LETTERS TO THE EDITORS

PHYSICS

Enhancement of the High-Spacing Meridional Reflexions in the X-ray Photograph of Keratin impregnated with Heavy-Metal Salts

ENHANCEMENT of the reflexions corresponding to certain orders of the fundamental longitudinal periodicity of 198 A. in the X-ray diffraction photograph of keratin treated with heavy-metal salts has been reported by Fraser and Macrae[1]. They showed, for example, that mercury-treated Lincoln wool fibres gave enhanced seventh, twelfth, sixteenth and nineteenth orders, but they failed to observe any such effect in fibres treated with silver nitrate.

In connexion with parallel electron microscope work being done in this laboratory[2], we have recently performed experiments in which various keratin fibres (Lincoln wool, mohair, human hair and pig bristle) have been impregnated with mercury acetate or silver nitrate after they had been treated with thioglycollic acid to reduce the disulphide groups. With the mercury, we find considerable differences between the diffraction effects produced in the different fibres, and would add the third, fourth and sixth orders to the list of those which can sometimes be enhanced.

Our most significant observations, however, have been made on the Lincoln wool fibres containing silver, for in these we find a quite exceptional enhancement of all the orders from the third to the tenth. Assessment of the absolute intensity of the scattering is made difficult by the high absorption of the metal, which makes a considerable reduction in specimen size necessary if X-rays are to be transmitted with reasonable intensity. However, if the specimen size and exposure are adjusted so that the conventional large-angle photograph can be discerned, the intensity of the scattering at low angles (corresponding to Bragg spacings greater than 20 A.) is so great that details of the discrete reflexions tend to be obscured; when the exposure is adjusted to allow these details to be observed, the photographic film is completely blank at higher angles of scattering.

To a first approximation, therefore, we can say that the effect of the silver is to enhance the meridional reflexions for orders up to the tenth at the expense of the higher orders. This can only mean that the silver is spread out at fairly wide intervals along the fibre axis. When the polarization and Lorentz factors are taken into account, it turns out that the eighth-order reflexion is the strongest by a factor of 2·5 at least; the tenth, sixth and third orders are also strong, and the fourth, fifth, seventh and ninth are present but relatively weak. The absence of the higher orders and the very great intensity of the eighth can be interpreted to mean that the silver atoms are distributed with some regularity at intervals of approximately 25 A. along the α-helix.

Whether the silver is taken up within or on the surface of the microfibril is at present being investigated with the electron microscope, and preliminary results (Sikorski, J., unpublished work) suggest that, as occurs with osmium staining, the metal is for the most part located on and between the microfibrils rather than in them. Since the diffraction effect described is conditional upon the reduction of the disulphide groups, it is tempting to suppose that in some parts of the fibre, at least, the cystine residues occur at intervals of 25 A. along the axis; it may be relevant that a relatively strong eighth-order reflexion occurs in untreated human hair[3] and Lincoln wool[4], but only a weak one in porcupine quill[3], which has a much lower sulphur content.

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[1] Fraser, R. D. B., and Macrae, T. P., *Nature*, **179**, 732 (1957).
[2] Sikorski, J., and Simpson, W. S., *Nature*, **182**, 1235 (1958?).
[3] Bear, R. S., and Rugo, H. J., *Ann. N.Y. Acad. Sci.*, **53**, 461 (1951).
[4] MacArthur, I., *Nature*, **152**, 38 (1943).

Meridional Reflexions in the X-ray Diffraction Photographs of α-Keratin

X-RAY diffraction photographs of various keratins taken with fine-slit collimators of high resolution display a rich series of meridional reflexions[1-3]. Their spacings may conveniently be regarded as orders of a macro-period of 198 A. with very few exceptions. Astbury[4] has used the spacings and intensities of reflexions reported by Bear and others, from porcupine quill tip, to derive a one-dimensional Patterson diagram, and to explore the possibility of finding the sequence of amino-acid residues in the protein chains of the crystalline portion of the keratin. It might well be that the differences among keratins could provide useful clues in this quest, and the present intention is to direct attention to them.

Photographs were taken using copper $K\alpha$ radiation in an evacuated camera at specimen-film distances of

Table 1. RELATIVE INTENSITIES OF MERIDIAN AND NEAR MERIDIAN REFLEXIONS

Order of 198 A.	Bear, Astbury	Group *A*	Group *B*	Group *C*
3	6	6	6	6
4	1	2	1	2
5	2	1 (38 A.)	2 (38)	0
6	0	0	2	0
7	4	5 (27·0)	5	3
8	2	3	5	6
9	2	1	1	1
10	4	5	5	4
11	3	5	0 or 1	0 or 1
12	0	1	1	0 or 1
13	1	2	2	2
14	0	1 (13·9)	0	0
15	1	3	1	1
16	4	5	3	3*
17	0	0	0	0
18	0	2	0	1
19	3	2	2	2

* Pig bristle 4, human hair 2, horse hair 3.