Effects of Reductive and/or Oxidative Treatment during Permanent Wave Procedure on Human Hair Keratin Films

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Abstract

Human hair keratin films were used in order to examine the effects of reducing and oxidizing agents. Thioglycolic acid and sodium bromate were employed as reducing and oxidizing agents, respectively. The white and opaque appearance of the keratin films turned transparent as the concentration of thioglycolic acid increased. However, when followed by the oxidizing treatment, the keratin films returned to their original white and opaque appearance. According to SEM observation, the keratin films consist of fine granular and reticular structures. The SEM observation of the keratin films after the reductive treatment showed dissolution and disappearance of such structures. Furthermore, when the films received sodium bromate treatment after the reductive treatment, reticular and granular structures within the films were found apparently reconstructed. By the reductive treatment of thioglycolic acid, the weight of the keratin films decreased. Electrophoretically, proteins with molecular mass of 10–30 kDa and approximately 90–120 kDa (about 94 kDa) were contained in the eluate after the reductive treatment. When comparing the time course of protein elution between human hair samples and keratin films by thioglycolic acid, the keratin films within a short period of time had the higher concentration of proteins eluting from them than hair samples. According to the calculation, proteins had eluted from the films by 2000–3000 times faster than from human hair samples, proving the high sensitivity of the films. Moreover, the FT-IR measurement of the keratin film was effective for detecting the formation of cysteic acid as an indicator of hair damage by permanent wave process. The keratin films exhibited reactivity as human hair to the reducing agent and oxidizing agent used in permanent wave treatment. Furthermore, keratin films indicate uniformity in structure, whereas human hair has complex and multilayered structure, consisting of cuticle, cortex, and medulla. We expect that the use of the keratin films can make the measurement of hair damage caused by permanent wave treatment easier and more convenient.

Key words: human hair keratin film, reduction and oxidation, permanent wave, keratin associated protein, keratin.

1. Introduction

Permanent wave treatment consists of the following process; the cleavage of disulfide (S–S) bonds within hair by reducing agent called waving lotion, followed by the recombination of S–S bonds by oxidizing agent called neutralizer. Therefore, the wave efficiency of permanent wave treatment depends on the behaviors of reducing agent and oxidizing agent in hair. In order to evaluate the effects of reducing and oxidizing agents, methods such as Kirby method,13 have been reported. Okano et al. reported correlation between hydrophobic character and waving efficiency of reducing agent by using Kirby method.13

On the other hand, during the permanent wave treatment, the recombination of S–S bonds remain incomplete by oxidizing agent, resulting in the decreased number of S–S bonds when the permanent wave treatment is finished. The decrease in a number of S–S bonds has an impact on the mechanical properties and damage resistibility of hair. Thus, many reports exist regarding the hair damages caused by permanent wave treatments. By using transmission electron microscope, Maruyama et al. have reported the occurrences of stainability change in cuticles and void in cortex, after reducing and oxidizing treatment for 30 min each, by commercial permanent wave solution.13 Furthermore, by using atomic force microscopy, Kitano et al. have reported the decrease of elastic modulus (Young’s modulus) in microfibril of the hair (about one seventh). It was observed in hair strands which were treated by thioglycolic acid, and sodium bromate solution.4

It is possible to quantify hair damage caused by permanent wave treatment, by using tensile strength as an index, before and after the treatment. The tensile strength measurement is used widely in the hair damage researches relating to permanent wave treatments.567 Wortman et al. reported the change in hair tensile properties during reductive and oxidative treatments, by placing hair sample in 300 mM thioglycolic acid solution, 1 M thioglycolic acid solu-