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Effects of Blue Light on the Skin

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Abstract. In recent years, the research on blue light has gradually become more sophisticated. It is found that blue light causes great damage not only to the retina but also to our skin so protection against blue light has become the focus of public attention. This paper mainly reviews the effects of blue light on human skin, mainly including the performance and mechanism of blue light on the skin, and the application of anti-blue light technology in cosmetic research and development.

Keywords: blue light, skin damage, anti-blue light, cosmetics.

1. Introduction

The damaging effects of UVA and UVB rays on the skin have been extensively researched.[1–6] Recently, researchers and cosmetic formulators are focusing more on elucidating the damaging consequences of environmental stressors such as pollution and exposure to blue light, also known as high-energy visible light (HEVL).[7–11] Research shows that blue light cannot only hurt eyes but also disrupt circadian rhythms and cause skin pigmentation, photoaging, and sagging.[12–14,9,15]

In addition to the blue light contained in the sun, blue light is also found in digital products such as mobile phones and computers.[16] The skin is increasingly exposed to artificial blue light as a result of the widespread usage of technological devices. Therefore, in order to better protect the skin from damage, this article will introduce the mechanism of blue light damage to the skin and the measures to protect the skin against blue light damage. Part 2 will cover the effects and mechanisms of blue light on human skin, while Part 3 will cover blue light preventive measures as well as various anti-blue light products.

2. Skin Damage By Blue Light

The various effects of blue light on the skin were initially used in clinical treatment. Because blue light is regarded to be the most effective form of bilirubin breakdown and also has antibacterial and anti-proliferative effects, it is used in neonatal phototherapy (NNPT) to treat neonatal jaundice, microbial infections, and severe atopic dermatitis (AD).[17–19]

Although blue light has been shown to be advantageous in the clinical treatment of skin, more and more research research have indicated that it can harm the skin and disrupt the circadian rhythm. The effect of blue light on circadian rhythm is mainly manifested in the disruption of the body's natural biological clock, resulting in poor sleep quality and even trouble to fall asleep. In terms of the skin, blue light can cause skin pigmentation as well as photoaging and sagging.

2.1 Mechanisms

Blue light affects circadian rhythms through hormones. Melatonin secreted by the pineal gland in the human brain is a sleep-inducing hormone. Blue light can suppress the production of melatonin, resulting in poor sleep quality. The blue light that electronic devices emit interrupts the circadian cycle of skin cells when used before bedtime. Skin physiological functions such as skin barrier function, skin blood flow, and skin keratin-forming cell proliferation are dependent on the skin's circadian rhythm, which affects skin hydration and detoxification.[20,21]

Skin aging results from many factors, including endogenous and exogenous. As an exogenous factor, blue light can induce skin aging by inducing the onset of oxidative stress and by damaging fibroblast cells. Irradiation of human skin equivalents with visible light induces the production of ROS, proinflammatory cytokines, and matrix metalloproteinase (MMP-1) expression.[22] Blue light can penetrate the dermis of the skin. Under blue light irradiation, mitochondria in cells produce reactive oxygen species(ROS).[15,23] ROS has an oxidative reaction with mitochondria, DNA, and cellular structures containing lipids, such as cell membranes, mitochondrial membranes, and lysosomes, which causes mitochondrial and DNA damage. From the external appearance, blue light causes untimely skin aging by inducing cells to produce free radicals, causing damage to fibroblasts in the skin dermis and lessening the extracellular matrix.[24] Another study shows that visible light exposure may also contribute to photoaging by enhancing collagen breakdown. The enzyme matrix metalloproteinases (MMPs) have been displayed to degrade collagen and forestall future collagen formation.[25]

In addition to erythema, heat damage, and free radical production, visible light has been shown to induce dark and persistent pigmentation. Studies conducted on the backs of healthy volunteers showed that visible light initiated more pronounced and longer-enduring hyperpigmentation in contrast to UVA and UVB. Blue light induced more pronounced hyperpigmentation enduring as long as 3 months. Just subjects with dark skin types responded to visible light exposure and showed hyperpigmentation, while volunteers whose skin types are I and II did not display a response to blue light. The shorter wavelengths of visible light even contribute to the relapses of pigmentary disorders such as melasma.[26,9]

As indicated by research, OPN3 is the essential sensor in melanocytes that controls hyperpigmentation triggered by short wavelengths of visible light. After blue light stimulates OPN3, it actuates a calcium flux which activates CAMKII, CREB, ERK, and p38, prompting MITF phosphorylation and an expansion in tyrosinase, DCT, and finally melanin in the cells.

Furthermore, the formation of multimeric tyrosine/phosphorus complexes in response to blue light irradiation can explain the strong and long-lasting hyperpigmentation observed in dark skin types (type III and higher skin). The complexes are mostly produced in dark-skinned melanocytes and cause tyrosinase activity to be sustained.[27]

3. Prevention Strategies

Formulators have attempted to produce components for skin care/sunscreen products that protect against UVB or UVA radiation as well as give photoprotection against visible light rays as the damage caused by blue light to the skin continues to be uncovered.

3.1 Physical Protection

Mica, pearl powder, boron nitride, and substances that refract and mirror visible light are examples of physical protection materials that can directly block blue light.[28]

3.2 Radiation Absorption

There are some blue light absorbers in plants, such as lutein, zeaxanthin, coffee beans, and so on. These blue light safeguards can reduce the transmission rate of blue light by absorbing blue light so as to protect the skin from blue light. Plant-based blue light absorbers are more reasonable for use in cosmetics.

Lutein retains noticeable light at the greatest frequency of 445 nm, which is in the blue light band. Therefore, lutein has a filtering effect on blue light, which can reduce the intensity of blue light and diminish the generation of free radicals stimulated by photons. Hence lutein has an effective protective effect on blue light.[29]

Lutein likewise has an antioxidant effect, which can guard skin fibroblasts against the damage caused by blue light irradiation because lutein can reduce the restraint of proliferation of skin fibroblasts by blue light irradiation, decrease the level of ROS production in fibroblasts, and defer the cell aging caused by blue light irradiation.[28]

3.3 Improvement Of Hyperpigmentation

The effect of visible light on the human body is that it causes excessive pigmentation of the skin and the residual pigmentation caused by blue light is more permanent than that induced by UVA and UVB.

Dragosine® is an anti-blue light ingredient developed by Symrise. Carnosine (β-alanyl-L-histidine) is the active component. The efficacy of Dragosine® was tested in human in vitro epidermal melanocyte culture and human ex vivo skin irradiation experiments, demonstrating that Dragosine® inhibits visible light-induced pigmentation effectively.[30]

3.4 Regulation Of Circadian Rhythms

The circadian cycle is responsible for maintaining the normal physiological rhythms of the human body, such as sleep, appetite, hormone release, etc. Clariant has developed a product to address this problem: B-Circadin, the main component of LESPEDEZA CAPITATA leaf/stem extract, which contains two glycosylated flavonoid active ingredients—carlinoside and isoschaftoside. The flavonoids help resinchronic the skin cells' circadian rhythm, which effectively regulates physiologically rhythm-dependent biological functions such as water channel proteins and modulate blue light-mediated oxidative stress.[20,30]

3.5 Delaying Skin Aging

Skin damage caused by visible light is mainly due to exposure to the blue light spectrum (400-500 nm), which generates reactive oxygen species (ROS) that causes skin cell damage and diminishes the self-renewal ability of skin cells. ROS is a significant element in promoting the skin aging process.

BlumilightTM, a cocoa seed extract containing molecular peptides, saccharides, and polyphenols with excellent antioxidant potential, was created by Ashland in the United States. Research results show that the addition of Blumilight helps preserve the opsin content in keratinocytes cells, and significantly reduces mitochondrial and cellular reactive oxygen species (ROS) triggered by blue light stress.

4. Conclusion

Exposure to blue light will harm human health. It can cause circadian rhythm disturbance, induce pigmentation, and accelerate skin aging and sagging. Cosmetic formulators are working on the research and development of ingredients that can reduce the damage of blue light on the skin and repair it by adding blue light filters, antioxidants, and other means.

5. Discussion

This article covers the effects of blue light on the skin and techniques to prevent blue light damage, but the introduction of the mechanism and the description of the new anti-blue light technology are not comprehensive enough. Future research will also need to focus on the development of new products for the photoprotection of human skin, such as new antioxidants.

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