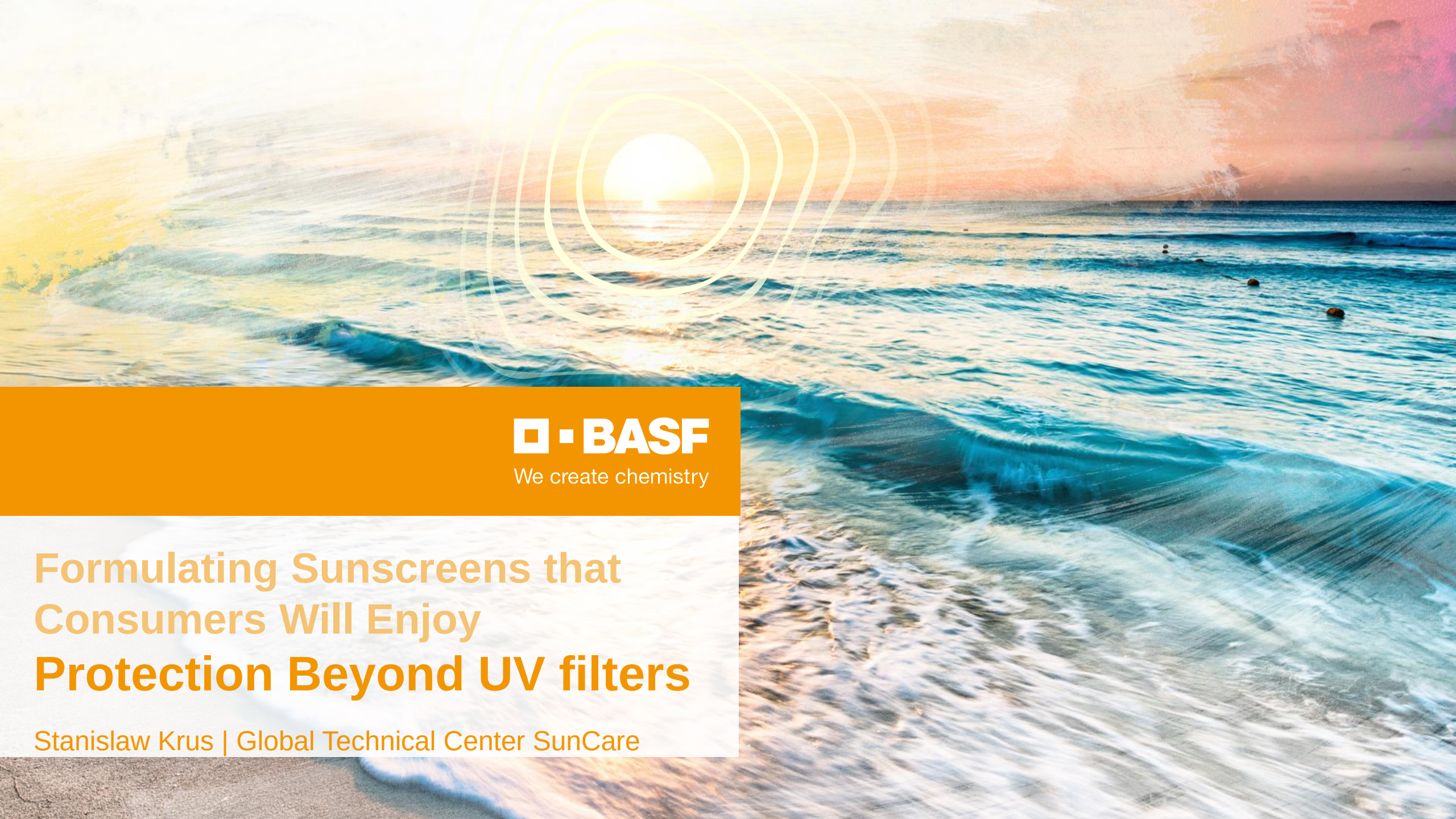

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Formulating Sunscreens that Consumers Will Enjoy

Protection Beyond UV filters

Stanislaw Krus | Global Technical Center SunCare

Conscious beauty **demands more...**

Impact on human health

- Potential endocrine **disrupting activity**
- **UV Filters dermal penetration** data required by FDA

Environmental impact

- **Acute toxicity** to the aquatic environment
- Chronic **aquatic toxicity**
- Endocrine **disrupting** activities
- **Bioaccumulation**

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UV filter under discussion Europe

Octocrylene	**Human Health** 2005 – 2021 Potential endocrine disruptor activity; Skin sensitization due to the BP residues | degradation to BP in sun care products | 2020 SCCS opinion: OCR up to 9% in sprays **Planet Health** 2012 - 2020 - … ECHA CoRAp List, CLP classification Chronic Aquatic Toxic - C1
Ethylhexyl Salicylate	**Human Health** SCCS opinion ongoing **Planet Health** 2021-2022 ECHA CoRAp List, CLP classification Chronic Aquatic Toxic - C1
Homosalate	**Human Health** 2020 SCCS opinion: HMS up to 0.5% in sun care, 7.34% in face sun care
Ethylhexyl Methoxycinnamate	**Human Health** 2001 - … Potential Endocrine disruptor activity | SCCS opinion ongoing **Planet Health** 2008 EHMC, BP3 suspected to cause coral bleaching | 2016 ECHA CoRAP list, CLP classification Chronic Aquatic Toxic – C2
Titanium Dioxide	**Human Health** Discussion on inhalation risk ongoing **Planet Health** 2018 ECHA CoRAP list
Zinc Oxide	**Human Health** Discussion on inhalation risk ongoing 2017ECHA CoRAP list (nano) **Planet Health** 2017 ECHA CoRAP list (CLP classification Chronic Aquatic toxic - C1)

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UV filter under discussion USA

Ethylhexyl Methoxycinnamate [Octinoxate]	**Human Health** 2019 – GRASE Category III (not sufficient data available) **Planet Health** 2008 EHMC, BP3 suspected to cause coral bleaching 2018 | 2019 | 2021 ban of use in State of Hawaii | Palau | US Virgin Island
Benzophenone-3 [Oxybenozone]	**Human Health** 2019 – GRASE Category III (not sufficient data available) **Planet Health** 2008 EHMC, BP3 suspected to cause coral bleaching 2018 | 2019 | 2021 ban of use in State of Hawaii | Palau | US Virgin Island
Cinoxate, Dioxybenzone, Ensulizole, Homosalate, Meradimate, Octisalate, Octocrylene, Padimate O, Sulisobenzone, Avobenzone	**Human Health** 2019 – GRASE Category III (not sufficient data available) **Planet Health** 2021 ban of use in State of Hawaii
Titanium Dioxide	**Human Health** 2019 GRASE Category I
Zinc Oxide	**Human Health** 2019 GRASE Category I

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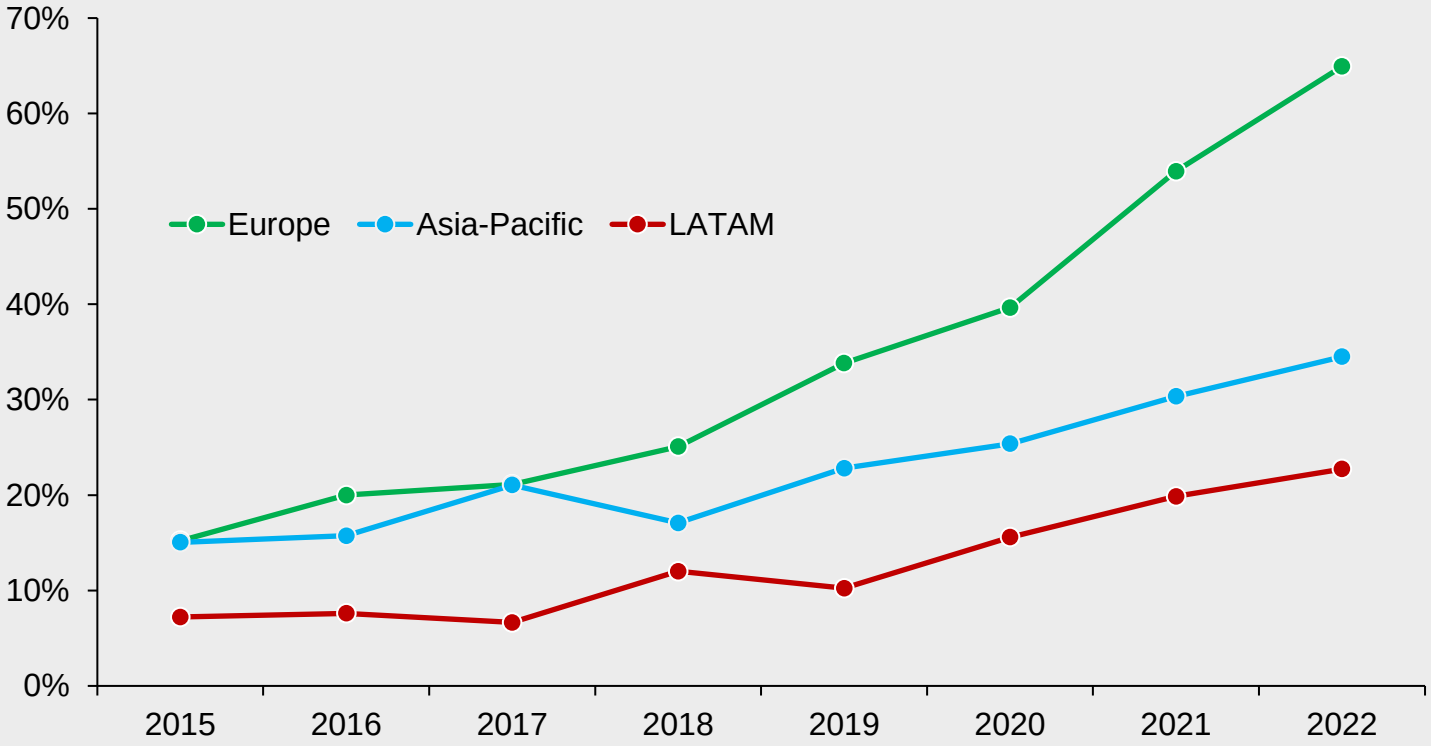
Market reaction

Formulating out UV filter under concerns worldwide

OCR and EHMC free sun care products



In each of evaluated regions one can observe significant increase of products without OCR, EHMC
Trends is the strongest in Europe, followed by Asia-Pacific and LATAM

Search for products
where Region matches Europe
and Sub-Category matches Sun - Sun/Sunbed Exposure
and Claims matches one or more of [Biodegradable; Carbon Neutral; Ethical - Environmentally Friendly Package; Ethical - Recycling; Ethical - Environmentally Friendly Product] as the claim and Date Published is between Jan xxxx and Dec xxxx

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Consequences | solutions

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Reaction of the Industry

Problem:

Difficult to achieve high performance with limited selection of UV filters

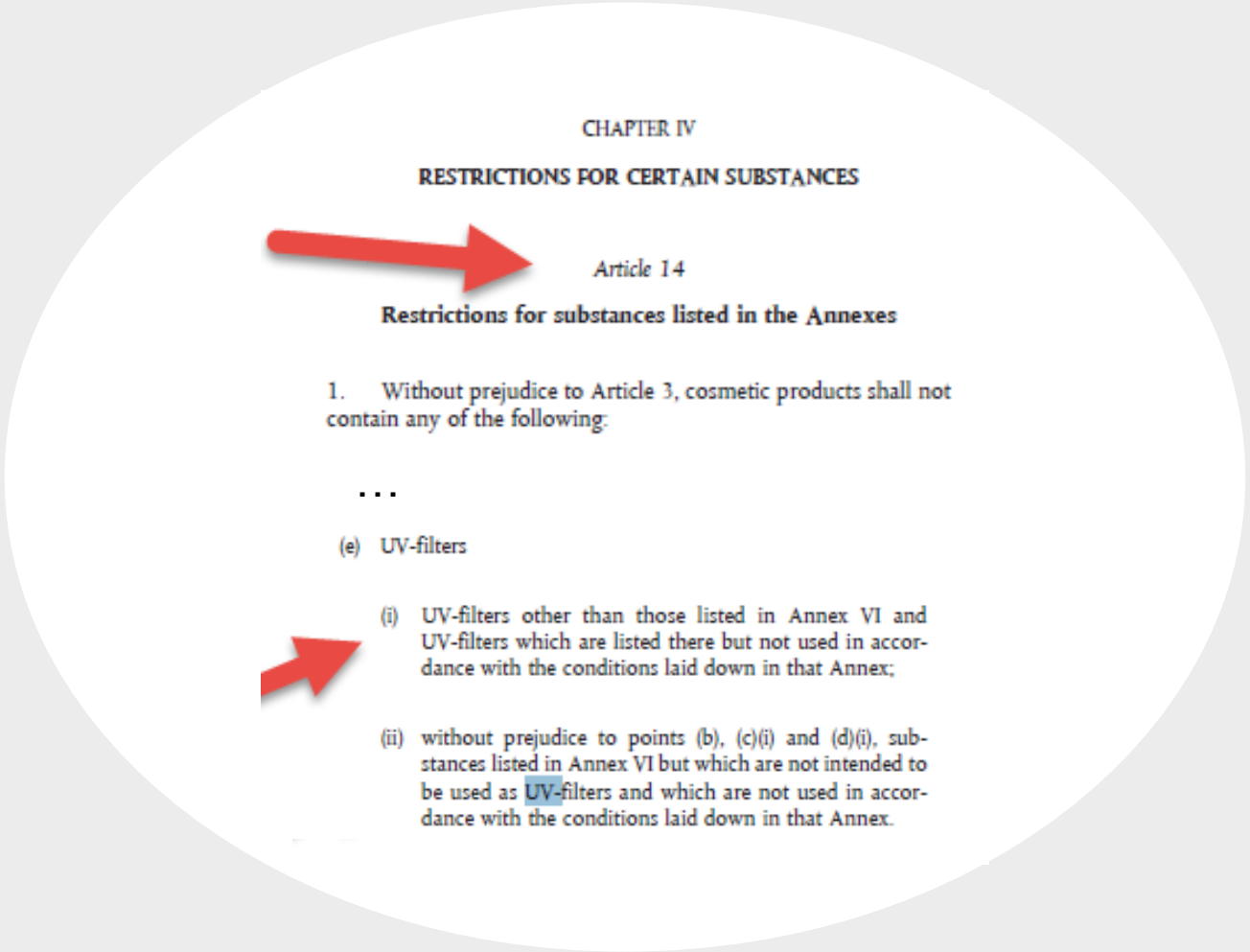
Potential solution:

The use of boosters to reach the desired performance with acceptable sensory

Boosters can be **scattering particles** or **film formers**, but also nonregistered UV filters or stabilizers with UV absorber function

“Stabilizers” of UV Filters | EU Cosmetic Regulation

- Some ingredients are promoted as BMDBM **photostabilizers** by quenching its photoexcited state
- These ingredients show inherent absorbance exceeding the one of registered UV filters **BUT are NOT LISTED in the annex VI** of EC regulation and have no SCCS opinion
- This issue of using non-official registered UV filters was addressed by several organizations
- Market products had to be removed from the market due to the use of non-registered molecules showing UV absorbance



CHAPTER IV

RESTRICTIONS FOR CERTAIN SUBSTANCES

Article 14

Restrictions for substances listed in the Annexes

1. Without prejudice to Article 3, cosmetic products shall not contain any of the following:

...

(e) UV-filters

(i) UV-filters other than those listed in Annex VI and UV-filters which are listed there but not used in accordance with the conditions laid down in that Annex;

(ii) without prejudice to points (b), (c)(i) and (d)(i), substances listed in Annex VI but which are not intended to be used as UV-filters and which are not used in accordance with the conditions laid down in that Annex.

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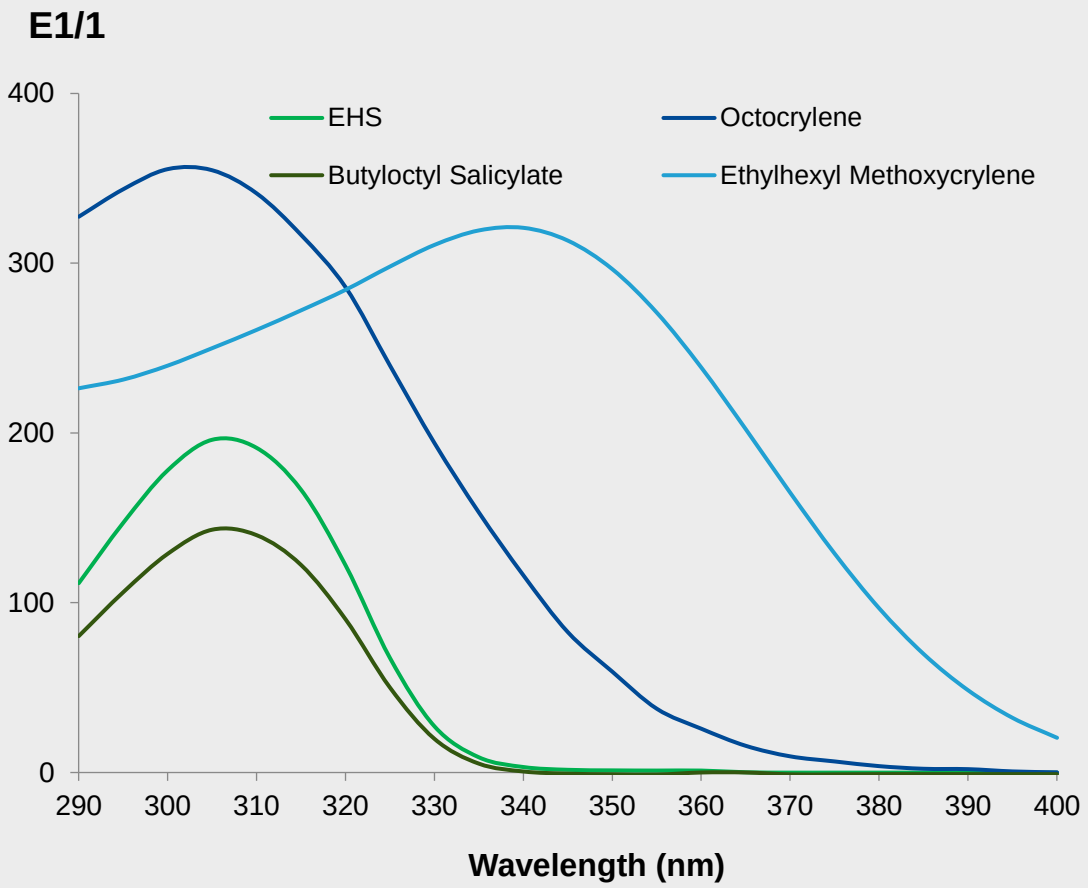
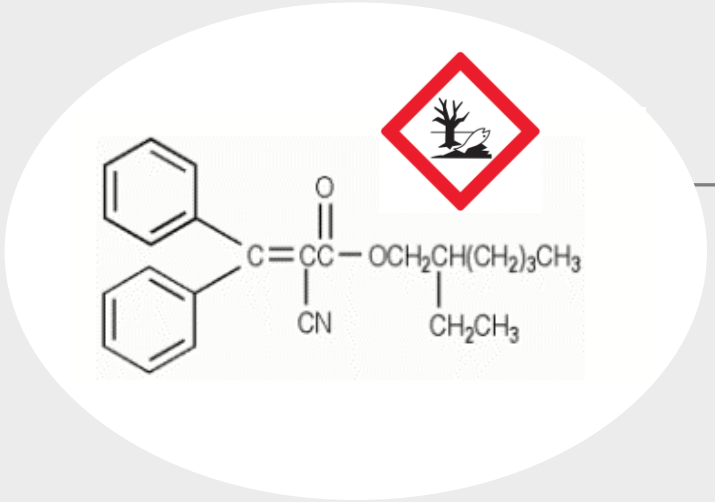
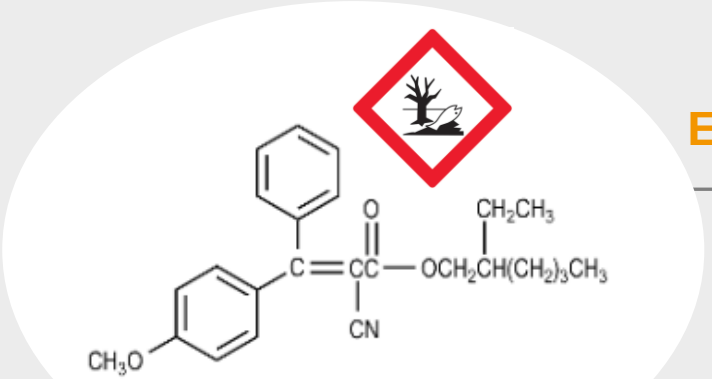
Comparison of Absorption UV filter & Stabilizer





Octocrylene

Registered **UV filter** re-evaluated by ECHA, and in the request of SCCS



Ethylhexyl Methoxycrylene

Non registered (illegal) UV filter, no evaluation requested

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Consequences | solutions

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Tinomax™ CC

Functionalized natural-based particle

Suitable for skin and sun care formulations bringing significant **sensory enhancement** due to **homogeneous particle shaping**

Lengthening your UV protection with SPF and UVA improvement

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Tinomax™ CC
Technical profile

INCI Name	Calcium Carbonate, Hydroxyapatite
Appearance	Off-white fine powder
Particle size (d50%)	3 - 4 µm
Preservative	None
Recommended use level	3.0%

Natural-based functionalized $CaCO_3$ and Hap particle

Ecotoxicological profile **improvement** of formulations

SEM images (**10k magnification**)

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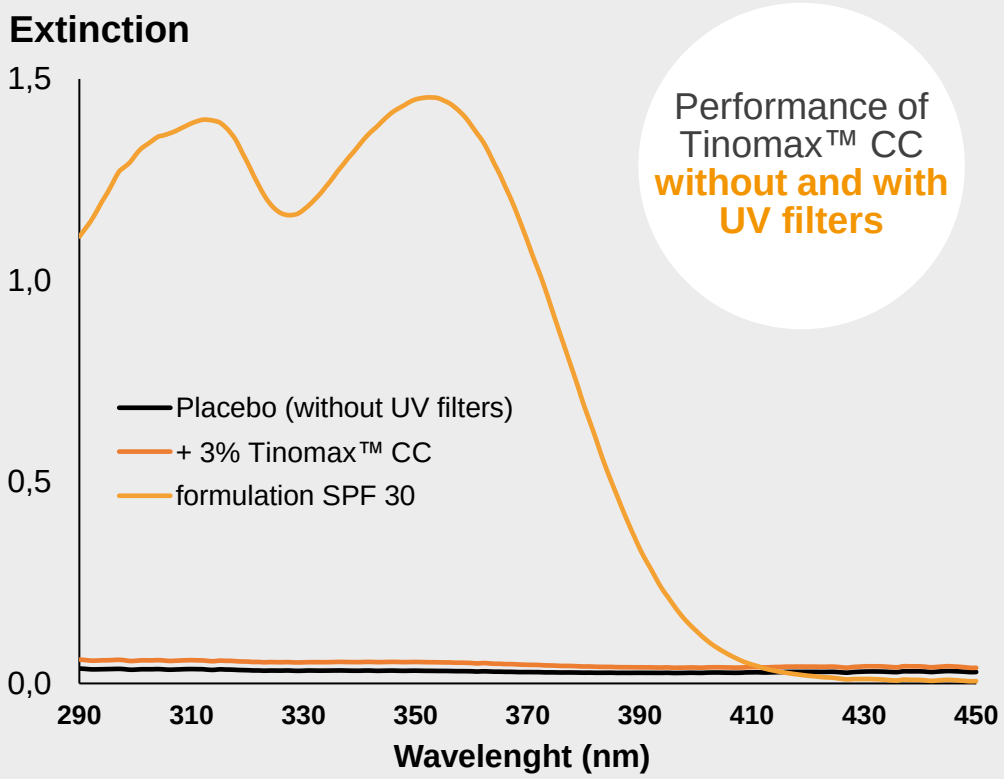
Performance

Performance of
Tinomax™ CC itself



Performance of Tinomax™ CC **without and with UV filters**

Tinomax™ CC shows no impact on UV / Blue light absorption, when used without UV filters in formulation

Tested formulations

	Trade name	INCI	UV-20-034-29-1	UV-20-034-29-2	UV-20-034-12-33
A	Eumulgin® VL 75	Lauryl Glucoside (and) Polyglyceryl-2 Dipolyhydroxystearate (and) Glycerin	4,00	4,00	4,00
	Lanette® O	Cetearyl Alcohol	2,00	2,00	2,00
	Cutina® PES	Pentaerythrityl Distearate	2,00	2,00	2,00
	Cetiol® B	Dibutyl Adipate	10,00	10,00	10,00
	Cetiol® Sensoft	Propylheptyl Caprylate	5,00	5,00	5,00
	Euxyl PE 9010	Phenoxyethanol and Ethylhexylglycerin	1,00	1,00	1,00
	Uvinul® T 150	**Ethylhexyl Triazone**	**-**	**-**	**3,00**
	Tinosorb® S	**Bis-Ethylhexyloxyphenol Methoxyphenyl Triazine**	**-**	**-**	**3,00**
	Uvinul® A Plus	**Diethylamino Hydroxybenzoyl Hexyl Benzoate**	**-**	**-**	**7,00**
	Neo Heliopan OS	Ethylhexyl Salicylate	-	-	5,00
B	Water	Aqua	72,80	69,80	54,80
	Glycerin	Glycerin	3,00	3,00	3,00
	Verdessence™ Xanthan	Xanthan Gum	0,20	0,20	0,20
	Tinomax™ CC	**Calcium Carbonate, Hydroxyapetite**	**-**	**3,00**	**-**

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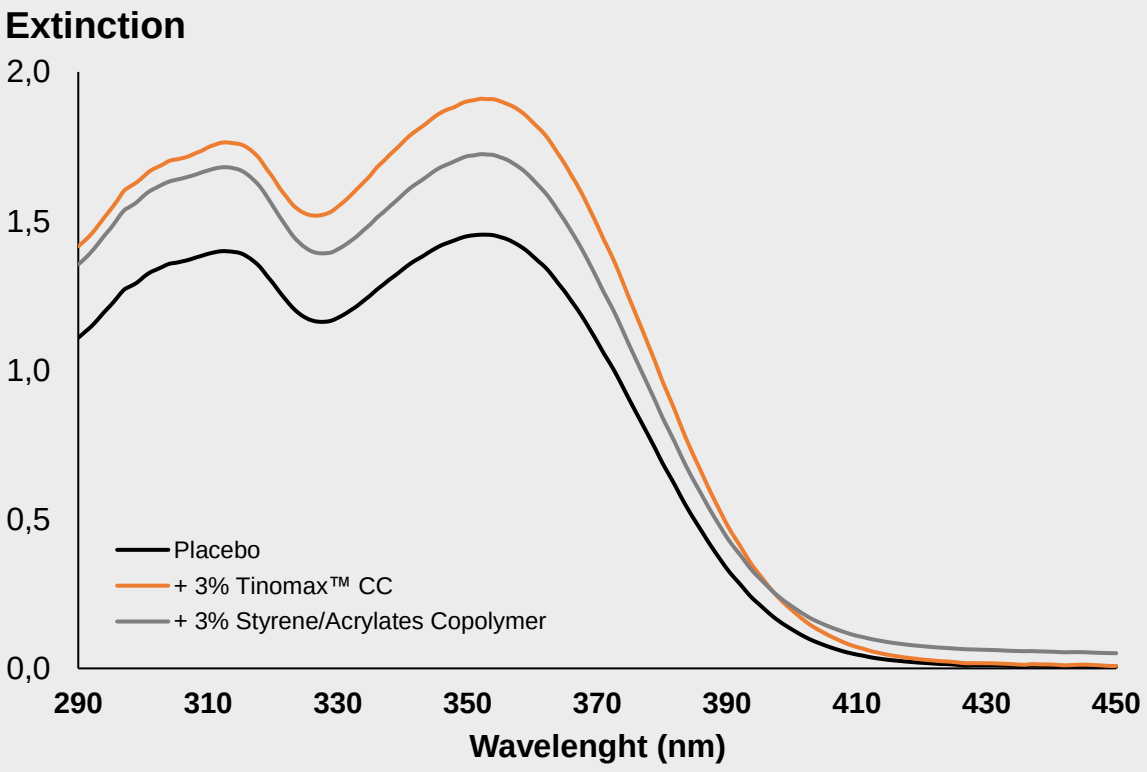
Performance
in sun care
products

Performance in formulation

with oil soluble UV filters



	Trade name	INCI	UV-20-034-12-33	UV-20-034-12-21	UV-20-034-12-34
A	Eumulgin® VL 75	Lauryl Glucoside (and) Polyglyceryl-2 Dipolyhydroxystearate (and) Glycerin	4,00	4,00	4,00
	Lanette® O	Cetearyl Alcohol	2,00	2,00	2,00
	Cutina® PES	Pentaerythrityl Distearate	2,00	2,00	2,00
	Cetiol® B	Dibutyl Adipate	10,00	10,00	10,00
	Cetiol® Sensoft	Propylheptyl Caprylate	5,00	5,00	5,00
	Euxyl PE 9010	Phenoxyethanol and Ethylhexylglycerin	1,00	1,00	1,00
	Uvinul® T 150	Ethylhexyl Triazone	3,00	3,00	3,00
	Tinosorb® S	**Bis-Ethylhexyloxyphenol Methoxyphenyl Triazine**	**3,00**	**3,00**	**3,00**
	Uvinul® A Plus	**Diethylamino Hydroxybenzoyl Hexyl Benzoate**	**7,00**	**7,00**	**7,00**
	Neo Heliopan OS	Ethylhexyl Salicylate	5,00	5,00	5,00
	Water	Aqua	51,80	54,80	54,80
B	Glycerin	Glycerin	3,00	3,00	3,00
	Verdessence™ Xanthan	Xanthan Gum	0,20	0,20	0,20
	Tinomax™ CC	**Calcium Carbonate, Hydroxyapatite**	**-**	**3,00**	**-**
	Benchmark	Styrene/Acrylates Copolymer	-	-	3,00

Improvement of performance was observed in combination standard UV filters

- Internal

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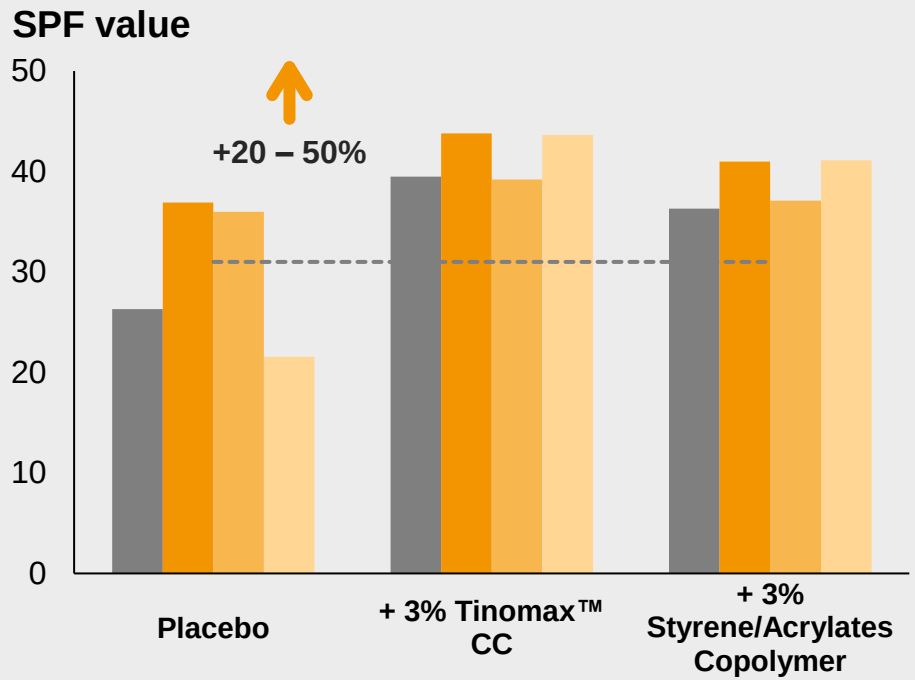
Performance in formulation

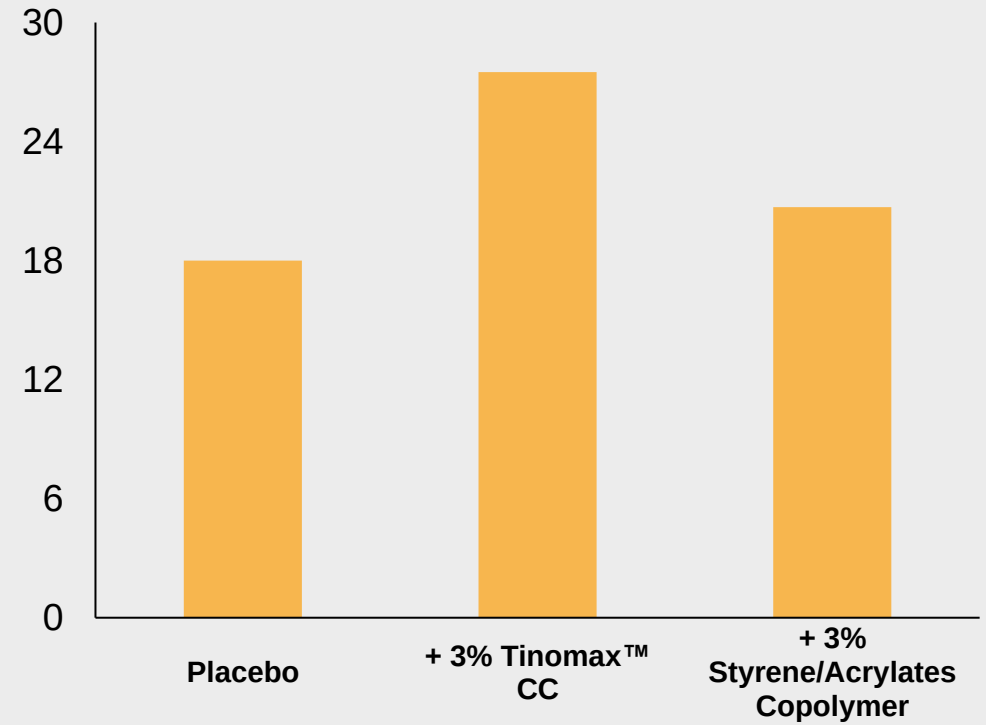
with oil soluble UV filters

SPF



	Placebo	+ 3% Tinomax™ CC	+ 3% Styrene/Acrylates Copolymer
SPF in vivo Institute 1	26,3	39,5	36,3
SPF in vivo Institute 2	36,9	43,8	41,0
SPF in vivo Institute 3	36,0	39,2	37,1
SPF in vitro	21,5	43,6	41,1
SPF in silico	31	31	31

UVA-PF



	Placebo	+ 3% Tinomax™ CC	+ 3% Styrene/Acrylates Copolymer
UVA-PF in vitro (SPF av in vivo)	18,0	27,5	20,7

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Performance in formulation

with inorganic oil dispersible UV filter(s)

	Trade name	INCI	UV-20-034-22-1	UV-20-034-22-2
	Z Cote® HP1	Zinc Oxide	25,00	25,00
A	Dow Corning ES-5600 Silicone Glycerol Emulsifier	Cetyl Diglyceryl Tris(Trimethylsiloxy)silylethyl Dimethicone	1,50	1,50
A	Dow Corning FZ-3196	Caprylyl Methicone	7,50	7,50
A	Xiameter PMX 200 350 cps	Dimethicone	3,00	3,00
A	Cetiol® 4 All	Dipropylheptyl Carbonate	4,50	4,50
B	Dow Corning ES-5600 Silicone Glycerol Emulsifier	Cetyl Diglyceryl Tris(Trimethylsiloxy)silylethyl Dimethicone	5,00	5,00
B	Arlamol HD-LQ-(RB)	Isohexadecane	1,00	1,00
B	Dow Corning 9041 Silicone Elastomer Blend	Dimethicone, Dimethicone Crosspolymer	3,00	3,00
B	Cetiol® ABV	C12-15 Alkyl Benzoate	3,00	3,00
B	Euxyl PE9010	Phenoxyethanol, Ethylhexylglycerin	1,00	1,00
	Water	Aqua	40,50	37,50
C	Glycerin	Glycerin	5,00	5,00
C	Tinomax™ CC	Calcium Carbonate, Hydroxyapatite		3,00

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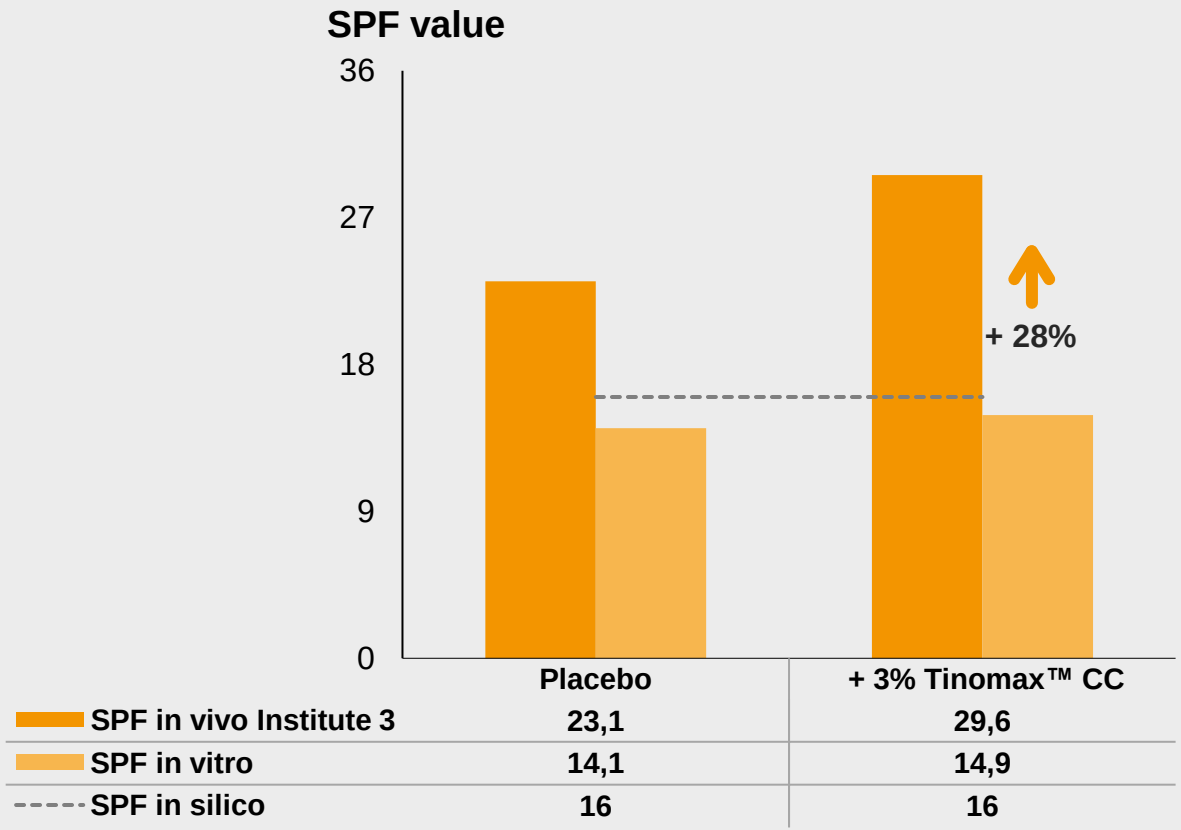
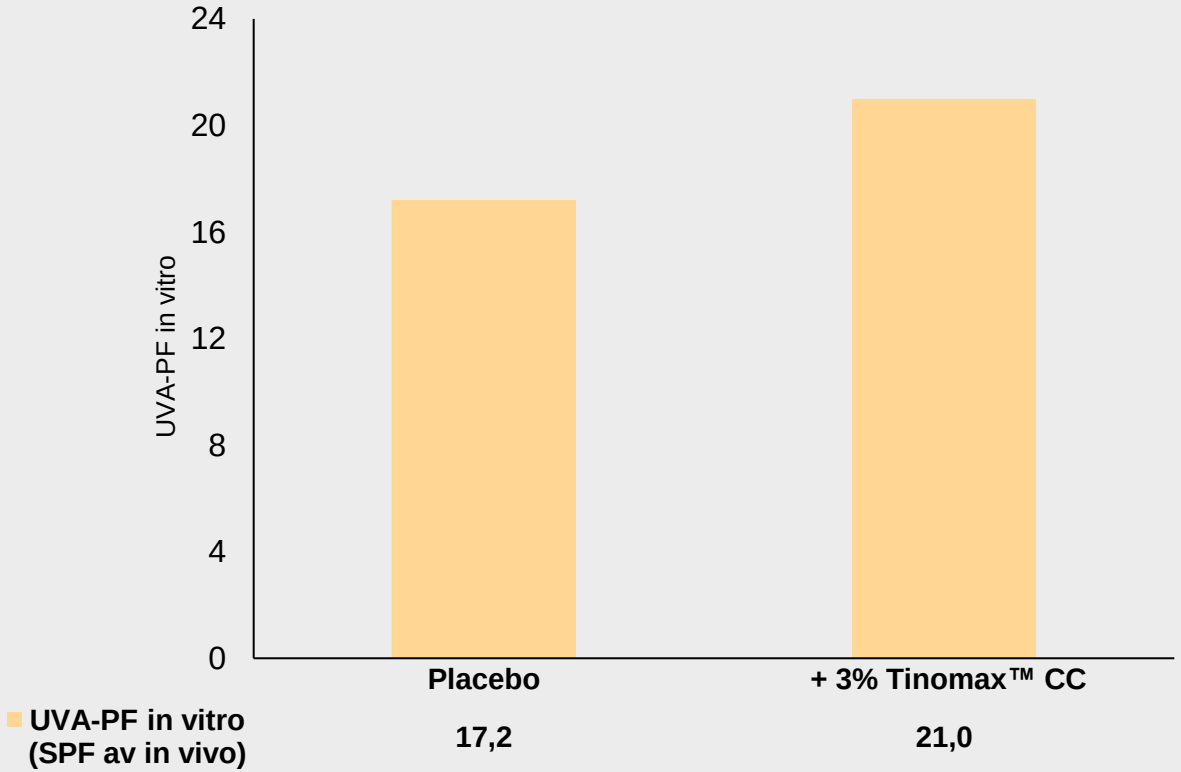
Performance in formulation

with inorganic oil dispersible UV filter(s)

SPF



UVA-PF



Higher improvement of performance was observed with *in vivo* method
Applying inorganic UV filters dispersed in oil phase

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Impact on the formulation aestethics

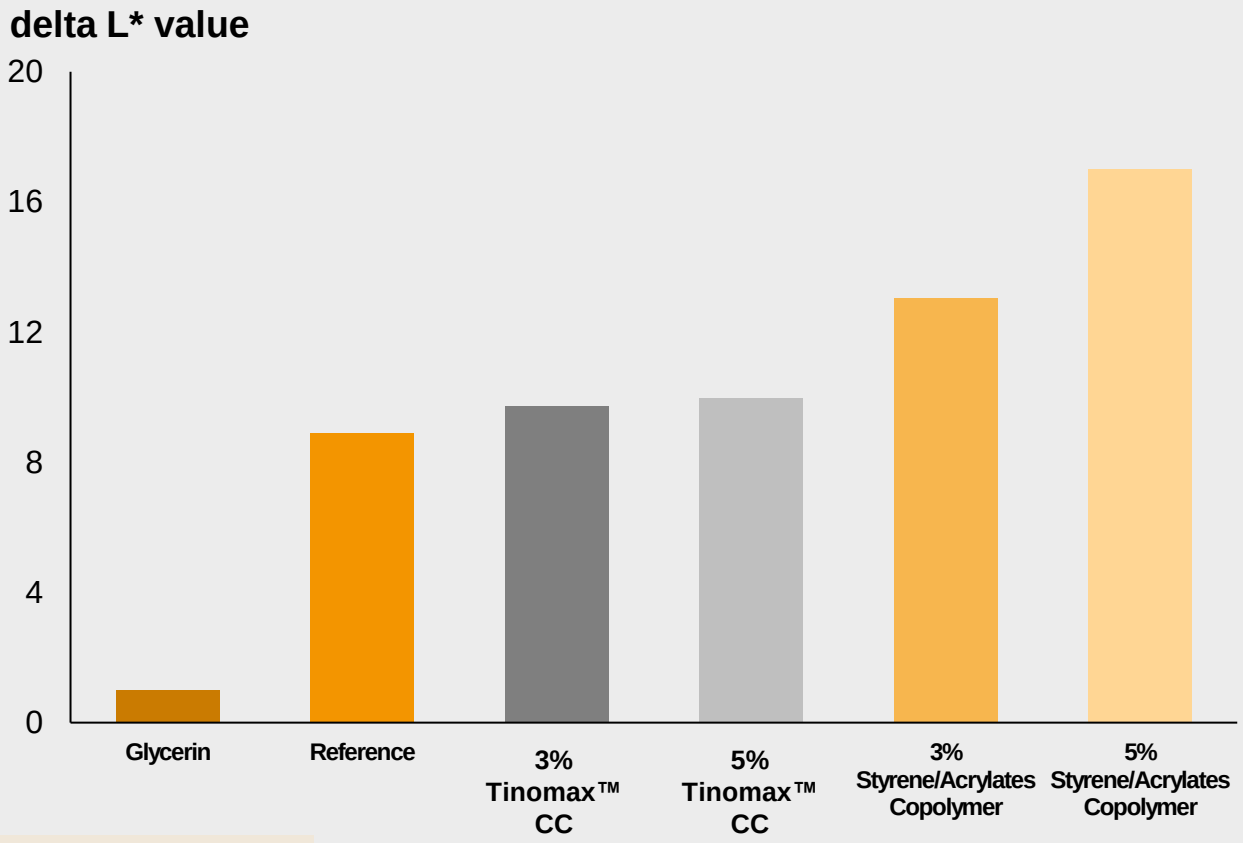
Whitening on the skin

Tinomax™ CC - Whitening test

Tested formulations

	Trade name	INCI	% by weight	% by weight
	Cetiol® B	Dibnutyl Adipate	6,00	6,00
	Cetiol® CC	Dicaprylyl Carbonate	3,00	3,00
	Cetiol® OE	Dicaprylyl Ether	3,00	3,00
	Euxyl PE 9010	Phenoxyethanol and Ethylhexylglycerin	1,00	1,00
	Uvinul® T 150	EHT	2,00	2,00
	Tinosorb® S	BEMT	1,00	1,00
	Uvinul® A Plus	DHHB	4,00	4,00
	Neo Heliopan OS	EHS	5,00	5,00
B	Water	Aqua	68,00	68,00
	Eumulgin® SG	Sodium Stearoyl Glutamate	1,00	1,00
	Glycerin	Glycerin	2,00	2,00
	Cosmedia® SP	Sodium Polyacrylate	0,60	0,60
	Verdessence™ Xanthan	Xanthan Gum	0,20	0,20
	Edeta® BD	Disodium EDTA	0,20	0,20
		Styrene/Acrylates Copolymer	Qs	-
	Tinomax™ CC	Calcium Carbonate, Hydroxyapatite	-	Qs

Results



No whitening effect observed for the formulation with Tinomax™ CC, compared to reference formulation and significant better compared with benchmark

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Enhance sun care performance through formulation base

Type of formulation, emulsifiers may improve SPF and UVA

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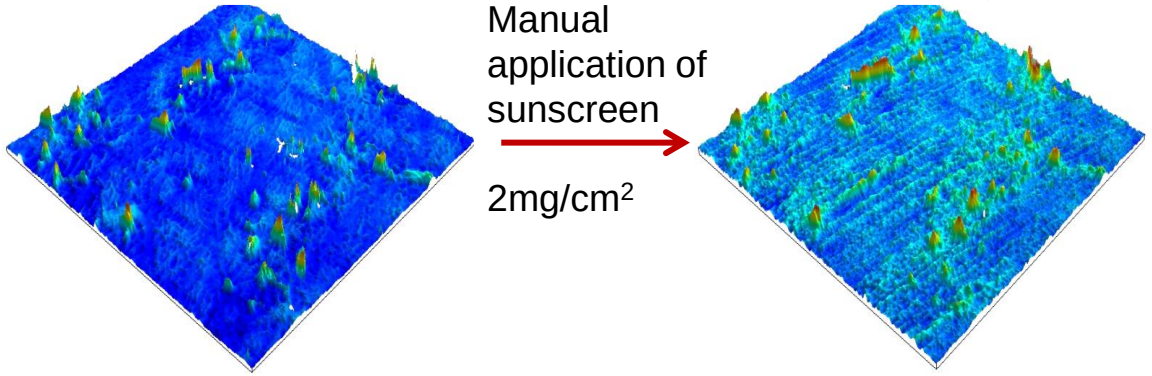
Film thickness distribution *in vitro* assessment



- Topographical measurement of a specific skin area before cream application (S1)
- Manual application of 2mg/cm² sunscreen
- Topographical measurement of the same skin area after sunscreen application (S2)

Film of sunscreen = point per point difference of the topography after and before sunscreen application

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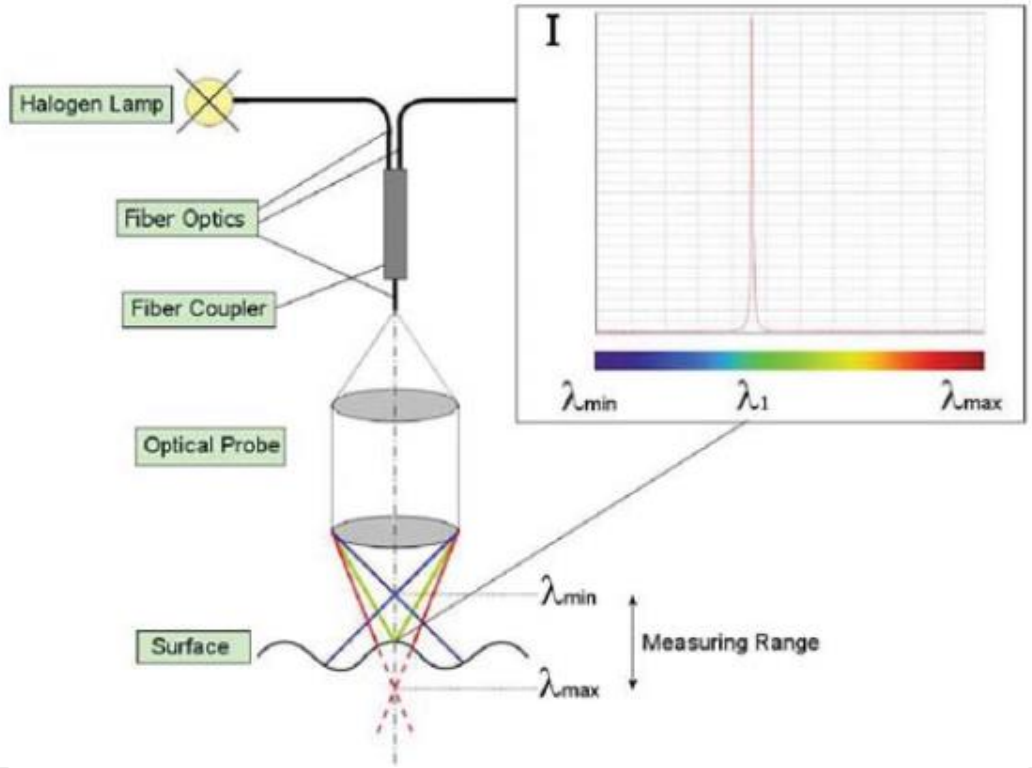
Film thickness distribution *in vitro* assessment

Non-contact surface metrology measurements

Altimet, Thonon-Les-Bains, FR

White light chromatic aberration principle



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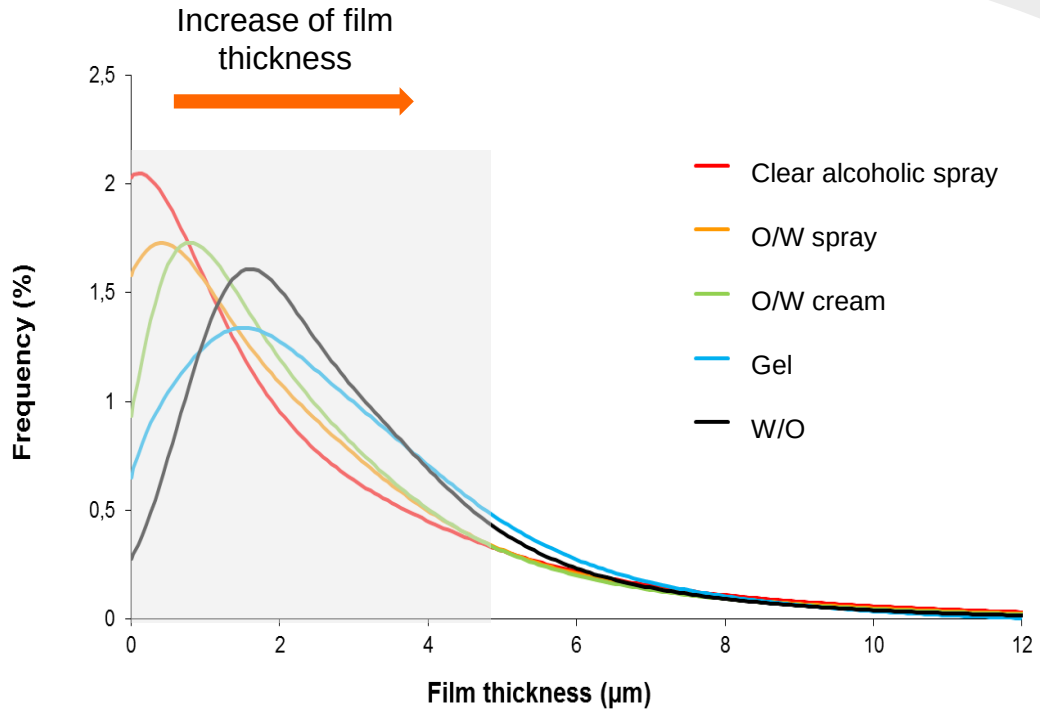
Film thickness distribution of the 5 vehicles



Application procedure:
spreading 1 with high pressure

- Shape of distribution curve differs between the vehicles
- Particularly, the percentage of film thicknesses 0 – 5µm differed
- No differentiation for film thicknesses above 8 µm
- Film thickness increased in the order OW-S < CAS < OW-C < GEL < WO

M. Sohn et al, „Film thickness frequency distribution of different vehicles determines sunscreen efficacy“, J.Biomed.Opt. 19(11),115005 (2014)

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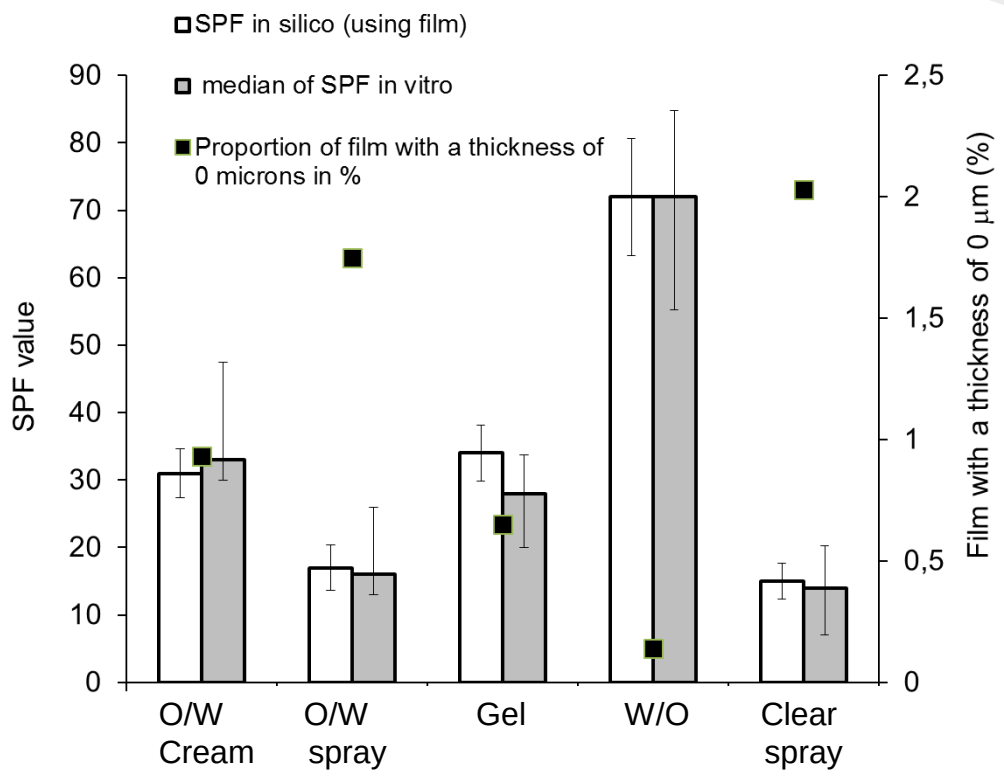
Film thickness distribution *in vitro* assessment



- Significant impact of vehicle on SPF *in vitro* (Kruskal-Wallis, $p < 0.05$)
- Great difference of the percentage of film with thickness = 0µm between vehicles
- The greater the percentage of film thickness = 0µm, the smaller the SPF
- Very good agreement between SPF in silico (using film) and SPF in vitro for every sunscreen

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Enhance sun care performance through formulation base

hydrophobic waxes may improve SPF and UVA

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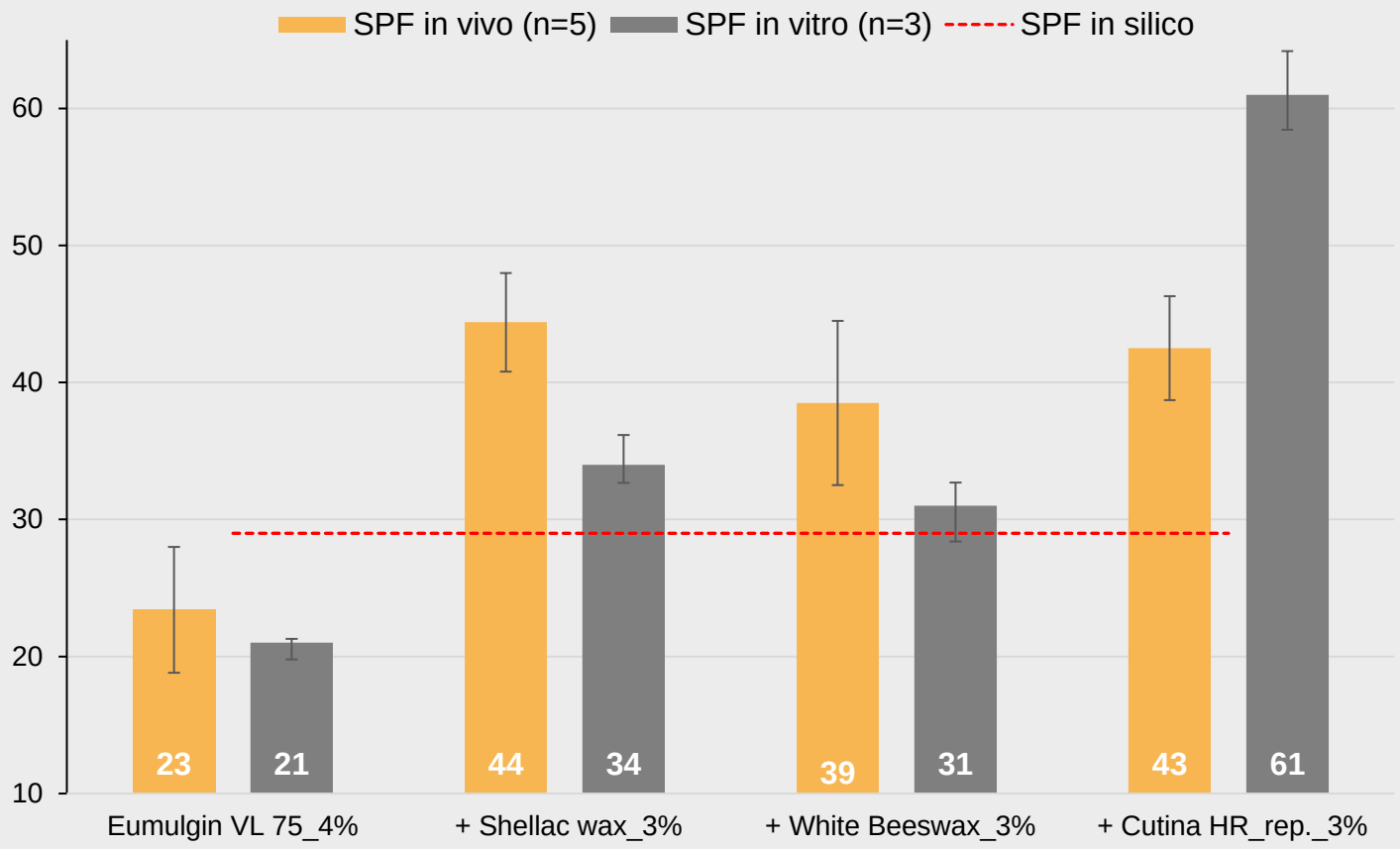
Impact of lipophilic thickeners | waxes

SPF value



- **SPF** may be impacted by the thickening of the oil phase
- Hydrophobic Waxes as Hydrogenated Castor Oil – **Cutina® HR Flakes** shows the best perfromance
- Confirmation of the in vitro observed boosting effect with **SPF in vivo** tests

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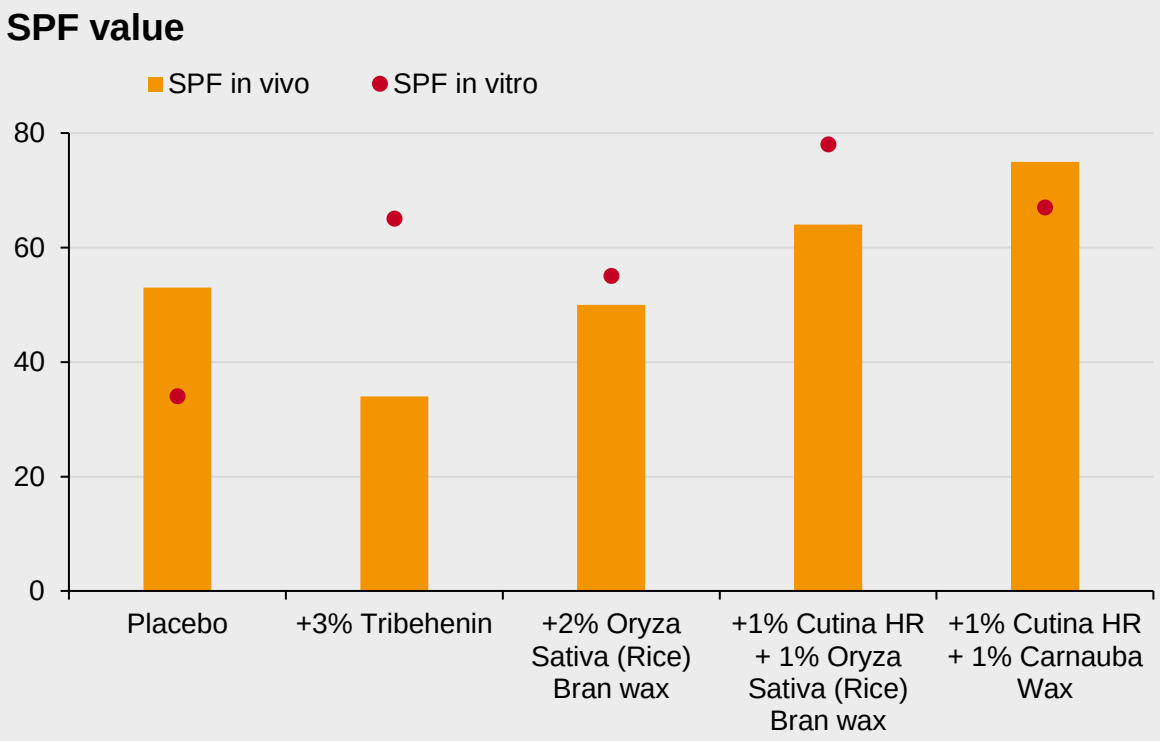
Performance in end formulation

with selected waxes

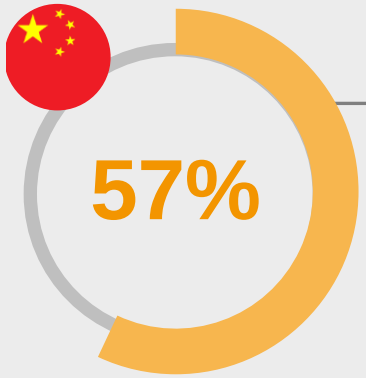


	Trade name	INCI	% by weight
		Sucrose Polysterate, Cetyl Palmitate	3,00
	Eumulgin® Prisma	Disodium Cetearyl Sulfosuccinate	0,80
	Lanette® O	Cetearyl Alcohol	1,50
	Cetiol® B	Dibutyl Adipate	12,00
	Cetiol® CC	Dicaprylyl Carbonate	5.00
A	Cetiol® OE	Dicaprylyl Ether	3,00
	Euxyl PE 9010	Phenoxyethanol and Ethylhexylglycerin	1,00
	WR agent	-	Qs
	Uvinul® A Plus	**Diethylamino Hydroxybenzoyl Hexyl Benzoate**	**6,50**
	Uvinul® T 150	**Ethylhexyl Triazone**	**3,00**
	Tinosorb® S	**Bis-Ethylhexyloxyphenol Methoxyphenyl Triazine**	**1,00**
	Water	Aqua	Qs
B	Glycerine	Glycerine	3,00
	Verdessence™ XGN	Xanthan Gum	0,50
	Neutrol® MGDA	Trisodium Dicarboxymethyl Alaninate	0,20
	Water	Aqua	10,00
C	Eusolex 232	Phenylbenzimidazole Sulfonic Acid	1,50
	NaOH 30%	Sodium Hydroxide	Qs
D	**Tinosorb® A2B**	**Tris-Biphenyl Triazine (nano), Aqua, Decyl Glucoside, Disodium Phosphate, Butylene Glycol, Xanthan Gum**	**5,00**

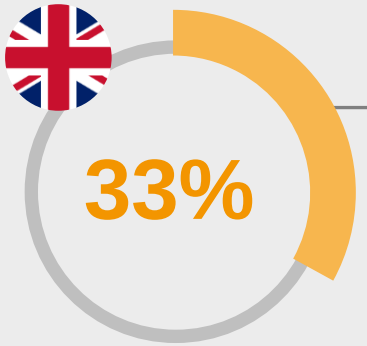
- **Enhancement of performance** provided by **waxes (Cutina® HR)** observed also in end formulation

Consumers are Changing

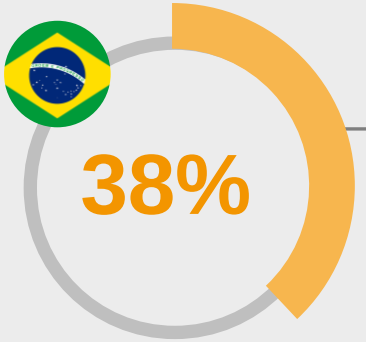
Consumers interested in more skin benefits and less environmental impact



Of Chinese sunscreen users agree that **sunscreen products should provide more skin benefits**



Sunscreen users in UK think **added skincare benefits are important when buying products**



Of Brazilian sunscreen users show **interest in buying sunscreen products that don‘t negatively impact the environmental**

Source: Mintel

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EcoSun Pass

an approach to calculate the environmental **impact of SunCare formulations**

The BASF EcoSun Pass

Considering all these parameters, more eco-compliant sunscreen formulations can be developed

The EcoSun Pass is calculated depending on:

- Quantity of UV filter used
- UV filter type used in formulation
- SPF & UVA -PF value

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Summary | conclusions

Consumers interested in sunscreens efficient and safe for human and planet health

Challenge:

Difficult to achieve high performance with limited selection of UV filters

Solution:

Use of functionalized natural-based particle providing lengthening of UV protection with SPF and UVA improvement

Selection formulation chassis and ingredients such as hydrophobic waxes, providing greater film thickness and thus higher UV protection

EcoSun Pass offers a possibility to design more eco-compliant sunscreens

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Disclaimer

The proposed formulations and the suggested uses of BASF products described in this documentation are provided for information purposes alone.

This information illustrates suggested uses and benefits provided by these BASF products in regard to the application itself and/or manufacturing, processing, handling or storage of the finished personal care products.

BASF has performed no inhalation safety assessments either on the example compositions from the example formulations, on any possible conditions of application of these formulations, or the use of any of the individual ingredients in other personal care formulations designed for similar intended and foreseeable uses.

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