SPF BOOSTER COMBINATIONS:

a strategy for achieving highly effective and sensory sun care products using microscopical, rheological and texture characterization

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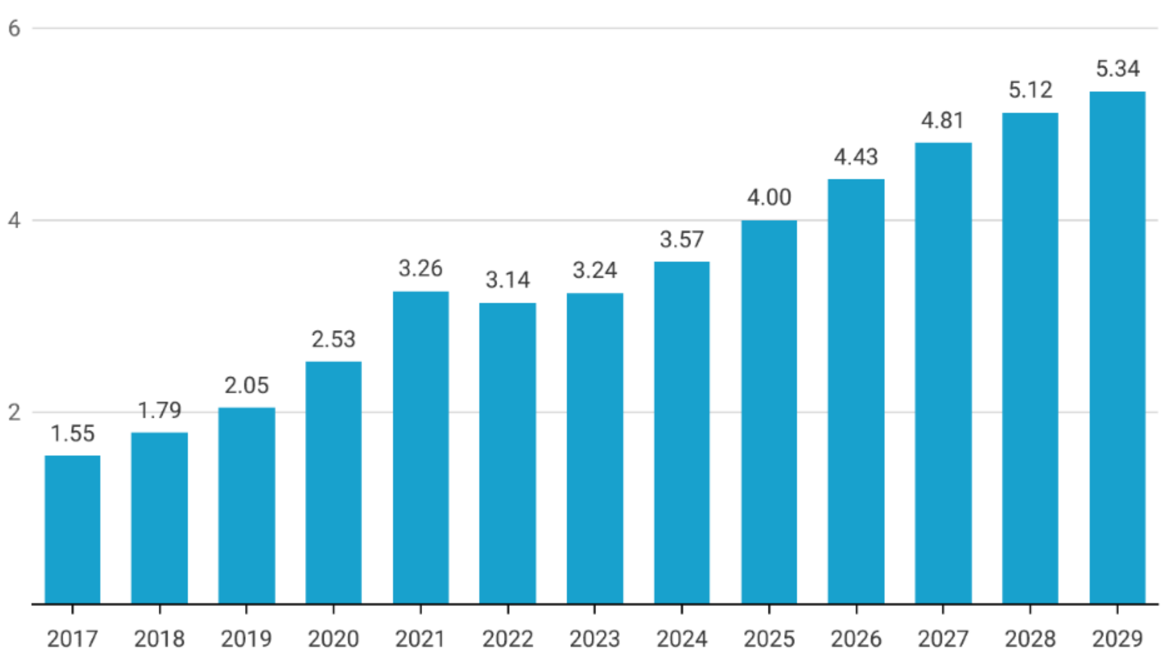
Growing global emphasis on sun protection

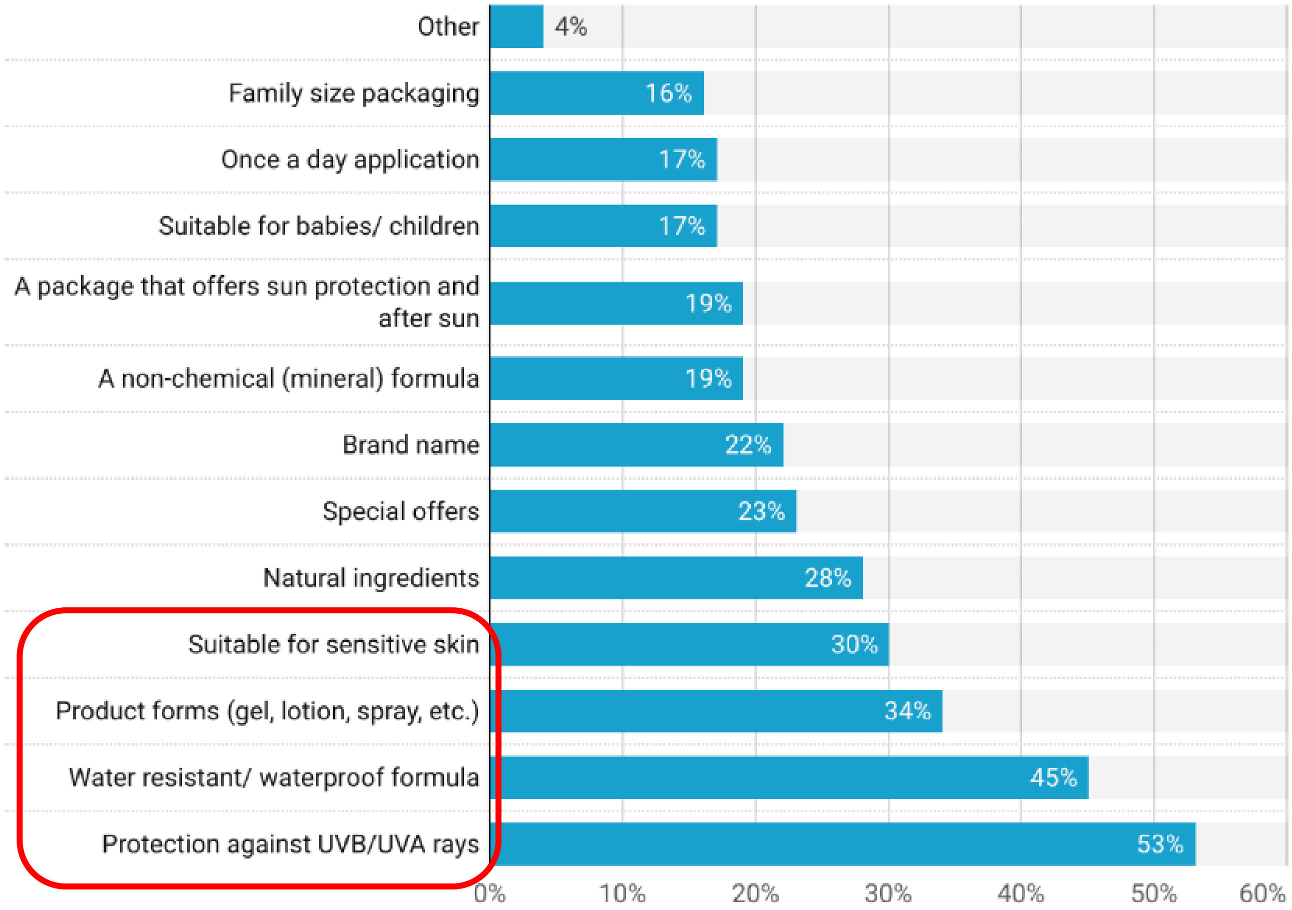
Global sun protection market size



(Size in USD billion)

Source: Market.us Media

Leading factors considered when buying sunscreens



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The ideal sunscreen

1
EFFICACY
broad-spectrum protection against UVA and UVB radiation

2
SAFETY
non-irritating and not to cause allergic reactions. Kindness to sensitive skin

3
TEXTURE
Light, fast absorbing, not greasing, dry skin after application

4
APPLICATION
Easy erogation, high spreadability, film-forming properties, water resistance

5
COSTS
Low cost-formula, budget-friendly formula

6
ENVIRONMENT
biodegradability, reduced release into aquatic environments

UV - FILTERS

High SPF require **high amounts** of UV filters → Impact on **sensory properties**

Regulatory restrictions over time → **Growing attention** about systemic exposure

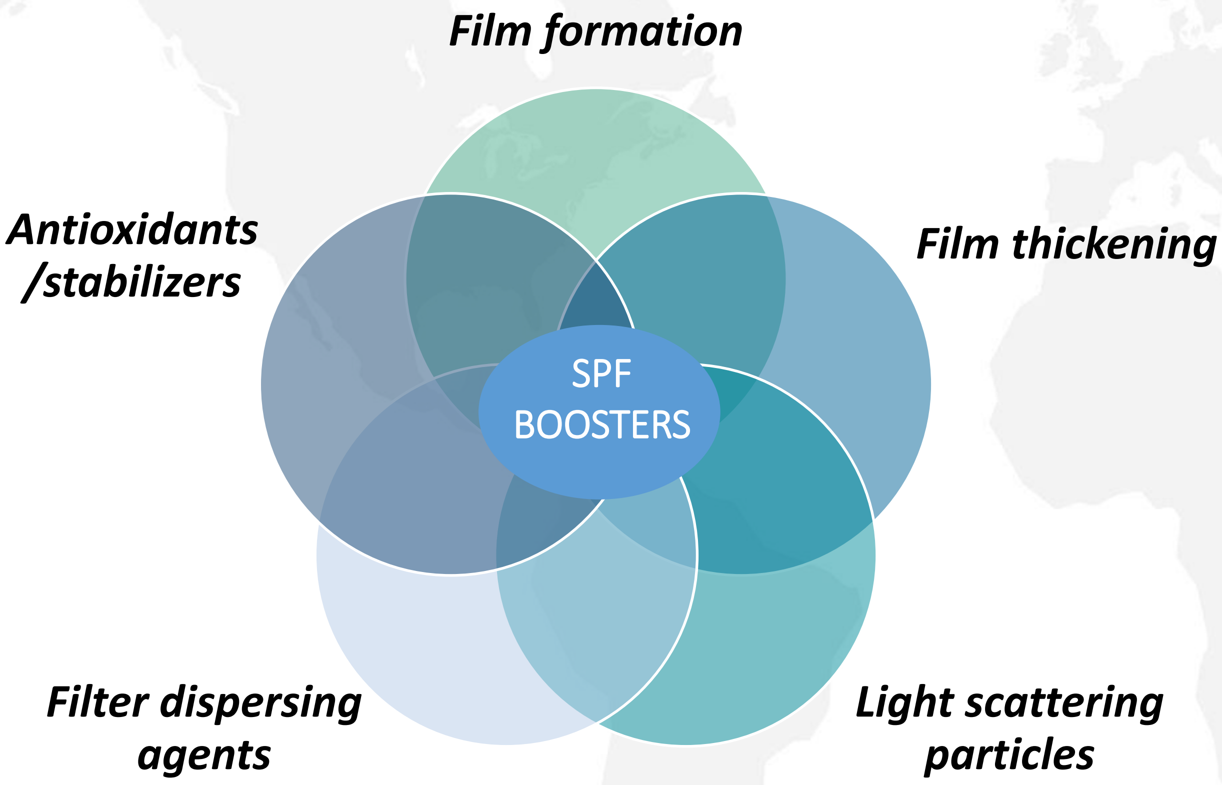
New-generation filters for better **photostability** and **performance** → **Formulation challenges** (cost, solubility and compatibility)

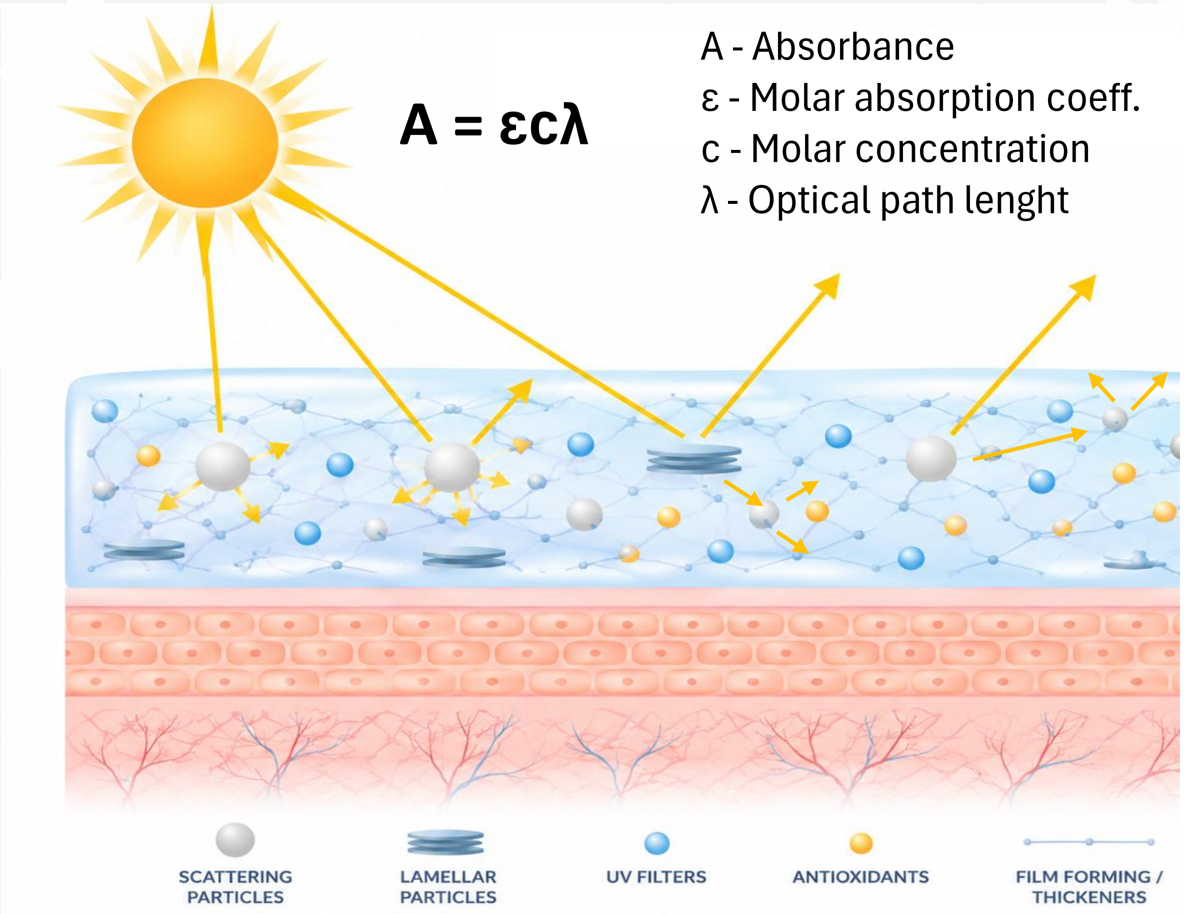
Alternative strategies for high-performance sun care

Optimizing protection, safety, sensoriality with fewer UV filters.

SPF BOOSTERS

enhance sunscreen performance through multiple mechanisms without directly acting as UV filters, allowing for a reduction in the percentage of UV filters in the formulation.





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AIM OF THE WORK

To develop a systematic protocol for selecting and combining SPF boosters while maintaining stability, morphology and sensory profile of a **light fluid O/W sunscreen formula**

	INCI	ABBR.
Hydrophilic boosters	Microcrystalline cellulose	*R*
	Cellulose/cellulose gum, 3% fibrillated cellulose in water	*V*
Lipophilic boosters	Hydrogenated castor oil, jojoba esters, tocopherol	N
	Hydrogenated palm oil, saccharum officinarum extract	*U*
	Copernicia cerifera wax, Oryza sativa wax	*H*
Solid spherical boosters	Zeolite	*Z*
	Silica	*S*
	Calcium sodium borosilicate	*C*
	Cellulose	*D*
Solid lamellar booster	Magnesium potassium fluorosilicate	*M*
Film formers	Trimethylpentanediol/Adipic acid/Glycerin crosspolymer	*W*
	Polyglyceryl-3 Stearate/Sebacate crosspolymer	*F*

Using **combinations** of SPF BOOSTERS (different mechanisms of action)

Maximize the **performance** of sun care product

NO **texture-rheology** modification

Preserved mechanical **stability**

NO impact on the **costs** of the formula

PROTOCOL

FORMULATION

B - O/W fluid emulsion

with organic and mineral filters (BASF Sunscreen Simulator calculated SPF 40)

Emulsifying system:

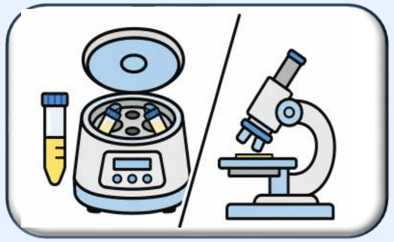
Potassium cetyl phosphate

Tribehenin PEG-20 esters

Oily phase: 18.2% w/w

Thickeners:

Polyacrylate Crosspolymer-6; Hydroxyethyl Acrylate/Sodium Acryloyldimethyl Taurate Copolymer



STABILITY ASSESSMENT

Mechanical stress test

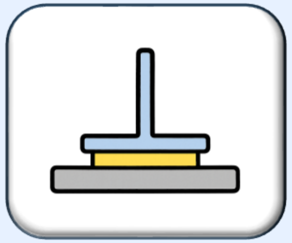
Centrifuge

4800 rpm for 30 min

Morphological analysis

optical microscopy

40X-100X magnification



RHEOLOGY

Amplitude sweep

Freq: 1Hz; Strain: 0.01-1000%

Frequency sweep

Freq. 100-0.01Hz; Strain: LVER

Combined procedure

1. Oscillatory: fixed strain and 1Hz-3’
2. Steady shear: (5000 s^{-1}/ 5’)
3. Oscillatory: fixed strain and 1Hz-30’

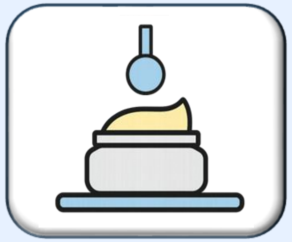
Parameters

G’ – storage modulus

G’’ – loss modulus

G* - complex modulus

Tanδ – loss factor G’’/G’



TEXTURE ANALYSIS

Immersion test

load cell: 10 N

speed: 1.3 mm/sec

probe: nylon sphere (d=2cm)

Parameters

Firmness (N)

Consistency (N.mm)

Cohesiveness (N)

Adhesiveness (N.mm)

Stringiness (mm)

SPF IN VITRO TEST

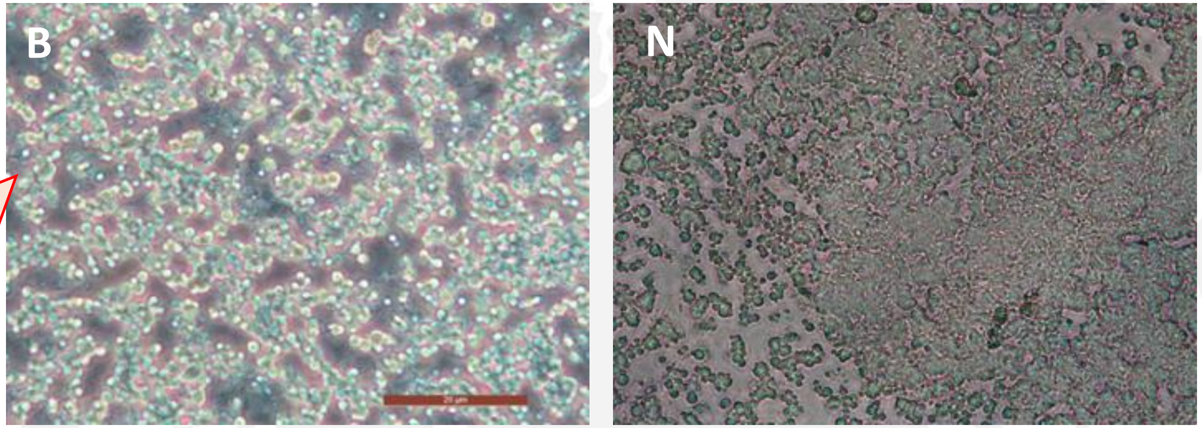
ISO 24443:2022

Performed by an external lab

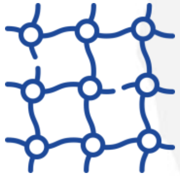
Assessment of SPF changes induced by booster combinations.

CHARACTERIZATION OF SINGLE SPF BOOSTER IN EMULSION

	CENTRIFUGE (4800RPM/30MIN)	MICROSCOPY (DROPLETS SIZE)	G* 1Hz (Pa)
B	STABLE	HOMOGENEOUS	
R	STABLE	HOMOGENEOUS	
V	STABLE	HOMOGENEOUS	
N	STABLE	INHOMOGENEOUS	
U	STABLE	HOMOGENEOUS	
H	STABLE	HOMOGENEOUS	
Z	SEPARATED	-	-
C	STABLE	HOMOGENEOUS	
S	STABLE	HOMOGENEOUS	
D	STABLE	HOMOGENEOUS	
M	STABLE	HOMOGENEOUS	
W	STABLE	HOMOGENEOUS	
F	STABLE	HOMOGENEOUS	



Optical microscopy at 100X of the base emulsion B and the emulsion containing N.



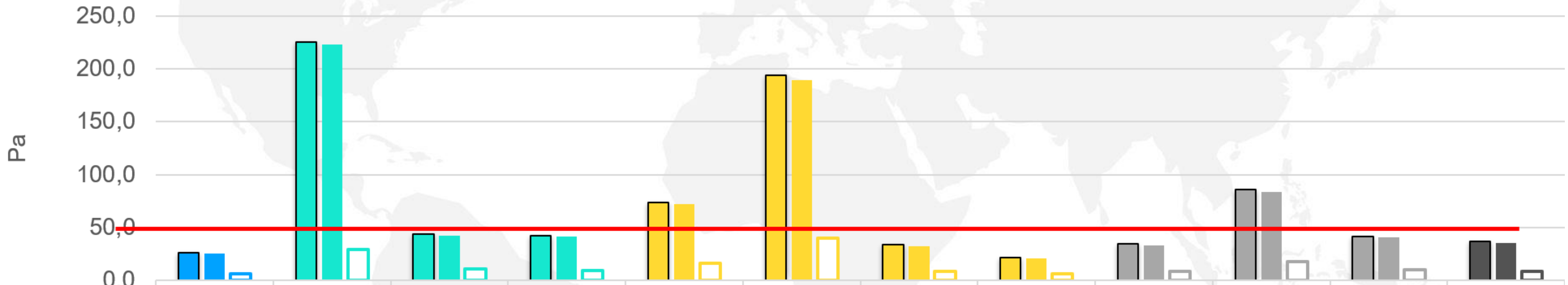
Not all SPF boosters are compatible with a fluid O/W sunscreen.

- excessive viscosity
- morphology issues
- Instability
- excessive structuring

CHARACTERIZATION OF SINGLE SPF BOOSTER IN EMULSION

A G* greater than 50Pa was considered too far from emulsion B rheological behaviour

☀ excessive structuring, heavy texture



	B	R1%	V3%	V5%	U3%	U5%	H3%	H5%	C3%	S5%	D1%	M3%
G* (Pa)	26,3	225,3	43,5	42,7	73,9	193,9	33,7	21,6	34,5	86,0	41,9	36,6
G' (Pa)	25,5	223,4	42,1	41,6	72,2	189,7	32,6	20,7	33,3	84,1	40,6	35,5
G'' (Pa)	6,7	29,6	10,8	9,7	16,1	39,9	8,3	6,3	8,9	18,1	10,3	9,0

Values of G, G' and G'' at 1Hz of the boosters added in the base emulsion B.*

SPF BOOSTER COMBINATIONS AND CHARACTERIZATION

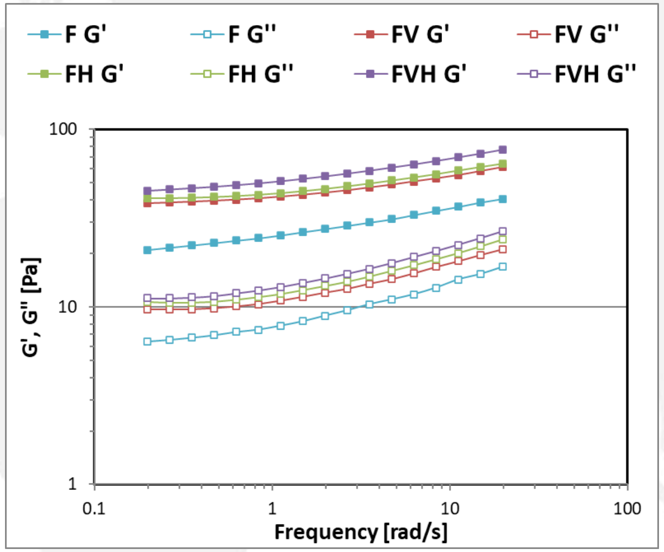
☀ *Film former* + *Lipophilic* + *Hydrophilic Boosters*

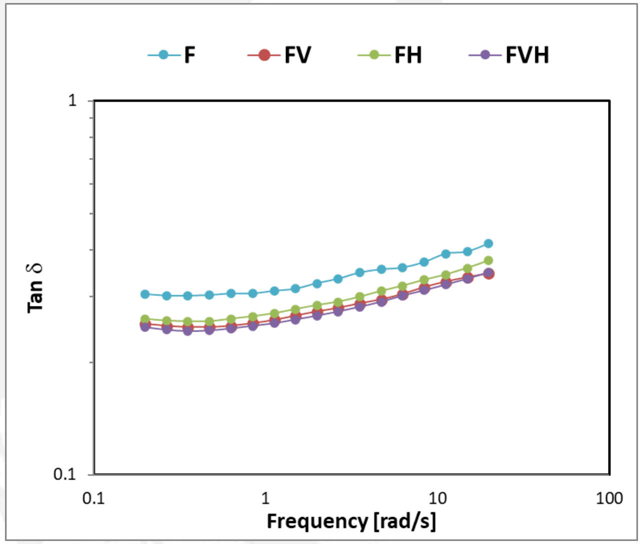
	F	FV	FH	FVH
% F	1	1	1	1
% H			1	1
% V		2		2

Polyglyceryl 3-stearate/ sebacate copolymer

Copernicia cerifera wax, oryza sativa wax

Cellulose gum





Trend of G' and G'' and tanδ in function of oscillation frequency for samples F, FV, FH, FVH.

☀ ↑ of emulsion viscoelastic properties (acceptable)

☀ Increase of elasticity (↓tanδ)

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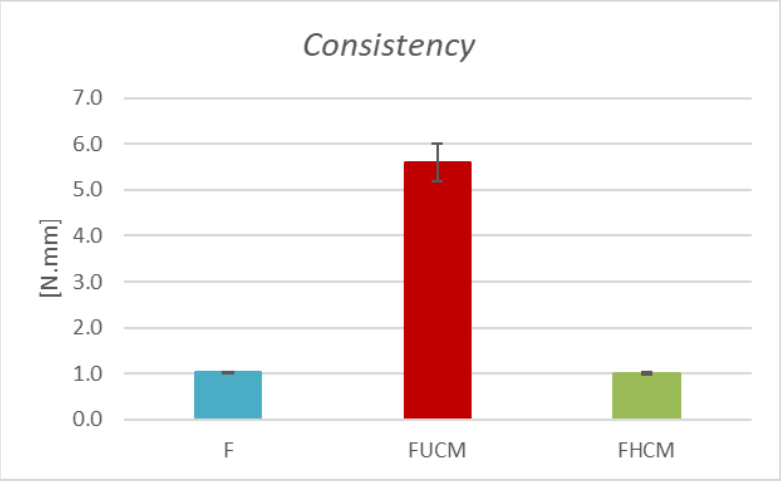
SPF BOOSTER COMBINATIONS AND CHARACTERIZATION

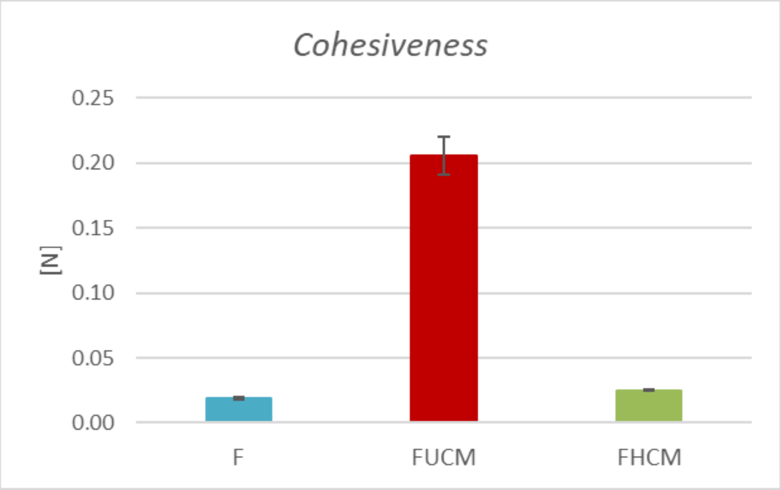
☀ *Film former* + *Lipophilic booster* + *Mineral particles (spherical and plane)*

	F	FUCM	FHCM	
% F	1	1	1	*Polyglyceryl 3-stearate/ sebacate copolymer*
% U		2		*Hydrogenated castor oil, saccharum officinarum extractc*
% H			1	*Copernicia cerifera wax, oryza sativa wax*
% C		3	3	*Calcium sodium borosilicate*
% M		0.5	0.5	*Magnesium potassium fluorosilicate*

☀ FUCM shows a significant increase in consistency and cohesiveness over time

incompatibility between U and the particle system





Texture parameters consistency and cohesiveness of samples F, FUCM, FHCM.

SPF BOOSTER COMBINATIONS AND CHARACTERIZATION

☀ *Film former* + *Lipophilic* + *Hydrophilic Boosters* + *Mineral particles*

	F	FVHC	FVHCM	FVHD	FVHDM
% F	1	1	1	1	1
% H		1	1	1	1
% V		2	2	2	2
% D				1.5	1
% C		1.5	1		
% M			0.5		0.5

Polyglyceryl 3-stearate/ sebacate copolymer

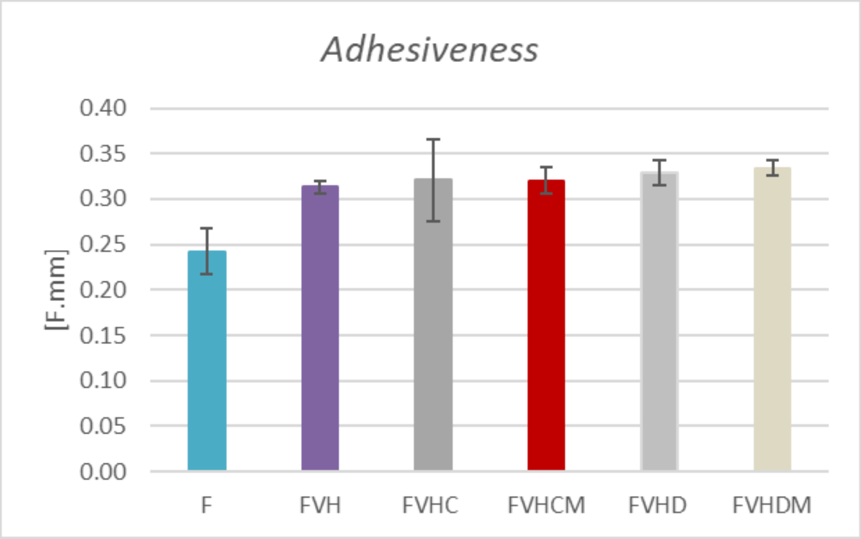
Copernicia cerifera wax, oryza sativa wax

Cellulose gum

Cellulose

Calcium sodium borosilicate

Magnesium potassium fluorosilicate



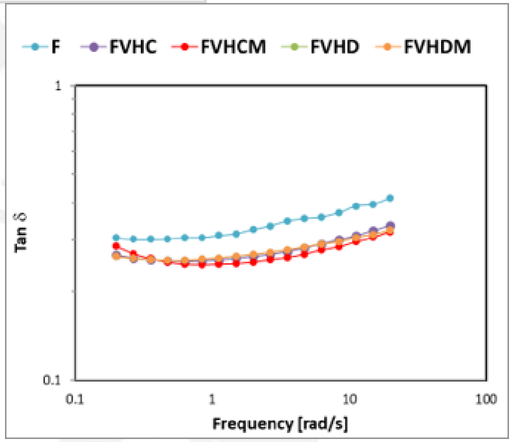
☀ ↑ adhesiveness

☀ ↑ **elasticity**

For all booster combinations

Solid particles have no significant impact on the emulsion texture properties

Adhesiveness and tanδ values for samples F, FVH, FVHC, FVHCM, FVHD and FVHDM.



SPF BOOSTER COMBINATIONS AND CHARACTERIZATION

☀ *Film former + Lipophilic + Hydrophilic Boosters + Mineral particles*

	F	FVHC	FVHCM	FVHD	FVHDM
% F	1	1	1	1	1
% H		1	1	1	1
% V		2	2	2	2
% D				1.5	1
% C		1.5	1		
% M			0.5		0.5

Polyglyceryl 3-stearate/ sebacate copolymer

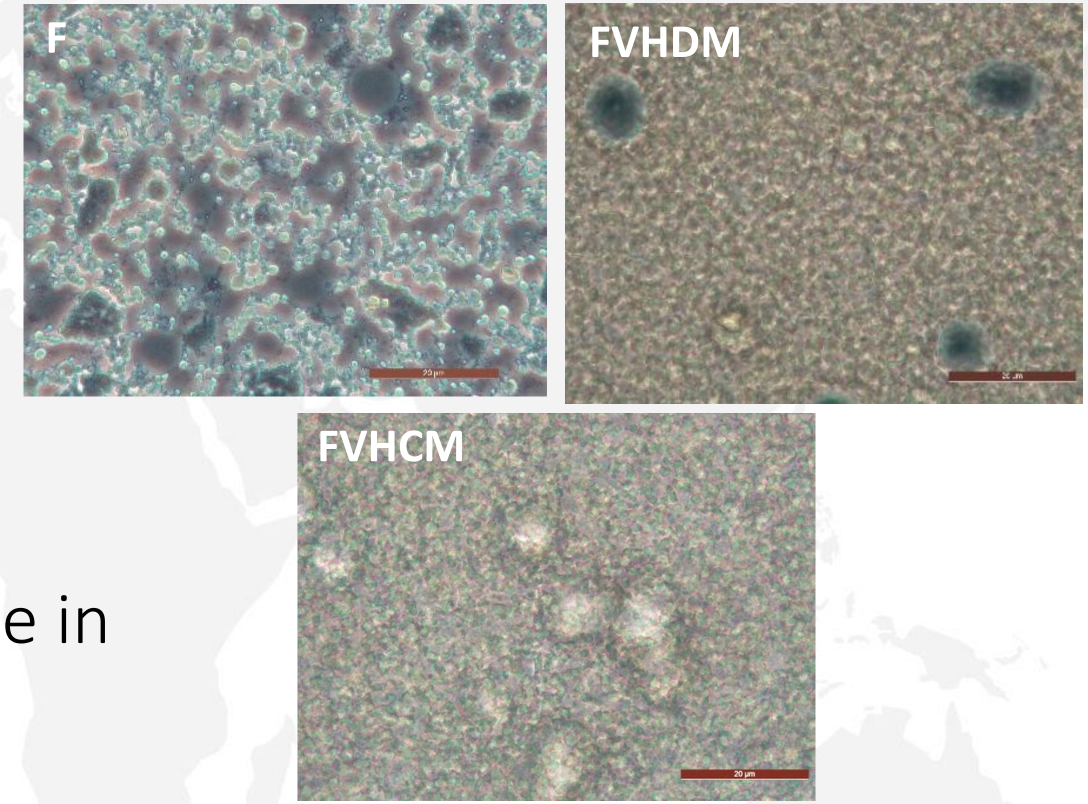
Copernicia cerifera wax, oryza sativa wax

Cellulose gum

Cellulose

Calcium sodium borosilicate

Magnesium potassium fluorosilicate



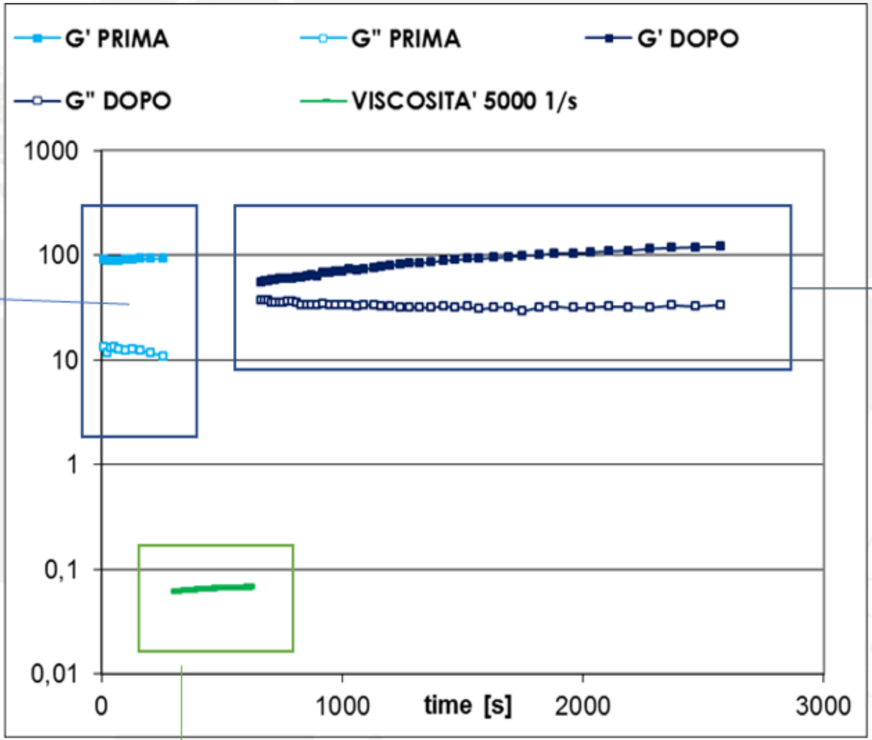
Optical microscopy at 100X of sample FVH, FVHDM and FVHCM.

☀ spherical solid particles clearly visible in the emulsion: smaller droplets

EVALUATION OF APPLICATION PROPERTIES

RHEOLOGICAL ANALYSIS IN FUNCTION OF TIME
sequence of steps in continuous and oscillatory motion

STEP 1 - BEFORE APPLICATION:
Oscillation at Constant Amplitude and Frequency

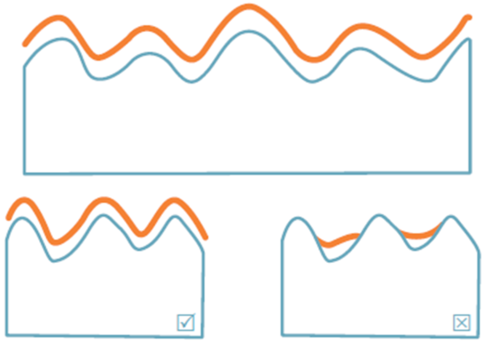


STEP 3 - AFTER APPLICATION:
Oscillation at Constant Amplitude and Frequency

STEP 2 - APPLICATION:
Constant Shear Rate
(5000 s^{-1} x 5 min)

DURING APPLICATION

AFTER APPLICATION

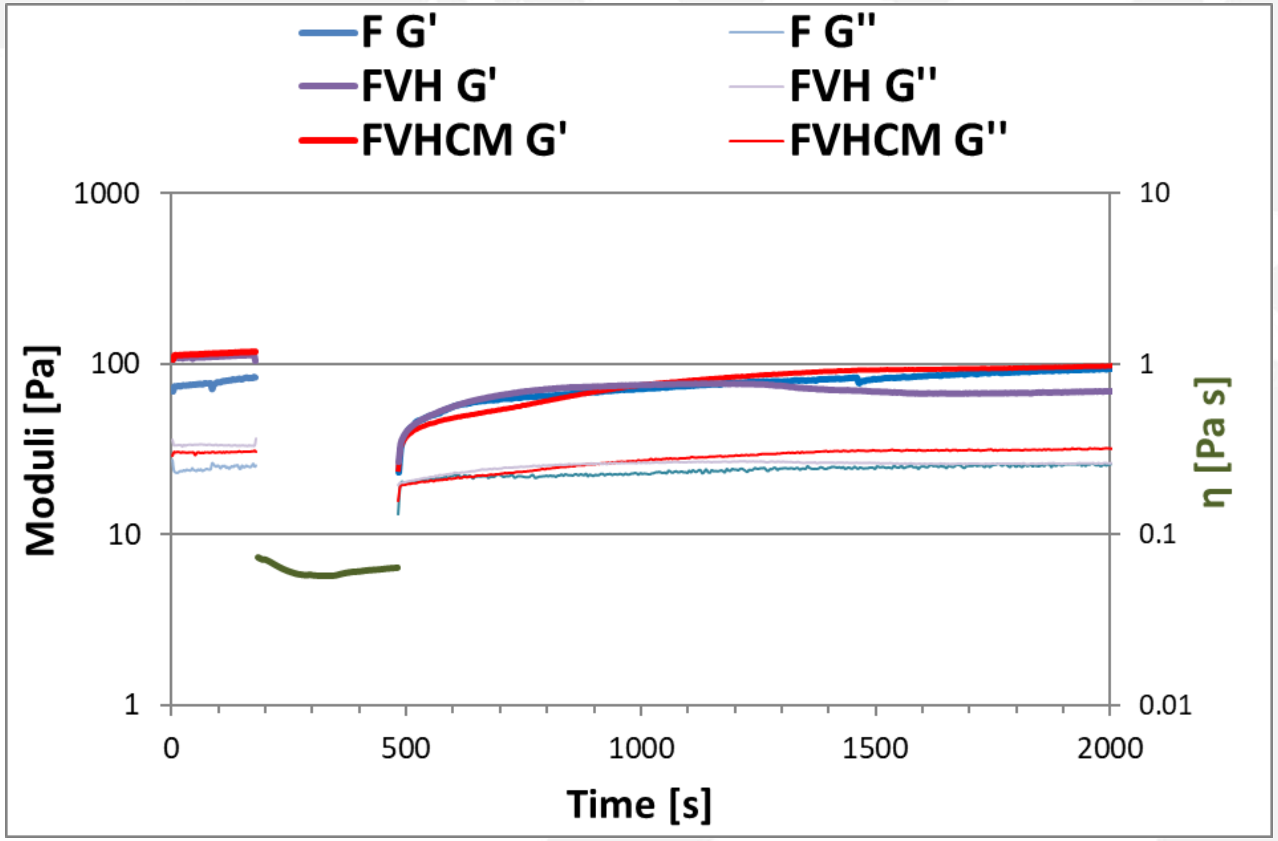


Homogeneous distribution

Inhomogeneous distribution

EVALUATION OF APPLICATION PROPERTIES

☀ *Film former* + *Lipophilic* + *Hydrophilic Boosters + Mineral particles*

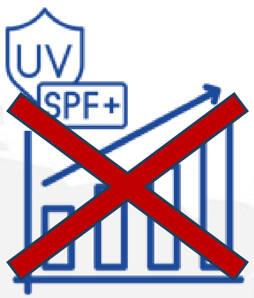


Trend of G' and G'' of F, FVH, and FVHCM before and after a constant shear rate of 5000 s^{-1} for 5 minutes.

Despite the rheological strengthening induced by SPF boosters,

no improvement in structural recovery was observed compared to the base formulation.

SPF EVALUATION



☀ *Film former + Lipophilic + Hydrophilic Boosters + Mineral particles*

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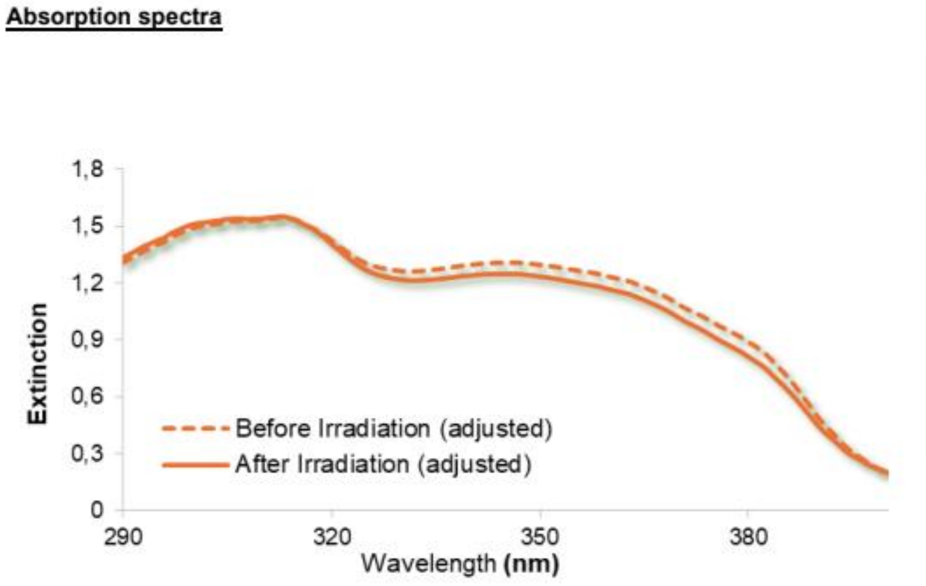
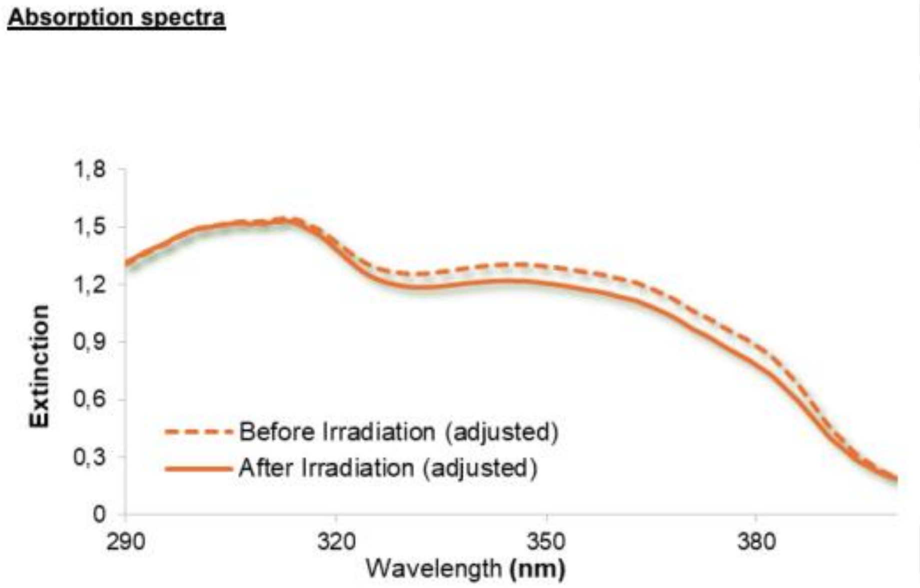
F



FVHCM



the in-vitro SPF test revealed that no significant increase in the overall SPF occurred between the analyzed formulations.

CONCLUSIONS

APPROACH

MICROSCOPY – RHEOLOGY - TEXTURE ANALYSIS

are effective screening tools for raw materials and formulations

FINDINGS

Stable, compatible and sensory-friendly booster combinations identified

→**FVHCM**

OUTCOME

For **highly fluid spray** emulsions, ↑ SPF require **formulation changes** affecting rheology, texture and sensoriality

LIMITATIONS

High booster levels may often compromise fluidity, sensory properties and costs

Thanks for your attention!

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