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Effects of scalp dermatitis on chemical property of hair keratin

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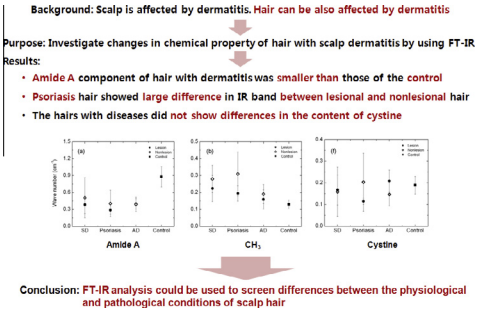
HIGHLIGHTS

- Effect of scalp dermatitis on chemical properties of hair was investigated by FTIR.
- Amide A component of hair with dermatitis was smaller than those of the control.
- Psoriasis hair showed difference in IR band between lesional and nonlesional hair.
- Changes induced by scalp dermatitis were different with weathering.
- IR can be used to screen difference between physiological–pathological condition.

GRAPHICAL ABSTRACT



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ABSTRACT

The effects of scalp dermatitis (seborrheic dermatitis (SD), psoriasis, and atopic dermatitis (AD)) on chemical properties of hair keratin were investigated by Fourier transform infrared (FT-IR) spectroscopy. Hairs were collected from lesional regions affected by SD, psoriasis, and AD and non-lesional regions separately. The hairs with SD were taken from patients with ages of 16–80 years. The ages of patients with psoriasis ranged from 8 to 67 years, and all patients exhibited moderate disease. Hairs with AD were taken from the patients with ages of 24–45 years and the average SCORing atopic dermatitis (SCORAD) was 48.75. Hairs from 20 normal adults were collected as a control. The FT-IR absorbance bands were analyzed by the Gaussian model to obtain the center frequency, half width, height, and area of each band. The height and area of all bands in the spectra were normalized to the amide I centered at 1652 cm^{-1} to quantitatively analyze the chemical composition of keratin. The spectra of hair with scalp dermatitis were different with that of control, the amide A components centered at 3278 cm^{-1} were smaller than those of the control. The psoriasis hair showed a large difference in the IR absorbance band between lesional and non-lesional hairs indicating good agreement with the morphological changes. The hairs with diseases did not show differences in the content of cystine, which was centered at 1054 cm^{-1}, from the control. The chemical properties of keratin were not significantly different between the hairs affected by SD, psoriasis, and AD. However, the changes induced by scalp dermatitis were different with weathering. Therefore, FT-IR analysis could be used to screen differences between the physiological and pathological conditions of scalp hair.

Introduction

Skin diseases such as seborrheic dermatitis (SD), psoriasis, and atopic dermatitis (AD) are the most common diseases affecting scalp hair [1–5]. As these diseases are chronic, superficial, and

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inflammatory, they have a negative influence on patient quality of life [6]. SD causes erythematous patches that are usually covered by large, yellow, greasy scales [1]. Psoriasis attacks not only soft keratin but also hard keratin; thus, causes pitting in nails and hair [2,3]. AD is a major public health problem worldwide because of the rapid increase in prevalence [4,5]. AD is characterized by itchy papules and shows a high incidence of scalp dermatitis.

In previous work, we examined the effects of SD, psoriasis, and AD on the hair shaft using atomic force microscopy (AFM) [7–9]. The morphology and surface properties of the hair shaft were damaged significantly by these skin diseases. The layered structure of the cuticle was disordered, and the surface was rough. The edge of the cuticle becomes torn, collapsed, and corrugated. These damages to the hair shaft were dependent on a variety of diseases. Hair with SD had very thick scales which was 7-fold thicker than control hair [7]. Hair shafts with scalp psoriasis frequently exhibited macropits (diameter, >0.5 μm; area, >0.25 μm^2) compared to non-lesion and control hairs [8]. AD affected hair was characterized by a thick and globular pattern of scales [9].

The chemical components of the hair shaft can be easily changed by environmental conditions, such as ultraviolet (UV) radiation, heat, humidity, and chemical agents [10,11]. According to Fourier transform infrared (FT-IR) spectroscopy results, the distal root of the hair shaft has more cysteic acid than that of the proximal root because of weathering [11]. Chemical treatments such as bleaching or waving cleave the disulfide bonds in the keratin and also induce oxidative damage that can be analyzed by the S=O absorbance band near 1040 cm^{-1} [12].

In this study, we investigated the effects of scalp dermatitis (SD, psoriasis, and AD) on the chemical properties of hair keratin using FT-IR spectroscopy. IR spectroscopy has been used in biology to determine chemical properties, and the mid-IR (4000–500 cm^{-1}) is particularly relevant to hair keratin analysis, because this region covers the fundamental vibrations of most common chemical bonds in keratin [13–15]. FT-IR spectra were obtained from hair with SD, psoriasis, AD, and a healthy control. The FT-IR spectra absorbance bands were analyzed qualitatively and quantitatively to assign changes in the hair keratin associated with scalp dermatitis.

Materials and methods

Hair samples

Hairs affected by SD, psoriasis, and AD were examined separately in lesional and non-lesional regions. Hairs with SD were taken from patients with ages of 16–80 years (mean, 49.9 ± 21.4; eight males and seven females). Non-lesional hair shafts were obtained from normal appearing scalp adjacent to the SD patch. The ages of the patient with psoriasis ranged from 8 to 67 years (mean, 40.4 ± 15.11 years; nine males and six females). The duration of disease was 1–20 years (mean, 10 ± 6.51 years). All patients exhibited moderate disease (Psoriasis Area and Severity Index, range 2.1–8.7; mean, 5.60 ± 2.18) [16]. Hairs with AD were taken from eight patients with ages of 24–45 years (mean, 31.0 ± 9.78 years; six males and two females). The average SCORing atopic dermatitis (SCORAD) was 48.75 (range, 40–80). Note that the SCORAD is a widely accepted index reflecting disease severity [17]. Non-lesional hair shafts were obtained from normal looking scalp 3–5 cm away from the lesion. Hairs from 20 normal adults (healthy controls) with ages of 13–67 years (mean 45.4 ± 23.6 years) were examined in the same manner. Subjects with other systemic diseases were excluded. Subjects with a history of hair dying, permanent waving within the previous 18 months, and excessive sun exposure within the previous 6 months were also excluded.

FT-IR spectroscopy

The chemical bonding properties of hair keratin were investigated using FT-IR spectra (Infinite Gold FT-IR serious, Thermomatt-

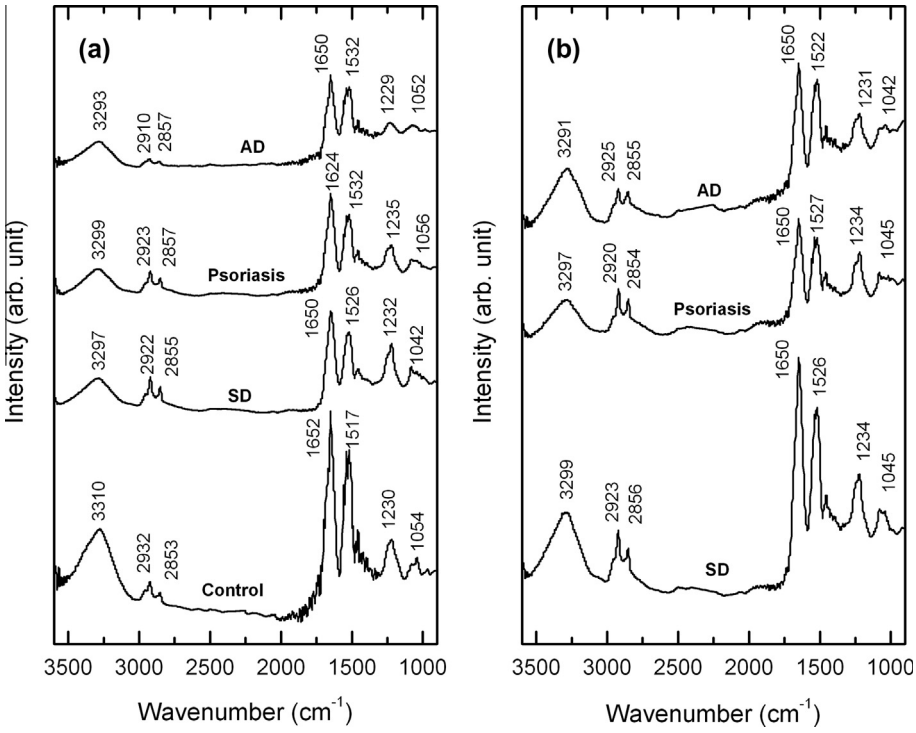

Fig. 1. Representative Fourier transform-infrared (FT-IR) spectra of human hair with scalp dermatitis (SD, psoriasis, and AD) and a control. Spectra were obtained at lesional (a) and non-lesional (b) regions.