advanced sun protection

with Titanium Dioxides and Functional Fillers

Pigments & Functional Materials (PM-PFC-RT)
June 2017

MERCK

Agenda

1 **Introduction**

- 2.1 Effects of **visible light/ HEV** on skin
- 2.2 Performance of titanium dioxides in the HEV light range
- 2.3 Performance of functional fillers in the HEV light range

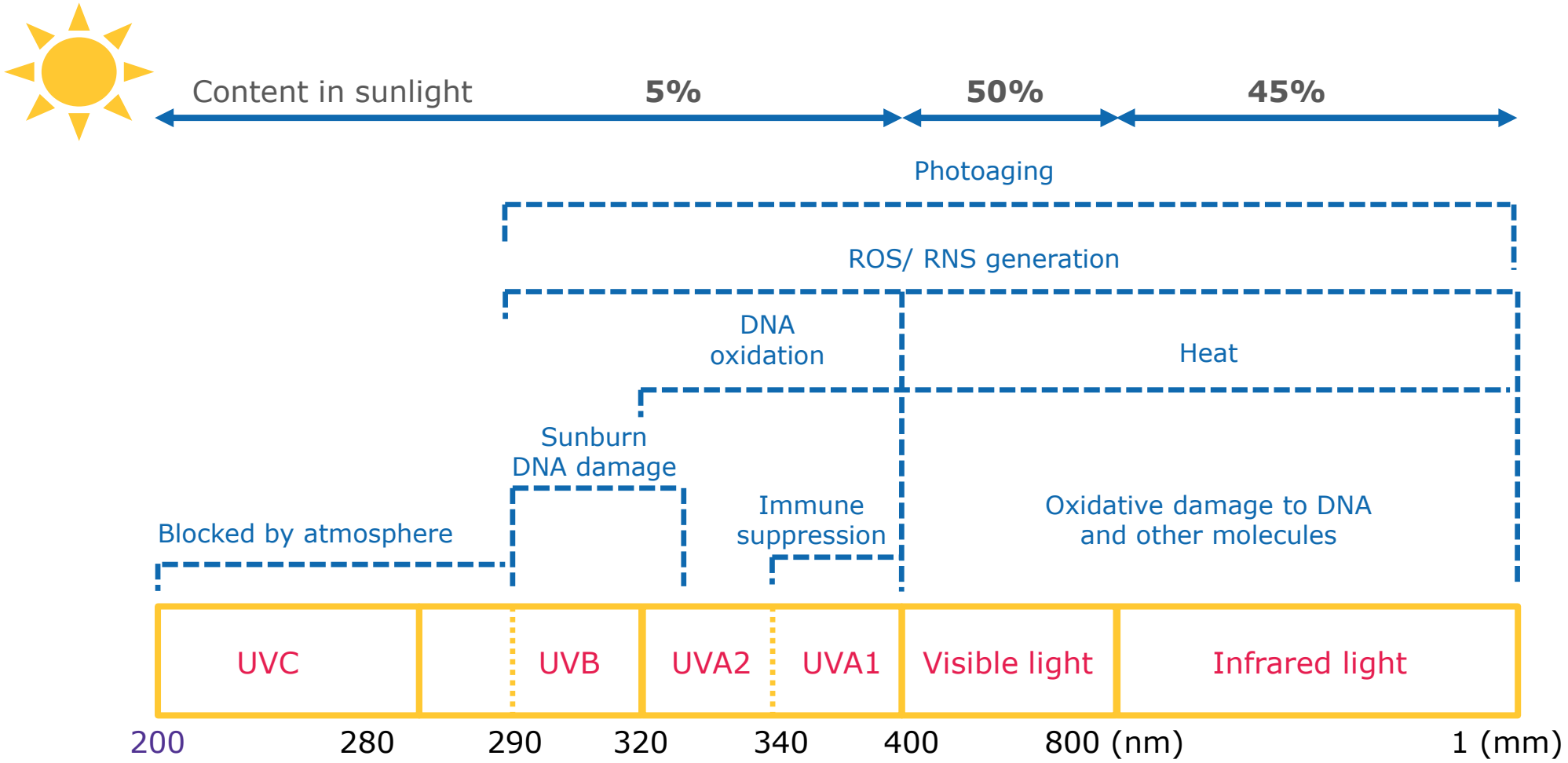
- 3.1 Effects of **near infrared light** on skin
- 3.2 Performance of titanium dioxides in the near- infrared light range
- 3.3 Performance of functional fillers in the near-infrared light range

4 **Conclusion**

5 **Appendix: References/ Test Materials**

01 introduction

Solar radiation spectrum
Impact on skin



Source [1]: Int. Journal Cos. Science 2013, 35, 224-232

Solar radiation spectrum
Impact on skin layers

Ultraviolet light (100-400 nm)

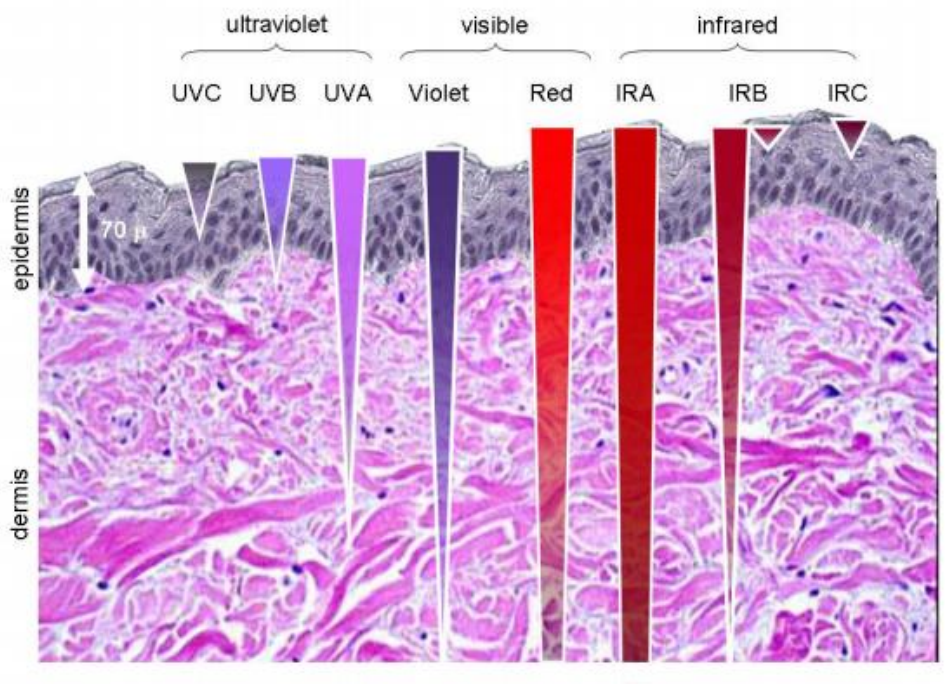
- UVC (100-280 nm) absorbed by ozone in the atmosphere
- **UVB** (280-320 nm) absorbed by epidermis and keratinocyte DNA
- **UVA** (320-400 nm) penetration to dermis

Visible light (400-800 nm) penetration to dermis

- **Blue/violet light or HEV** (400-500 nm)

Infrared light

- **IR-A** (800-1450 nm) penetration to dermis
- IR-B (1450-3000 nm) absorbed by epidermis
- IR-C (3000 nm- 1 mm) absorbed by epidermis



Source [13] : SCENIHR, Health Effects of Artificial Light, 2012

Market trend (Mintel Database)

Cream Gel, SPF 40, Thailand

- UVB/ UVA/ **HEV**
- Formulated with HEV shield
- org. UV filters, TiO_2, extracts

Sun Cream SPF 50, Spain

- UVB/ UVA/ **HEV**
- org. UV filters, TiO_2, extracts and antioxidants

UV sunscreen, SPF 40, Japan

- UVB/UVA/ **blue/ far- infrared**
- Enriched with 5 ceramides
- org. UV filters, extracts

Dry Touch Gel, SPF 50+, Argentina

- UVB/ UVA/ **IR**
- enriched with XL-Protect
- org. UV filter and TiO_2

Energizing Protective Milk, SPF 30, France

- UVB/ UVA/ **VIS/ IR**
- Fractionated **melanin absorbing VIS and reducing free radicals**

Invisible Face Gel, SPF 30, Netherlands

- UVB/ UVA/ **VIS/ IR** + tan
- org. UV filters, AO and extracts

MINTEL | GNPD

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UV, VIS and IR protection

Second defense line:
Extracts and antioxidants only catch the free radicals already formed due to over exposure to UV, HEV (blue light) and IR-A light. It’s a responsive action.

First defense line:
To prevent the skin from harmful damage due to over exposure, absorption, scattering, reflection in UV as well as in HEV (blue light) and IR-A light should be the first choice.
A combination of both would be perfect.

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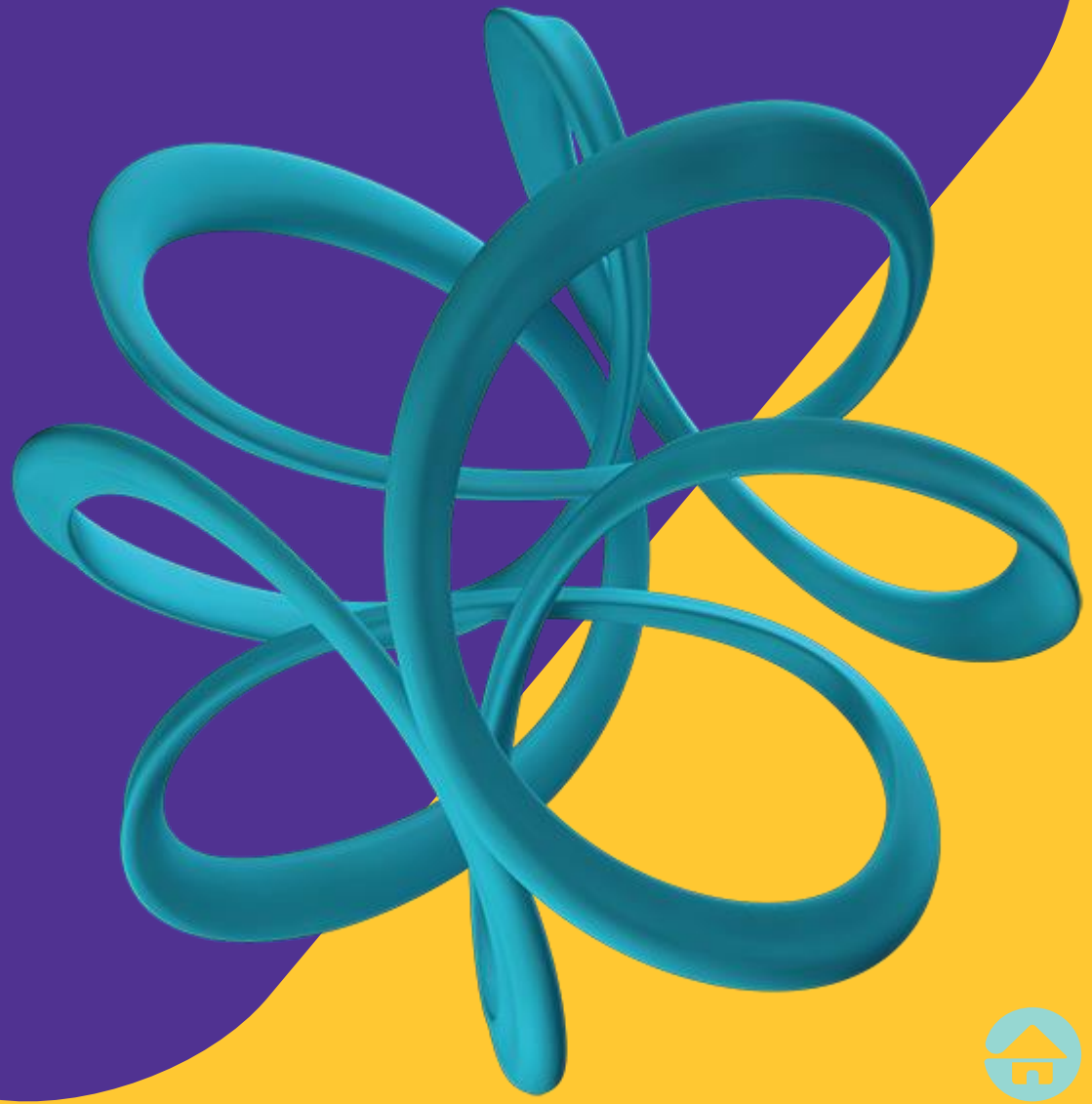
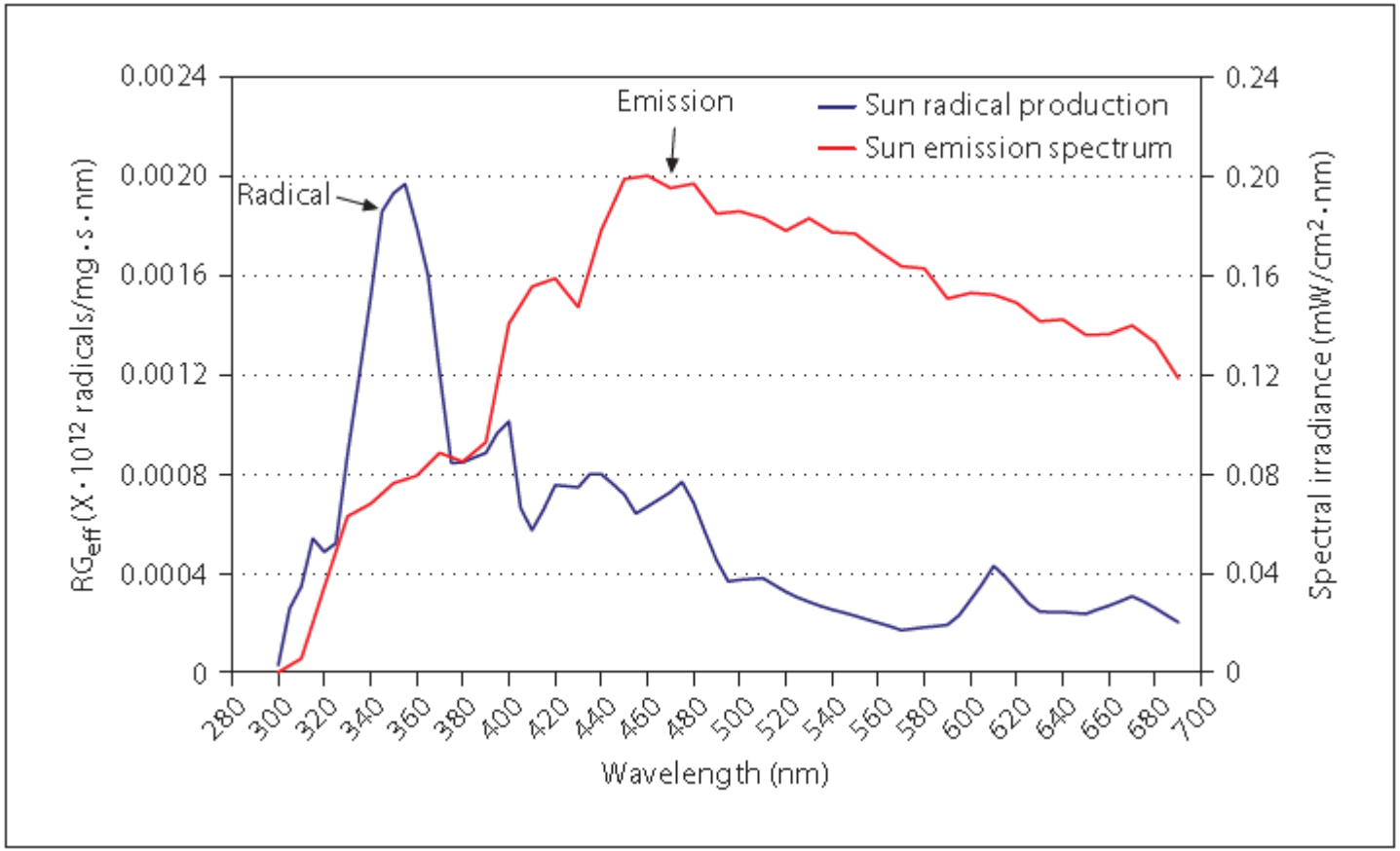
02 visible light (VIS)/ high energy visible light (HEV)

2.1 Effects of VIS / HEV light on skin



Effect of visible light/ HEV on skin
Radical formation by sun



Source [15] : Skin Pharmcol Physiol, 2009, 22: 31-44

Radical formation in human skin – *ex vivo,* determination by ESR in the range 300 – 700 nm

- **50% of radicals formed in the UVA range and approx. 50% in visible light.**
- **~ 35% in the region of high energy visible light (HEV)**

Effect of visible light/ HEV on skin
Overexposure

Harmful effects on skin

Effects [6,10]

- Production of ROS, pro-inflammatory cytokines, MMP-1 and (MMP)-9 expression
- Decreased type 1 procollagen expression
- Depressed immunity and suppressed healing

Signs of premature aging

- Wrinkles
- Sagging skin
- Increased dryness
- Inflammation and redness
- Hyperpigmentation at 415 nm [3]

Effect of visible light/ HEV on skin
Sources of high energy visible light (HEV)

1

white daylight

2

lights sources

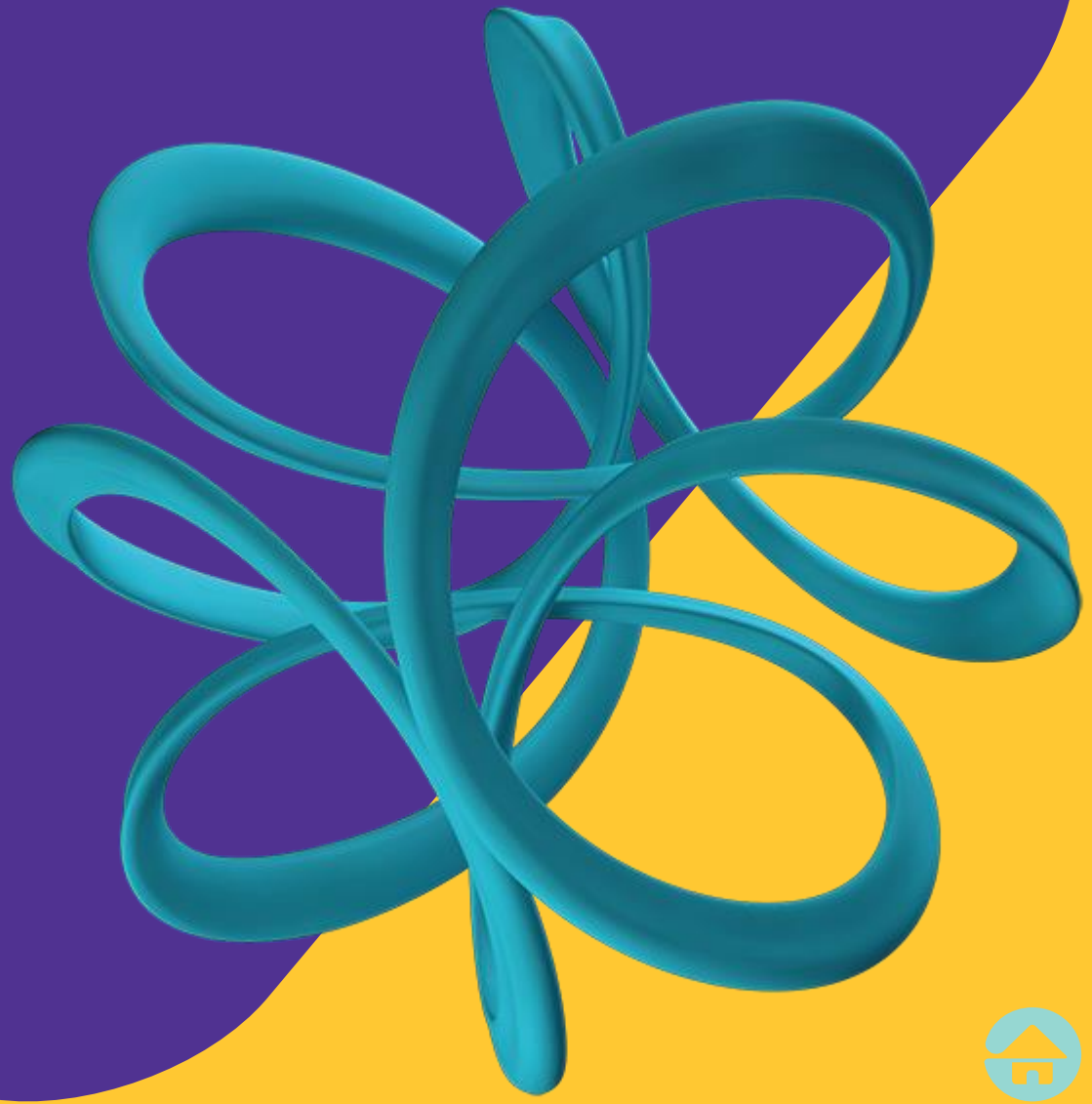
Replacement of traditional light bulbs by LEDs, electronic devices

3

reflective surfaces

like snow, concrete, sand, water, glass

2.2 performance of TiO_2 in VIS/ HEV range



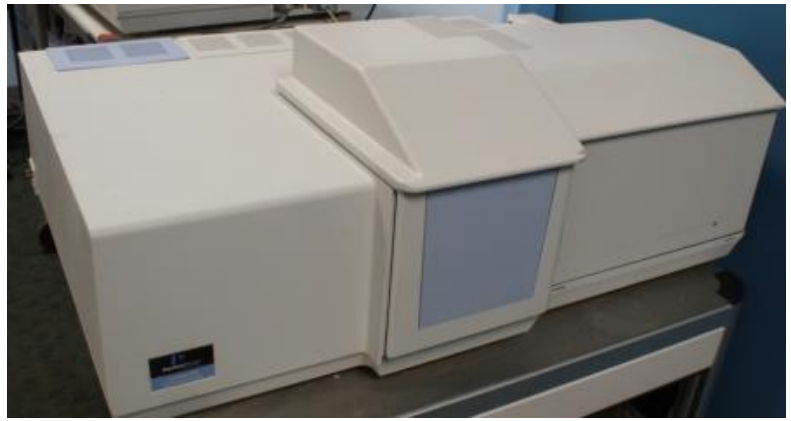
Performance of TiO_2 in visible light/ HEV range
Test Design

products Placebo emulsions: (I) o/w, (II) w/si and (III) gel

Test emulsions (I), (II), (III) with **Titanium Dioxide (5 - 25 %)**

Method Photometric measurements of the transmission T (%) with Perkin Elmer Lambda 900 in short cut cuvettes:

- Defined film thickness of 0.1 mm
- Wavelength: **VIS: 400 – 800 nm**
  HEV: 400 – 500 nm



Read out Protection (%)= [1- $T_{(\text{emulsion with } TiO_2)}$/ $T_{(\text{base emulsion})}$] x 100

(I) O/W test formulation

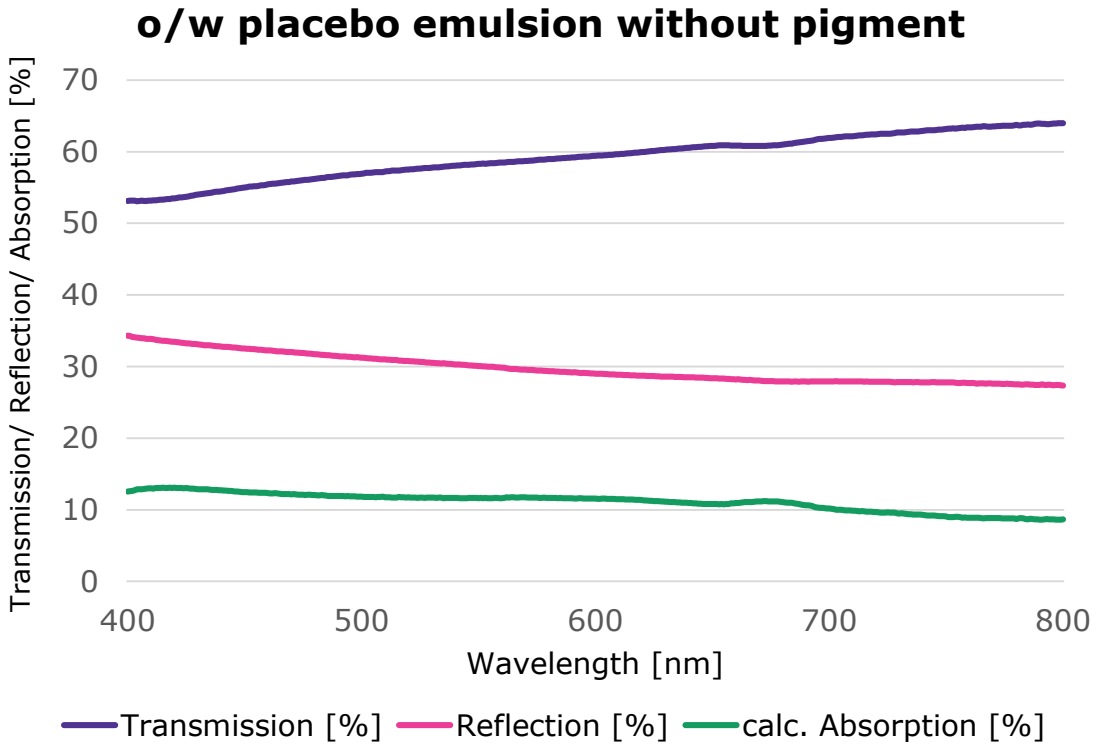
MDA-S-134-x
Sun protection lotion with Titanium dioxide

Ingredients	Art. No.	INCI (EU)	[%]
A			
Titanium dioxide			**3 - 25 %**
RonaCare® AP	1.30163 (1)	BIS-ETHYLHEXYL HYDROXYDIMETHOXY BENZYLMALONATE	2.00
Montanov 202	(2)	ARACHIDYL ALCOHOL, BEHENYL ALCOHOL, ARACHIDYL GLUCOSIDE	3.50
Montanov 14	(2)	MYRISTYL ALCOHOL, MYRISTYL GLUCOSIDE	1.50
Cetiol AB	(3)	C12-15 ALKYL BENZOATE	6.00
Massocare® HD	(4)	ISOHEXADECANE	4.00
Miglyol 812 N	(5)	CAPRYLIC/CAPRIC TRIGLYCERIDE	10.00
B			
Glycerol 85%	1.04091 (1)	GLYCERIN, AQUA	4.00
Keltrol® CG-RD	(6)	XANTHAN GUM	0.80
Water, demineralized		AQUA	ad 100
C			
Preservatives			q.s.

Procedure:
Heat up phase A (without Eusolex® T-PRO) to 75°C-80°C. Disperse Eusolex® T-PRO in phase A and heat up to 75°C-80°C. Pre-dissolve Keltrol CG-RD in phase B and heat up to 75°C - 80°C. Add phase A to B while stirring. Homogenize. Below 40°C add phase C.

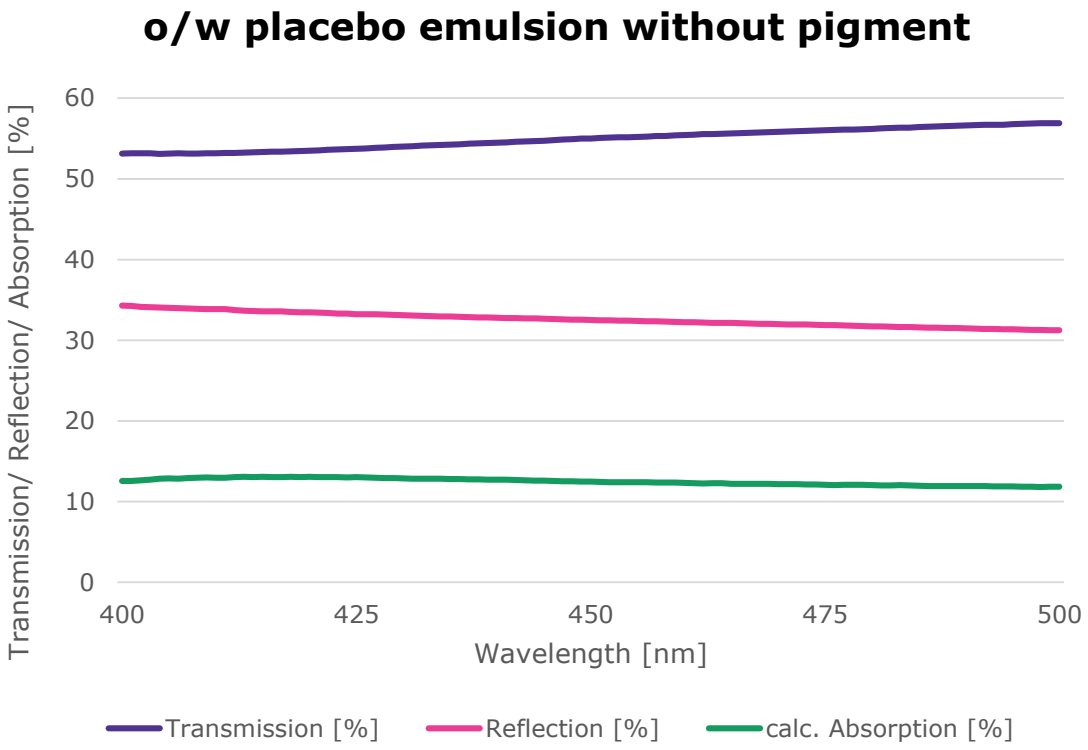
(I) Transmission/ Reflection/ Absorption in o/w emulsion

Visible light protection



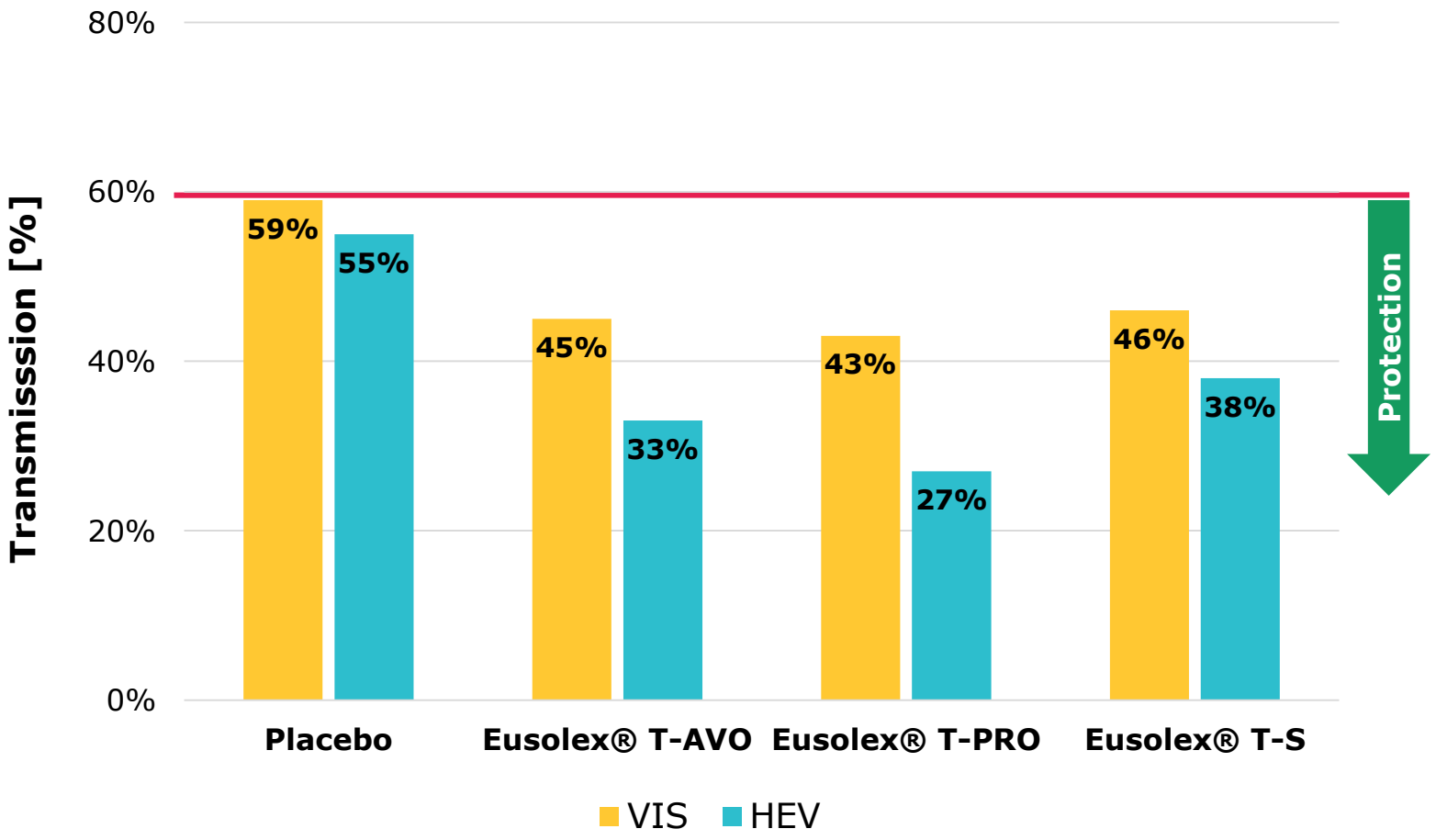
~ 60% Transmission
~ 30% Reflection (including Scattering)
~ 12% calculated Absorption

HEV protection



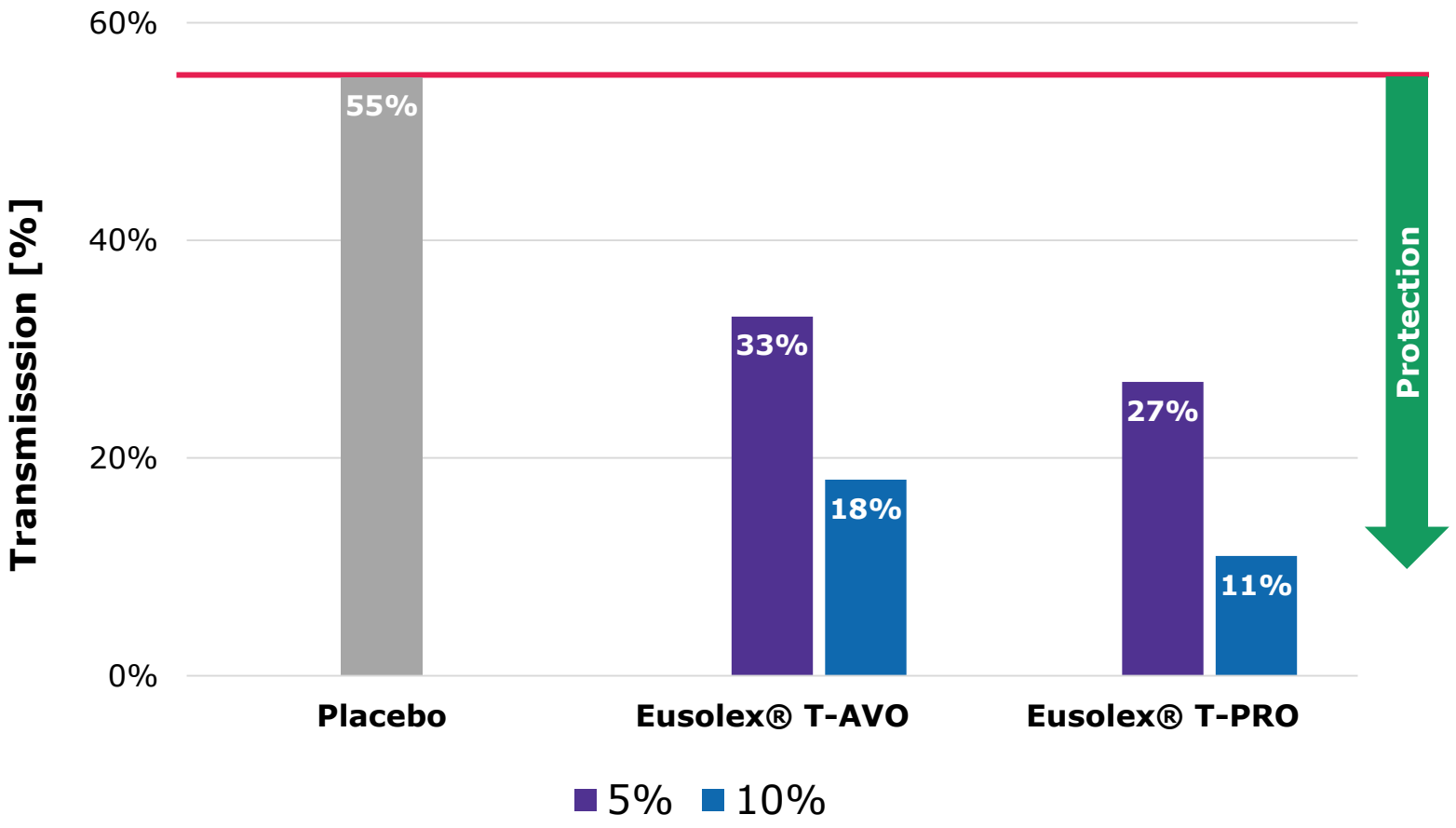
~ 55% Transmission
~ 32% Reflection (including Scattering)
~ 12% calculated Absorption

VIS protection vs. HEV protection
(I) Performance of 5% Titanium Dioxide in o/w formulation



- In this o/w emulsion system, good protection against VIS and same ranking in HEV light can be achieved with **5% Titanium Dioxide UV filters –**
  in HEV, up to 50% protection with Eusolex® T-PRO vs. basis emulsion

HEV protection
(I) Performance of 5-10% Titanium Dioxide in o/w formulation



- Increased HEV protection can be achieved with increased concentrations of **Eusolex® T-AVO and Eusolex® T-PRO – up to 80%** vs. basis emulsion

(II) W/Si test formulation

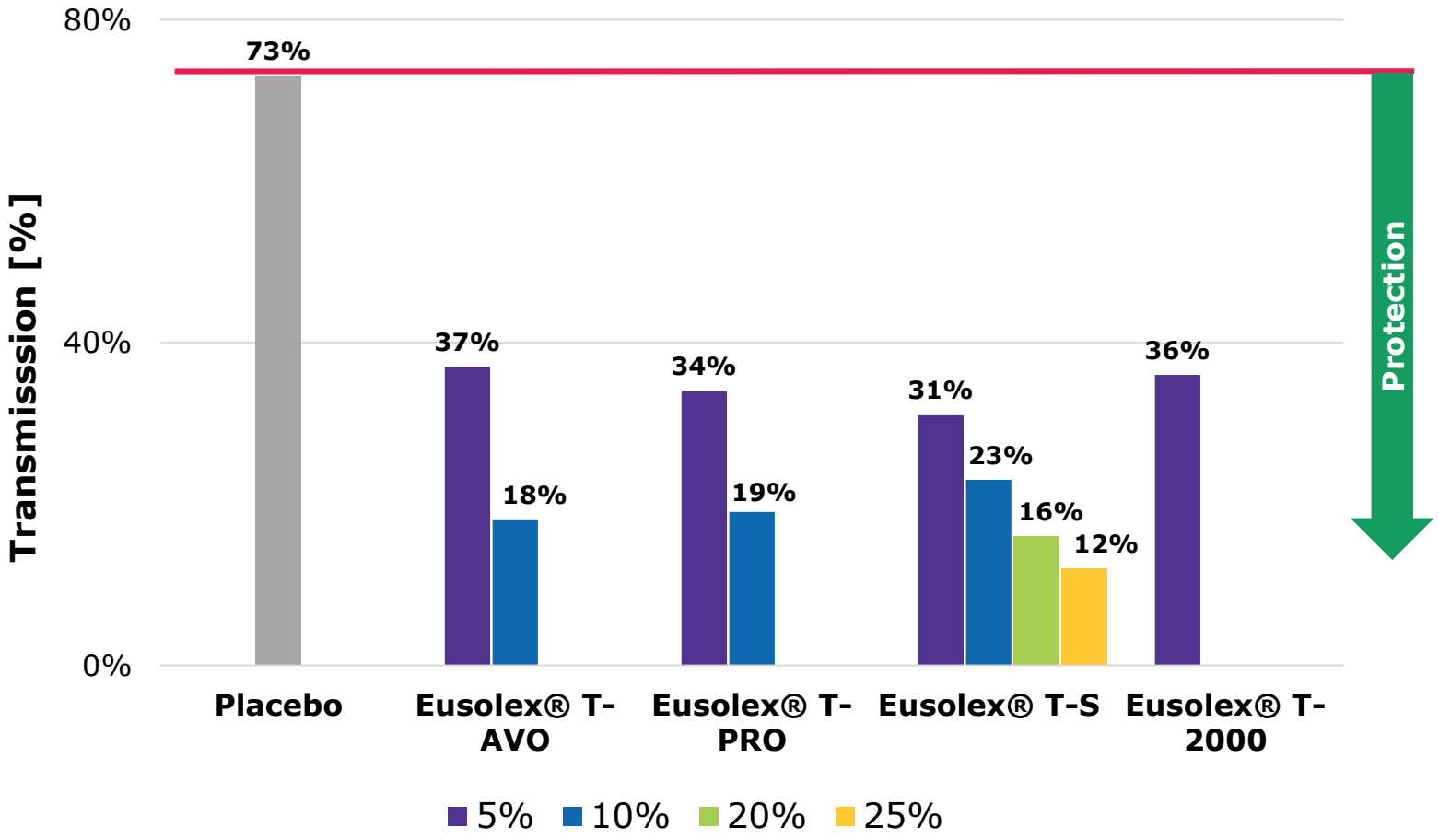
SU-11-x
Sun protection milk
with Titanium dioxide

Ingredients	Art. No.		INCI (EU)	[%]
A				
KSG-210		(1)	DIMETHICONE, DIMETHICONE PEG-10/15 CROSSPOLYMER	3.00
KSG-15		(1)	CYCLOPENTASILOXANE, DIMETHICONE/VINYL DIMETHICONE CROSSPOLYMER	2.00
KF96-A-6cs		(2)	DIMETHICONE	5.00
KF-995		(1)	CYCLOPENTASILOXANE	5.00
KF-6028		(1)	PEG-9 POLYDIMETHYLSILOXYETHYL DIMETHICONE	1.00
Crodamol TN		(3)	ISOTRIDECYL ISONONANOATE	4.00
B				
Titaniumd dioxide				**3-25**
Lanol 99		(5)	ISONONYL ISONONANOATE	15.00
Xiameter® PMX-0345		(6)	CYCLOPENTASILOXANE, CYCLOHEXASILOXANE	15.00
Abil Wax 9801		(7)	CETYL DIMETHICONE	6.00
C				
RonaCare® Sodium Chloride	1.32260	(4)	SODIUM CHLORIDE	1.00
tri-Sodium Citrate-Dihydrate	1.06446	(4)	SODIUM CITRATE	0.20
1,2-Propanediol	1.07478	(4)	PROPYLENE GLYCOL	2.00
Water, demineralized			AQUA	ad 100

Procedure:
Combine ingredients of phase A with mixing.
Combine ingredients ob phase C with mixing.

Premix phase B with high agitation and homogenize.
Add phase B to phase A while gentle stirring. Homogenize again.
Add phase C to phase A/B slowly while stirring and homogenize.
Cool down to room temperature whilst stirring.

HEV protection
(II) Performance of Titanium Dioxide in w/si formulation



- **TiO_2 UV filters** could reduce HEV transmission **up to 85%** compared to the placebo emulsion.
- Performance dependent on use level, coating/ surface treatment of TiO_2

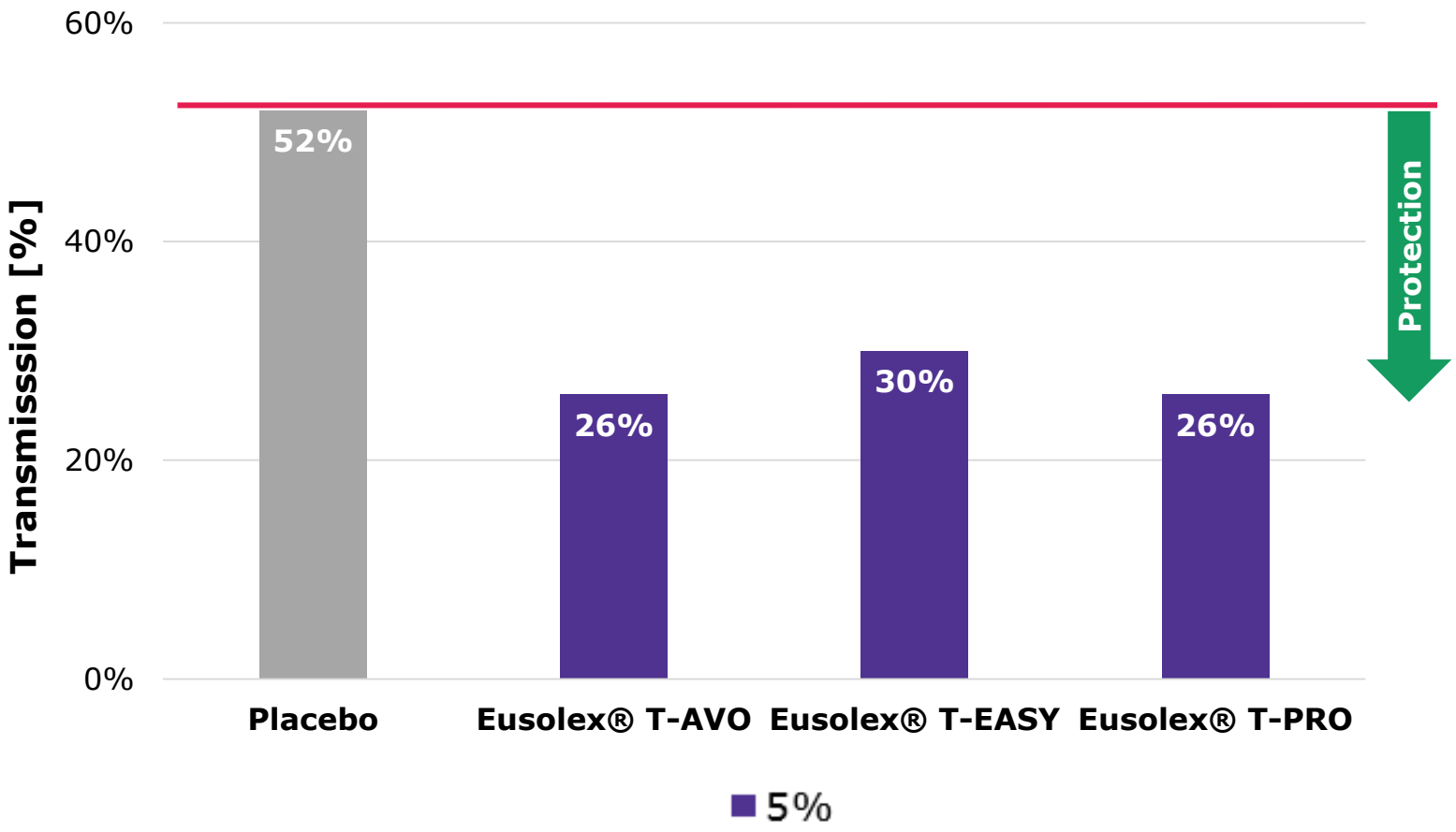
(III) Gel test formulation

MDA-S-135-x
Sun Protection Gel
with Titanium dioxide

Ingredients	Art. No.	INCI (EU)	[%]
A1			
Eusolex® OCR	1.05377 (1)	OCTOCRYLENE	10.00
Eusolex® OS	1.06949 (1)	ETHYLHEXYL SALICYLATE	5.00
Eusolex® 9020	1.05844 (1)	BUTYL METHOXYDIBENZOYLMETHANE	5.00
RonaCare® AP	1.30163 (1)	BIS-ETHYLHEXYL HYDROXYDIMETHOXY BENZYLMALONATE	1.00
Antaron V-216	(2)	PVP/HEXADECENE COPOLYMER	1.00
Cetiol CC	(3)	DICAPRYLYL CARBONATE	6.00
Abil Wax 2434	(4)	STEAROXY DIMETHICONE	1.20
Xiameter® PMX-0345	(5)	CYCLOPENTASILOXANE, CYCLOHEXASILOXANE	3.00
A2			
Titanium dioxide			**5%**
B1			
RonaCare® Ectoin	1.30200 (1)	ECTOIN	0.30
RonaCare® Disodium EDTA	1.32221 (1)	DISODIUM EDTA	0.10
Glycerol 85%	1.04091 (1)	GLYCERIN, AQUA	3.00
Water, demineralized		AQUA	54.50
B2			
Carbopol® Aqua SF-1 OS Polymer	(6)	ACRYLATES COPOLYMER	3.00
B3			
Sodium Hydroxide, 10%	1.05588 (1)	AQUA, SODIUM HYDROXIDE	0.90
C			
Ethanol 96%	1.00971 (1)	ALCOHOL	3.00
D			
Preservatives (q.s.)			0.00

Procedure:
Add phase B2 to phase B1 and neutralize with phase B3 to pH 6.8. Dissolve phase A1 at about 50-60°C. Disperse phase A2 in phase A1 (with a dissolver disc). Add phase A slowly to phase B while stirring. Then add phase C and D. Homogenize. Check pH value (pH 6.5 to 7.0).

HEV protection
(III) Performance of 5% Titanium Dioxide in gel formulation

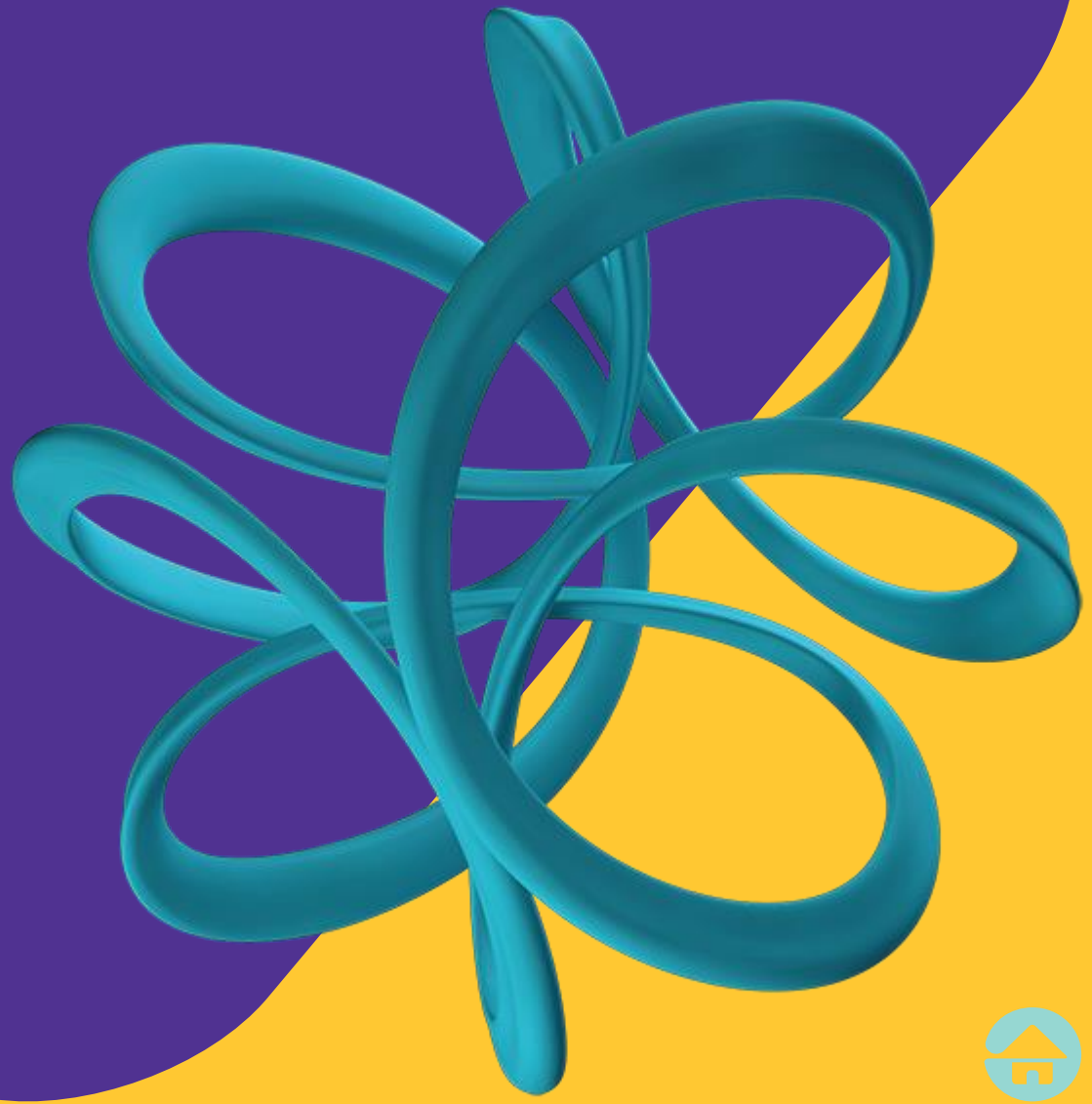


- In this gel system, **TiO_2 UV filters at 5% use level** could reduce HEV transmission **up to 50%** compared to the basis emulsion.

Summary VIS/HEV protection
Performance of titanium dioxides

- It could be shown that titanium dioxides give an excellent protection against visible light (400-800 nm), with the focus on **HEV range (**400-500 nm).
- The effect is dependent on the type of Titanium Dioxide, use level and type of formulation.
- Best performance in the HEV range could be achieved by **Eusolex® T-PRO** in an o/w emulsion but also **Eusolex® T-AVO** and **Eusolex® T-S** showed good results.
- In the w/si emulsion **Eusolex® T-S** showed the best ability to reduce the transmission in the HEV light, close to **Eusolex® T-PRO, T-2000 and T-AVO**
- Only **Eusolex® T-AVO**, **Eusolex® T-PRO** and **Eusolex® T-EASY** lead to stable gel formulations. They all showed a good protection against HEV light.

2.3 performance of functional fillers in VIS/ HEV range



Performance of fillers in visible light/ HEV range
Test Design

products

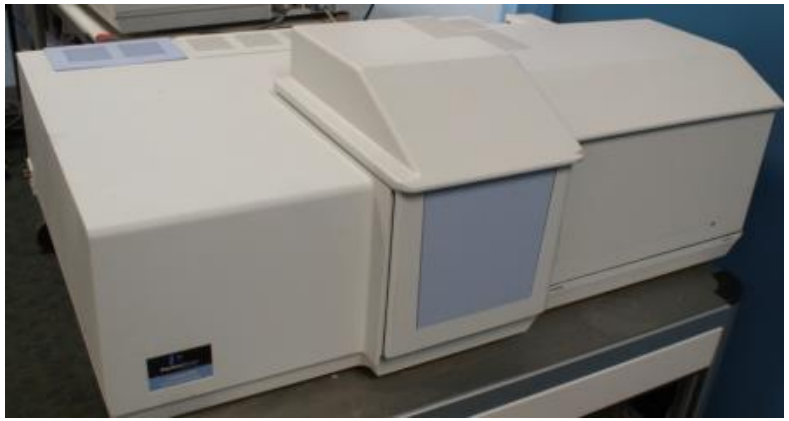
o/w Placebo emulsions

o/w Test emulsions with **functional fillers (3-5 %)** (I)

Method

Photometric measurements of transmission T (%) with Perkin Elmer Lambda 900 in short cut cuvettes:

- Defined film thickness of 0.1 mm
- Wavelength: **VIS: 400 – 800 nm**
  HEV: 400 – 500 nm



Read out

Protection (%)= $[1- T_{(\text{emulsion with } TiO_2)}/ T_{(\text{base emulsion})}] \times 100$

(I) o/w test formulation

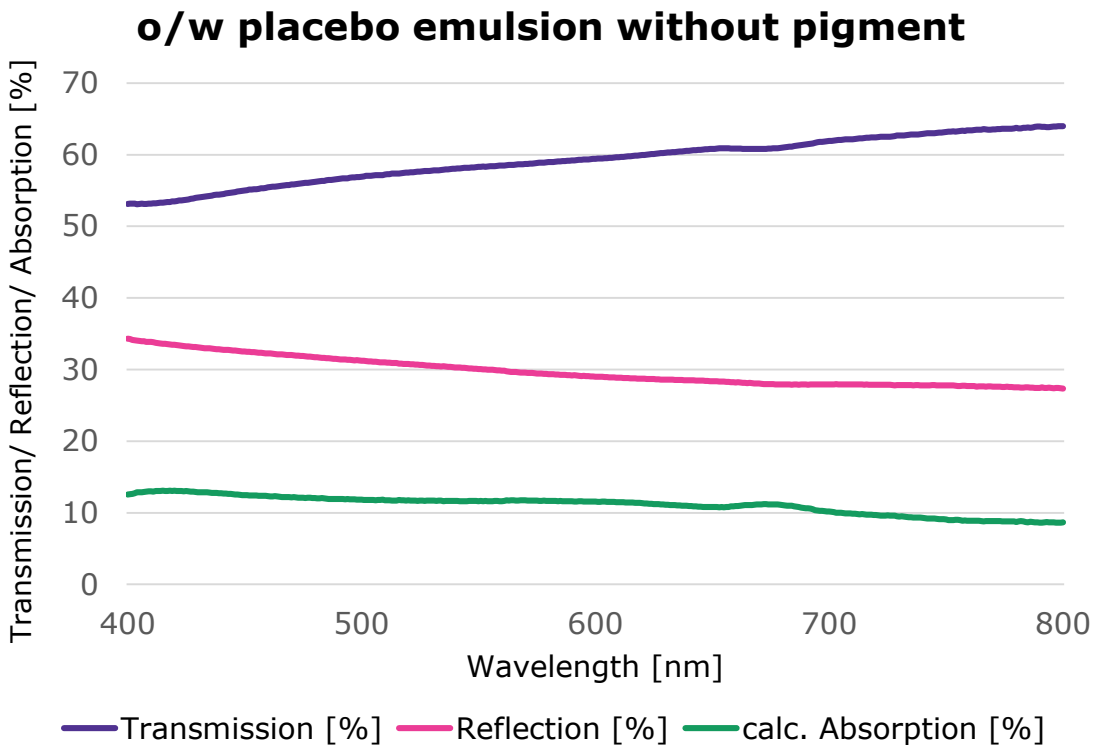
MDA-S-134-x
Sun protection lotion with Filler

Ingredients	Art. No.	INCI (EU)	[%]
A			
RonaCare® AP	1.30163 (1)	BIS-ETHYLHEXYL HYDROXYDIMETHOXY BENZYLMALONATE	2.00
Montanov 202	(2)	ARACHIDYL ALCOHOL, BEHENYL ALCOHOL, ARACHIDYL GLUCOSIDE	3.50
Montanov 14	(2)	MYRISTYL ALCOHOL, MYRISTYL GLUCOSIDE	1.50
Cetiol AB	(3)	C12-15 ALKYL BENZOATE	6.00
Massocare® HD	(4)	ISOHEXADECANE	4.00
Miglyol 812 N	(5)	CAPRYLIC/CAPRIC TRIGLYCERIDE	10.00
B			
Filler			**3 - 5 %**
Glycerol 85%	1.04091 (1)	GLYCERIN, AQUA	4.00
Keltrol® CG-RD	(6)	XANTHAN GUM	0.80
Water, demineralized		AQUA	ad 100
C			
Preservatives			q.s.

Procedure:
Heat up phase A (without Eusolex® T-PRO) to 75°C-80°C. Disperse Eusolex® T-PRO in phase A and heat up to 75°C-80°C. Pre-dissolve Keltrol CG-RD in phase B and heat up to 75°C - 80°C. Add phase A to B while stirring. Homogenize. Below 40°C add phase C.

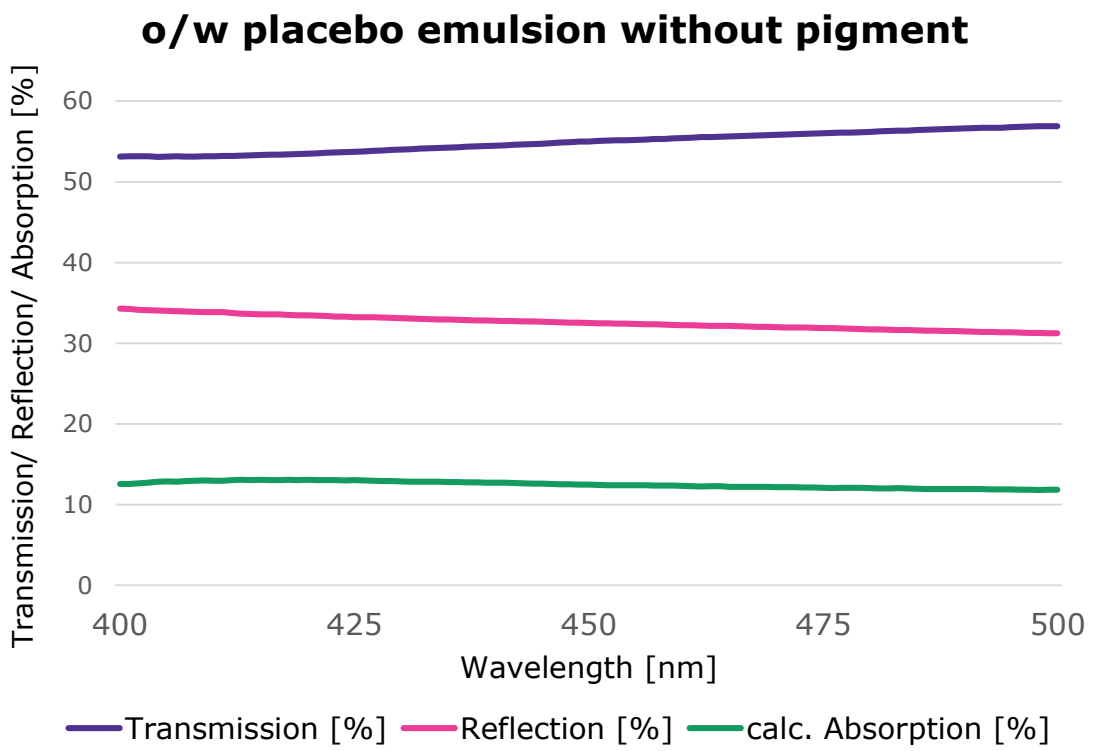
(I) Transmission/ Reflection/ Absorption in o/w emulsion

Visible light protection



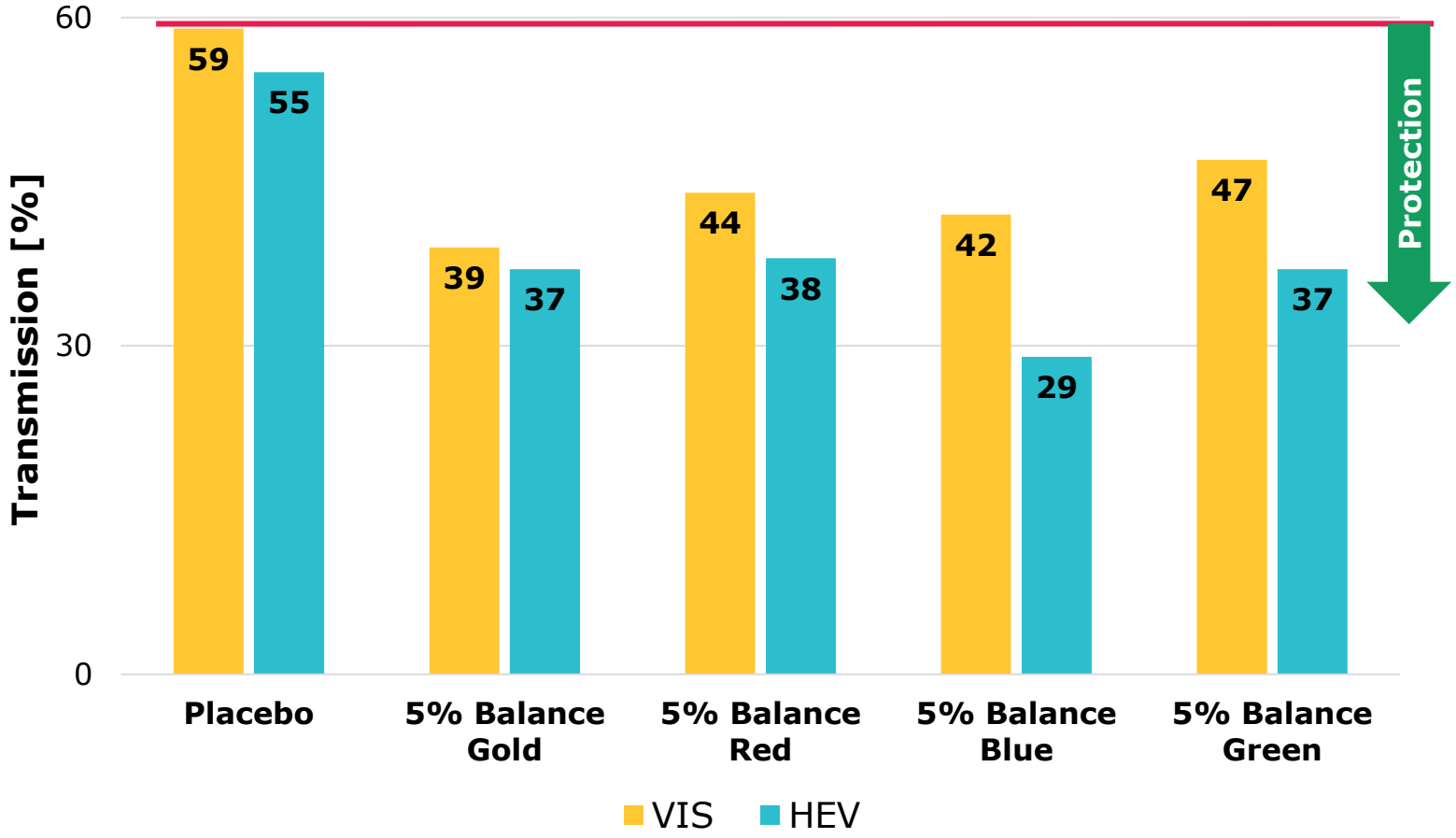
~ 60% Transmission
~ 30% Reflection (including Scattering)
~ 12% calculated Absorption

HEV protection



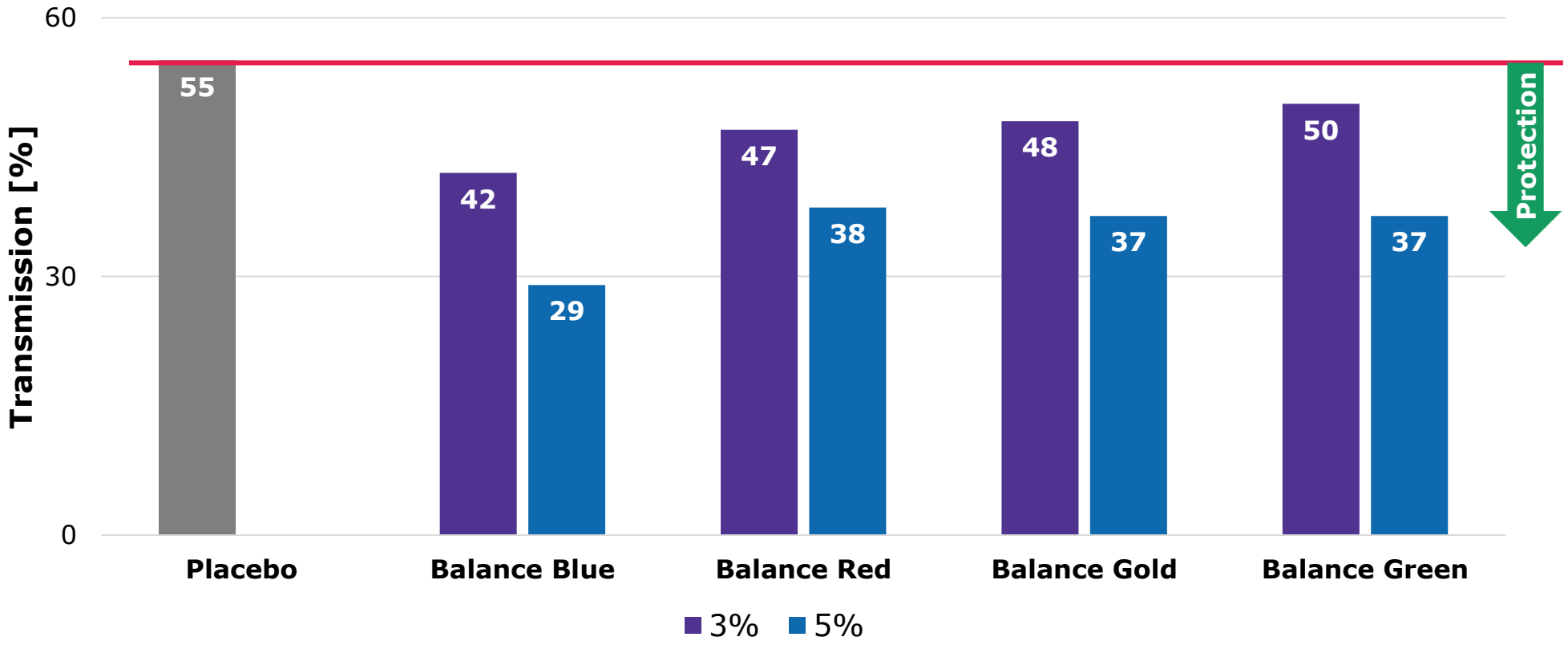
~ 55% Transmission
~ 32% Reflection (including Scattering)
~ 12% calculated Absorption

VIS protection vs. HEV protection
(I) Performance of 5% filler in o/w formulation



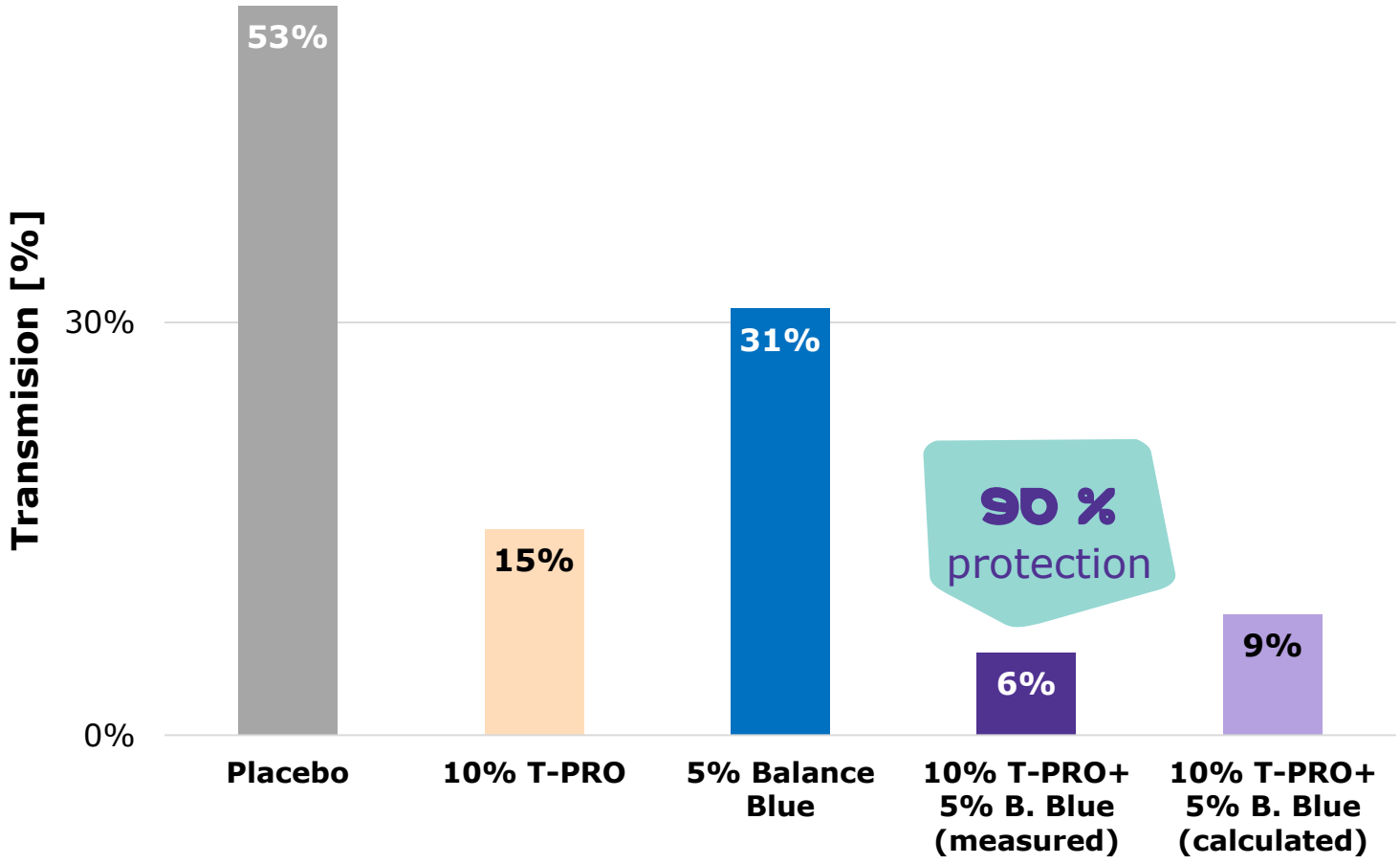
- In this o/w emulsion system, good protection against VIS and HEV light can be achieved with **5% filler –**
  in HEV, up to 50% protection with RonaFlair® Balance Blue vs. basis emulsion

HEV protection
(I) Performance of 3-5% filler in o/w formulation



Increased HEV protection can be achieved by increased concentration of RonaFlair® Balance Blue.

HEV protection
(I) Performance of filler + titanium dioxide in o/w formulation



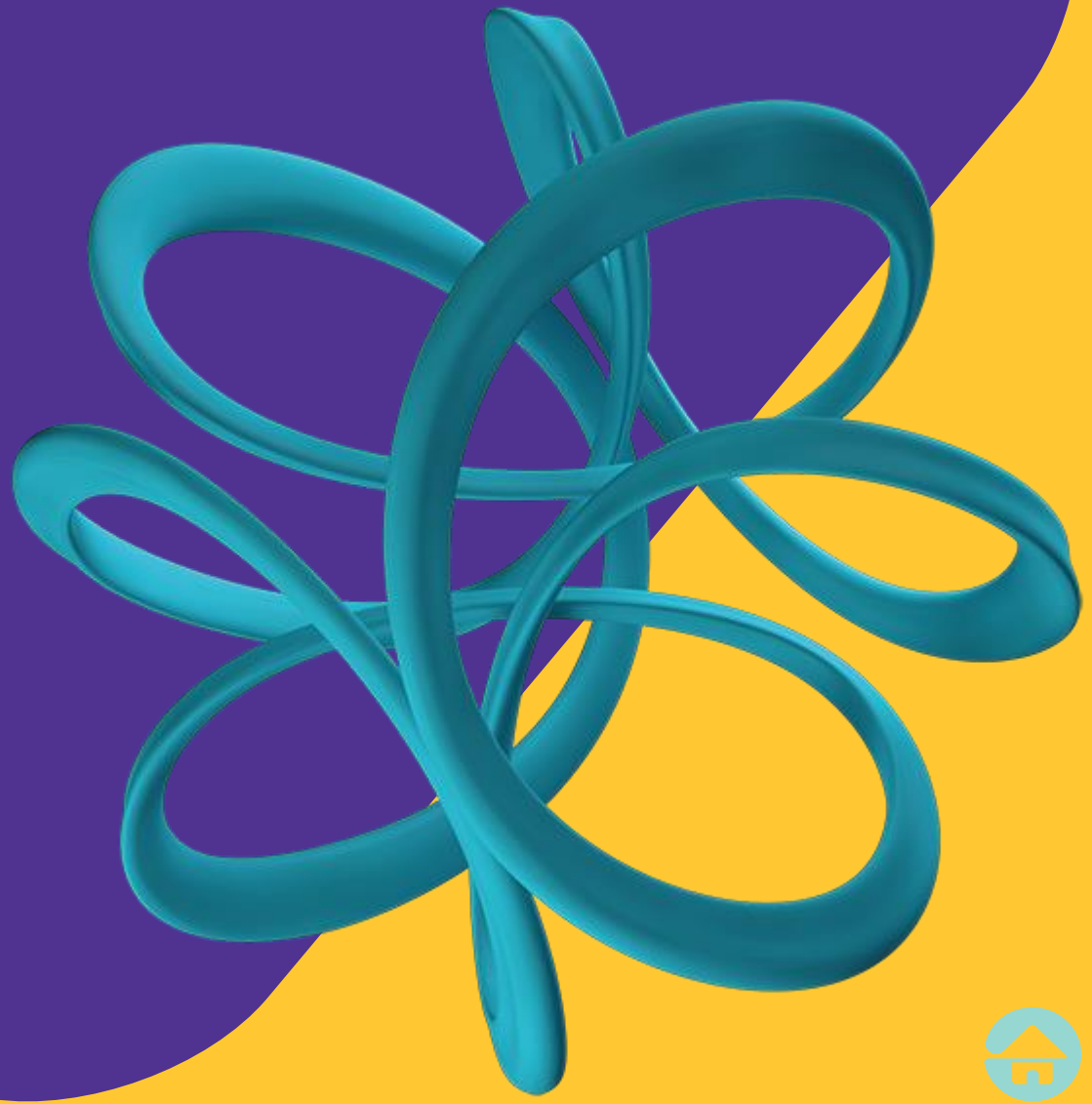
- Tandem **Eusolex® T-PRO / RonaFlair® Balance Blue** achieved an exceptional **transmission reduction of HEVL of ~ 90%,** which corresponds to the addition of the protection effects of both single materials (72% for Eusolex® T-PRO **PLUS** 42% for RonaFlair® Balance Blue)

Summary VIS/HEV protection
Performance of functional fillers

- It could be shown that RonaFlair® Balance Colors give an excellent protection against visible light (400-800 nm) with focus on **HEV range** from 400-500 nm.
- The effect is dependent on the type of functional filler and use level.
- Excellent performance in the HEV range could be achieved by **RonaFlair® Balance Blue** in an o/w emulsion but also **RonaFlair® Balance Red, Balance Gold and Balance Green are effective.**
- Depending on the final formulation also a combination can be recommended: best results are obtained with a **combination of RonaFlair® Balance Blue and Eusolex® T-PRO**

03 Near- infrared light

3.1 Effects of near-infrared light on skin

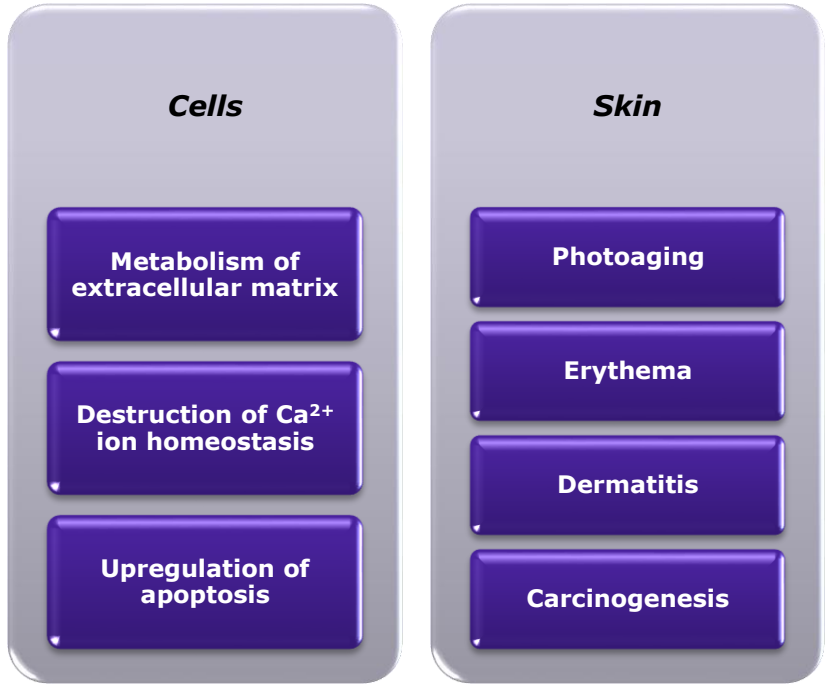


Effect of near infrared light on skin
Why infrared light protection?

Near-infrared light or IR-A ranges from 800-1450 nm.

IR radiation has the lowest energy, but its contribution to solar spectrum reaching human skin is about 45%. [1]

At low doses IR-A (1-10 J/cm²) stimulates therapeutic effects (treatment of inflammatory processes), but at high doses (>120 J/cm²) **harmful effects** are reported.[12]



Effect of near infrared light (n-IR) on skin
Why infrared light protection?

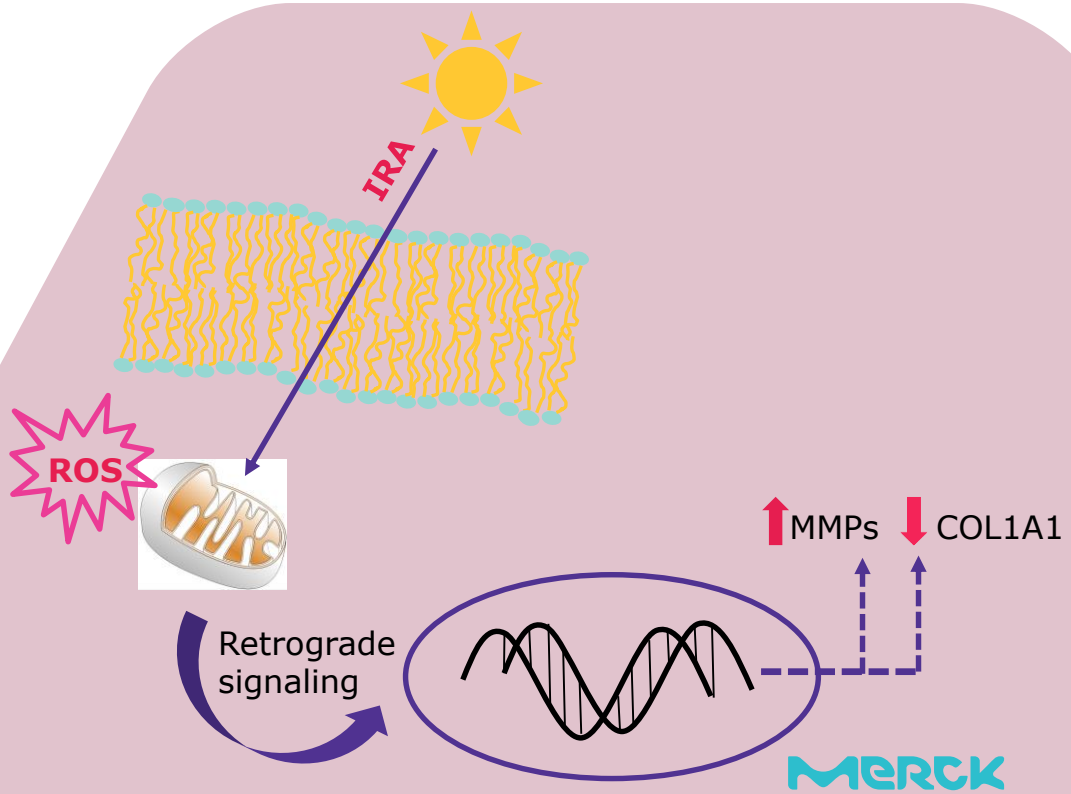
- **IR-A radiation** (800 - 1450 nm)
  - Direct (**dose dependent**) and secondary (**heat generated**) formation of dermal mitochondrial ROS and active nitric oxides (NO) in dermal fibroblasts [16]
  - Direct and indirect increase in MMP-1 (collagen degradation), MMP-9 (elastin degradation) expression in dermal fibroblasts [12]
  - Decrease type I procollagen expression (COL1A1) [6]
  - Alteration in expression of genes involved in skin aging [16]

PHOTOAGING

Clinical signs: wrinkle formation, loss of skin tone,…

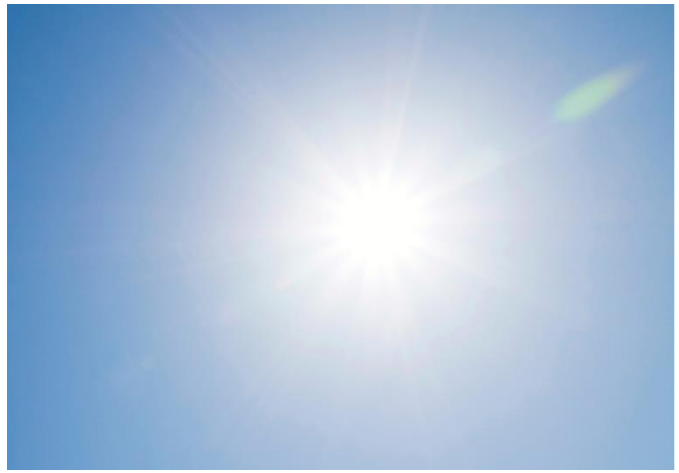
- IR-B (1450-3000 nm) and IR-C (3000nm- 1mm) mainly absorbed by water in epidermal layers – heat formation

Adapted from *Int. Journal Cos. Science 2013, 35, 224-232*



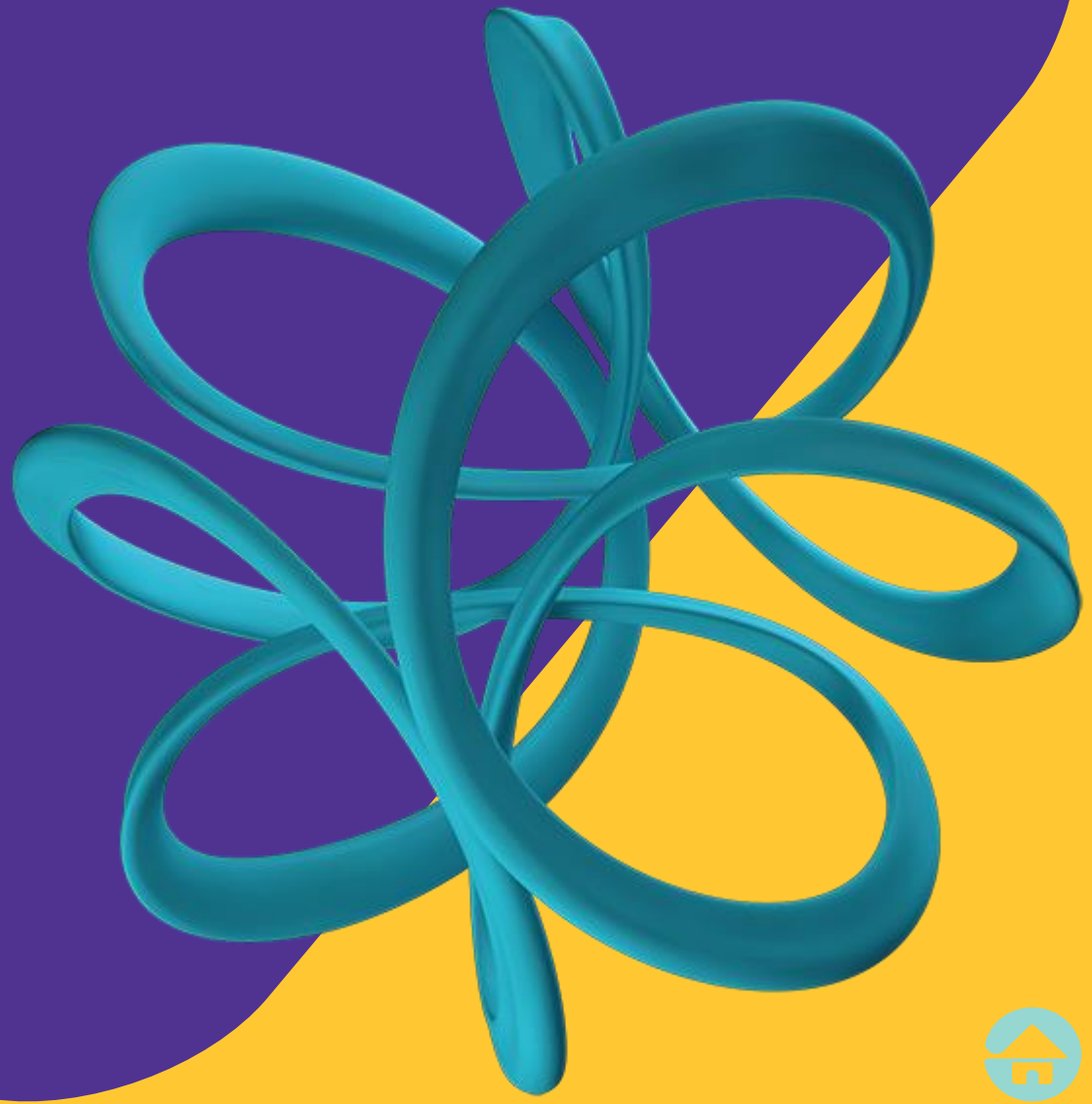
IR light sources

1. **Natural sunlight**
2. **Fire**
3. **Radiators**
4. **IR heating**



Source: conrad.electronic.co.uk
Quartz IR Radiator 1500 W 9m²

3.2 performance of TiO_2 in near-infrared light range



Performance of TiO_2 in IR-A range
Test Design

products

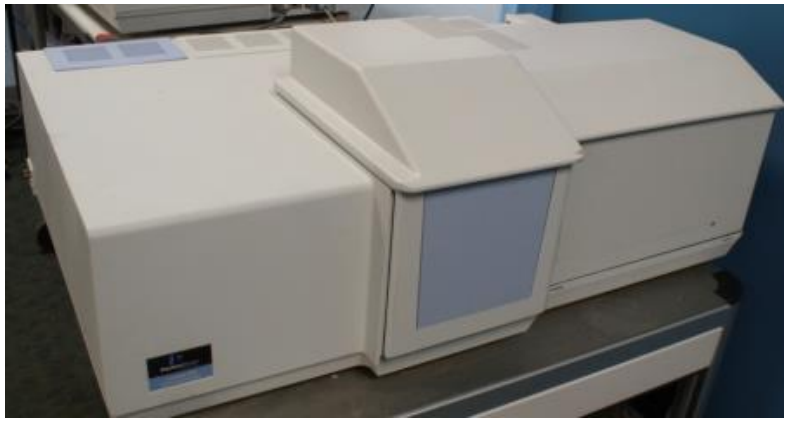
Placebo emulsions: (I) o/w, (II) w/si

Test emulsions (I), (II) with **Titanium Dioxide (5 - 25 %)**

Method

Photometric measurements of transmission T (%) with Perkin Elmer Lambda 900 in short cut cuvettes:

- Defined film thickness of 0.1 mm
- Wavelength: **800 – 1450 nm**



read out

Protection (%)= [1- $T_{(emulsion\ with\ TiO_2)}$/ $T_{(base\ emulsion)}$] x 100

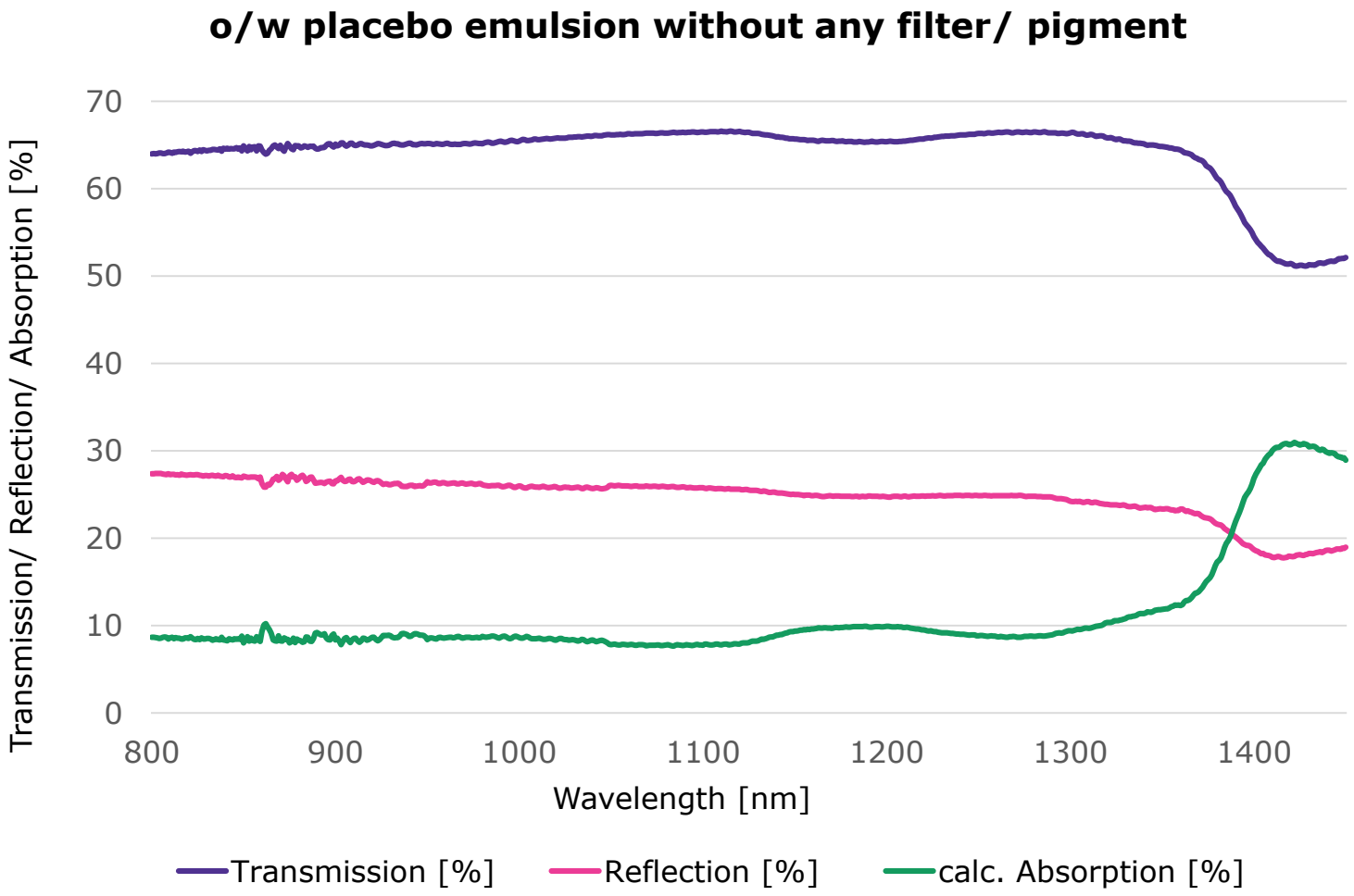
(I) o/w test formulation

MDA-S-134-x
Sun protection lotion with Titanium dioxide

Ingredients	Art. No.	INCI (EU)	[%]
A			
Titanium dioxide			**3 - 25 %**
RonaCare® AP	1.30163 (1)	BIS-ETHYLHEXYL HYDROXYDIMETHOXY BENZYLMALONATE	2.00
Montanov 202	(2)	ARACHIDYL ALCOHOL, BEHENYL ALCOHOL, ARACHIDYL GLUCOSIDE	3.50
Montanov 14	(2)	MYRISTYL ALCOHOL, MYRISTYL GLUCOSIDE	1.50
Cetiol AB	(3)	C12-15 ALKYL BENZOATE	6.00
Massocare® HD	(4)	ISOHEXADECANE	4.00
Miglyol 812 N	(5)	CAPRYLIC/CAPRIC TRIGLYCERIDE	10.00
B			
Glycerol 85%	1.04091 (1)	GLYCERIN, AQUA	4.00
Keltrol® CG-RD	(6)	XANTHAN GUM	0.80
Water, demineralized		AQUA	ad 100
C			
Preservatives			q.s.

Procedure:
Heat up phase A (without Eusolex® T-PRO) to 75°C-80°C. Disperse Eusolex® T-PRO in phase A and heat up to 75°C-80°C. Pre-dissolve Keltrol CG-RD in phase B and heat up to 75°C - 80°C. Add phase A to B while stirring. Homogenize. Below 40°C add phase C.

IR-A protection
(I) Transmission/ Reflection/ Absorption in o/w emulsion



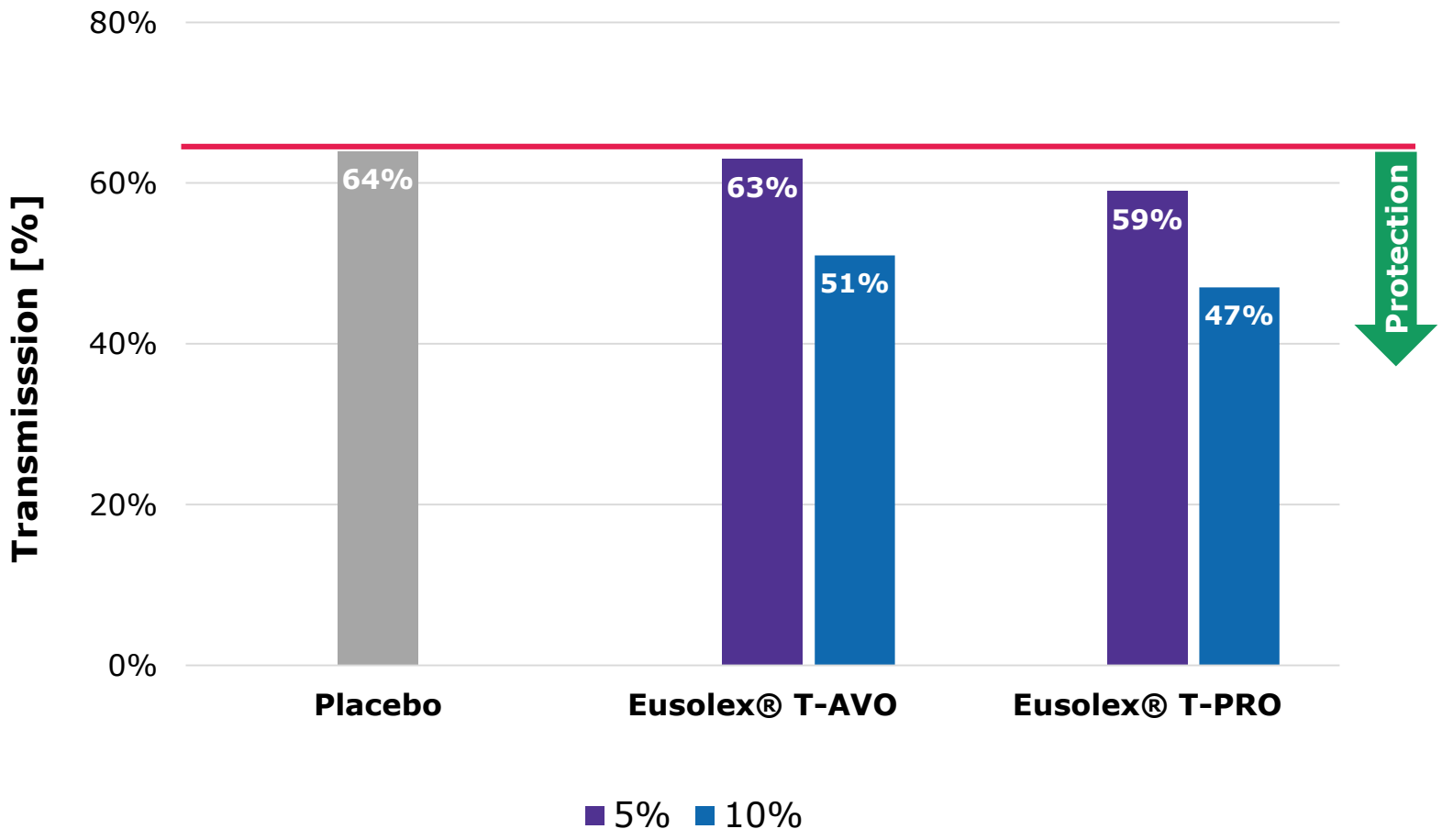
Placebo:

~ 65% Transmission

~ 25% Reflection (including Scattering)

~ 8% calculated Absorption

IR-A protection
(I) Performance of Titanium Dioxide in o/w formulation



- In this o/w emulsion system, **Eusolex® T-PRO** and **Eusolex® T-AVO** could reduce IR-A transmission at a use level of 10%.

(II) w/si test formulation

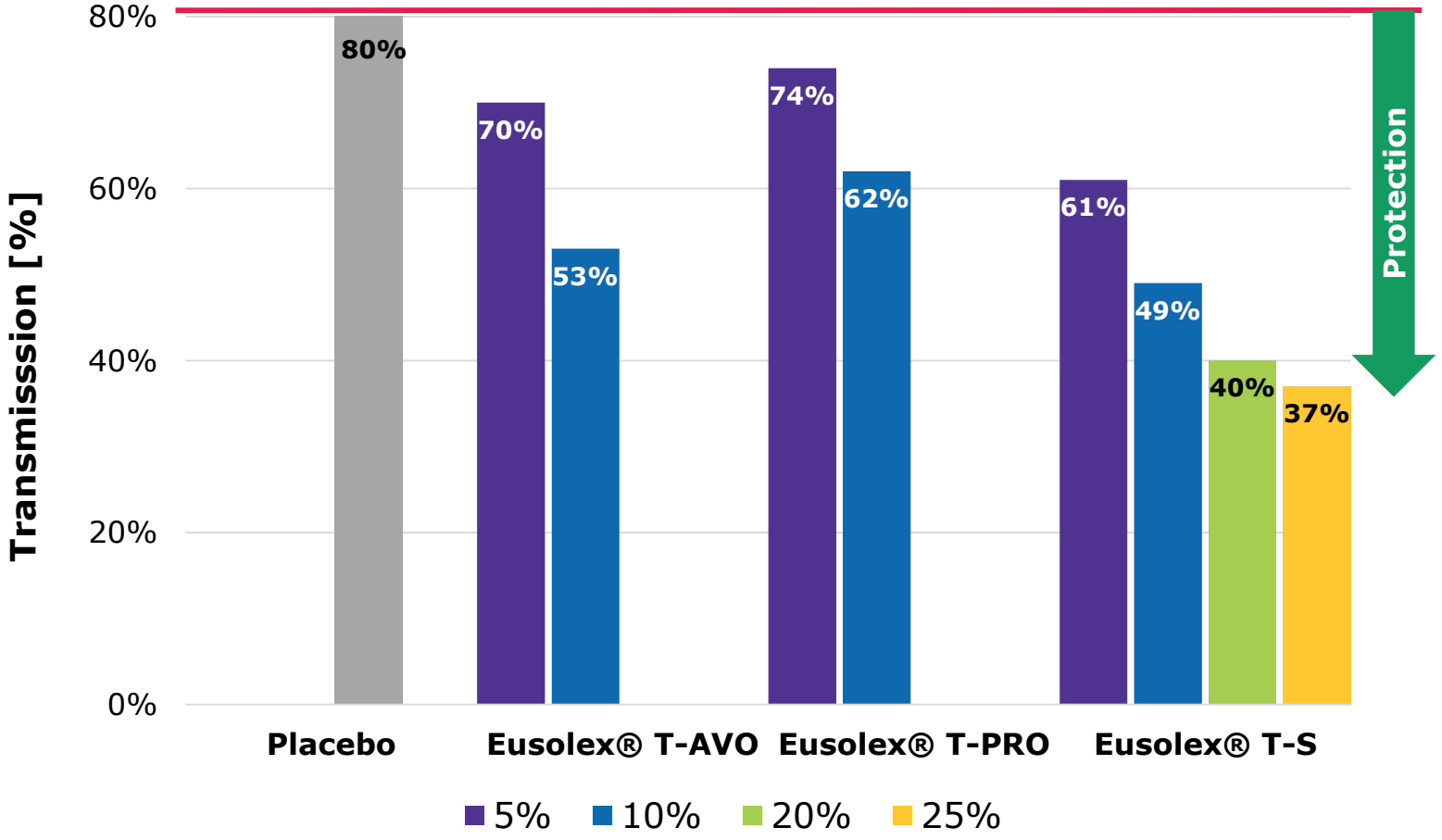
SU-11-x
Sun protection milk
with Titanium dioxide

Ingredients	Art. No.		INCI (EU)	[%]
A				
KSG-210		(1)	DIMETHICONE, DIMETHICONE PEG-10/15 CROSSPOLYMER	3.00
KSG-15		(1)	CYCLOPENTASILOXANE, DIMETHICONE/VINYL DIMETHICONE CROSSPOLYMER	2.00
KF96-A-6cs		(2)	DIMETHICONE	5.00
KF-995		(1)	CYCLOPENTASILOXANE	5.00
KF-6028		(1)	PEG-9 POLYDIMETHYLSILOXYETHYL DIMETHICONE	1.00
Crodamol TN		(3)	ISOTRIDECYL ISONONANOATE	4.00
B				
Titaniumd dioxide				**3-25**
Lanol 99		(5)	ISONONYL ISONONANOATE	15.00
Xiameter® PMX-0345		(6)	CYCLOPENTASILOXANE, CYCLOHEXASILOXANE	15.00
Abil Wax 9801		(7)	CETYL DIMETHICONE	6.00
C				
RonaCare® Sodium Chloride	1.32260	(4)	SODIUM CHLORIDE	1.00
tri-Sodium Citrate-Dihydrate	1.06446	(4)	SODIUM CITRATE	0.20
1,2-Propanediol	1.07478	(4)	PROPYLENE GLYCOL	2.00
Water, demineralized			AQUA	ad 100

Procedure:
Combine ingredients of phase A with mixing.
Combine ingredients ob phase C with mixing.

Premix phase B with high agitation and homogenize.
Add phase B to phase A while gentle stirring. Homogenize again.
Add phase C to phase A/B slowly while stirring and homogenize.
Cool down to room temperature whilst stirring.

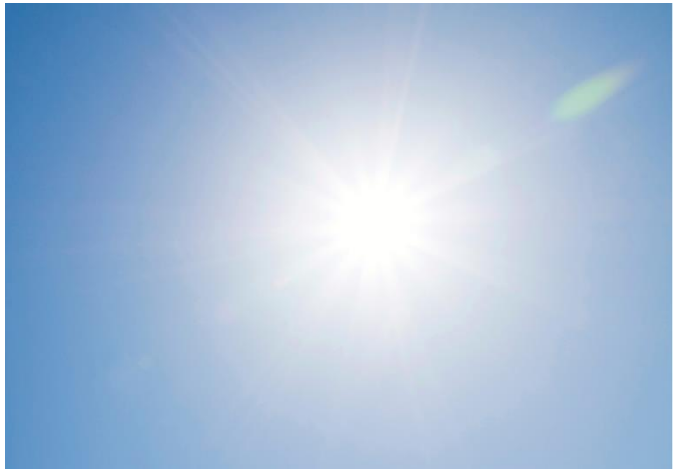
IR-A protection
(II) Performance of Titanium Dioxide in w/si formulation



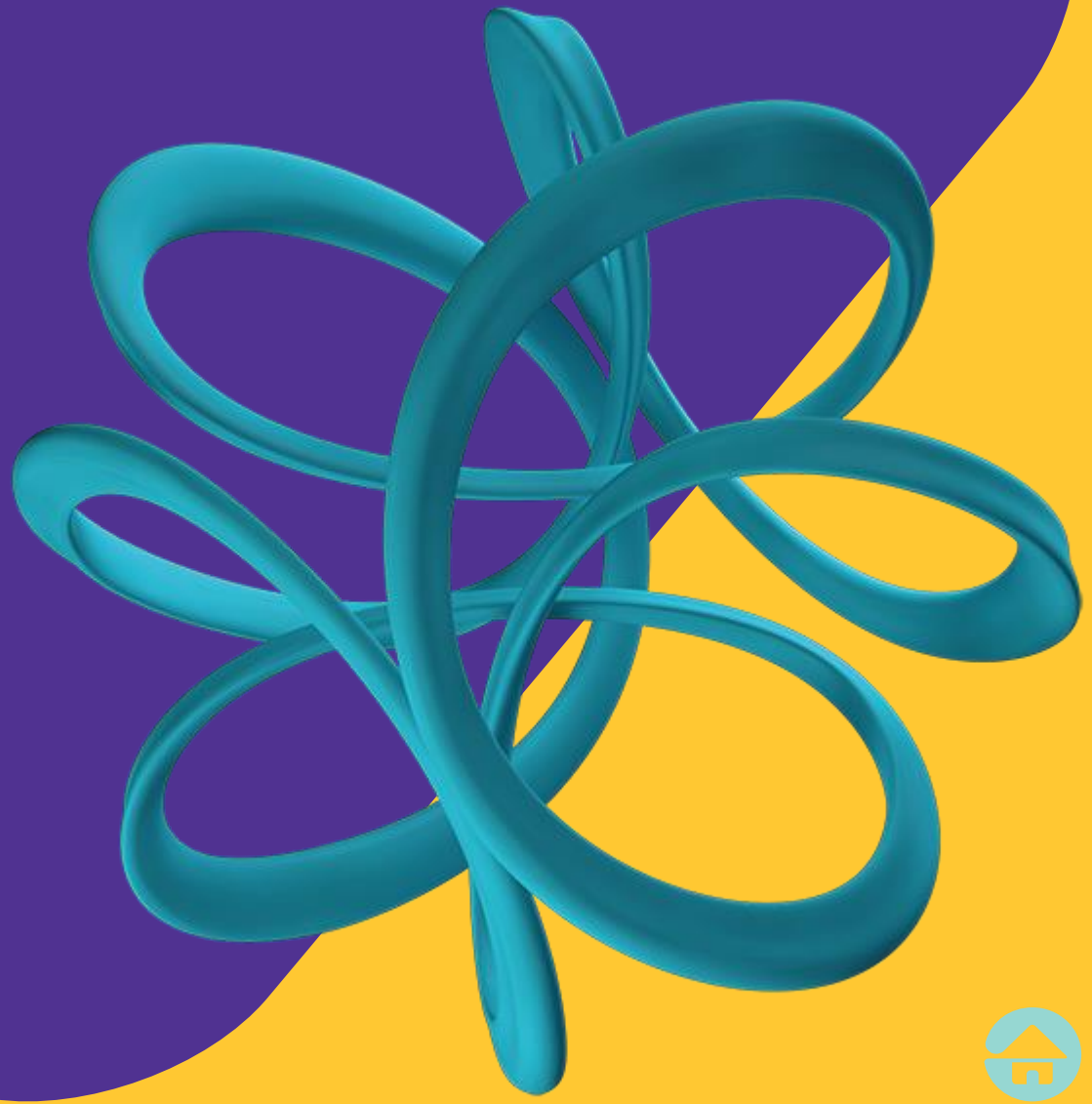
- In this w/si emulsion system, **TiO_2 UV filters** could reduce IR-A transmission **up to 55%** compared to the basis emulsion.
- Performance dependent on use level, coating/ surface treatment of TiO_2

IR-A protection – Summary
Performance of titanium dioxides

- It could be shown that titanium dioxides protect against IR-A light (800-1450 nm).
- The effect is dependent on the type of Titanium Dioxide, use level and type of formulation.
- Best performance could be achieved by **Eusolex® T-PRO** in an o/w emulsion. Additionally only this titanium dioxide type works also as second defense line due to its antioxidative properties.
- In a w/si emulsion, **Eusolex® T-S** showed the best ability to reduce the transmission in the IR-A light.



3.3 performance of functional fillers in near-infrared light range



Performance of fillers in IR-A range
Test Design

products

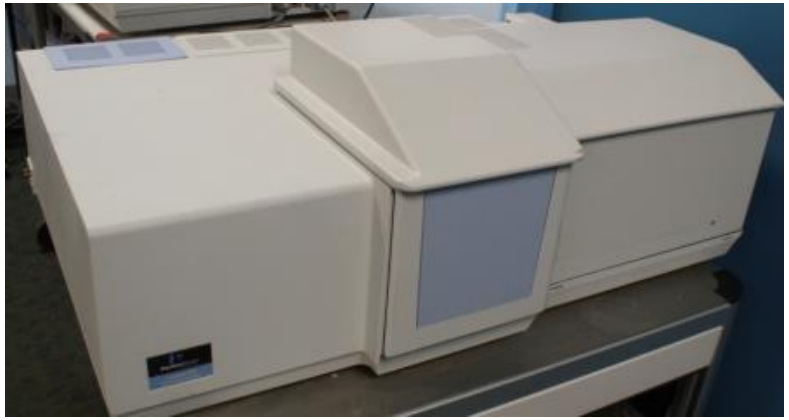
o/w Placebo emulsions

o/w Test emulsions with **functional fillers (3-5 %)** (I)

Method

Photometric measurements of transmission T (%) with Perkin Elmer Lambda 900 in short cut cuvettes:

- Defined film thickness of 0.1 mm
- Wavelength: **800 – 1450 nm**



Read out

Protection (%)= $[1- T_{(\text{emulsion with } TiO_2)}/ T_{(\text{base emulsion})}] \times 100$

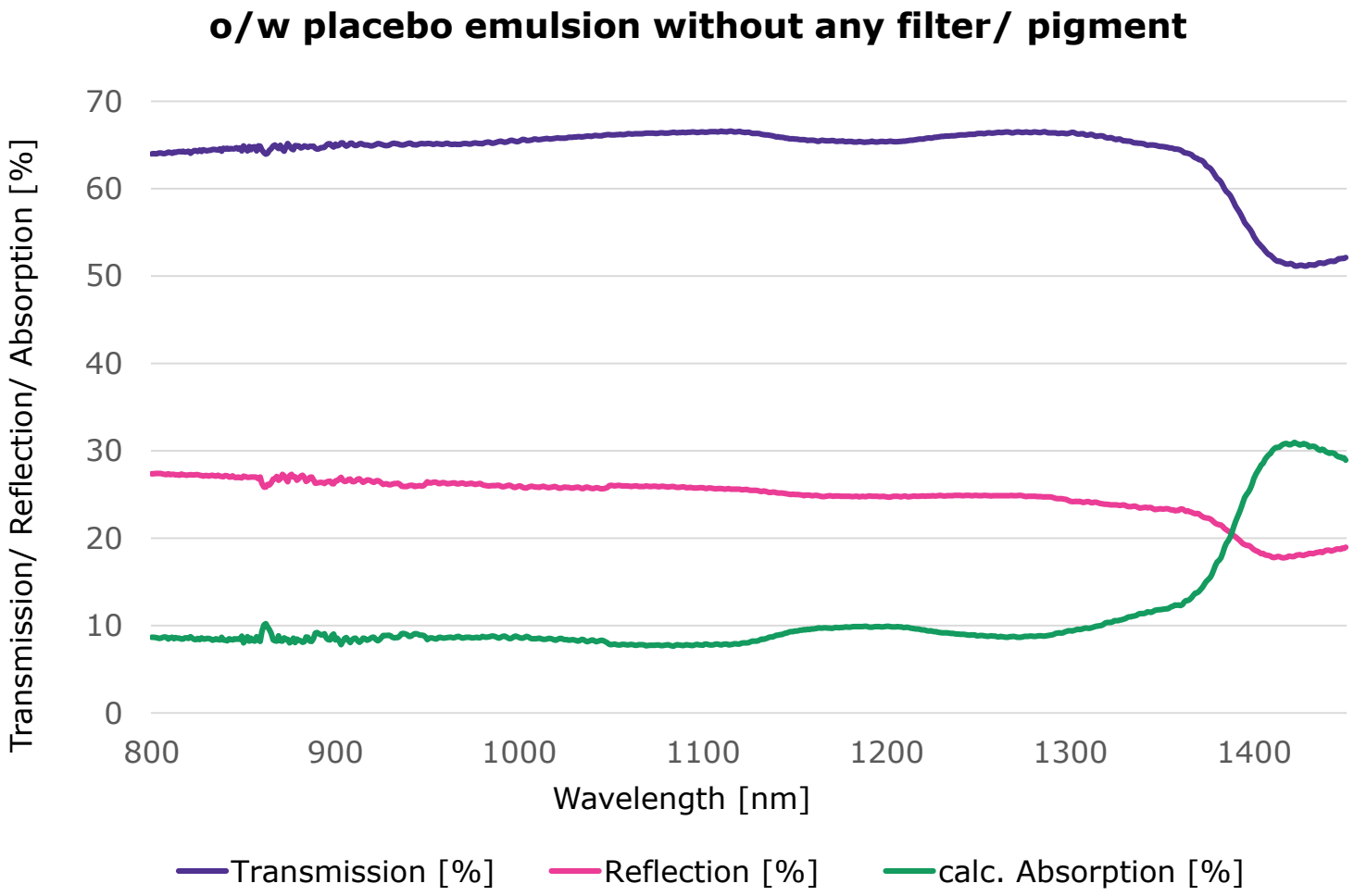
(I) o/w test formulation

MDA-S-134-x
Sun protection lotion with Filler

Ingredients	Art. No.	INCI (EU)	[%]
A			
RonaCare® AP	1.30163 (1)	BIS-ETHYLHEXYL HYDROXYDIMETHOXY BENZYLMALONATE	2.00
Montanov 202	(2)	ARACHIDYL ALCOHOL, BEHENYL ALCOHOL, ARACHIDYL GLUCOSIDE	3.50
Montanov 14	(2)	MYRISTYL ALCOHOL, MYRISTYL GLUCOSIDE	1.50
Cetiol AB	(3)	C12-15 ALKYL BENZOATE	6.00
Massocare® HD	(4)	ISOHEXADECANE	4.00
Miglyol 812 N	(5)	CAPRYLIC/CAPRIC TRIGLYCERIDE	10.00
B			
Filler			**3 - 5 %**
Glycerol 85%	1.04091 (1)	GLYCERIN, AQUA	4.00
Keltrol® CG-RD	(6)	XANTHAN GUM	0.80
Water, demineralized		AQUA	ad 100
C			
Preservatives			q.s.

Procedure:
Heat up phase A (without Eusolex® T-PRO) to 75°C-80°C. Disperse Eusolex® T-PRO in phase A and heat up to 75°C-80°C. Pre-dissolve Keltrol CG-RD in phase B and heat up to 75°C - 80°C. Add phase A to B while stirring. Homogenize. Below 40°C add phase C.

IR-A protection
(I) Transmission/ Reflection/ Absorption in o/w emulsion



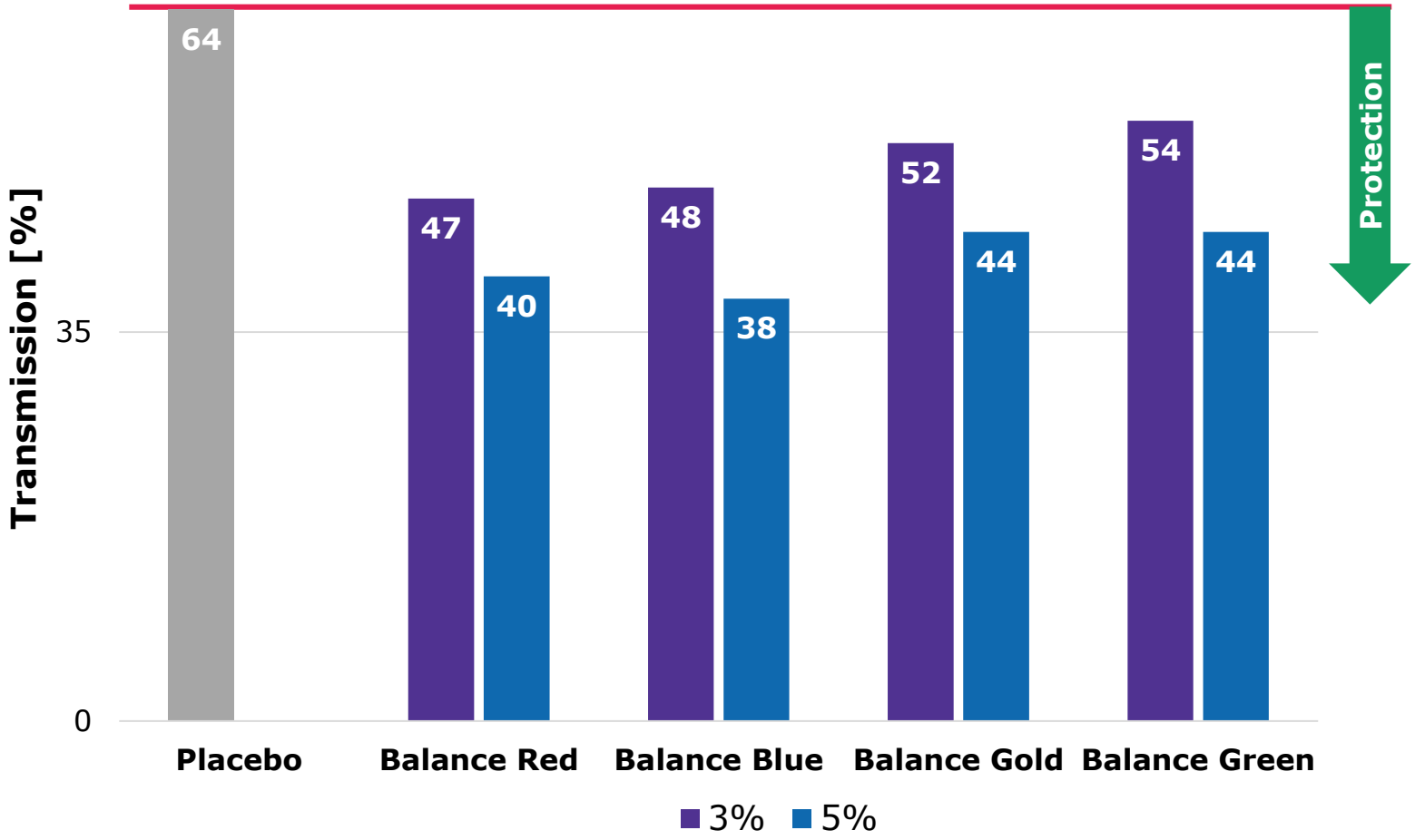
Placebo:

~ 65% Transmission

~ 25% Reflection (including Scattering)

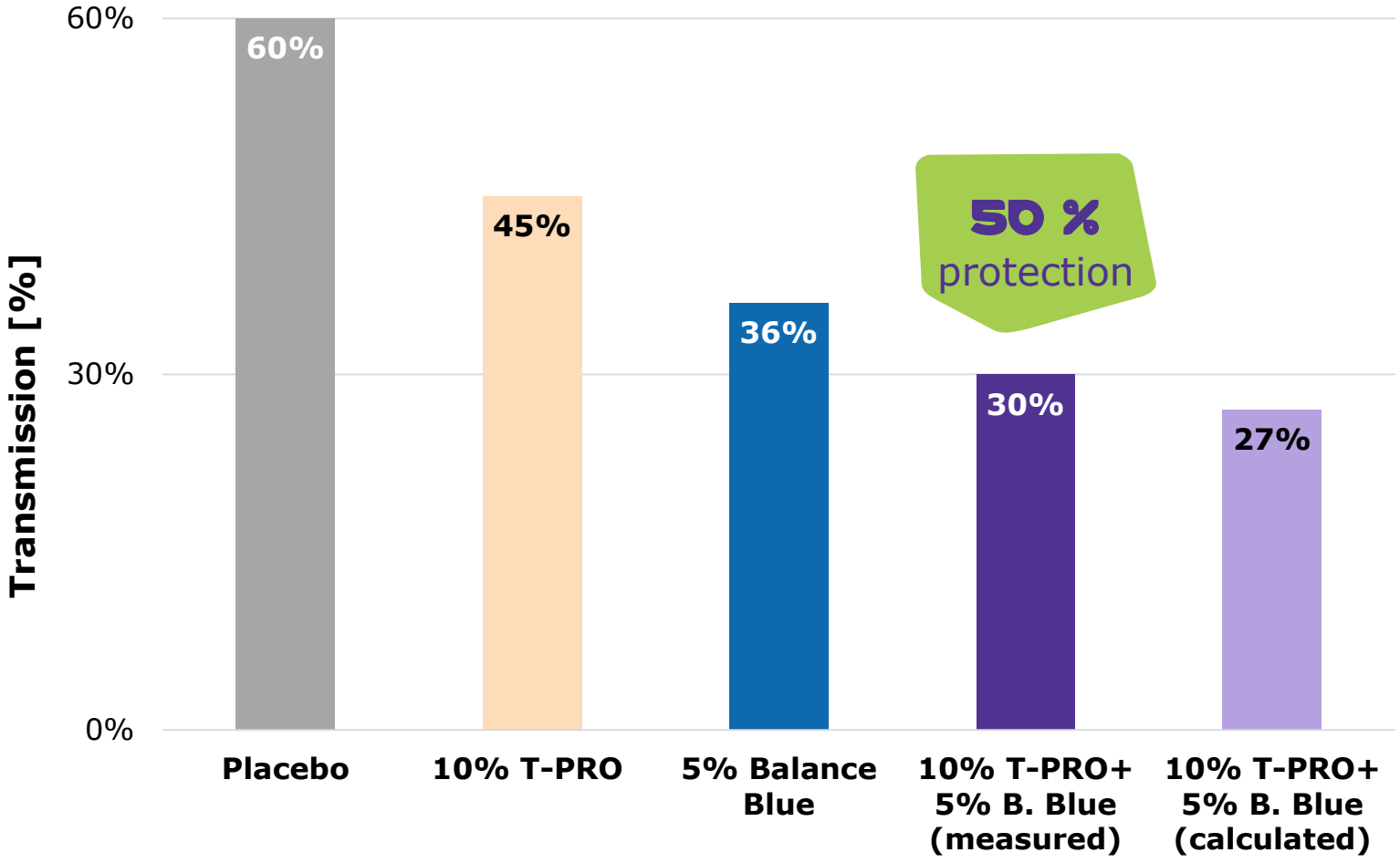
~ 8% calculated Absorption

IR-A protection
(I) Performance of functional fillers in o/w formulation



- In this o/w emulsion system, **RonaFlair® Balance Blue** and **Balance Red** could reduce IR-A transmission **up to 40%** at 5% use level.

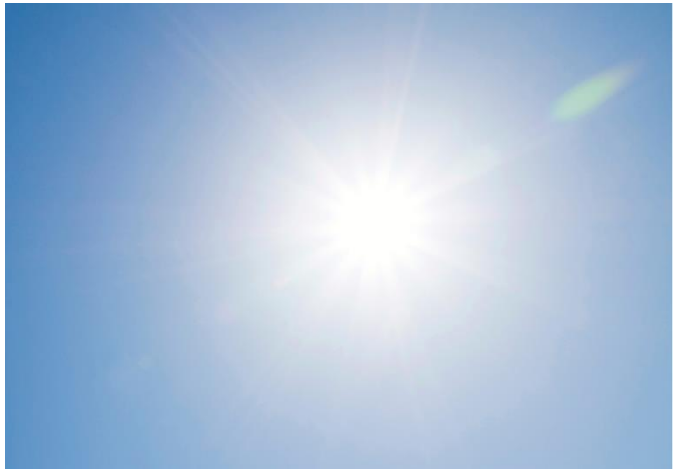
IR-A protection
(I) Performance of filler + titanium dioxide in o/w formulation



- Combination **Eusolex® T-PRO / RonaFlair® Balance Blue** provided a superb **transmission reduction of 50% of IR-A light.**
- **Additive effects:** 25% for Eusolex® T-PRO **PLUS** 40% for RonaFlair® Balance Blue

Summary IR-A protection
Performance of functional fillers

- It could be shown that functional fillers protect against IR-A light (800-1450 nm).
- The effect is dependent on the type of functional filler and the use level.
- Excellent performance could be achieved by **RonaFlair® Balance Blue and Balance Red** in an o/w emulsion.
- A combination of RonaFlair® Balance Blue and Eusolex® T-PRO gives an additional protection.



04 conclusion

protective solution for
N-IR and HEV protection as
first defense line through

Titanium dioxide & Functional Fillers

alone or in combination
depending on formulations and claims

MERCK

06 appendix

Test materials
Titanium dioxides

Merck name	INCI	Properties	Description
Eusolex® T-AVO	Titanium dioxide (nano), Silica	Hydrophilic powder, can also be added to oil phase	Alumina free, nature-identical, for ‚green' cosmetics, pushes Avobenzone efficacy
Eusolex® T-EASY*	Titanium Dioxide (nano), Silica, Cetyl Phosphate	Hydrophobic powder, can also be added to water phase	Alumina free, excellent compatibility with demanding raw materials
Eusolex® T-PRO	Titanium Dioxide (nano), Alumina, Manganese Dioxide	Hydrophilic powder, can also be added to oil phase	The transparent anti-aging pigment, nature-identical, for ‚green' cosmetics
Eusolex® T-S	Titanium Dioxide (nano), Alumina, Stearic Acid	Hydrophobic powder	Vegetable derived surface coating, nature-identical, for ‚green' cosmetics

*not available for Europe

Test materials
Filler

Merck name	INCI	Properties	Description
RonaFlair® Balance® Blue	Titanium dioxide, Mica, Tin oxide	Bluish- white powder medium coverage	Helps to compensate a rather yellowish skin base, e.g. of Asian skin alone or in combination with Balance Gold and Red.
RonaFlair® Balance® Red	Titanium dioxide, Mica, Tin oxide	Reddish white powder medium coverage	Adds natural freshness and luminosity to any skin type. Can be combined with Balance Gold and Blue to modify any existing skin tone.
RonaFlair® Balance® Green	Titanium dioxide, Mica, Tin oxide	Greenish-white powder medium coverage	Provides a visible effect due to its intensive interference. Effective in compensating reddish parts of the skin.
RonaFlair® Balance® Gold	Titanium dioxide, Mica, Tin oxide	Yellowish white powder high coverage	Provides high Chroma. Helps to balance out slightly reddish skin. Darker skin types will be brightened nicely.

Literature

1. Dupont et al: Beyond UV radiation: A skin under challenge, Int. Journal Cos. Science 2013, 35: 224-232
2. Schieke et al: Cutaneous effects of infrared radiation: from clinical observations to molecular response mechanisms, photodermal photoimmunol Photomed 2003, 19: 228-234
3. Duteil et al: Differences in visible light-induced pigmentation according to wavelengths: a clinical and histological study in comparison with UVB exposure, Pigment Cell Melanoma Res, 27: 822-826
4. Sklar et al: Effects of ultraviolet radiation, visible light, and infrared radiation on erythema and pigmentation: a review, Photochem Photobiol Sci, 2013, 12: 54
5. Mahmoud et al: Effects of visible light on the skin, Photochem and Photobio, 2008, 84:450-462
6. Cho et al: Infrared plus visible light and heat from natural sunlight participate in the expression of MMPs and type I procollagen as well as infiltration of inflammatory cell in human skin *in vivo*, Journal of Dermatological Science 2008, 50: 123-133
7. Schieke et al: Infrared-A radiation-induced matrix metalloproteinase 1 expression is mediated through extracellular signal-regulated kinase ½ activation in human dermal fibroblasts, Society of Investigative Dermatology 2002, 1323-1329
8. Calles et al: Infrared-A radiation influences the skin fibroblast transcriptome: mechanisms and consequences, Journal of Investigative Dermatology 2010, 130: 1524-1536

Literature

9. Shaath et al: Infrared radiation & skin protection, The Sunscreen Filter 2012, www.happi.com
10. Liebel et al: Irradiation of skin with visible light induces reactive oxygen species and matrix degrading enzymes, Journal of Investigative Dermatology 2012, 132: 1901-1907
11. Mahmoud et al: Impact of long-wavelength UVA and visible light on melanocompetent skin, Journal of Investigative Dermatology 2010, 130: 2092-2097
12. Akhalaya et al: Molecular action mechanisms of solar infrared radiation and heat on human skin, Ageing Research Reviews 2014, 16: 1-11
13. Mattsson et al: Scientific Committee on Emerging and Newly Identified Health Risks SCENIHR, Health Effects of Artificial Light, 2012
14. James et al: Sunscreens: Myths, controversy and photo protection beyond UV, www.dermascope.com
15. Zastrow et al: The missing link – light-induced (280-1600 nm) free radical formation in human skin, Skin Pharmacol Physiol 2009, 22:31-44
16. Schroeder et al: The role of near infrared radiation in photoaging of the skin, Experimental Gerontology 2008, 43: 629-632
17. Randhawa et al: Visible light induces melanogenesis in human skin through a photoadaptive response, Johnson and Johnson Skin Research Center 2015

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