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Evaluating the synergy between naturally coated Zinc Oxides in SPF 50+/UVA balanced sunscreens

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Introduction

The use of sunscreen as an essential part of one's daily routine is becoming more popular due to increased awareness of the effects of ultraviolet (UV) radiation on human skin. Companies are investing more in ingredients with a higher percentage of natural origin in the formulation of sunscreens— including extracts and nutrient compositions, in addition to conventional mineral filters [1]. Though heralded for their environmental and skin care benefits, these physical filters have always presented a greater challenge for formulators due to the white cast they leave on the skin, potentially leading to underapplication [2]. However, they are increasingly used in sun protection products as they are safer than organic filters [3] and can be applied in natural formulations due to their mineral origin [4]. Zinc Oxide (ZnO) is an inorganic filter that can be formulated in powder or dispersion forms. Its primary particle size (PPS) can vary between 20 and 500 nm. ZnO protects the skin against the harmful effects of UV light via scattering and primarily absorption [5,6].

The objective of this study was to investigate potential synergies between naturally coated Zinc Oxides with different particle sizes in a broad-spectrum SPF 50+ sunscreen formulation with a high natural origin index, to determine effective combinations of ZnO for high protection.

Materials & Methods

ZnO powders with primary particle size ranging from 20 to 300 nm were surface treated to render them hydrophobic. The 25 nm ZnO was coated with a mixture of Stearoyl Glutamic Acid and Polyhydroxystearic Acid, while the other ZnOs were coated only with Stearoyl Glutamic Acid. These treatments improve dispersibility, stability and natural origin index of the powders [7]. The treated Zinc Oxide powder or combination were incorporated into a water-in-oil (W/O) emulsion. The use level for all formulations was set at 23.65%.

All samples were subjected to in vivo SPF assessment according to the ISO24444:2019 methodology [8]. The study was carried out on 3 female research participants, between 18 and 70 years old. The research participants included in the study panel had an ITA° value ≥ 28°, determined by colorimetric methods, and were not tanned in the test area. Irradiations were carried out 15 minutes after applying the product, using the Multiport 601 device with a 300 W xenon arc lamp (model 601-300, serial# 9542, 19658 and 13549, Solar Light Co Inc). Likewise, the samples were subjected to in vivo PFA testing according to ISO24443:2021 method [9] with 3 female participants (18 - 70 years) and the same criteria as those for the SPF study.

Results & Discussion

All formulations maintained their organoleptic characteristics throughout the 3 months at room temperature and 45°C in the oven. There was no change in color or odor, nor was there any evidence of phase separation.

Table 1. Comparison of ZnO Blends vs. Single Grade

Formulation	PPS (nm)	Use level (%)	SPF	PFA	PFA/SPF
SMP2	25	23.72	43.0	14.5	0.34
SMP3	300	23.72	41.5	14.5	0.35
SMP1	300	9.7	50.0	22.0	0.44
	25	13.95			

Table 2. Contribution of Each ZnO in ZnO Blends

Formulation	PPS (nm)	Use level (%)	SPF	PFA	PFA/SPF
SMP1	300	9.7	50.0	22.0	0.44
	25	13.95			
SMP4	300	9.7	41.5	11.6	0.3
SMP5	25	13.95	33.3	10	0.3

Table 3. Effect of PPS on Efficacy of ZnO Blends

Formulation	PPS (nm)	Use level (%)	SPF	PFA	PFA/SPF
SMP8	300	9.7	39.9	11.6	0.29
	20	13.95			
SMP1	300	9.7	50.0	22.0	0.44
	25	13.95			
SMP6	300	9.7	41.5	24.3	0.58
	35	13.95			
SMP7	300	9.7	39.9	12.5	0.31
	60	13.95			

Conclusion

Among mineral filters, Zinc Oxide is often formulated in sunscreens. It is preferred over Titanium Dioxide because it can be used alone as the main UVA/UVB active ingredient and produces less white cast. Combining Zinc Oxides with different primary particle sizes can result in high-protection sunscreens with a high naturalness index. Specifically, the combination of non-nano ZnO (300 nm) and nano ZnO (in the range of 25 to 35 nm) has shown high synergy in both SPF and PFA scores. This understanding can be beneficial for the development of high SPF broad-spectrum sunscreen formulations.

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