of Foersterling and Fréedericksz, who used mirrors obtained by spreading melted selenium over a well cleaned glass plate, and heating in a sand-bath at 180° C. Pfund determined R by a direct method, using mirrors obtained in the above manner. His results are shown in curve P, Fig. 5.

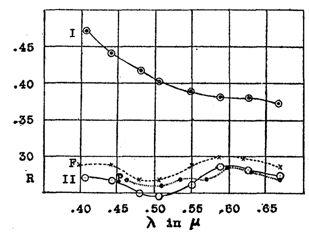

Fig. 5.

Reflecting Power.

With the crystal in the first principal position, quite different results were obtained, there being no similarity whatever to the results for the other position. It is interesting to note that the index of refraction as determined for this position is more than 15 per cent. greater than that found by any observer for other forms of selenium. There is no other known element with so high a refractive index.

The results show that isolated hexagonal crystals of selenium are doubly refracting. This points to the possibility that all such crystalline substances that reflect metallically have in general three sets of optical constants (two in any one plane); and that when one determines the

λ in μ.	First Principal Position.					Second Principal Position.				
	$\bar{\phi}_1$.	$\bar{\psi}_1$.	n_1.	k_1.	R_1.	$\bar{\phi}_2$.	$\bar{\psi}_2$	n_2.	k_2.	R_2.
.406	78° 47′	12° 32′	4.40	.458	.472	71° 45′	8° 40′	2.86	.320	.273
.441	78 13	10 54	4.26	.395	.442	71 37	8 42	2.83	.319	.269
.480	77 34	9 51	4.12	.357	.419	71 07	7 35	2.77	.277	.252
.505	77 23	8 53	4.05	.317	.404	71 01	7 38	2.75	.276	.249
.550	77 11	7 31	4.05	.269	.393	71 46	7 42	2.87	.275	.264
.589	76 59	6 18	4.04	.229	.384	72 40	8 54	3.00	.315	.288
.626	77 01	5 20	4.09	.188	.383	73 13	5 16	3.17	.184	.285
.668	76 47	4 58	4.02	.172	.374	72 57	3 42	3.15	.132	.276

optical constants for any crystalline substance, used in mass, only a certain mean set of values is obtained.

In conclusion, I wish to acknowledge indebtedness to the staff of the physical laboratory of the State University of Iowa for the use of apparatus, and especially to Professor L. P. Sieg for suggesting the problem.

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