A Quantitative X-Ray Study of Alpha–Beta Transformation in Keratin

THE first X-ray diffraction studies of the α–β transformation in keratin were made by Herzog and Jancke[1] and Astbury and Street[2]. Since then it has occupied a pivotal position in all attempts to determine the molecular structure of proteins. Recently, Bendit[3] has reported the variation of the peak intensity of the 5·1 A., 4·6 A. and 9·8 A. reflexions against percentage extension for Lincoln wool and concluded therefrom that Astbury's hypothesis of a molecular transformation based on a 1 : 1 correspondence of the intensity variation of the first two reflexions is not tenable. However, no quantitative X-ray study of the degree of order introduced with extension has been yet reported.

The outstanding reflexions in the alpha-photograph of human hair are the meridional strong arc of spacing 5·15 A., made up of (020) flanked on either side by (120), and the composite equatorial reflexions (001), (101), (300) and (201), spread over 3 A. and having a mean spacing of 9·8 A. The (100) reflexion, because of its proximity to the centre and poor definition, does not lend itself to an easy evaluation and is therefore omitted. During the course of transformation from alpha to beta, which sets in at about 30 per cent extension, the meridional arc begins to close up while there appears on the equator a new spot of 4·65 A., and the overall definition of the photograph also improves. However, the dark arc never completely disappears. If we denote the total intensity of the meridional and equatorial spots by I_m and I_e, respectively, then the degree of order, Ω, may be defined by the relation :

$$\Omega = \frac{I_e - I_m}{I_e + I_m} \times 100$$

This expression has the advantage of being independent of all exposure factors.

In order to carry out an experimental determination of this degree in three different varieties, X-ray photographs, using copper K_α radiation, monochromatized by reflexion from a calcite crystal, were taken of bundles of human hair well-combed to ensure parallelism and held taut between two pin-vices one of which was movable and carried a screw-gauge to measure extension. The fibres were always stretched in water at room temperature and supercontracted by stretching first in steam and later allowing them to recover in steam itself. Intensity measurements were made by Moll's recording-type microphotometer and they were reduced to the same scale. The results obtained are shown in Table 1.

These results show that the change is exponential. Initially there is a rapid rise in the degree of order, but from 60–70 per cent extension the change is not very large. The behaviour of golden hair is much nearer to that of black than to that of white. The difference may be due to the presence of air bubbles in white hair. On treatment with cuprammonium hydroxide it was found that the fibre-pattern disappeared completely because of the contraction arising from an extra folding of the chains induced by co-ordination of the absorbed copper with appropriate groups in the keratin chain. A study of this 'reversible super-contraction' produced on washing with dilute sulphuric acid is also being made, and a detailed account of the work will be published elsewhere.

Table 1

Variety	Super-contracted	Un-stretched	Stretched (per cent)			Treated with cuprammonium hydroxide
			40	60	70	
Black	38·13	43·97	51·9	53·19	54·09	0
Golden	37·58	41·8	48·01	50·12	51·12	0
White	34·21	37·03	43·82	45·83	46·60	0

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[1] Herzog, R. O., and Jancke, W., "Festschrift der Kaiser Wilhelm Gesellschaft" (1921).
[2] Astbury, W. T., and Street, A., *Phil. Trans. Roy. Soc.*, A, **230**, 75 (1932).
[3] Bendit, E. G., *Nature*, **179**, 535 (1957).

Fibrous Structure in Cheese Curd

IN the manufacture of Cheddar cheese the curd granules fuse under gravity into solid blocks, usually 6–12 in. in thickness. At the same time some spreading or flow of the blocks takes place. This flow appears to be responsible for the characteristic fibrous texture in the 'cheddared' curd. In designing a curd-fusing or cheddaring machine Czulak and Hammond[1] took account of this fact and arranged, following initial compression into a solid block, to submit the curd to pressure in a longer chamber, thereby giving flow in one direction. Curd cheddared in this machine has a greatly increased longitudinal fibrous structure, strips of curd some 20 in. in length being readily torn from the block.

Microscopic examination by fluorescence methods of sections of the curd cut parallel to the direction of flow shows a network of long casein fibrils of a minimum thickness of 0·1μ. The picture at a magnification of about 1,400 resembles that of coagulated blood fibrin as shown in the electron photomicrograph of Wolpers and Ruska[2]. In sections cut transversely to the direction of flow, or in curd

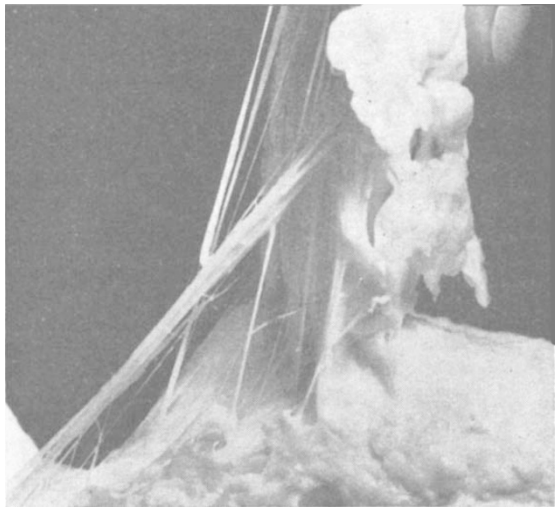

Fig. 1