

Blend of ZnO powders and Its Dispersion for Balanced UV Protection

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Introduction

In recent years, consumers started to demand UVA protection in addition to UVB protection from sunscreen products. There has been also a shift of regulation in major markets that corresponds to such a need. Europe will have the most stringent requirement to ensure sunscreen products to provide balanced protection in UVA and UVB.

Recent Regulation Change on Sunscreen Products

Region	UVA labeling/ requirement	Test method	Status
EU	PFA to be 1/3 of SPF	PPD	Recommended in Sept, 2006
USA	Low, medium, high, highest	PPD or In-Vitro	Proposed in Aug. 2007

Zinc oxide is widely used as a UVA sunscreen agent. Commercial zinc oxide can differ greatly in their particle size. It was found in our study that ZnO can effectively attenuate UVB when the size is very small. Therefore, the objectives in this work are :

- To investigate closely the effect of size on UV attention by ZnO
- To develop a product to achieve SPF 30+ with a 3/1 ratio recommended by EU commission.

Experimental

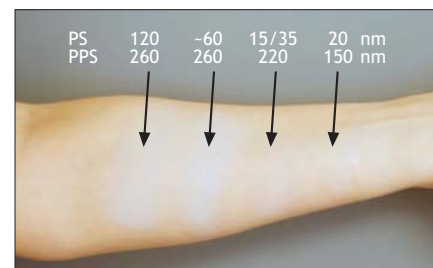
- ZnO of various size was treated with Isopropyl Titanium Triisostearate or Triethoxycaprylylsilane Crosspolymer for easy dispersion
- Treated Zinc was dispersed in isononyl isononanoate or C12-15 Alkyl benzoate and milled to the desired size.
- ZnO dispersions were used to make in W/O sunscreen lotion
- SPF and PFA (PPD method) were tested in-vivo on 3 panelist
- Particle size in dispersion was measured using a NICOMp C370 photo correlation size analyzer. Mean size of intensity weighted distribution was reported.
- Primary particle size of ZnO is calculated from their BET specific surface area.

Test W/O Sunscreen Formula

Part	%	INCI name
1	3.00	Cetyl Dimethicone
	7.50	Cyclomethicone
	6.00	Isononyl Isononanoate
	0.50	Methyl Glucose Sesquistearate
	2.00	Dioctyl Malate
	5.00	Polyglyceryl-4 Isostearate (and) Cetyl Dimethicone Copolyol (and) Hexyl Laurate
2	21.33	Zinc Oxide dispersion in Isononyl Isononanoate
3	51.07	Water
	0.50	Sodium Chloride
	2.50	PEG-150/Decyl Alcohol/Smdi Copolymer
	0.60	Phenoxyethanol (and) parabens
	100	

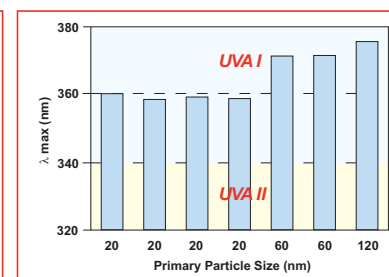
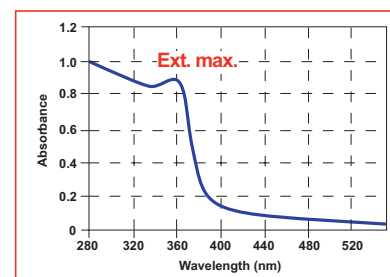
Effect of size on transparency and UV attenuation

Zinc oxide has a refractive index of 1.99 that is significantly lower than that of TiO₂. In general, it does not give much whitening even when the size is quite big. It can be made to be extremely transparent by grinding ultra fine grade. Therefore, it can be used at a very high level with minimal whitening.



Fair skin
All dispersions diluted to 20% ZnO in Cyclopentasiloxane

The level of absorption of ZnO in UVA and UVB is fairly uniform. When the size of ZnO become smaller, the surface area increase and the absorption becomes strong. But, peak of maximum absorption shifts to a lower wavelength as size decreases, leading to the loss of protection in UVA-I region. This may cause a reduction in PFA score.



ZnO was milled before being diluted

Effect of size on SPF and PFA efficacy

The sun screen lotions were made with 15% of ZnO and were drawn down at a thickness of 12 μm. As expected, all formulas showed high transparency.

Active : 15% ZnO, 12μm film				
PPS	60nm	13/15nm	20nm	20nm
Size in Dispersion	165nm	228nm	167nm	130nm

SPF efficacy:

It is very clear that the smaller the size in dispersion, the more effective ZnO is in protecting against UVB. At a size of 130 nm or smaller, ZnO can be a very effective UVB sunscreen. It is interesting to note that it is the aggregate size rather than the primary particle size that has a decisive influence on SPF score.

PFA efficacy:

For UVA protection, there is an optimal size range, which was found to be about 165 - 220 nm. When size is larger, the ZnO is not fully utilized for absorption. When the size is smaller, the effective absorption range narrows.

Formula	KSL-037B (W/O)	KSL-016 (W/O)	KSL-016A (W/O)	KSL-016B (W/O)	KSL-043 (W/O)
PPS (nm)	- 100	15 - 35	60	20	20
PS in disp. (nm)	263	228	163	166	130
Active (%)	16	14.97	14.97	14.97	13.80
SPF	12.6	14	20.4	17.4	25.4
SPF / Active%	0.79	0.93	1.36	1.16	1.84
PFA	5.83	7.50	7.58	8.17	4.75
PFA / Active%	0.46	0.50	0.51	0.54	0.34
SPF / PFA	2.2 / 1	1.9 / 1	2.7 / 1	2.1 / 1	5.4 / 1

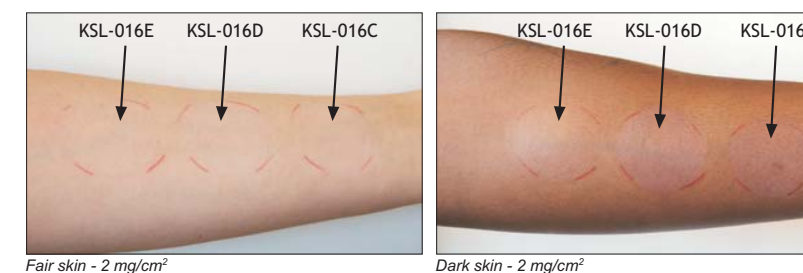
ZnO blend for balanced protection (WO Pat. Appl. 2007048057 A2)

It clearly from the above results that optimal size for UVA and UVB for ZnO is different. In order to formulate for a balanced UV protection, the combination of different size is necessary. Thus, a ZnO dispersion with very small size was chosen to provide UVB protection. A few ZnO dispersions with much large size were used to provide UVA protection.

Formula	KSL-016C (W/O)	KSL-016D (W/O)	KSL-016E (W/O)
ZnO 1	PPS (nm)	20	20
	PS in disp. (nm)	very small	very small
	Active (%)	12	10
ZnO 2	PPS (nm)	60	15-35
	PS in disp. (nm)	large	medium
	Active (%)	10	10
	SPF	31.4	30
	PFA	11.6	8.7
	FDA Rating	High	High
	Ratio	2.7 / 1	3.4 / 1

All formulas have SPF 30+ and PA +++, indicating excellent broad-spectrum protection. KSL-016C used sizes at two extremes, and the results met 3/1 ratio. So high balanced UV protection was achieved with a blend of ZnO with sizes at two extremes.

Although the ZnO is used at high level (20% or more), the lotions were highly transparent.



Conclusion

The UV attenuation of zinc oxide depends more on its aggregate size than the primary size. At a very small size, it can be an effective SPF provider. However, the most effective size against UVA is much larger. A transparent sunscreen lotion with very balanced UV protection (SPF 30+, 3/1 ratio) was successfully formulated using a blend of ZnO with two different particle sizes.

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