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Sunscreens and Hair Photoprotection

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Photoprotection as it pertains to hair is not a common topic addressed by the dermatologist. Hair is nonliving and requires no protection from ultraviolet (UV) radiation because carcinogenesis of the hair shaft itself is not possible. If hair proteins are altered by sun exposure, damaged hair can be removed and replaced by new growth. Thus, at first glance, the whole issue of photoprotection for the hair might seem irrelevant; however, patients frequently consult the dermatologist for advice on hair growth and appearance problems. Hair photoprotection is an important part of maintaining the cosmetic value of the hair shaft. This article focuses on the chemical effects of UV radiation on the hair shaft, hair photoaging, intrinsic hair UV photoprotective mechanisms, and the use of hair sunscreens. The whole science of hair and photoprotection is currently in its infancy and an area of focused research within the hair care product and salon industries.

Hair and ultraviolet radiation

Much of the understanding regarding hair and how it interacts with UV radiation has come from the textile industry. Natural fibers, such as wool, cotton, silk, and rayon, discolor when exposed to sunlight. White fabrics tend to take on a light brown/yellow color, a process known as photoyellowing. The same chemical process of photoyellowing also can occur in natural unprocessed human hair. Human hair contains two pigments, eumelanin and pheomelanin, accounting for the brown and red hues seen in hair, respectively. A third melanin pigment, known as oxymelanin, is found in unprocessed human hair that has been exposed to sunlight. Oxymelanin is an oxidative photodegradation product [1]. While the presence of this photodegraded melanin decreases the cosmetic value of the hair, it also chemically affects hair dye and permanent wave solution interaction with the hair shaft [2]. Most importantly, the amount of oxymelanin present equates with the degree of hair shaft photoaging.

UV radiation also damages the hair lipids, so photodamaged hair is dull and dry. Intact hair lipids are required to coat the hair shaft imparting shine and manageability. Manageability is the ease with which the hair shaft can be styled. Hair that is devoid of intact lipids is subject to static electricity, fractures easily with combing friction, and appears frizzy.

Hair photoaging and endogenous protection

To understand hair photoaging, it is necessary to understand how UV radiation interacts with the proteins of the hair shaft. Hair is a complex nonliving structure with an outer cuticle that provides a hard protective barrier for the inner cortex. The cortex is composed of fibrillar proteins, which are responsible for the mechanical strength of the hair shaft. Melanin pigments are contained in the cortex embedded in an amorphous protein matrix. Sometimes the hair shaft may contain a medulla, but the function of this inner structure is largely unknown and is found less frequently in mature hair shafts. Sunlight damages the strength of the hair shaft by increasing the scission of the cystine disulfide bonds. The hair disulfide bonds prevent the hair shaft from fracturing with minimal trauma. Thus, the primary photoaging effect of sunlight on hair is physical weakening of the shaft.

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The second major effect of sunlight on the hair shaft is oxymelanin production, previously mentioned [3]. While oxymelanin leads to pigment dilution and lightening of hair color, it is the pigments within the hair shaft that provide the only source of endogenous photoprotection. The natural pigments actually prevent disulfide bond disruption, preserving the strength of the hair shaft, even though a hair color change occurs. In other words, chemical alterations in the hair pigment function to protect the protein structural backbone of the hair [4]. Hair contains the original pigment sunscreen, which is an area of rapid technical development in the commercial skin sunscreen industry.

Topical hair photoprotection

Until recently, the main approach to topical exogenous hair photoprotection was no different than skin photoprotection. UV-B and UV-A sunscreens were added to formulations designed for hair use, such as instant conditioners, styling gels, and hair sprays. The main problem with this topical approach to hair photoprotection was the failure to create an even film protecting the entire surface area of every hair on the head, This topical approach is impossible to achieve because the collective surface area of the hair on a human head is huge. Another challenge is creating a sunscreen formulation that adheres to the hair cuticle. Furthermore, coating each and every hair shaft with an equal thickness of sunscreen without making the hair seem limp or greasy is a cosmetic challenge no hair care product has yet overcome. This dilemma led cosmetic researchers to question whether photoprotection could be imparted to the hair shaft through another means, perhaps through the internal structure of the hair shaft.

Intrinsic hair photoprotection

An analysis of the internal structure of the hair shaft led to some interesting insight into possible mechanisms of photoprotection. The natural color of the hair shaft results from a combination of visible light absorption and light-scattering abilities of the pigment granules distributed within the cortex. Exposure of the hair to sunlight leads to lightening of the hair color, known as bleaching, and ultimately damage to the fiber itself, as discussed earlier. The pigment lightening is obvious when looking at a woman with long brown hair. The distal hair tips have a reddish hue, whereas the proximal hair shafts have a brown hue. This loss of pigment and the resultant amino acid changes seem to predispose the hair shaft to more accelerated photoaging. This result led the cosmetics industry to question whether alterations in hair color could be used to enhance intrinsic hair photoprotection.

Industry hair researchers have demonstrated that unpigmented hair is more susceptible to UV-induced damage than pigmented hair, meaning that the color granules are providing some protection from oxidative damage [5]. The rate of cystine disulfide bond breakage caused by environmental exposure is greater for unpigmented than pigmented hair. Thus, white hair and advanced gray hair are more susceptible to the damaging effects of UV radiation than youthful pigmented hair. Even though hair dyes are damaging to the hair shaft, the photoprotective effects of replacing hair shaft pigments may offset some of this damage.

Methods of enhancing intrinsic photoprotection

If natural pigments within the hair shaft provide photoprotection, preserving the hair cosmetic value with synthetic pigments deposited on the cuticle and within the cortex by way of hair dyes may be possible. Two types of hair dyes exist that can artificially increase the hair shaft pigments: semipermanent and permanent.

Semipermanent hair dyes are composed of a combination of dyes, such as nitrophenylenediamines, nitroaminophenols, and amionanthraquinones. These dyes are left on the hair 25 minutes and are used in combination to arrive at the final desired color. Damage occurs to the hair fibers on dyeing; however, as the hair is exposed to longer periods of UV radiation, the initial damaging effect of the dyeing procedure is outweighed by antioxidant effect of the color deposited on and in the hair shaft. Thus, white hair that is undyed exhibits more mechanical strength damage from UV radiation than semipermanently dyed hair after 4 days of exposure. The darker the hair dye color, therefore, the more photoprotection provided. The semipermanent hair colors are a mixture of dyes designed to create the desired final color. Usually, a mixture of reds and blues are used to create brown. The red pigments produce better photoprotection than the blue pigments. The red dyes likely are absorbing the more energetic part of the UV spectrum than the blue dyes.

This same effect was also observed with permanent hair dyes. Permanent hair dyes penetrate more deeply into the hair shaft creating color because of an