Development of Functional Cosmetics Brand “Lunamer”

Taichi MURAGUCHI*, Tomomi TATEISHI*, Ikuko OOGARU*, Karin KUROIWA***, Takeharu TANI***, Naoko YOSHIDA**, Hideyasu ISHIBASHI**, and Takuji KOSUGI*

Abstract

Skin dullness is one of the major problems for women of a certain age. Although some hypotheses for the causes were postulated, for examples the structure of the skin surface or pigmentation of proteins, they have not been proven completely. As a result of our optical analyses including measurement using polarized images and OCT, it turned out that a key for a clear skin is a healthy epidermal layer which does not affect light. Thus, we have developed an active vitamin E (tocotrienol) emulsion, named Clear-nano Vitamin E, which is effective to prevent damage on the epidermal layer caused by environmental factors. We have created the “Lunamer” series containing Clear-nano Vitamin E and the other selected active ingredients based on Fujifilm’s original “Clear & Charge” concept in an effective formula, for the purpose of improving the healthiness of the epidermal layer.

1. Introduction

Fujifilm has engaged in the development of functional cosmetics, applying its technology for reproducing clear images on films to the field of creating clear skin. In July 2012, as a new functional cosmetics brand, it launched the “Lunamer” range onto the market.

First, targeting the skin dullness that women start to feel in their 20s or 30s, we clarified its mechanism by conducting optical analyses. Then, based on our original Clear & Charge concept, which is the best approach to solve that problem, we have produced the Lunamer range containing five selected ingredients, including Clear-nano Vitamin E, that take care of sensitive skin gently but thoroughly, aiming to realize clear and brilliant skin from inside to outside (Fig. 1).

Fig. 1 New cosmetic brand “Lunamer”.

2. Factors that cause skin dullness

It is advocated that the following four factors are the main causes of skin dullness (Fig. 2).

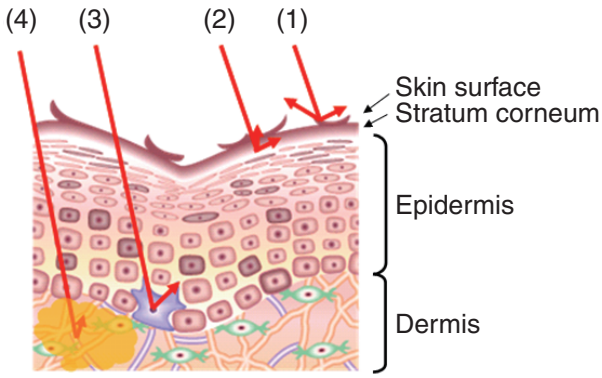

Fig. 2 Presumed causes of dull skin.

(1) Bumps on the skin surface
(2) Disordered stratum corneum
(3) Epidermal pigmentation (melanin)
(4) Dermal pigmentation (saccharification, carbonylation)

However, the detailed mechanism was not yet understood. Then, we tackled this issue and discovered the following by applying optical analysis methods that we have developed in the field of photographic technology.

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* Pharmaceutical & Healthcare Research Laboratories
Research & Development Management Headquarters
FUJIFILM Corporation
Ushijima, Kaisei-machi, Ashigarakami-gun, Kanagawa 258-8577, Japan
** Imaging Technology Center
Research & Development Management Headquarters
FUJIFILM Corporation
Miyanodai, Kaisei-machi, Ashigarakami-gun, Kanagawa 258-8538, Japan
*** Frontier Core-Technology Laboratories
Research & Development Management Headquarters
FUJIFILM Corporation
Ushijima, Kaisei-machi, Ashigarakami-gun, Kanagawa 258-8577, Japan

3. Findings from our original optical analysis technology

3.1 Analysis of skin dullness by image measurement

Light that falls on the skin surface is reflected and scattered. Some goes inside the skin, where it is scattered and absorbed. The light not absorbed returns to the skin surface. Normally, we see that returned light (Fig. 3).

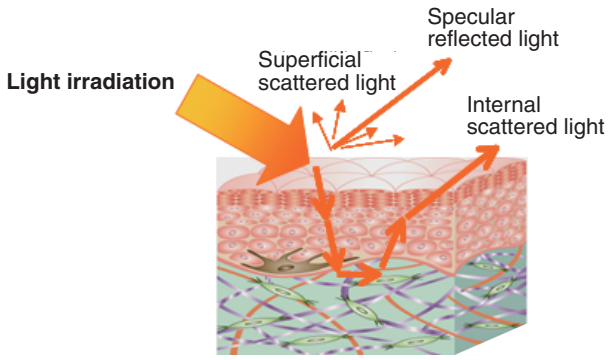

Fig. 3 Light reflection of human skin.

As described above, it is supposed that multiple causes are involved in skin dullness but the detailed mechanism is yet to be explained. We built a new hypothesis that it may be caused by the disordered propagation of light inside the skin, more specifically, in the epidermis. To verify this hypothesis, we conducted a visualization of the light conditions on the surface of or inside the skin with polarized image measurement technology that allows separation measurement of light.

Polarized image measurement technology utilizes the polarization property of light (difference in the vibration direction). Light that returns to the surface after being scattered inside the skin will be reflected irregularly because of the material properties and unevenness inside the skin. Therefore, such light is different from the one reflected on the skin surface in its polarization property. By measuring and imaging this change of polarization property, light that takes those two different paths can be separated.

We conducted the polarized image measurement with test volunteers aged from their 20s to 50s, with dull skin and clear skin. Light that returned to the skin surface after being scattered inside was measured and image processing, such as tone adjustment, was applied; then the light quantity distribution was analyzed (Fig. 4).

The image comparison of dull skin with clear skin revealed that, in the former, the quantity of light that returned from inside the skin was small overall and its distribution was uneven.

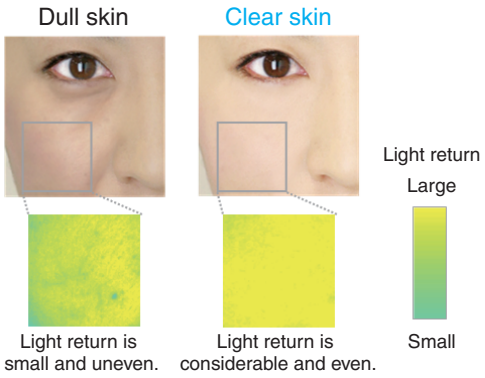

Fig. 4 Result of dull skin analysis using polarized images.

3.2 Tomographic analysis of the skin layer by OCT

By applying optical coherence tomography (OCT) as used for medical imaging diagnosis, we then visualized from what depth the light that went into the skin returned to the surface[1]. Irradiating the cheek with near infrared (1.3 μm) laser beams, we measured the time taken until light returned and assessed from what location more light returned. Fig. 5 shows the results of the comparison between dull skin and clear skin. Locations marked in blue in the figure return light. As shown, in dull skin, the overall light return was small. In contrast, in clear skin, much more light returned through the epidermis from the deep skin (dermis).

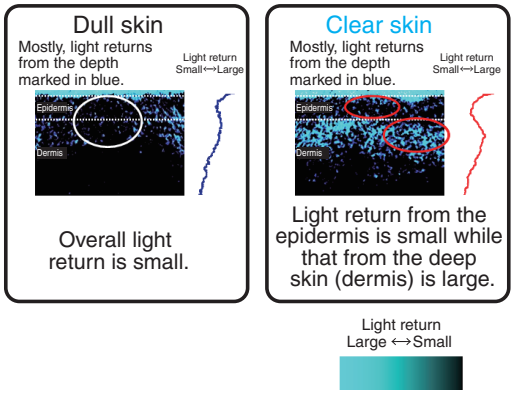

Fig. 5 OCT (Optical Coherence Tomography) images of dull skin and clear skin.

3.3 Simulation of light propagation

Furthermore, we analyzed, via simulation, light propagation inside the skin to elucidate the difference between dull and clear skin. Light scattering and absorption inside the skin are caused by the cellular-level microstructure. Therefore, to precisely reproduce light propagation in the microstructure, we employed an electromagnetic wave analysis technique, the finite-difference time-domain method (FDTD); then, measured and visualized the time elapsed

from light entering to leaving the skin via scattering (Fig. 6). In dull skin, light was scattered on the epidermis and attenuated rapidly. In contrast, in clear skin, light passed through the epidermis and was scattered in the deep skin after reaching the dermis, from where more homogeneous light was reflected. This reveals that it is important to remove the cause of light scattering and absorption on the epidermis.

That is, clear skin allows homogeneous light to return from the inside of skin and, to establish this condition, it is essential to keep the epidermis healthy, free of the factors that disturb light.

4. Clear & Charge approach

To allow light to scatter evenly from the epidermis, it is necessary to eliminate not only the roughness of the skin surface but also the optical diffuseness inside the skin. To maintain internal skin health, a care method must be established that helps create healthy skin as well as increases skin resistance against everyday environmental stresses (such as UV-rays, cigarette smoke and exhaust gas). To meet that need, we developed the functional cosmetics Lunamer, which is based on our original *Clear & Charge* concept for gentle and thorough skin care to grow healthy skin (Fig. 7). It contains five ingredients in due proportion, that keeps epidermal cells healthy and enables light to return evenly from the deep skin.

4.1 What is active vitamin E (tocotrienol)?

There are two kinds in vitamin E: tocopherol (ordinary type) and tocotrienol (active type) whose structure is partly different from the former (Fig. 8).

Active vitamin E is a scarce substance. In the natural world, palm oil contains the highest proportion but the amount is merely 0.8 g per kg (800 ppm). This rarity has prevented the promotion of its research. Nevertheless, in basic research, it has been reported that active vitamin E has a greater neuroprotective effect and antioxidant capability inside cells than ordinary vitamin E[2]. In our research, active vitamin E exhibited 70 times greater performance in the prevention of UVB-induced inflammatory substance generation than the oil-soluble vitamin C derivatives (VCIP) approved as a main whitening agent. The effect was also greater than ordinary vitamin E (Fig. 9). In addition, it was confirmed that active vitamin E had a concentration-dependent effect on the detoxification (deoxidization) of harmful substances such as active oxygen and radical organic matter.

4.2 Development of Clear-nano Vitamin E

Active vitamin E is very effective but it is nearly insoluble in water. This prevents effective application to the skin and blending into cosmetics without affecting their functionality and usability. In addition, its stability in formulation is low because of its high antioxidant property.

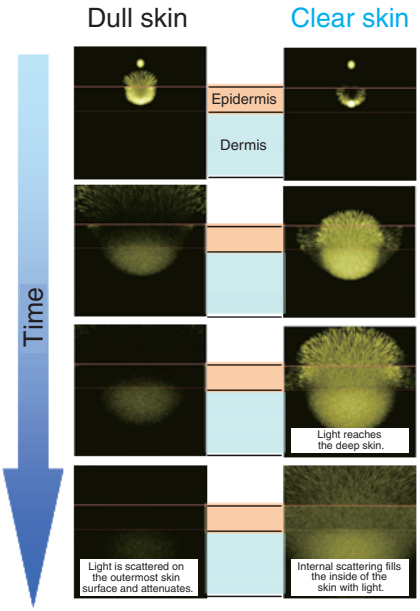

Fig. 6 Cross-sectional images of simulated light propagation in dull skin and clear skin.

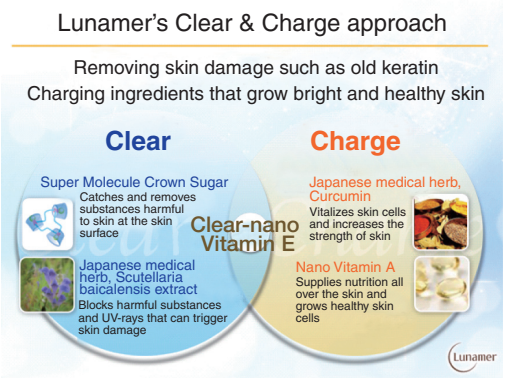

Fig. 7 "Clear & Charge" concept.

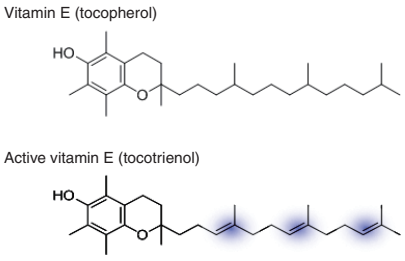

Fig. 8 Molecular structures of tocopherol (widely used) and tocotrienol.

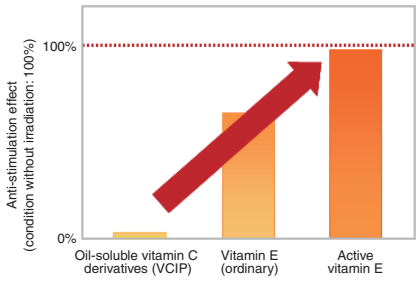

Fig. 9 Inhibition of UVB-induced inflammation by antioxidant properties.

To solve those problems, we created the world's smallest-class, water-soluble nano-particles (60 nm) by fully utilizing our original nano technology. Nanonization increases the surface area of those particles, which makes them unstable. To respond to this, we developed the new *nano-protect* design, which has improved the stability of active vitamin E greatly by the appropriate use of oils with different polarities. We thus succeeded in the development of Clear-nano Vitamin E expected to be useful in skin care (Fig. 10).

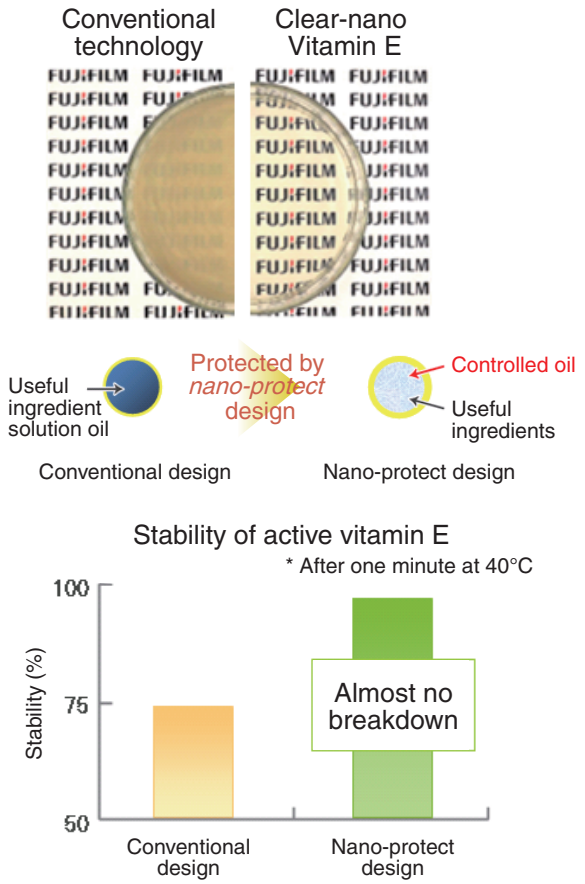

Fig. 10 Stability of Clear-nano Vitamin E.

To check the permeability of Clear-nano Vitamin E to the stratum corneum, we performed the following procedures: occluded application of Clear-nano Vitamin E to the inside of the upper arm and wash; collection of the skin tissue from the stratum corneum by tape stripping; quantity determination of the specimens; and comparison. As a result, its permeability was found to be up to eight times greater than that of non nano-particles.

4.3 Other useful ingredients

Other than Clear-nano Vitamin E, the Lunamer range includes two *Clear* ingredients and two *Charge* ingredients. One of the former-type ingredients is named Crown Sugar. It is a kind of oligosaccharide and catches harmful substances with its inclusion effect. The other is an extract of the Japanese medical herb, scutellaria baicalensis, which keeps the skin away from harmful substances and UV damage that accelerate early-stage aging[3), 4)]. As *Charge* ingredients, the Japanese medical herb, curcumin, increases the production of detoxification enzymes in the skin cells; and nano vitamin A, which is nanonized stable-type vitamin A oil, affects epidermal cells and promotes their reproduction.

Each item of the Lunamer range contains all those five ingredients, each designed for its particular properties.

5. Empirical verification of the effect on the skin

To confirm the effectiveness of the Lunamer range, a two-week continuous use experiment was conducted. Six test subjects in their 20s and 30s used the cleansing foam (every morning and night) and the wipe-off essence Lunamer Brightener (only at night) and their skin conditions before and after the experiment were compared.

Table 1 shows the increase of the brightness (L* value) of pores and over the cheek after the two weeks of use. For three out of the six, both L* values increased by at least 0.5 after the experiment and their skin conditions were improved.

Table 1 Increase in the brightness of pores and cheeks after two weeks continuous use.

Increase of the L* value	Less than 0.5	0.5 to 1.0	More than 1.0
L* value of pores	3	2	1
L* value over the cheek	3	2	1[*1]

In addition, before and after the continuous use experiment, the spectral reflectance curves for the cheek were measured with the Topcon SR-3 spectroradiometer. As an example, the curves for one test subject ([*1] of Table 1) are given in Fig. 11. The skin dullness reduced because of the decreased yellow reflected light around 580 nm and the skin tone was improved because of the increased red reflected light at 600 nm and over.

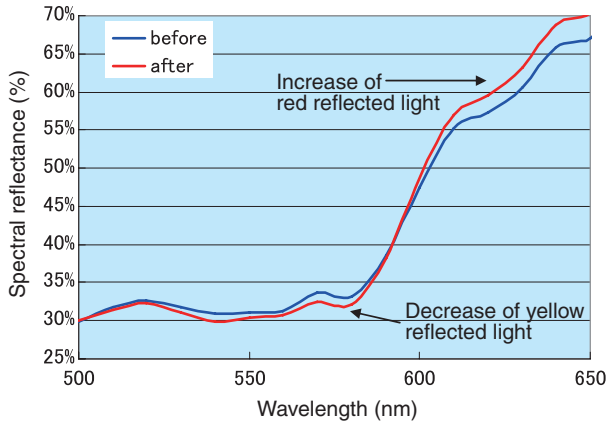

Fig. 11 Color change on cheeks after two weeks continuous use.

6. Conclusion

The new functional cosmetics brand, Lunamer, described in this paper was created from discoveries brought about by our original optical analysis technology to solve discovered problems with our unique nano technology. These functional cosmetics can be provided only by Fujifilm.

To solve skin problems, we will keep utilizing our analysis technology cultivated via experience in the photography industry. Through product development from new points of view and based on science, which is only possible by Fujifilm, we will strive to contribute to the further improvement of the quality of people's lives.

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