Biological Science

11B, 4A/2008G536, 2010G542

Correlation between Ca accumulation and induction of oxidative damage in human hair determined by X-ray imaging

Atsushi ITO*[1], Takafumi INOUE[2], Kouji TAKEHARA[2], Yoshiaki TAKI[1], Taichi YOSHIMURA[1], Kunio SHINOHARA[3]
[1]School of Engineering, Tokai Univ., Hiratsuka, Kanagawa 259-1292, Japan
[2]Kanebo Cosmetics Inc., Odawara, Kanagawa 250-0002, Japan
[3]Adv. Res. Inst. for Sci. and Eng., Waseda Univ., Shinjuku, 169-8555 Tokyo

Introduction

Possible correlation between Ca content in human hair and the incidence of human breast cancer [1] demonstrated one of the important applications of X-ray elemental analysis. Since Ca content was increased by the treatment of an oxidative colorant [2], the contribution of oxidative damage to the increase of Ca content would be one of critical factors in determining the standard range of Ca content in normal human hair.

We have measured the distribution of oxidative damage of cystine, a major component in normal human hair, by soft X-ray contact spectromicroscopy at the S-K absorption edge, and identified the oxidation product as a cysteic acid [3].

In the present study, we further demonstrated a close correlation between Ca content and oxidative damage by comparing the distributions of Ca and cysteic acid in cross sections of normal human hairs.

Materials and Methods

For the mapping of cysteic acid and Ca, X-ray contact microscopy with an electronic zooming tube with a resolution of about 0.5 μm was employed at the S-K edge for cysteic acid and at the Ca-K edge for Ca at BL-11B. Another analysis of Ca distribution has been carried out by X-ray fluorescence imaging at BL-4A. X-ray fluorescence imaging has higher sensitivity but lower spatial resolution around 5 μm, compared with the above X-ray contact microscopy.

Hair specimens were prepared from normal women with or without bleach treatment. At the position of around 20 cm from hair roots, they were cut 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 X-ray contact images of cystine, cysteic acid and Ca. Images in the upper row (panels a, b and c) and the lower row (panels d, e and f) are for bleached hair with oxidative damage and for normal hair, respectively. The bleached hair had more Ca content (panels c and f) along with more amount of cysteic acid (panels b and e). These results strongly suggest a close correlation between Ca content and the degree of oxidative damage. In addition, for the central area of the hair called medulla, the Ca abundance clearly observed in the panel f is not likely to result from oxidative damage, because Ca in this area was more rich in the untreated hair which happened to have clear medulla structure compared with the bleached specimen. The Ca distribution was also confirmed from X-ray fluorescence imaging for the same specimens as shown in Fig. 2. The bleached hair has more Ca content, and the distribution looked not so uniform with a preference for a peripheral region, cuticle. The cuticle seems to be easily subjected to oxidative damage by external stresses, resulting in more accumulation of Ca. In addition, the marked accumulation of Ca in the medulla of untreated hair was also demonstrated.

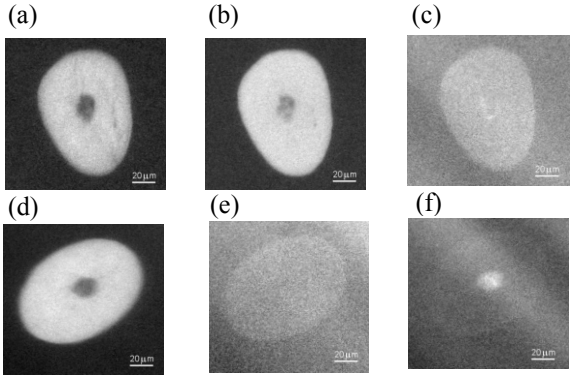
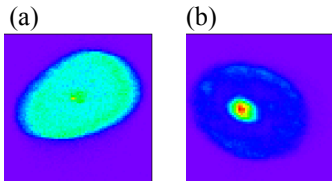


Fig. 1. Cystine, cysteic acid and Ca distributions in human hair. cystine (a), cysteic acid (b) and Ca (c) in bleached hair. cystine (d), cysteic acid (e) and Ca (f) in untreated hair.



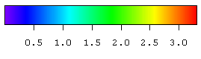


Fig. 2. Ca distribution in human hair. (a): bleached hair; (b): untreated hair.

References

[1] J. Chikawa et al., J. X-ray Sci. Tech., **15**, 109 (2007).
[2] K. E. Smart et al., J. Cosmet. Sci., **60**, 337 (2009).
[3] A. Ito et al., PF Activity Report 2008 **#26**, 219 (2010).

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