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Structural Analysis of a Single Keratin Fiber by Scanning Microbeam SAXS

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Introduction

Human hair is one of many keratinous fibers. Its diameter typically varies between 40 to 150 μm. The surface of a hair fiber is covered with the thin scale-like cells, the so-called cuticle, and the inside of the cuticle is mainly filled with the cortical cells which are composed of the intermediate filaments (IFs) surrounded by the matrix proteins. There are various fiber shapes in human hair and it is commonly accepted that the curl shapes of hair fibers are roughly classified by their origin in the three major ethnic groups: African hair which has a strong curl shape, Caucasian hair which is apt to have a moderately waved shape and Asian hair which has a comparatively straight shape. In the case of Merino wool, it was found that the fiber crimp was associated with the bilateral distribution of the different types of cortical cells [1], the so-called orthocortex and paracortex. Munro and Carnaby [2] showed that the bilateral distribution of the orthocortex and the paracortex could be the cause of the fiber crimp.

Swift [3] has previously observed two cortical cell types in human hair. He refers to these two cortical cell types as the human orthocortex and the human paracortex, and describes that the distribution of these two types relates to the ethnic origin, having a different degree of the fiber curvature.

These results, however, were obtained by transmission electron microscopy (TEM) observations. Although TEM is useful for exploring micro- and nano- structures, it is hard to determine the dominant structure over the whole fiber. In addition, TEM needs chemical agents for sample preparation, which would artificially affect the sample condition. Moreover, biological materials are apt to be damaged by the electron beam; therefore, alternative experimental methods are needed for further understanding of the human hair structure.

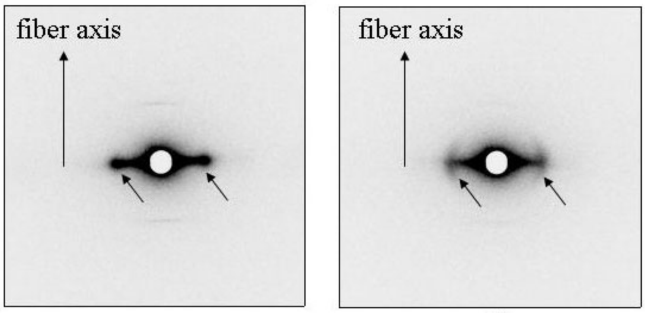
The purpose of the present study is to explore the difference of the internal structure between the inner and the outer side of the curvature for curly human hair in the intact condition, and to understand the macroscopic curvature of the fiber from the aspect of the internal nanostructure. The experiment was achieved by measuring SAXS patterns with an X-ray microbeam, scanning the fiber in the transverse direction.

Experimental

The experiments were performed at BL-4A. Two dimensional SAXS patterns were measured with a X-ray microbeam (size : 5 μm) scanning a curly human hair single fiber at several positions in the transverse direction with a 5 to 10 μm step from outer to inner sides of the fiber curvature.

Results and Discussion

Figure 1 shows typical SAXS patterns. Major intensity maxima, which have been attributed to the lateral packing between IFs [4, 5], are observed along the equator (indicated by arrows) and clear differences are found between the inner and the outer side (Figures 1(a) and 1(b), respectively). The intensity maxima of the former are stronger and narrower in the azimuth direction, compared to the latter. These differences denote that curly human hair has a laterally heterogeneous IFs arrangement, associated with its curved shape. It is noteworthy that these differences were observed for African hair, curly Caucasian hair and also curly Asian hair, but were not distinguished for less curly (almost straight) Caucasian and Asian hair fibers. We extracted the equatorial intensity profiles from the 2-dimensional SAXS patterns of the cortex after subtraction of the parasitic scattering, and compared them with those calculated based on the IF distribution model proposed by Briki et al. [4]. From an analogy with Merino wool [6], the distribution of different types of the cortex in human hair is strongly suggested.



(a) (b)

Fig.1 Typical SAXS patterns of a curly human hair fiber. (a) The inner side of the curvature. (b) The outer side of the curvature. Short arrows indicate the major intensity maxima along the equator.

References

[1] M. Horio, T. Kondo, Text. Res. J. 23 (1953) 373-386.
[2] W. A. Munro, G. A. Carnaby, J. Text. Inst. 90 Part1 No.2 (1999) 123-136.
[3] J. A. Swift, in: P. Jollès, H. Zahn, H. Höcker (Eds.), Formation and Structure of Human Hair, Birkhäuser Verlag, Basel, 1997, pp.150-175.
[4] F. Briki, B. Busson, J. Doucet, Biochem. Biophys. Acta 1429 (1998) 57-68.
[5] R. D. B. Fraser, T. P. MacRae, A. Miller, J. Mol. Biol. 10 (1964) 147-156.
[6] Y. Kajiura, *et al,* J. Appl. Cryst. 38, 420 -425 (2005)

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