Heat Damage to the Cortex and Cuticle Sheath of Human Hair Produced by Hot Appliances

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Abstract

Hair fibres from donors who frequently use hot appliances were found to show the presence of cracks, cuticle cell lifting, and also the presence of multiple pores ($\varphi \sim 0.1 - 1.0\ \mu m$) and voids ($\varphi \sim 2 - 5\ \mu m$) inside the cortex. All these forms of damage could be reproduced in the laboratory with virgin hair fibres after the application of various blow-drying and/or hot-iron straightening cycles. Blow dryers caused mainly the formation of short longitudinal cracks at the cuticle sheath surface, while hot irons produced long transversal cracks, cuticle cell lifting/removal, and the formation of pores and voids inside the hair cortex. Hot irons were also seen to produce a softening of hair proteins that resulted in distortions of hair shape. The short longitudinal cracks produced by blow drying occurred by the rapid contraction of water swollen cuticle cells as they were being dehydrated ([1]). In contrast, the formation of long transversal cracks and cuticle cell lifting/removal produced by hot irons resulted as a consequence of the high levels of friction set up between hot iron and hair at high temperatures. Pore and void formation were caused, on the other hand, by the combined effects of protein denaturation and explosive water evaporation that occurred at the high temperatures of hot irons. The effects of some polymers on heat damage will be discussed.

Introduction

Recently the cosmetic community has made a strong effort to understand the various physical and chemical changes taking place in hair during its exposure to hot appliances. For instance, it has been reported that damage to hair by blow dryers occurs mainly at the cuticle sheath and manifests itself in the form of short transversal cracks ([1]). Damage to hair by hot irons has also received a great deal of attention. Among the several changes reported to occur with hot irons is the modification of the keratin denaturation enthalpy. ([2-4]). Chemical changes in the protein structure of the hair cortex have also been observed to occur as a consequence of the hot iron high temperatures. Tryptophan degradation and the appearance of other oxidation products are among the main chemical changes reported by some authors ([5, 6]). Cuticle cell lifting, cracking, and hair breakage were also shown to occur when hot irons were applied to hair under harsh conditions ([7]).

In this paper additional results are presented which show that different manifestations of heat damage exist and that most of these deleterious chemical and physical processes gradually extend towards the centre of the cortex. The type of damage and its degree of extension across the hair fibre was seen to be dependent on the temperature gradients set up by the heat flow conditions imposed by the various heat appliances. As it will be shown in the result section, depending on the hot appliance and its usage conditions, damage may appear in hair either at its surface, at the hair cortex periphery, or deeper inside the hair fibre. The types of physical damage appearing in these regions are in the form of cracks, pore and void formation, or in the form of severe distortions in the shape of the hair fibres. The paper also analyzes experimental work performed with polymers that may help to mitigate these effects.

Experimental

The method used to analyze the presence of physical damage in the hair fibres was by microscopy using SEM and also by Optical Microscopy using a Hi-Scope from Hirox Model KH-3000. Hair of Asian (Japanese), Caucasian (European), and African origin obtained from International Hair Importers (IHI) was used in the evaluations. The Caucasian and Asian hair was ~ 8 inches long and the African hair was ~ 4 inches long. For blow drying tests, sets of 10 fibres per evaluation were subjected to a total of 20 cycles of washing/blow drying. Each blow drying cycle consisted in: 1) washing the hair fibres with the shampoo under consideration; and 2) rinsing the fibres with tap water followed by 10 seconds of blow drying. The temperature used during blow drying and measured at the level of the wet hair surface was ~ 80°C. The selected hair fibres from European and Japanese origin had average diameters of ~ 71 ± 13 μm and 82 ± 11 μm, respectively, while those of African origin were ~ 69 ± 15 μm in diameter.