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“A study on UV-blocking material with SPF Booster effect”

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1. Introduction

Skin aging is a complex process that occurs due to the decline in the function of tissues and organs that make up the human body, as well as various internal and external factors. Aging is largely divided into intrinsic aging, which occurs naturally over the course of biological time, and exogenous aging, which is caused by environmental factors such as ultraviolet rays, air pollution, and stress. Among these, exogenous aging caused by ultraviolet rays (UV) is called ‘photoaging’ and is identified as the main cause of accelerated skin elasticity loss, wrinkles, and pigmentation.

UV rays are classified into UVA (320–400 nm), UVB (280–320 nm), and UVC (200–280 nm) according to their wavelengths. Among these, UVB penetrates into the epidermis of the skin, causing DNA damage and mutations, and can cause skin cancer in the long term. On the other hand, UVA reaches the deeper dermis layer and induces the production of reactive oxygen species (ROS), which promotes the decomposition of collagen and elastin, becoming the main cause of premature skin aging.

In order to block the harmful effects of UV rays, the use of sunscreen is essential, and various physical and chemical blocking ingredients have been developed. However, some UV blocking ingredients are restricted for use internationally or are only permitted below a certain content due to side effects such as skin irritation, allergic reactions, and environmental toxicity. These regulations act as a factor that can hinder the overall UV protection effect of the product.

Therefore, in this study, we sought to develop a new sunscreen material that could complement the limitations of existing sunscreen ingredients and ensure both safety and efficacy. A liposome formulation was designed using TES-Trioleate (Tris-Oleoyltromethamine Ethane Sulfonic Acid), which has been proven to protect against cell damage caused by ROS and UVA. Furthermore, a composite blocking material with SPF Booster function was developed by applying a polyurethane component that can physically block UV rays by forming a thin film when applied to the skin.

When these new materials were applied to existing sunscreen formulations, it was confirmed that the SPF value was significantly improved through a synergistic effect with existing UV-blocking ingredients. Therefore, the UV-blocking material developed in this study can be applied to various cosmetic products, and it is expected that it can be utilized as an alternative material that can solve the problem of restrictions on the use of existing ingredients

2. Materials and Methods

Materials and Instruments

Hydrogenated lecithin (Lipoid, Germany) was used to prepare TES-Trioleate-applied liposomes. Glycerin (IOI OLEOCHEMICAL, Malaysia), C12-15 Alkyl Benzoate (BASF, China), and Caprylic/Capric Triglyceride (BASF, China) were employed as solvents. TES-Trioleate was synthesized in-house by the direct reaction of 2-[tris(hydroxymethyl)-methylamino]-1-ethanesulfonic acid and Oleoyl Chloride.

For the preparation of the water-soluble polyurethane liquid material, Luvigel Star AT3 (BASF, Spain), a mixture of Polyurethane-39 and purified water, was used. 2,3-Butanediol (GS Caltex, Korea) served as a solvent, while 1,2-Hexanediol (Shinsung Materials, Korea) and Ethylhexylglycerin (Ashland, UK) were used as preservatives.

A homogenizer (Primix, Japan) and a high-pressure microfluidizer (Micronox, Korea) were utilized for liposome preparation. A disper mixer (Primix, Japan) was used for producing the water-soluble polyurethane liquid material. A UV protection factor analyzer (Solar Light Company, USA) was used to measure the sun protection factor (SPF).

Preparation of TES-Trioleate Liposome

The preparation process for TES-Trioleate liposomes is shown in Table 1. Hydrogenated lecithin was dissolved in a mixture of glycerin and water at 80 °C using a homogenizer for 20 minutes. Separately, TES-Trioleate was completely dissolved in C12-15 Alkyl Benzoate and then added to the lecithin solution, followed by additional homogenization at the same temperature for 20 minutes. Subsequently, Caprylic/Capric Triglyceride was added and the mixture was homogenized again under identical conditions. After that, liposomes were manufactured by passing the mixture three times at 1,000 bar using a high-pressure microfluidizer (Micronox, Korea). The liposomes completed through this process were called TES-Trioleate liposomes.

	Ingredient Name	%
A	Glycerin	50.00
	Water	14.50
	Hydrogenated Lecithin	2.50
B	C12-15 AlkylBenzoate	3.00
	Tris-Oleoyltromethamine Ethane Sulfonic Acid (TES-trioleate)	3.00
C	Caprylic/Capric Triglyceride	27.00
Total		100.00

Table 1. *Composition of TES-Trioleate liposome*

Preparation of SPF Booster

The manufacturing process for the water-soluble polyurethane liquid material is is shown in Table 2. Luvigel Star AT3 was mixed with purified water, 2,3-Butanediol, 1,2-Hexanediol, and Ethylhexylglycerin at room temperature using a disperser mixer for 30 minutes. The prepared water-soluble polyurethane solution was then blended with TES-Trioleate liposome at a ratio of 9:1 to produce the SPF Booster.

	Ingredient Name	%
A	Luviset STAR at3 (Polyurethane-39, Water)	66.95
	Water	11.00
	2,3-Butanediol	20.00
	1,2-Hexanediol	2.00
	Ethylhexylglycerin	0.05
Total		100.00

Table 2. *Composition of the water-soluble polyurethane liquid material*

Preparation of Sun Cream Containing SPF Booster

To evaluate the sun protection efficacy, sun creams containing 1%, 3%, and 5% of SPF Booster were formulated, as shown in Table 3. The control group consisted of sun creams containing only organic UV filters Ethylhexyl Methoxycinnamate, Octocrylene, and Butyl Methoxydibenzoylmethane without SPF Booster, with an expected SPF value of 17.5 and PA++(DSM Sunscreen Optimizer). Additionally, a cream containing neither SPF Booster nor organic UV filters was prepared for comparison.

The manufacturing method of Sun Cream is to measure the water-based raw materials including SPF Booster and heat them to 80℃. Separately, the oil-based raw materials including UV blocking agent were measured and heated to 80℃. After that, the water-based and oil-based phases were mixed and homomixed at 4,000 rpm for 20 minutes. Then, additives were added and homomixed at 4,000 rpm for 5 minutes, and then cooled to 30℃

and defoamed to complete the manufacturing. The control Cream was also manufactured under the same conditions and methods and used for UV protection factor analysis.

	Ingredient Name	Control 1	Control 2	1%	3%	5%
A	Water	80.93	69.93	68.93	66.93	64.93
	1,2-Hexanediol	2.00	2.00	2.00	2.00	2.00
	Ethylhexylglycerin	0.05	0.05	0.05	0.05	0.05
	Disodium EDTA	0.02	0.02	0.02	0.02	0.02
	SPF Booster	-	-	1.00	3.00	5.00
B	Stearic Acid	1.00	1.00	1.00	1.00	1.00
	Cetostearyl alcohol	1.50	1.50	1.50	1.50	1.50
	Cetearyl glucoside (and) Cetearyl Alcohol	2.50	2.50	2.50	2.50	2.50
	C12-15 Alkyl Benzoate	10.00	10.00	10.00	10.00	10.00
	Ethylhexyl Methoxycinnamate	-	7.00	7.00	7.00	7.00
	Octocrylene	-	3.00	3.00	3.00	3.00
	Butyl Methoxydibenzoylmethane	-	1.00	1.00	1.00	1.00
C	Sodium Acrylate/Sodium Acryloyldimethyl Taurate Copolymer & Isohexadecane & Polysorbate 80	2.00	2.00	2.00	2.00	2.00
Total		100.00	100.00	100.00	100.00	100.00

Table 3. *Composition of Sun Creams for SPF analysis*

Measurement of Sun Protection Factor (SPF)

A sample amount of 1.3 mg/cm2 was accurately applied to a 50 mm × 50 mm PMMA (Polymethyl Methacrylate) plate and spread uniformly. After allowing the plate to stand at room temperature for 10 minutes, a blank plate was measured to obtain the reference value, followed by measurement of the sample's UV protection performance.

3. Results

UV protection factor measurement results

In order to determine the synergistic effect of SPF Booster with existing UV protection ingredients, 1%, 3%, and 5% were prescribed to Sun Cream formulations, and then the SPF index and PA grade were measured using UV protection factor analysis equipment. The SPF index analysis results are shown in Fig. 1. The SPF values of 1%, 3%, and 5% Cream were 18.01, 18.91, and 20.40, respectively, which significantly increased the SPF value compared to the control group. In addition, it was confirmed that SPF Booster increased the SPF value in a concentration-dependent manner. Next, the PA value analysis results are shown in Fig. 2. The PA values of 1%, 3%, and 5% Cream were 7.22, 7.48, and 8.03, respectively, which significantly increased compared to the control group. In particular, the 5% Cream had a result corresponding to PA+++ with 8.03. Therefore, it can be confirmed that SPF Booster has a synergistic effect with existing UV protection ingredients, increasing the SPF index and PA grade.

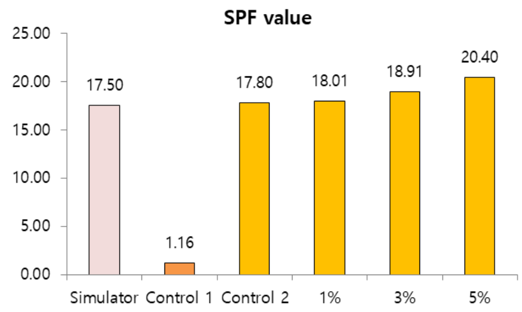

Figure 1. *SPF index analysis results of Sun Cream with SPF Booster applied*

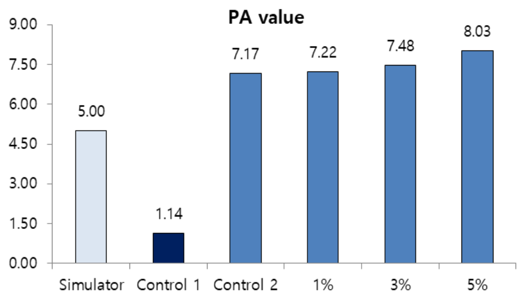

Figure 2. *PA index analysis results of Sun Cream with SPF Booster applied*

4. Discussion

In this study, the effects of adding SPF Booster to existing Sun Cream formulations at concentrations of 1%, 3%, and 5% on UV protection were evaluated. As a result of the analysis of the sun protection factor (SPF) and UVA protection rating (PA), both SPF Booster-added groups showed significant increases compared to the control group.

As a result of the SPF analysis (Figure. 1), the SPF values of Sun Creams containing 1%, 3%, and 5% were 18.01, 18.91, and 20.40, respectively, which showed a statistically significant increase compared to the control group. In particular, the concentration dependency was confirmed, in which the SPF value gradually improved as the concentration increased. This suggests that SPF Booster can enhance the efficacy of sunscreens by supplementing the UV absorption or blocking effect.

In the PA analysis results (Figure. 2), the 1%, 3%, and 5% Sun Creams showed PA values of 7.22, 7.48, and 8.03, respectively, which were significantly increased compared to the control group. In particular, the 5% Cream showed results corresponding to the PA+++ grade, indicating that the UVA blocking ability was also enhanced.

The results of this study confirmed that the application of SPF Booster can effectively improve the functional performance of UV protection products. It shows the possibility of being a material that simultaneously considers efficiency and safety in the development of various UV protection products in the future.

5. Conclusion

In this study, as a measure to enhance the effectiveness of sunscreens, SPF Booster was applied and added to Sun Cream formulations, and then SPF and PA values were analyzed. As a result of the experiment, it was confirmed that the SPF and UVA protection grade (PA) significantly increased compared to the control group when SPF Booster was applied at concentrations of 1%, 3%, and 5%. In particular, the SPF value showed a concentration dependency that gradually improved with increasing concentration, and the 5% Cream showed results corresponding to the PA+++ grade.

These results suggest that SPF Booster can effectively enhance the effectiveness of sunscreens through synergy with existing UV protection ingredients. It also suggests the possibility of implementing the same or higher UV protection effect while reducing the amount of existing UV protection ingredients used. This shows its value as an alternative material that can meet consumer demands for safety and eco-friendliness. In the future, we plan to conduct additional human application tests and long-term stability evaluations to more specifically verify the efficacy of the SPF Booster developed in this study, and we plan to further expand the commercial applicability through various formulation optimizations.

Reference

[1]. Seong Jang Kim, Yeon Jeong Ju, In Young Kim (2020) Nanomedicines for Therapy of Bladder Cancer Skin Improvement Effects and Development of Liposome Capsule Technology Using Centella Asiatica Extract Powder. Journal of the Korean Applied Science and Technology 37(5):1285-1297.

[2]. Jae-Young Yeon, Jeong Min Seo, Jun Tae Bae, Cheong Hee Lee, Sang Gil Lee, Hyeong Bae Pyo, Jin Tae Hong (2014) A Study on the Factors that Influence the Sun Protection Factor(SPF) and Protection Factor of UV-A(PA) in Sunscreen J. of Korean Oil Chemists' Soc., 31(3):422-439

[3]. Na Rae Jo, Hyun A Gu, Su Ah Park, Seat Byeol Han, and Soo Nam Park (2012) Cellular Protective Effect and Liposome Formulation for Enhanced Transdermal Delivery of Isoquercitrin. J. Soc. Cosmet. Scientists Korea 38(2):103-118

[4]. Sang Yong Kang and Hyung Joong Kim (2008) Synthesis of Polyurethane-polyacrylate Hybrid Emulsions Journal of Adhesion and Interface 9(1):16-21

[5]. J. M. Jensen, S. P. Dipl Ing, M.Witt, M. Brautigam, C. Neumann BTA, M. Weichenthal, T. R. Folster-Holst, E. Proksch (2009) Different effects of pimecrolimus and betamethasone on the skin barrier in patients with atopic dermatitis. Journal of Allergy and Clinical Immunology 124(3):19-28

[6]. Diane E. Heck, Donald R. Gerecke, Anna M. Vetrano, Jeffrey D. Laskin (2004) Solar ultraviolet radiation as a trigger of cell signal transduction. Toxicology and Applied Pharmacology 195(3):288-297

[7]. André Mahns, Rainer Wolber, Franz Stäb, Lars-Oliver Klotz, Helmut Sies (2004) Contribution of UVB and UVA to UV-dependent stimulation of cyclooxygenase-2 expression in artificial epidermis. Photochemical & Photobiological Sciences 3(3):257-262