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Spectromicroscopy of normal human hair for the mapping of oxidative area at the S-K absorption edge using soft X-ray contact microscopy

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Introduction

Spectromicroscopy has been widely recognized as a powerful tool for the mapping of specific chemical bonds or molecules in the various fields including biomedical application[1, 2]. In the previous report we have proposed a mapping of oxidative damage in human hair using XANES profiles at the sulfur K absorption edge[3]. Hair specimen has an advantage for spectromicroscopy over other biomedical specimens; Because it consists of mainly sulfur-rich amino acid, cystine, a product from cysteine, XANES at the S-K absorption edge is expected to be measured with a good signal to noise ratio compared with the case of mammalian cells[4], resulting in a map of molecules to be imaged in a good contrast. In addition, the oxidative damage product cysteic acid has a well separated absorption peak from that of cystine as demonstrated earlier[3].

In the present study we applied the spectromicroscopy to normal human hair to determine the occurrence and the location of oxidative stress.

Materials and Methods

The measurement of XANES of sulfur-containing biomolecules, cysteine, cystine and cysteic acid and the imaging of hair specimen were carried out at the BL-11B beamline over the photon energy range from 2460 to 2490 eV. For the X-ray imaging at the selected photon energies determined from the XANES measurements contact X-ray microscopy with an electronic zooming tube was used. It has enough spatial resolution for hair specimen and no focus adjustment is required in changing photon energy. Normal human hair kindly supplied from a female student with no treatment for permanent wave and bleaching was cut at the position of 8 cm from the hair root into small portions with approximate 20 μm thickness, and then placed on a SiN membrane. The opposite side of the membrane was coated with Au for a photocathode of the zooming tube.

Results and Discussion

Fig. 1 shows a cystine distribution in the cross-sectional image of the hair. The map was obtained by subtracting the absorption between the peak and the bottom energies of cystine. Uniformly distributed cystine was observed except the central area of medulla. On the other hand Fig. 2 shows a cysteic acid distribution obtained by the subtraction between the peak and the bottom energies of a cysteic acid. Preferential distribution in the peripheral area cuticle was clearly demonstrated in this study. Assuming the growth rate of hair is about 1cm per month, the specimen has been exposed to the air atmosphere for about 8 month. The hair may be subjected to the oxidative damage in a daily life for this period even though it suffered from no possible artificial oxidative damage resulting from permanent wave and bleach treatment. The present study suggests that oxidative damage occurs in the peripheral area in a daily life.

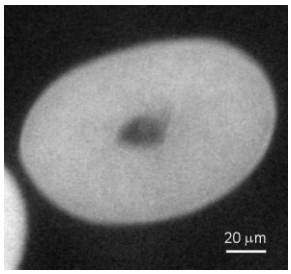

Fig. 1. Cystine map of normal human female hair by X-ray contact microscopy. The white area contains more cystine.

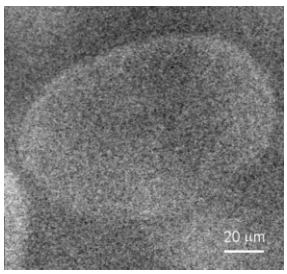

Fig. 2. Cysteic acid map of normal human female hair.

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