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Distribution of Ca in human hair and its relation to oxidative damage examined by X-ray contact spectromicroscopy and X-ray fluorescence mapping

Atsushi ITO*[1], Takafumi INOUE[2], Tomomitsu KAWAI[2], Kouji TAKEHARA[2], Satoru INOUE[1], Takayuki SHIMIZU[1], Kunio SHINOHARA[1]
[1]School of Engineering, Tokai Univ., Hiratsuka, Kanagawa 259-1292, Japan
[2]Kanebo Cosmetics Inc., Odawara, Kanagawa 250-0002, Japan

Introduction

We have been studying the relation between Ca accumulation and oxidative damage in human hair [1], intended to provide the possible explanation between Ca content and the incidence of human breast cancer [2]. X-ray spectromicroscopy using a contact microscope with an electronic zooming tube is a powerful tool for the observation at sub-micron resolution of the distribution of cysteic acid, an oxidation product of cystine used for an index of oxidation state of hair, at the S-K absorption edge [3] and for Ca mapping at the Ca-K absorption edge [1]. Alternatively for Ca distribution X-ray fluorescence mapping provides a more sensitive method but rather lower spatial resolution compared with the electronic zooming system. In the previous report, we investigated the induction of oxidative damage controlled by the treatment time of an oxidative agent in relation to the accumulation of Ca, and found that Ca accumulation in the peripheral part (cuticle) and the major part (cortex) followed the increase of oxidative damage, while in the central part (medulla) seemed to be independent of oxidation [4].

In the present study we focused on the accumulation of Ca in the medulla region by selecting hair specimen having medulla, because all hair specimens do not always possess medulla structure.

Materials and Methods

For the mapping of cysteic acid and cystine X-ray contact microscopy with an electronic zooming tube with a resolution of about 0.5 μm was employed at the S-K edge at BL-11B. Analysis of Ca distribution was carried out by X-ray fluorescence mapping at BL-4A.

Human hair specimens with medulla were selected using an IR scope to detect medulla nondestructively. For the artificial bleaching in the laboratory, hair specimens were soaked twice in a solution containing 1.2% ammonia and 3.5% hydrogen peroxide for 30 min. Ca soaking was performed with 10 mM $CaCl_2$ for 2 days with a daily change of the solution. These treatments were done for different specimens from the same lot. At the positions of around 1 cm and 14 cm from the root side, they were cut at the thickness of about 20 μm, and then placed on a SiN membrane with 100 nm thickness. The opposite side of the membrane was coated with Au as a photocathode of the zooming tube.

Results and Discussion

Fig. 1 shows X-ray images of cystine, cysteic acid and Ca in human hair specimens with medulla at the position of 14 cm from the root side. Every specimen shown in the panel a, b or c accumulated Ca in medulla even for the untreated control, although variation of Ca content was seen among hair specimens. By bleach treatment Ca in outer parts (cortex and cuticle) seemed to be removed (panel b), and further treatment of Ca soaking increased Ca in those areas significantly (panel c). Cysteic acid seemed to increase in all parts after bleaching, with a slightly preferential increase in the outer area. These results indicate that Ca accumulation in medulla is not originated from external oxidation treatment and suggest reflecting content of Ca supplied from hair matrix cells.

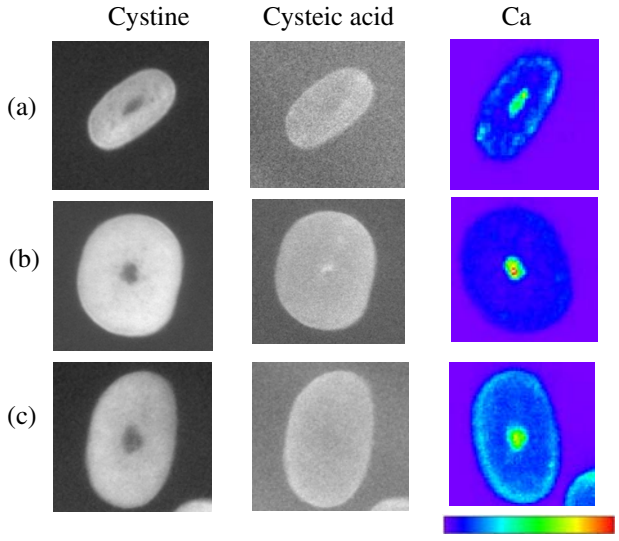

Fig. 1. Cystine, cysteic acid and Ca distributions in human hair with medulla. (a) control, (b) bleaching, (c) soaking in $CaCl_2$ solution after bleaching.

References

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* aeito@keyaki.cc.u-tokai.ac.jp