Biological Science

11B/2008G536

Mapping of oxidative damage in human hair with artificial oxidation treatments using soft X-ray contact microscopy

Atsushi ITO*[1], Takafumi INOUE[2], Kouji TAKEHARA[2], Tomotsugu KAMIYA[1], Hiroshige SAITO[1], Yukihiro MURATA[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

We have measured the distribution of oxidative damage of cystine, a major component in normal human hair without artificial treatments by soft X-ray contact microscopy to the photon energy of specific absorption in XANES of amino acids at the S-K absorption edge [1]. The oxidative damage was identified as a cysteic acid, a product of oxygen addition. The results showed that the oxidative damage was preferentially generated in the outer part of hair called cuticle. Furthermore the bleaching treatment of hair also increased the content of cysteic acid, but the detailed distribution has not been determined yet [2].

In the present study, we examined the relation between the artificial treatments including permanent waving, heating at curling iron or bleaching and oxidative damage, and the distribution of such oxidative damage with respect to that in the untreated hair.

Materials and Methods

To determine photon energies to be imaged, XANES of sulfur-containing biomolecules, cysteine, cystine and cysteic acid was measured at BL-11B over the photon energy range from 2460 to 2490 eV. For the X-ray imaging contact X-ray microscopy with an electronic zooming tube as a two dimensional detector was used at the resolution of about 0.5μm. Permanent waving was carried out by repeating sequential soaking with a reducing agent, ammonium thioglycolate and an oxidative agent, sodium bromate For the bleach treatment hair was soaked in the mixture of 3% H_2O_2 and 1.2% ammonia. For the curling iron treatment hair was heated 60 times at 120 ℃ for 3 min. Treated hairs 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 cystine (panel a) and cyteic acid (panel b) distribution in the cross-sectional image of the hair. Uniformly distributed cystine was observed except the central area of medulla, while cysteic acid showed very low level distribution over a whole area of the hair. In hairs treated with permanent wave or bleach process, cysteic acid was increased compared with untreated specimen (Fig. 1c and d). It should be noted that both treatments exhibited different distributions of cysteic acid with each other. Bleach treatment caused oxidative damage in the peripheral region similar to the naturally occurring damage as shown in the previous report [1]. The similar distribution was obtained for curling iron treatment hair. On the other hand, in the permanent wave treated hair the oxidation was more significant than bleaching, and was extended into the inner area of cortex, resulting in the uniform oxidative damage. Thus soft X-ray microscopy in combination with specific XANES absorption feature revealed that the popularly used hair treatments, bleaching and permanent waving caused the different distribution of oxidation area. In addition, the oxidative damage map could be applied to examine the effects of protective agents against oxidation.

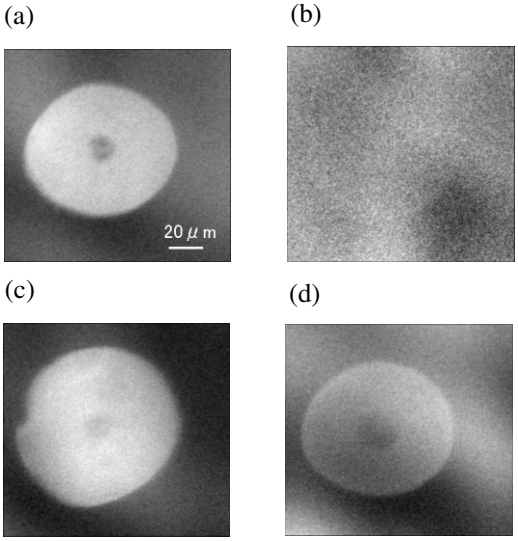

Fig. 1. Cystine and cysteic acid distribution of human hair. cystine map (a) and cysteic acid map (b) in untreated hair; cysteic acid map of hair with permanent waving (c) and bleaching (d).

References

[1] A. Ito et al., PF Activity Report 2008 #26, 219 (2010).
[2] A. Ito et al., PF Activity Report 2007 #25, 227 (2009).

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