We have launched the multifunction ultraviolet (UV) clear essence product "ASTALIFT White Perfect UV Clear Solution", which includes our original UV filter (designated as "D-UV guard") created by hybridizing a UV diffuser and a UV absorber, resulting in the only UV filter currently available that can completely protect against long wavelength UVA (370-400 nm). All UVA wavelengths (320-400 nm) are known to cause features of skin photo-aging, such as age spots, wrinkles, sagging, and discolorations. Long wavelength UVA (370-400 nm) not only easily penetrate through the glass windows in buildings and cars but also cannot be completely blocked by the conventional UV filters that protect human skin from UV radiation that causes skin dermal collagen modification via reactive oxygen species (ROS) production mediated by endogenous porphyrins. "ASTALIFT White Perfect UV Clear Solution" has both a great texture and high UV protection capacity. A newly developed visualization system named "One Shot UV-Visible Spectroscopic OCT" has successfully verified that the D-UV Guard thoroughly blocks UVA (370-400 nm) penetration into human skin.

1. Introduction

We offers the ASTALIFT skin care series using the four key technologies: nano technology, collagen research, antioxidation technology and photoreaction analysis and control technology we have accumulated during the development of photo films. In March 2015, we launched the UV clear essence and makeup base "Perfect UV Clear Solution" as part of the ASTALIFT Whit series (Fig. 1). This product is designed to address a problem of getting a suntan in spite of careful UV care (getting a suntan without realizing) (Fig. 2). Our survey shows that more than 65% of women are faced with this problem. The product protects against long wavelength UVA (370 to 400 nm, hereinafter referred to as UVA_{370-400}), which were sufficiently blocked.

This paper reports the mechanism behind worsening of skin dullness by UVA_{370-400} and newly developed two visualization systems.

2. Not completely blocked UVA_{370-400}

To prevent photo-aging (age spots and wrinkles), it is widely recognized that ultraviolet rays especially in the UVA range must be blocked as they penetrate deep into the skin. It is difficult to block all the UV rays with only one UV absorber that can be used for cosmetics. Two or more different absorbers are combined to provide UV protection in a wide wavelength range. With a UV diffuser like titanium oxide, the protector may cause white residues on the skin when it is made to block long wavelength rays. We have studied the transmittance of generally available UV absorbers used for cosmetics. They cannot fully block 370-nm and longer wavelength UV rays (Fig. 3). We therefore focused on UV light in this range (370 to 400 nm).

UVA_{370-400} accounts for about 50% of all the sun’s UVA rays. To study how much of the UV rays in this range penetrate into a building, we have measured transmittance of general glass for buildings (Fig. 4). The transmittance...
in this range is more than 80%. UVA\textsubscript{370-400} rays are shinning down even indoors through glass.

3. Visualization of UVA\textsubscript{370-400}

The irradiance levels of UVA\textsubscript{370-400} inside a building or a car considerably vary with sunniness or reflection of light. We have developed a new system for measuring UVA\textsubscript{370-400} \textit{in situ}. This system has a special camera with a band-pass filter that passes only UVA\textsubscript{370-400} and visualizes the intensity distribution of UVA\textsubscript{370-400} using images captured by the camera. Photographs of the inside of a car show that UVA\textsubscript{370-400} does not pass through the windshield as it is thick and it has a UV absorbing layer. But, UVA\textsubscript{370-400} passes through the side windows (Fig. 5 top). Images of an office show that UVA\textsubscript{370-400} not only passes through the windows but the rays are also reflected by white walls and clothes (Fig. 5 bottom). Those results show that people are exposed to UVA\textsubscript{370-400} where direct sunlight does not shine, like the inside of a building. They indicate that the UV rays in this range not fully blocked by the existing UV protectors for cosmetics contribute to the “ suntan in spite of care.”

![Fig. 1 ASTALIFT White Perfect UV Clear Solution](image1)

![Fig. 2 A questionnaire asked: “Do you feel that the color of your skin changes even when you are using a sunscreen?” (The in-house investigation. N = 9788)](image2)

![Fig. 3 The degree of transmittance exhibited by conventional ultraviolet absorbers](image3)

![Fig. 4 The transmittance of architectural glass](image4)

![Fig. 5 In situ imaging of long wavelength UVA (370-400 nm) inside a car near the window](image5)
4. **UVA\textsubscript{370-400} accelerates skin dullness.**

Some reports say that UVA\textsubscript{370-400} turns the skin black immediately. However, long-term changes in skin color were not analyzed in detail. Focusing on “color change of dermis = skin dullness”, we have analyzed the mechanism. It is known that pigments that naturally occur in human skin, due to UV energy, oxidize the adjacent cell membranes and other lipid, that produced lipid peroxide metabolite is bound with collagen and other protein, make skin colored. The half-life of collagen in dermis is as long as 15 years. During this period, the colored collagen is not metabolized. That is why dullness of dermis is said to take long to improve.

About UVA\textsubscript{370-400}, we have verified whether collagen is colored when active oxygen is produced. We first shed 385-nm UV light on the pigments that exist in the skin absorbing light in the range of 370 to 400 nm and compared the amounts of singlet oxygen generated. As a result, we have found that porphyrin generates singlet oxygen frequently. We have mixed lipid (linoleic acid) and collagen in the presence of porphyrin and shed UVA\textsubscript{370-400} on the solution. The result shows that colored collagen is generated irradiance-dependently (Fig. 6). It indicates that UVA\textsubscript{370-400} accelerates dermis dullness.

5. **Development of D-UV Guard formula that blocks UVA\textsubscript{370-400}**

There were no UV absorbers for cosmetics available that fully block UVA\textsubscript{370-400}. We have hybridized an organic absorber and an inorganic diffuser, developed a stable formula of D-UV Guard that can efficiently block UVA\textsubscript{370-400}. When an organic absorber and an inorganic diffuser are simply mixed, the effect of blocking UVA\textsubscript{370-400} is insufficient. When they are “hybridized”, the absorbing wavelength is increased and the range of 370 to 400 nm can be blocked (Fig. 7).

6. **Visualization of UVA\textsubscript{370-400} penetrating into skin**

In development of the formula of a UV protector, we needed a simple measurement method we could use for evaluation of light penetration and protection for various skin ages and skin types. With the existing technology available, a skin specimen has to be taken to measure it. It is an invasive method and not practical. We have newly developed the optical coherence tomography (OCT) using UVA\textsubscript{370-400}. A general OCT obtains information about the internal structure using infrared light that easily penetrates skin. Our OCT system captures tomographic images using various wavelength ranges of light. This system has been used for development of foundation. In this research, we have extended the range of the light source to UVA\textsubscript{370-400}. By the measurement with this OCT, penetration of the UV rays into the dermic layer is visualized for the first time. Also, we have confirmed that the D-UV Guard fully blocks out this range of UV light the skin (Fig. 8). Using this new non-invasive measurement method, it is made possible to find out the relationship between the application dose and the light penetration depth and evaluate various types of skins.
7. Texture design

It is important to use every day a cosmetic product that efficiently blocks UV A370-400. The newly developed "Perfect UV Clear Solution" not only has a sunscreen effect but also contains "Nano AMA," our original whitening active ingredient, and "Light Analyzing Powder," optical powder for brightening up skin. Despite being a good feel of lightly and smoothly, it is not flow out easily with sweat in summer. It would help repeated use (Fig. 9).

8. Conclusion

A wide variety of UV products with high SPF or PA are on the market. People are choosing products that suit their lifestyles and taking good care. Still, as shown by a survey, 65% of women feel that they have got a suntan in spite of care (changes in skin color hard to improve) during summer. We have focused on UVA370-400 that is hard to block with the existing UV products and that easily penetrate windows of a building or a car. We have found out a part of the mechanism behind skin dullness in the dermis (Fig. 10). Using our original formula technology, we have developed a cosmetic product that efficiently blocks UVA370-400. We have also succeeded in visualizing the blocking effect on skin using the OCT technology. We will continue to apply our optical technology, image analysis technology and measurement technology to the cosmetics field and develop functional cosmetics.

References


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