which is in fact the b axis of the monoclinic cell. There were occasional hollow or semi-hollow tabular crystals, probably due to twinning.

X-ray pictures of the nitrate were taken using film distances between 4 and 8 cm. The unit cell is monoclinic, probably $P2_1$. A reasonable choice of axes is

$$a = 27{\cdot}9,\ b = 63,\ c = 66{\cdot}3\ \text{Å},\ \beta \doteq 114\tfrac{1}{4}^\circ ,$$

as this makes all three axes parallel to the faces of the crystal, b being parallel to the longest dimension, and a to the shortest. Moreover, there is a marked tendency for low-order reflexions to be weak or absent for l odd.

The volume of the unit cell is close to half that of the wet tetragonal lysozyme chloride (of which a few pictures were taken) which is known (Palmer, Ballantyne & Gavin, 1948) to contain eight molecules, so that there is little doubt that there are four molecules in the unit cell, and therefore two molecules in the asymmetric unit. The absences mentioned above suggest that if we place one molecule at the origin there is a second one roughly half way along the c axis.

The crystals of lysozyme iodide were similar to the nitrate, though hollow forms were not observed. The few X-ray photographs taken suggest that its X-ray diffraction pattern is very similar to if not identical with that of lysozyme nitrate. It is understood from Dr C. H. Carlisle (personal communication) that lysozyme bromide is also very similar to the nitrate, and that the dry dimensions confirm that there are four molecules in the wet cell.

No further work has been done on these two lysozyme crystals, but they are more promising than the other crystals described in this paper and might perhaps repay further study.

It is a pleasure to acknowledge the help and advice of Dr M. F. Perutz and Dr J. C. Kendrew in teaching me to take X-ray photographs of proteins. I should also like to thank Dr C. H. Carlisle and Dr H. Gutfreund for allowing me to quote unpublished material.

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The polarization factor for inclined-beam photographs using crystal-reflected radiation.

By E. J. W. WHITTAKER, *Technical Division, Ferodo Ltd, Chapel-en-le-Frith, Stockport, England*

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The polarization factor for unpolarized incident radiation (*Internationale Tabellen*, 1935, vol. 2, p. 560), namely

$$P = \tfrac{1}{2}(1+\cos^2 2\theta)\ , \tag{1}$$

is independent of the geometrical features of the diffraction experiment, since it is a function of the Bragg angle only. When the incident radiation has been monochromatized by crystal reflexion, however, it is partially polarized. The polarization factor is therefore more complicated, and depends on the relative orientation of the reflecting planes of the monochromator crystal and those of the specimen, as well as on the Bragg angle of reflexion at each crystal. In the special case when the incident and reflected rays at both the monochromator and the specimen all lie in a plane, it is well known that the factor reduces again to the simple form

$$P = \frac{1+\cos^2 2\alpha \cos^2 2\theta}{1+\cos^2 2\alpha}\ , \tag{2}$$

where α is the Bragg angle for the reflexion at the monochromator. This formula is well known, since it applies to the equatorial plane of a suitably arranged powder- or single-crystal camera, and it is in such applications that crystal-reflected radiation has been predominantly employed. It is the purpose of this communication to derive the polarization factor in the general case, and to express it in terms of simple film co-ordinates to facilitate its application to inclined-beam photographs recorded on cylindrical films.

Let the diffracting crystal be located at O, the origin of orthogonal co-ordinates OX, OY, OZ such that the plane XOY contains the ray incident at O and also the ray incident on the monochromator crystal M. After diffraction, the ray proceeds along OP which makes an angle χ with the plane XOY, and its projection OQ, on this plane, makes an angle Υ_0 with OY (Fig. 1).

Consider a plane polarized ray incident on the monochromator crystal at the Bragg angle α and with its

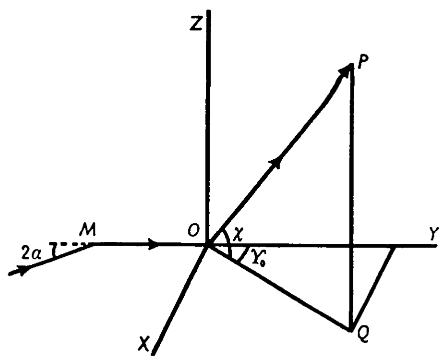

Fig. 1.

electric vector at an angle φ to the reflecting plane. After reflexion, a ray proceeds along MO with components of amplitude proportional to $\sin\varphi\cos 2\alpha$ and $\cos\varphi$, and polarized parallel to OX and OZ respectively. After diffraction at O, the X component will give rise to components of amplitude proportional to $-\sin\varphi\cos 2\alpha\sin\chi\sin\Upsilon_0$ polarized in the plane POZ and $\sin\varphi\cos 2\alpha\cos\Upsilon_0$ polarized perpendicular to this plane. The Z component gives corresponding components of amplitude proportional to $\cos\varphi\cos\chi$ polarized in the plane POZ and zero in the perpendicular direction. The intensity diffracted along OP is accordingly proportional to

$$(\cos\varphi\cos\chi-\sin\varphi\sin\chi\sin\Upsilon_0\cos 2\alpha)^2 + \sin^2\varphi\cos^2 2\alpha\cos^2\Upsilon_0\,.$$

After averaging this result over all values of φ, to allow for the unpolarized nature of the rays incident at M, we obtain

$$\tfrac{1}{2}(\cos^2\chi+\sin^2\chi\sin^2\Upsilon_0\cos^2 2\alpha+\cos^2\Upsilon_0\cos^2 2\alpha)\,.$$

Since, by a well known result, the intensity incident at O is proportional to $\frac{1}{2}(1+\cos^2 2\alpha)$, the polarization factor is

$$P=\frac{\cos^2\chi+\sin^2\chi\sin^2\Upsilon_0\cos^2 2\alpha+\cos^2\Upsilon_0\cos^2 2\alpha}{1+\cos^2 2\alpha}\,. \qquad (3)$$

The angles Υ_0 and χ are suitable film co-ordinates only in the normal-beam arrangement. In the inclined-beam arrangement suitable co-ordinates are μ, ν and Υ, where μ, ν are the inclinations of the incident and diffracted beams to the equatorial plane of the camera, and Υ is the azimuth of the diffracted ray defined in the usual way (Buerger, 1942, p. 297). It can then be shown by appropriate transformation of the axes of co-ordinates that

$$\cos\chi\sin\Upsilon_0=\cos\nu\sin\Upsilon$$

and

$$\cos^2\chi=\cos^2\nu\sin^2\Upsilon+\cos^2\mu\cos^2\nu\cos^2\Upsilon+\sin^2\mu\sin^2\nu + \tfrac{1}{2}\sin 2\mu\sin 2\nu\cos\Upsilon\,;$$

and hence, by substitution and rearrangement,

$$P=\{\cos^2 2\alpha+\cos^2\mu\cos^2\nu+\sin^2\mu\sin^2\nu + \cos^2\nu\sin^2\Upsilon(\sin^2 2\alpha-\cos^2\mu) + \tfrac{1}{2}\sin 2\mu\sin 2\nu\cos\Upsilon\}/\{1+\cos^2 2\alpha\}\,.$$

For purposes of numerical calculation this expression can be regarded as being of the form

$$P=A+B\sin^2\Upsilon+C\cos\Upsilon\,, \qquad (5)$$

where A, B and C are constants for any given layer line recorded with a given camera setting.

By putting $\alpha=0$ in the above expression we obtain

$$P=\tfrac{1}{2}\{1+(\cos\mu\cos\nu\cos\Upsilon+\sin\mu\sin\nu)^2\} \qquad (6)$$

as a convenient form of the factor for unpolarized radiation in terms of the same co-ordinates. Expression (6) can of course be more simply derived by direct trigonometrical transformation from (1).

I wish to thank the Directors of Ferodo Ltd for permission to publish this communication.

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