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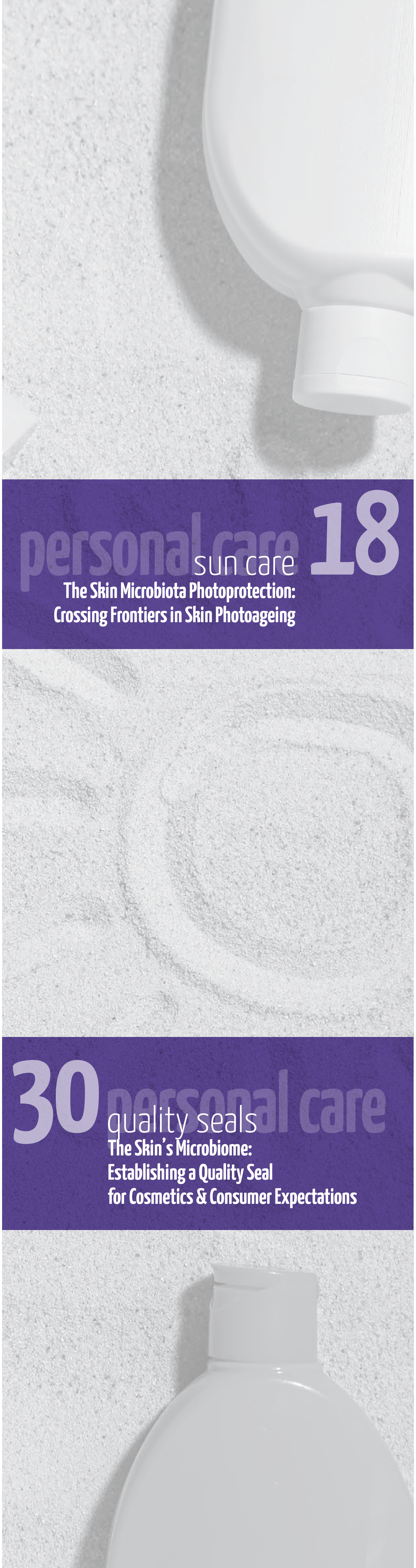

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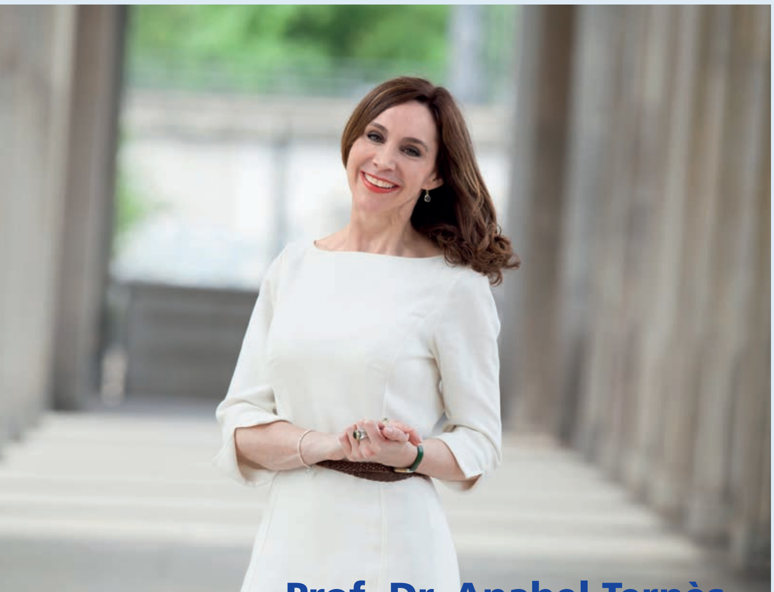
Synergizing Sustainability and Digitization for Future-Fit Business Strategies

A. Ternès



Prof. Dr. Anabel Ternès

is considered one of the leading figures in sustainability and digitalization. Forbes calls her "Superwoman," and Hypovereinsbank refers to her as "one of the outstanding managers and entrepreneurs in Germany."

She is the Managing Director of the SRH Institute for Sustainability Management in Berlin and a Professor of Communication Management. She has made a name for herself as a futurist, keynote speaker, author, and founder of sustainable startups.

She is the managing partner of GetYourWings, the learning space for future shapers, a partner at Quant Next, a sustainable online communication and marketing agency, and a shareholder of the WeQ-Future Skills Campus.

Anabel Ternès has extensive international leadership experience in business development for consumer goods companies, including Ideal Home Range, Samsonite, and Fielmann. She is involved in several committees and boards, including serving as an advisory board member of Plant for the Planet, a board member of the BITKOM Working Group in New Work, and as the President of the Club of Budapest Germany.

Anabel Ternès has received multiple awards for her entrepreneurial and voluntary engagement, including the CEO eLearning of the Year Award, Ambassador of Women Entrepreneurs by the German Federal Ministry of Economics initiative, the Google Impact Challenge, and recognition as a LinkedIn Top Voice in Sustainability.

She is a fellow of the Aspen Foundation, the Stiftung Bürgermut, and Nexus Global.

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The Disruptive Alliance:
How the Synergy of Sustainability and Digitization Leads Companies to Success.

The world is facing tremendous challenges: climate change, resource scarcity, and social injustice threaten the stability of our planet and future generations. In this time of crisis, businesses must rethink their strategies and make bold decisions to be sustainable. The synergy between sustainability and digitalization offers a unique opportunity to address these challenges and develop future-proof business strategies. However, in order to establish this connection, we must have the courage to formulate provocative theses and question existing paradigms.

Thesis 1:
Digitalization is a prerequisite for sustainable business strategies.

To be sustainable, companies need to optimize their processes and efficiently utilize resources. Digitalization allows for real-time collection and analysis of information to make informed decisions. By employing technologies such as the Internet of Things, artificial intelligence, and big data, companies can reduce energy and material consumption, minimize waste, and overall decrease their ecological footprint. Without digitalization, sustainability remains merely a lip service without real impact.

Thesis 2:
Sustainability and digitalization create new business opportunities.

The combination of sustainability and digitalization opens up entirely new markets and business fields for companies. Consumers are increasingly willing to invest in sustainable products and services. By utilizing digital platforms and innovative technologies, companies can personalize their offerings, strengthen customer dialogue, and enhance customer loyalty. At the same time, new business models such as the sharing economy, circular economy, and green e-commerce are emerging, creating not only economic success but also ecological and social value. Companies like Vitra serve as exemplary examples of this.

Thesis 3:
Digitalization promotes transparency and accountability for sustainability.

In a time when trust and credibility are becoming increasingly important, digitalization enables unprecedented transparency throughout the entire supply chain. Companies can make their sustainability goals measurable and disclose information about origin, production conditions, and social impacts. This builds trust with consumers and promotes corporate accountability. Those who uphold their sustainability promises are rewarded, while those who hide behind them face a loss of trust and image problems. Companies like Patagonia are exciting role models and absolute pioneers in this regard.

Thesis 4:
Sustainability and digitalization require transformative leadership.

The synergy of sustainability and digitalization calls for transformative leadership that is willing to break old thought patterns and take bold steps. Companies need to move away from short-term profit thinking and integrate long-term sustainability goals into their strategies. Leaders must demonstrate innovation and risk-taking to implement new digital solutions and develop sustainable business models. They must motivate and empower employees to embrace change and actively participate in the implementation of sustainability and digitalization initiatives. Only through transformative leadership can companies fully reach the range of opportunities that the synergy of sustainability and digitalization offers. The transformation is not easy and presents organizations with challenges as they embark on this journey. Greenpeace is one of the organizations that is in the process of transitioning its structure to a holistic one.

Thesis 5:
The combination of sustainability and digitalization leads to a competitive advantage.

Companies that embed sustainability and digitalization in their DNA have the opportunity to differentiate themselves from the competition. They can reduce operating costs, increase efficiency, and simultaneously achieve positive ecological and social impacts. Customers, investors, and talented employees are increasingly inclined to prefer sustainable companies and pledge their loyalty to them. This leads to a competitive advantage that enables companies to be successful in the long term and to lead the transition towards a more sustainable and digitalized future. Especially companies that may have disadvantages due to their geographical location or being B2B-oriented can benefit from this, as seen in the case of Vaude.

The synergy of sustainability and digitalization is a powerful alliance that sets companies on a path to success for a sustainable world. Bold decisions, transformative leadership, and the utilization of digital technologies are the keys to integrating sustainability into corporate strategies and harnessing the opportunities of digital transformation. By responding to and acting on these provocative theses, companies can not only strengthen their own resilience but also make a positive contribution to addressing global challenges and shaping a more sustainable future.

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UV Protection of Zinc Oxide Nanomaterials in Sunscreen Applications

T. Khalil, M. Köhler, K. Wegner, M. Ommer

abstract

In recent years, material properties have been widely adapted to meet specific application needs including cosmetics, coating, doping or modifying the structure. Nanoparticles have shown a positive development due to its own various properties, functionalities and its applications in Cosmetics. One example where consumer expectations grow and the demand increases are UV protectors or sun creams. It was concluded that nanoparticles can be used in cosmetics like sunscreen to increase UV protection and prevent bacteria growth simultaneously. The available products are characterized by advantages and disadvantages of the various UV protection factors, and so far, no single material combines all desired properties. Nanotechnology shows an advantage character as it can be used to change the properties of the finely produced nanoparticles and influences products from various sectors as well as industries for a wide variety of applications, UV protection being amongst them.

Inorganic UV-A Absorbers

In contrast to organic UV absorbers, inorganic UV absorbers are long-term stable because their structure ensures high photon stability. The inorganic absorbers are migration-resistant and remain in the product matrix. Examples of suitable inorganic UV absorbers are ZnO, TiO_2 or CeO_2, as their band gap energy is lower than the photon energy of UV-A and UV-B radiation [1-3]. There is no need for protection against UV-C radiation since this is absorbed by the ozone layer [4].

ZnO can serve as a broadband filter and protects against UV-A and UV-B radiation [5]. Other inorganic UV absorbers such as TiO_2 and CeO_2 exhibit lower protection in the wavelength range of UV-A radiation. In addition, the photocatalytic effect of TiO2 is critical for some applications [6].

In cosmetics, paints and coatings, these materials protect against UV radiation as inorganic UV absorbers by their physical properties. Due to their material specific band gap, they can absorb UV radiation in the range from 100 to 380 nm [7,8].

Nanoscale Zinc Oxide

Due to its absorption behavior, nanoscale ZnO is predestined for applications that require complete UV protection in combination with transparency. The absorption edge of ZnO is between 370 and 380 nm, depending among other things upon the particle size [8] and is therefore close to the visible wavelength range of light, which begins at around 400 nm. A special property of zinc oxide is its sharp absorption edge. This allows complete UV protection and excellent transparency can be achieved [9].

Other inorganic UV absorbers have different absorption edges. CeO_2 only offers UV protection up to 330 nm and TiO_2 up to 320 nm. Technical TiO_2 offers complete UV protection, but due to the large particles pigment effect, transparent applications are excluded [10-12].

Zinc oxide and titanium dioxide are always mentioned together, the distinction is that TiO_2 is more responsible for the UV-B spectrum, whereas ZnO is more effective in the UV-A range [11,13]. When micro sized ZnO particles are used as sunscreens, they have a considerable impact on UV attenuation. Zinc oxide particles are found on the *stratum corneum*, the epidermis (the top layer of your skin), where the UV radiation is scattered, absorbed and reflected, safeguarding the live skin underneath [10,14-15], so they act as a physical block. Additionally, the absorption of UV radiation by ZnO depends on the size of the particle. The absorption ability increases with the diameter [13,16]. ZnO dispersions should preferably have small nanosized and bigger micro sized particles to provide the essential balanced UV-A and UV-B protection, therefore the particle size should not be as small as possible. Specifically, UV-A-1 protection is influenced by aggregated ZnO particles of >100 nm, rather than <20 nm ZnO primary nanoparticles. It has diverse forms (rod-like, star-like, and isometric) and a 30-150 nm size distribution range [17-18]. The normal spherical size particles are between 200 nm and 1 µm [18], and present in clusters. The TiO2 ingredients in cosmetics are not allowed to be used in some countries because they are considered to be carcinogenic. But only after they react with UV rays [19].

Only nanoscale ZnO guarantees complete long-term UV protection with excellent transparency. ZnO can be used as a UV absorber in various fields of application. The focus is on paints and varnishes as well as plastics and cosmetics such as sunscreen products [19-21]. Also, nano-ZnO particles stay on the surface of the skin and within skin furrows, but did not penetrate the live epidermis or produce cellular toxicity. This is different from TiO_2 which has higher toxic potential and skin penetration ability. It may pass the blood–brain barrier and be identified in several tissues, including the lung, brain, and spleen. The result comes from in vivo experiments on mice [21-23].

Production of IBUpart® ZnO in the Pulsation Reactor

ZnO powder with primary particle sizes between 10 and 50 nm can be produced in pulsation reactors. A pulsation reactor with its pulsating flame is based on the principle of an entrained flow reactor **(Figure1)**.

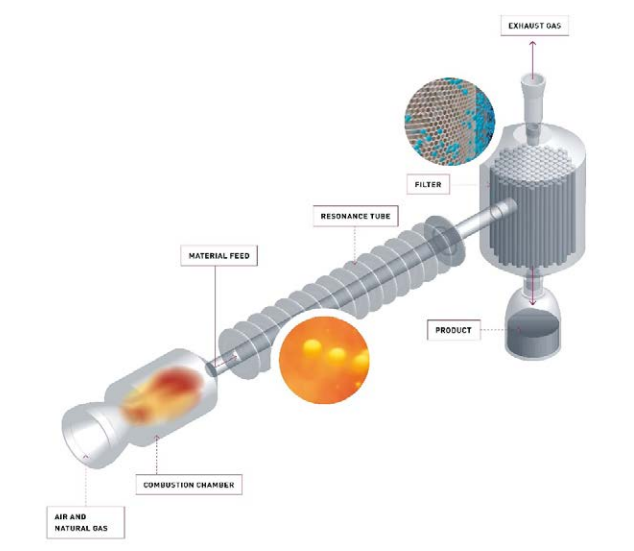

Fig. 1 Schematic Representation of a Pulsation Reactor

The material is treated in a pulsating hot gas stream with a residence time of fractions of a second to low single digits of seconds at temperatures between 250 and around 1300°C. The material can be fed as a suspension, solution or powder. The most important process parameters being treatment temperature, pressure amplitude and frequency of the pulsation, feed quantity and residence time. Pulsation reactors come in different sizes, from modular pilot plants to production scale.

In the pulsation reactor, a gas mixture is ignited in the combustion chamber. The resulting excess pressure is then discharged into the resonance tube. Due to the inertia of the outflowing gas flow, a vacuum is created in the combustion chamber for a short time, which draws in new fuel. This ignites and restarts the sub-process.

Depending on plant design and parameters, this sub-process is the starting point for the underlying frequency of a pulsation reactor, in a range of 1 to 500 Hz. The educt is introduced into the reaction tube, where the thermal treatment takes place during transport in the pulsating gas stream. After the reaction gas has exited the reaction chamber, the temperature of the gas flow is reduced by introducing a cooling gas before the product is separated in an exhaust gas filter or cyclone [24–25].

An advantage of the process is the homogeneous flow profile, which results in uniform process conditions for all particles. Feed rates of up to 150 kg per hour can be achieved in the pulsation reactor. Higher feed quantities are also tech-

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nically feasible, so that economically relevant quantities can be produced more cost-effectively without losing the advantages that pulsation reactors bring with them to produce nanoscale powders. For the material system under investigation, a liquid raw material containing zinc is injected into the pulsating hot gas. The special type of thermal treatment in the pulsation reactor results in a specific temperature-dwell-time curve for the particles. Typical characteristics are the short total dwell time of often well under one second, the particularly high heat transfer rate from the hot gas to the particles due to the pulsating gas flow (heating gradient) and the rapid cooling rate [26-29].

Test points	Product name IBUpart	Temp. ±10 °C	SSA m^2/g ± 2	C-content m% ± 0.1	Bulk density kg/m^3	D_{SSA} nm ± 2	$D_{Agglomerate}$ nm ± 10	D_{XRD} nm ± 1
VP1-T	Technicum	T1	70	1.6	80	13	150	8
VP2-P	ZnO-60	T1	60	1.2	80	15	160	9
VP3-P	ZnO-35	T2	35	0.29	90	30	250	18
VP4-P	ZnO-20	T3	20	0.15	100	50	500	25

D_{SSA} (nm) = 6000 / (SSA * Density ZnO in kg/m^3)

Table 1: Analysis of test samples.

Production and Characterization

A zinc-containing solution with a defined solid (oxide) content is fed into the pulsation reactor as educt. The raw material is vaporized and oxidized by the thermal treatment, resulting in the formation of nanoscale ZnO particles. Afterwards the hot gas is quenched with air to such an extent that on the one hand the particle formation process stops and on the other hand the final product can be separated in a filter system as a powder of agglomerated nanoparticles. In the investigation described in this article, the treatment temperature was varied between T1 and T3; T3>T2>T1. Afterwards the specific surface area, carbon content and crystallite size of the produced powders were characterized.

Table 1 shows the results of a powder synthesis for the various trial points. Specific surface areas (SSA) between 20 and 60 m^2/g on a production scale and 70 m^2/g in a pilot plant were reached. The difference between production and technical scale result from a higher production volume, which leads to larger particles and a lower specific surface area.

Within the trial series, the residual carbon content generated from the combustion of the educts decreased with increasing treatment temperature (**Figure 2**, left). In addition, a clear dependency between temperature and SSA can be seen in the investigated temperature window. The reduction in the process temperature resulted in an increase in the SSA. Crystallite sizes calculated using the Scherrer equation were between 8 and 25 nm (**Figure 2**, right). It is thus concluded that high quality nano-ZnO with various properties can be produced with the pulsation reactor.

The characterization of the powder by transmission electron microscopy (TEM) shows that the product consists of agglomerated nanoparticles with a primary particle size between 10 and 50 nm. The TEM images of the materials produced in this study are shown in **Figure 3** and **Figure 4**. They deliver

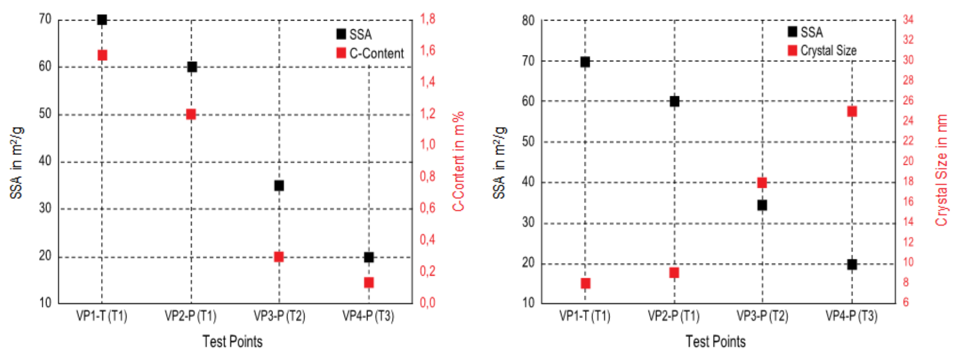

Fig. 2 Specific Surface Areas (SSA), residual carbon content and crystal size of Nanoscale Zinc Oxides Produced at Different Temperatures.

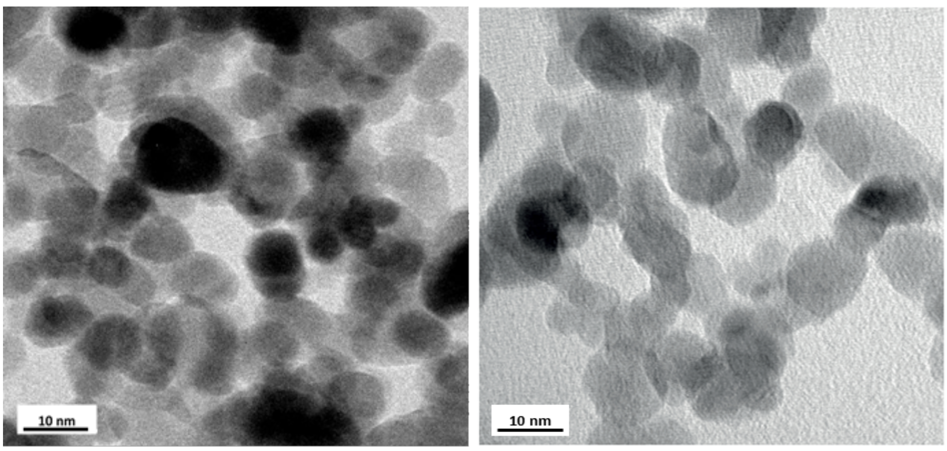

Fig. 3 TEM images of the ZnO products VP1 (left) and VP2 (right)

the following particle sizes: 10 to 15 nm for samples VP1 and VP2, 20 to 25 nm for sample VP3 and 20 to 50 nm for sample VP4.

The UV light spectra behavior of different ZnO powder

The powders were measured as 0.02 wt-% suspensions in water. All zinc oxides absorb UV light. The absorption edge shifts to higher wavelengths with increasing particle size. The transmission in visible light increases with decreasing particle size. The powders can be processed to suspensions by wet ball milling in different media. The UV-A range is from 320-400 nm and the UV-B range is from 280-320 nm. In general, zinc oxide shows both UV-A and UV-B absorption. The results of UV-Vis spectra of different zinc oxides are given in **Figure 5**.

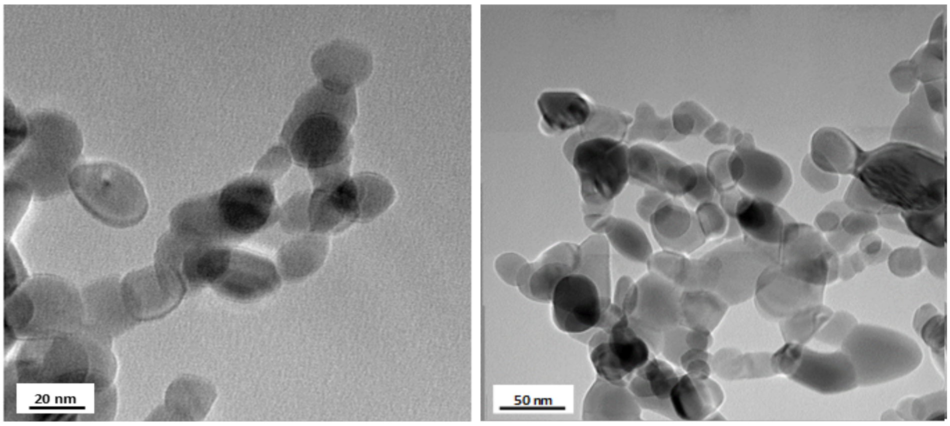

Fig. 4 TEM images of the ZnO products VP3 (left) and VP4 (right).

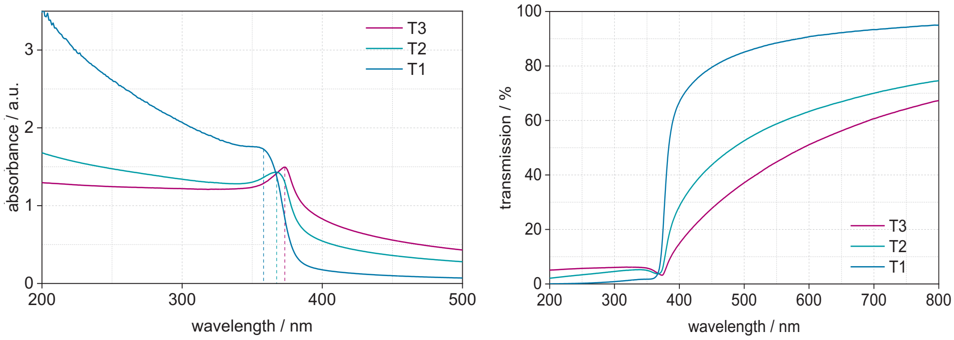

Fig. 5 UV-Vis of the ZnO products ZnO-20 (T3), ZnO-35 (T2) and Zn-60 (T1) Absorption (left) and Transmission (right).

According to the previous properties of different IBUpart ZnO **(Table 1)** and the UV-Vis specifications of ZnO powders, IBUpart ZnO-20 has been selected in sunscreen application due to the following results:

1. Higher agglomerate size D50 = 500 nm
2. More whiteness with C-content of 0,15 Wt.-%
3. Cover the highest wavelength value up to 380 nm as given in **Figure 5** left
4. Highest bulk density of more than 100 kg/m³

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Properties of IBUpart ZnO-20 in Sunscreen applications

The UV-Vis spectra of ZnO-20 and two different commercial references were analyzed. The powders were measured as 0.02 wt-% suspensions in water. The results are shown in **Figure 6**.

The UV-absorption spectra shows that IBUpart ZnO-20 has a higher absorbance value at the same wavelength in comparison to both different market reference commercial products. This emphasizes the application of IBUpart ZnO-20 for the sunscreen applications

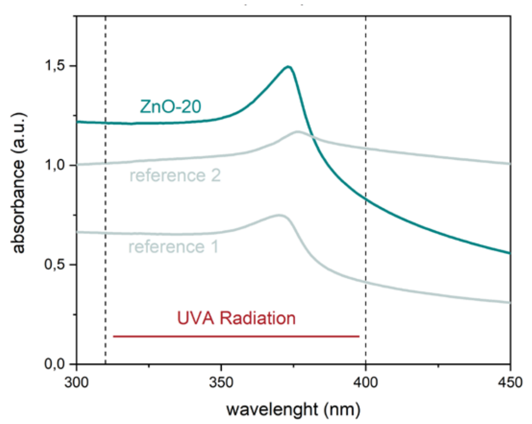

Fig. 6 UV-Vis of the ZnO powder ZnO-20 (T3), compared with two different commercial references

Production of different formulations and *in-vitro* studies in sunscreen

The basis for the two formulations was a recipe A [30-31] as well as a recipe B consisting of inorganic, natural and mineral ingredients [32]. It was referred to them as sunscreen basic formulations. The components and their function are given in **Table 2**.

The stable sunscreens were sent to the external institute HelioScreen in France to determine the sun protection properties.

Both formulations were tested at company HelioScreen. The test procedure was HePACK-SCREEN-1 which means evaluating the SPF, the UV-APF and critical wavelength (CW) which expresses the sun protection level of a sunscreen product through the full UV spectrum, using an adequate substrate on which the product has been spread and measured by means of a spectrophotometric method. For the sunscreens, two different formulations were used. The zinc oxide amount was 5 wt.-% **(recipe A)** nd 20 wt.-% **(recipe B)**, which is adjusted to real commercially available sunscreens. In **Table 3** the absorbers, the SPF and the critical wavelength (CW) in nm is listed.

In **recipe A**, IBUpart ZnO-20 has approximately the same sun protection factor as the other commercial zinc oxides. The standard, which contains only organic UV absorbers, has a SPF value of 13. With 5 wt -% ZnO 20 or reference 2 a SPF can be increased to 17. The additon of zinc oxide results in a SPF of 0.5-1 per 1 wt%. Therefore, a SPF value from the zinc oxide from 4-5 is reasonable for the used concentration.

In this formulation no zinc oxide reached 370 nm as critical wavelength, though no sunscreen has UV broadband protection. The reason might be that the zinc oxide reacts with the organic absorbers.

In **recipe B**, all sunscreens reached the critical wavelength of >370 nm. By using 20% by mass of zinc oxide, the following is achieved: ZnO-20 has a SPF of 10, reference 1 of 4 and reference 2 has a SPF of 11. Thus, ZnO-20 has a higher sun protection factor as reference 1 and a slightly lower SPF as reference 2.

Phase	Ingredient	Portion [wt.-%]	Function
A	Cetyl Alkohol	1	Surfactant
	Benzopenone 3	2.5	UV Filter
	Ethylhexylmethoxycinnamat	5	UV-B Filter
	Isopropyl Myristate	1	Binder, Perfume
	PVP/PA Copolymer	2	Binder, Stabilisator
	Stearic acid	6	Surfactant
	Wacker Belsil DM350	3.5	plasticizer
	Hydroxyethylcellulose	0.5	Binder
	Triethanolamine	2.5	Surfactant
	Water	60	Solvent
	Wacker-Belsil DM3096	16	Conditioner
B	coconut oil	37	Solvent
	jojoba oil	27	Plasticizer
	Aloe Vera Gel	24	Stabilisator
	beeswax	12	Binder

Table 2: Applied basic formulations

Sample	Zinc oxide [g/g] basic cream	Organic absorber [g/g] basic cream	SPF [-]	CW [nm]
Recipe A				
Reference 1	5	7	18.6±0.7	367
Reference 2	5	7	17±2.6	363
IBUpart® ZnO-20	5	7	17.3±1.8	362
Standard	0	7	13±0.1	
Recipe B				
Reference 1	20	0	4.2±0.1	382
Reference 2	20	0	11±1	372
IBUpart® ZnO-20	20	0	9.6±1.9	375
Standard	0	0	1	

Table 3: Produced sunscreen formulation: recipe A and B.

The additon of zinc oxide results in a SPF of 0.5-1 per 1 wt%. Therefore, a SPF value from the zinc oxide from 10 (ZnO-20) is reasonable for the used concentration.

Each zinc oxide in this formulation leads to broad spectrum UV protection. With its low SPF, reference 1 has a higher critical wavelength of 382 nm. The situation is different for reference 2 where the SPF is higher but the critical wavelength lower (372 nm) and thus 3 nm lower than with the ZnO-20. The results are shown in **Figure 7**.

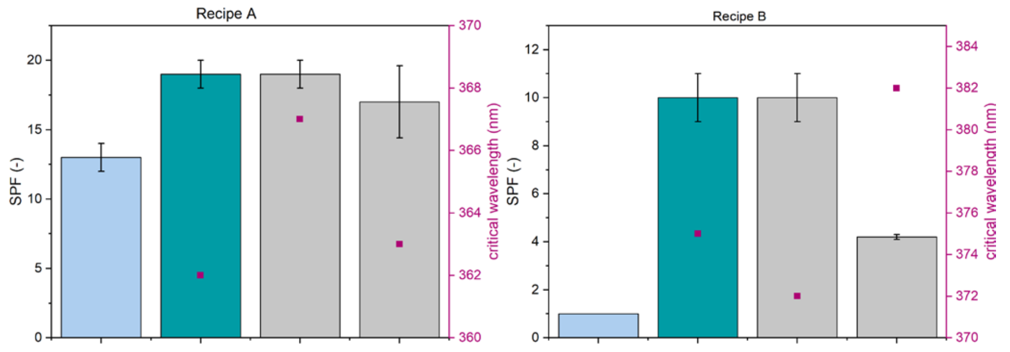

Fig. 7 SPF and CW of the ZnO powder IBUpart ZnO-20 (T3) in different sunscreen formulation, compared with two different commercial reference powder

However, in recipe B, all zinc oxides have a critical wavelength >370 nm. Therefore IBUpart ZnO-20 is appropriate for sunscreen application. Moreover, the values correlate with the standard and result in realistic values for the zinc oxide concentration in both formulations.

Accordingly, the ZnO produced in the pulsation reactor offers optimum behavior regarding SPF and critical wavelength compared to a commercially available ZnO references.

The production of ZnO in the pulsation reactor eliminates the visual disadvantage by producing a primary particle size in the nanometer range (10 nm – 50 nm). The individual particles then form agglomerates, which reach the required size for the application as sunscreen product. Compared to individual particles with more than 20 nm, these have better sun protection properties. The advantage of the zinc oxide produced in the pulsation reactor is the relative cost efficiency of the process, coupled with the low concentration required to provide full UV protection.

Conclusion for UV-sunscreen protection through suncream contain IBUpart ZnO-20

In this article, a process for the thermal production of nanoscale ZnO particles with specific properties for UV protection applications with pulsation reactor technology was presented. At small particle size of about 10 to 50 nm, a comparatively large specific surface area was achieved.

During the synthesis of nanoscale ZnO powder in the pulsation reactor, the influence of characteristic process parameters was investigated using various analysis methods. The characteristic properties of the optimized suspensions were investigated for the use as transparent inorganic UV protection and the results were discussed in this work. The UV protection characteristics remain during processing into a suspension.

Production in the pulsation reactor is advantageous compared to classical manufacturing methods such as sol gel and precipitation. These are associated with a multi-stage and thus energy- and resource-intensive production. In addition, they are difficult to scale and require harmful chemicals. The ZnO produced in the pulsation reactor allows large-volume applications – thanks to the low ZnO concentration required to provide full UV protection for use in cosmetics, paints and varnishes.

The own product IBUpart ZnO-20 as active ingredient shows UVA and UVB absorbing properties. It is comparable or has advantages in the properties to commercially available zinc oxides. In recipe A higher SPF values can be reached, but the critical wavelength is too low for the usage in sun protection applications. The increased SPF comes from the organic absorbers.

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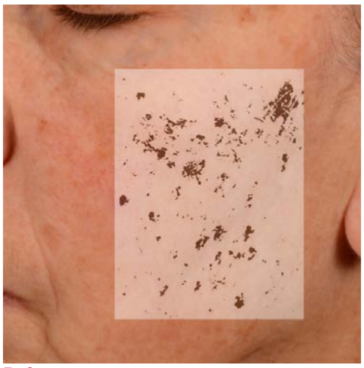

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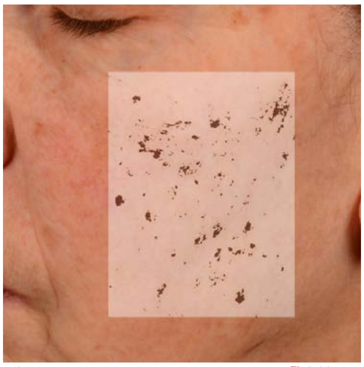

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SPF Boosting? Naturally, Natural!

M. Busch, M. Issleib, L. Jung, C. Teubner

Consumer wishes change based on a growing consciousness for the environment and people. Also, regulations change and evolve due to current and updated scientific findings. This also affects the range of commonly used UV filters. As an industry, we develop products that address these trends and meet those requirements. Consequently, we must find innovative ways to develop and optimize sunscreen products where SPF boosters play an important role.

SPF boosters shall increase the value of SPF and preferably UVA-PF and allow to reach higher sun protection factors with the same amount of UV filters. These products are not considered as UV filters because they, alone, do not significantly contribute to SPF or UVA. But they can help sunscreen formulators to answer the demands for high SPF products while considering a limited choice of UV filters.

In the pursuit of developing a SPF booster based on renewable and biodegradable raw materials we have evaluated potential candidates for their efficacy. These were incorporated in sunscreen preparations and compared to a placebo formulation without SPF booster, starting with *in-vitro* measurements of the UV absorbance based on ISO 24443:2021, followed by evaluation of the impact of the SPF booster concentration. The most promising candidates were further tested on their performance in water-in-oil as well as oil-in-water emulsion systems and with mineral and organic UV filters according to the different *in-vivo* methods ISO 24444:2019, FDA monograph standard 21CFR201.327 and hybrid diffuse reflectance spectroscopy.

To extend the set of data the influence of UVA and UVB absorbance was examined as well as the impact on the sensorial profile when adding a SPF booster to an already existing formulation.

Showing outstanding efficacy in *in-vitro* and *in-vivo* evaluations of the sunscreen protective properties the wax blend SymEffect™ UV performs in different emulsion systems and works with a variety of UV filter combinations to boost the SPF. Additionally, the balance between UVA and UVB absorbance of the initial sunscreen formulations is kept on the same level when including the wax blend, and the final sensory profile is comparable to the placebo formulations.

Introduction

The sun care market evolved over time from products that were mainly developed for the use at the beach and during outdoor activities, while nowadays also day creams and lotions frequently claim sun protection properties.

High SPF sunscreens demand high concentrations of mineral and/or organic UV filters. But the choice of widely accepted UV filters narrows due to regulatory restrictions and consumer expectations. Solutions are needed to increase the efficacy of the formulations or to use less UV filters while maintaining the level of protection. Symrise has developed a naturally based solution to enhance the SPF with a wax blend based on natural derived ingredients. This enables cosmetics manufacturers to achieve higher protection at the same UV filter concentration.

SymEffect™ UV (INCI: Hydrogenated Palm Oil, *Saccharum Officinarum* (Sugarcane) Extract) is this synergistic wax blend, fully based on natural derived ingredients and designed for maximum UV protection.

The wax blend has a Natural Origin Content of 100% according to ISO 16128:2 and is vegan suitable.

Materials & Methods

The performance of a SPF booster can first be tested *in-vitro* after the application on a substrate by the determination of an absorbance curve compared to a placebo formulation **(Figure 1)**. Subsequently the increased absorbance with the SPF booster should result in an elevated SPF when tested on human skin (*in-vivo* measurement) as well. *In-vitro* measurements function as indication of the efficacy at the beginning of development while in-vivo measurements are required to validate the results.

In-vitro SPF testing

Our method of *in-vitro* testing for SPF is based on ISO 24443:2021 „Determination of sunscreen UVA photoprotection *in vitro*" [1] in which the UV-transmittance through a thin film of sunscreen sample spread on a roughened substrate, before and after exposure to a controlled dose of radiation from a defined UV exposure source is measured.

This method allows to test several samples in an early development stage and indicates the efficiency of SPF boosters in comparison to placebo sunscreen formulations.

After evaluating SPF boosters for their general efficacy in a further step the dose dependent effect is measured by testing the same formulation with different concentrations of the active ingredient.

As the basis of emulsions can differ substantially a product that is boosting the SPF of sunscreens works ideally in both systems: Water-in-oil emulsions, where water droplets are dispersed in the oil phase, and oil-in-water emulsions in which the oil droplets are dispersed in the water phase.

Additionally, UV filter combinations that form the foundation of the sunscreens protective characteristics can differ per region due to e.g., regulatory limitations of allowed UV filters but also in terms of the class they belong to. The main two categories are "mineral" and "organic" UV filters. Titanium Dioxide and Zinc Oxide are the two insoluble pigments that make up the category of mineral UV filters, while organic UV filters contain carbon atoms and are mostly soluble in either water or oil.

To secure the performance of SPF boosters in a broad selection of formulations it should demonstrate efficiency with these different emulsion and UV filter systems *in-vitro* and *in-vivo*.

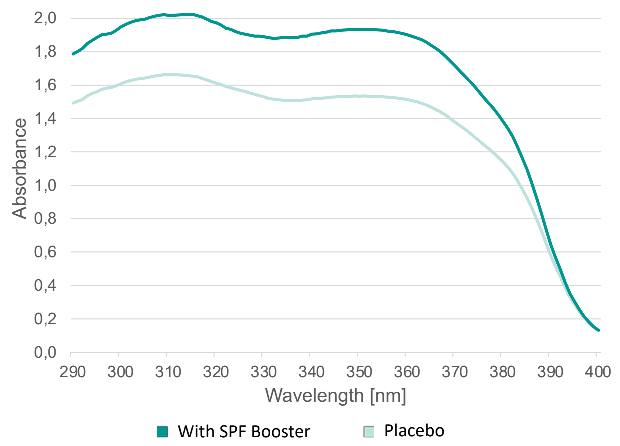

Fig. 1 Increased absorbance

In-vivo SPF testing

Successful *in-vitro* test results should be verified with in-vivo tests, for which different accredited standard methods are available:

The international standard ISO 24444:2019 "*In vivo* determination of Sun Protection factor (SPF)" [2] specifies the procedure selecting and preparing test subjects, applying the sunscreen product and exposing the skin of participants to UV radiation. SPF values are measured and calculated based on the amount of UV radiation required to produce a minimal erythemal dose (MED) in protected and unprotected skin.

FDA monograph standard 21CFR201.327 [3] is a regulatory standard established by the Food and Drug Administration (FDA) for labelling of sunscreen products. One requirement

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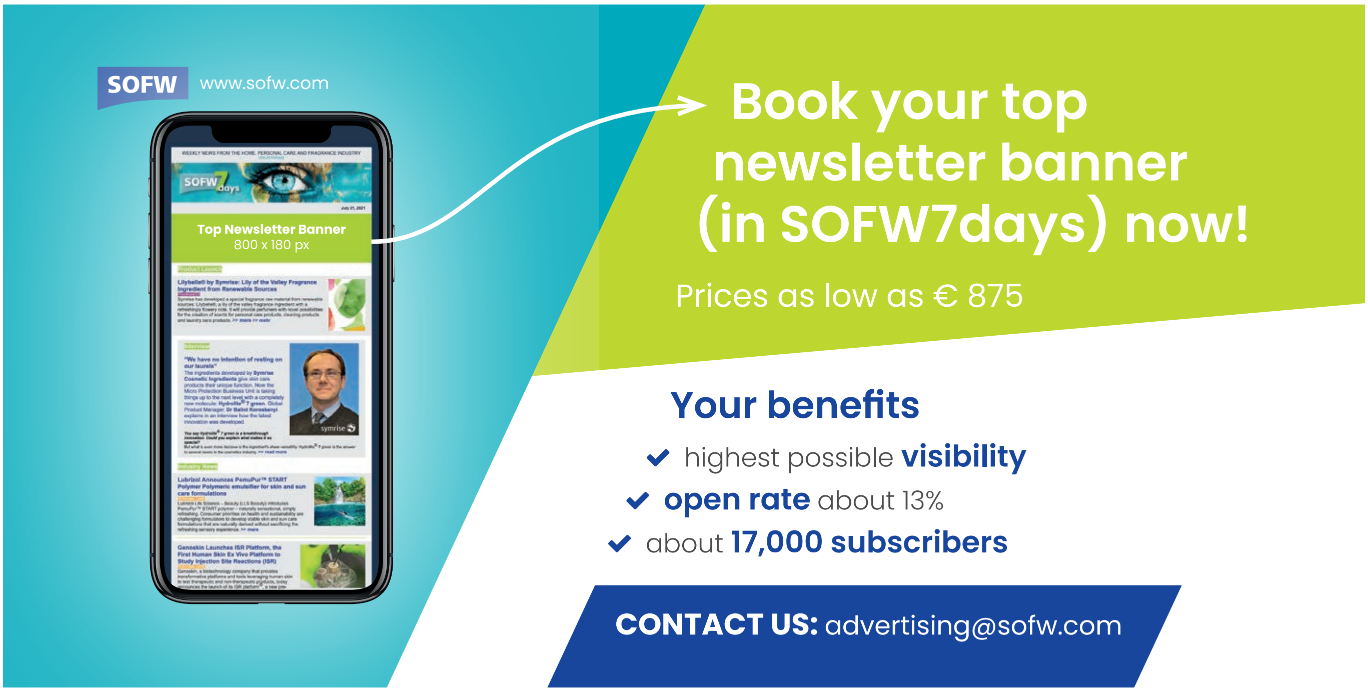

is that sunscreen products must be tested for SPF in accordance with the methods specified in the FDA's "Final Rule for Labelling and Testing Requirements for OTC Sunscreen Drug products" that differ slightly in terms of the procedure and equipment used compared to ISO 24444:2019.

The determination of sun protection by Hybrid Diffuse Reflectance Spectroscopy (HDRS) [4] represents a noninvasive in-vivo method as it does not provoke an erythemal skin reaction by UV irradiation. It combines the transmission measurements on a substrate, similar to the *in-vitro* SPF method, with a diffuse reflectance spectroscopy on the skin in which the erythemal UVB radiation is not visible. The HDRS technology is one of the alternative methods for *In-vivo* SPF testing ISO 2444:2019, recommended by Cosmetics Europe [5].

As the sun protection factor is mainly based on the absorbance and reflection of UVB radiation it is important to evaluate the impact on the balance between UVA and UVB absorbance when including a SPF booster in order to comply with minimal regulatory requirements for the UVA protection of sunscreen products depending on the region.

Sensory test

In a sensory assessment of 18 trained panelists the sensorial profile of our formulas was tested, following a defined routine for evaluation of 22 parameters. The panelists evaluate only one formulation at a time and don't compare two or more formulations in parallel. As the evaluation happens under the same circumstances a comparison between any formulation is possible. In this study we have compared the formulations to placebo formulations without the wax blend.

The parameters are divided into three categories according to a typical encounter with a new cosmetics product.

1. Product description (5 parameters) - evaluation of first impression of the product
2. First sensorial skin feel (9 parameters) – sensory impression during application
3. End skin feel, 3 minutes after application (8 parameters) – sensory impression after application

Each parameter is ranked from a scale of 0 – 4 with higher values indicating the parameter is more pronounced.

Results

In-vitro SPF testing

The wax blend SymEffect™ UV proves its effectiveness from 2 to 5% when tested *in-vitro* from oil-in-water systems with a rising boost of the SPF as the concentration increases **(Figure 2)**.

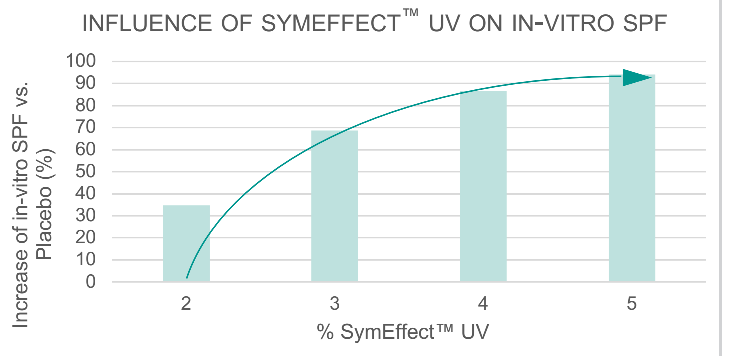

Fig. 2 Influence of SymEffect™ UV on *in-vitro* SPF

Considering cost-in-use, the performance of the wax blend in different concentrations, measured according to the ISO 24443:2021 "Determination of UVA photoprotection *in vitro*", shows at 3% use level the most efficient SPF boosting.

In-vivo SPF

Based on the *in-vitro* results the wax blend was incorporated at 3% use level in different O/W emulsions that contain a variety of UV filter systems that are either suitable for mineral or chemical sunscreens. To compare the direct effect on the SPF an emulsion base with the wax blend and without (placebo) was tested.

The formulations were screened depending on the UV filter system for their *in-vivo* SPF **(Figure 3)** according to the:

- * FDA Monograph Standard 21CFR201.327 [3],
- ** ISO 24444:2019 "*In vivo* determination of Sun Protection factor (SPF)" [2] or
- *** Determination of Sun Protection by HDRS" [4].

The efficacy of the wax blend could be shown in-vivo with different combinations of organic UV filters **(Figure 3)** and in different test methods. Whereas the final performance can be affected by the formulation-base or UV filter combinations.

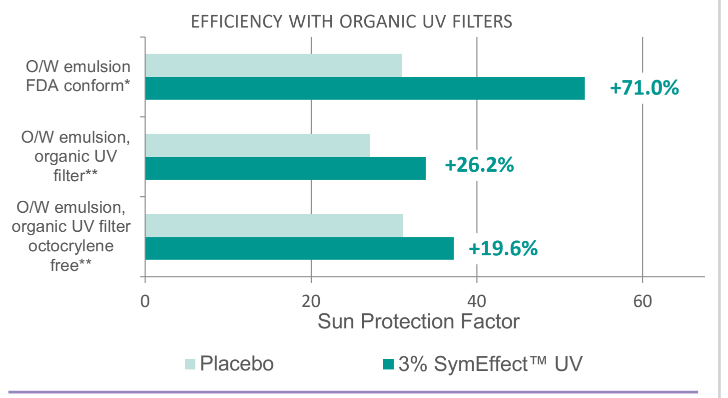

Fig. 3 SymEffect™ UV efficiency with organic UV-filters

In the sunscreen formulation that contained a combination of UV filters conforming to the Food and Drug Administration (FDA) guidelines, a boosting effect on the SPF of +71.0% could be achieved. This is typically realized only by incorporating a substantial concentration of additional UV filters.

Although the increase of the SPF is dependent on the formulation in which the wax blend is used, with a minimum of 19.6% a significant boosting is achieved in all tested formulations containing organic UV filters.

To investigate the influence on the *in-vivo* SPF in mineral sunscreens, 3% of the wax blend were formulated in a water-in-oil emulsion as well as an oil-in-water emulsion. Both emulsions were tested according to the "Determination of Sun Protection by HDRS" and resulted in an *in-vivo* SPF increase of up to approx. 50% vs placebo formulation **(Figure 4)**.

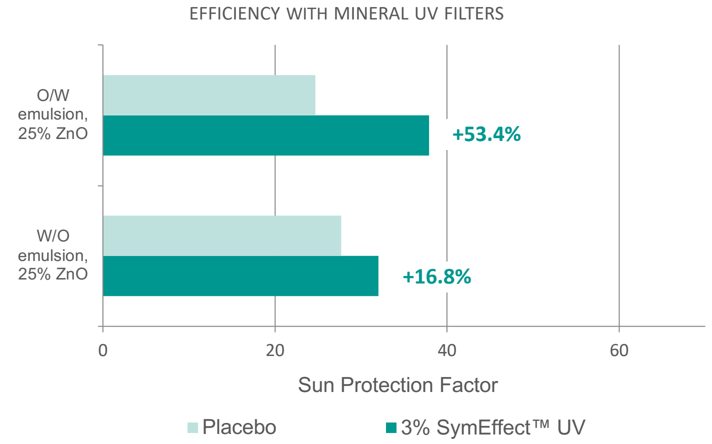

Fig. 4 SymEffect™ UV efficiency with mineral UV-filters

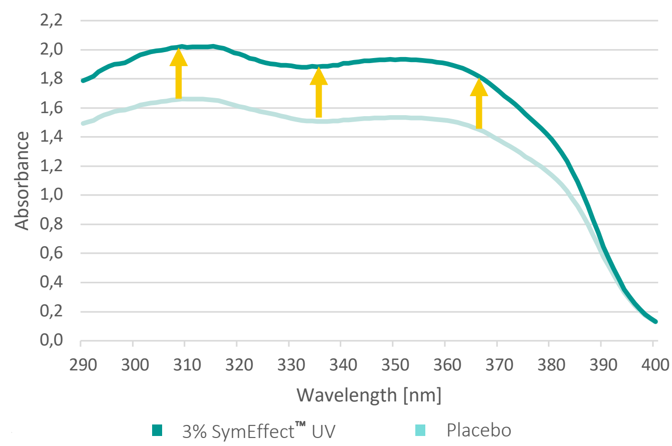

Fig. 5 Influence of SymEffect™ UV on the UVA-Balance

Impact on the UVA balance

As the Sun Protection Factor is mainly based on the absorbance and reflection of UVB radiation it is important to evaluate the impact on the balance between UVA and UVB absorbance when including a SPF booster to comply with regulatory requirements for the UVA protection of sunscreen products depending on the region. In the European union sunscreens should provide a UVA balance of at least 33.33% [6].

In the *in-vivo* tested formulations, the wax blend increases the absorbance curve evenly over the entire wavelength range and thus maintains the balance between UVA and UVB protection **(Figure 5)**.

Calculating the UVA-Balance according to the commission's recommendation of 22nd September 2006 (notified under document number C(2006) 4089) for placebo formulation and the emulsion with the wax blend, no significant deviations were found **(Table 1)**.

Consequently, it could be validated that SymEffect™ UV promotes both UVA and UVB absorbance in formulations evenly.

Formulation	UVA-Balance with and without SymEffect™ UV
O/W emulsion organic UV filters; octocrylene-free	54 % +/- 2 %
W/O emulsion 25% ZnO	45 % +/- 2 %
O/W emulsion FDA conform	38 % +/- 1 %

Table 1 Influence of SymEffect™ UV on the UVA-Balance

FORMULATIONS
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Impact on Formulations sensorial aspects

Depending on the formulation an addition of ingredients can have very variable impacts. That is why we have tested the sensorial impact of the wax blend in different emulsion bases. The sensory profile of an oil-in-water emulsion with organic water- and oil-soluble UV filters is very different from a water-in-oil emulsion with a high concentration of mineral UV filters.

In the sensory profile of the W/O emulsion with mineral UV filters **(Figure 6)** the peaking during evaluation of the first impression is slightly increased which indicates a viscosity supporting effect of the wax blend. During application and for the final skin feel after 3 minutes the parameters are similarly pronounced with or without the wax blend.

A similar effect is seen in the sensory profile of an O/W emulsion with water- and oil-soluble UV filters **(Figure 7)**. The addition of the wax blend increases the cushion effect and consistency, while the skin feel during application and in the final skin feel is comparable.

Conclusively, the impact on the sensorial aspects of both formulations by the addition of the wax blend SymEffect™ UV is limited to parameters of the first sensory impression, while the skin feel during and after application is kept comparable.

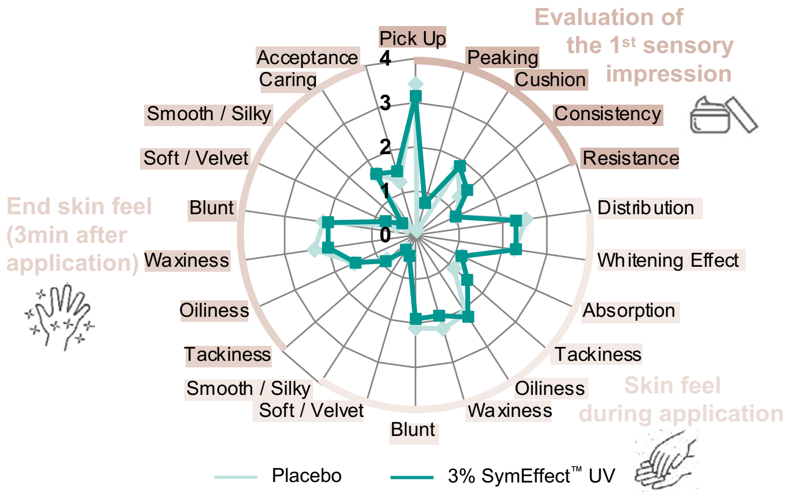

Fig. 6 Sensory profile of W/O emulsion with 25% mineral UV filter

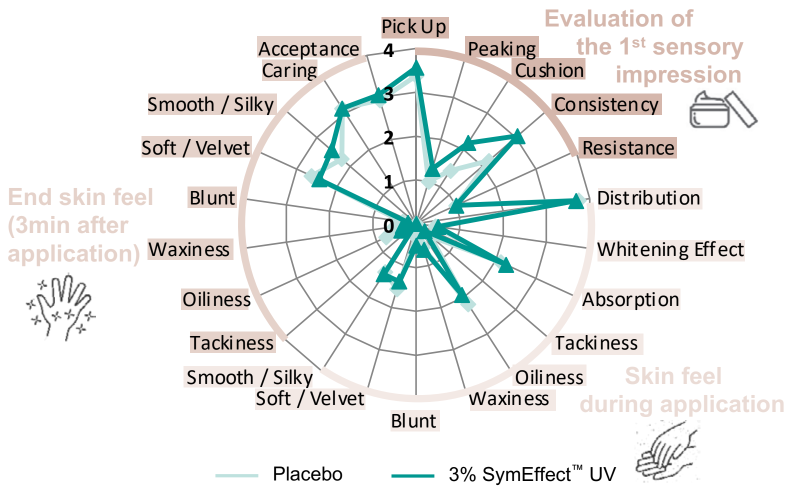

Fig. 7 Sensory profile of O/W emulsion with water- and oil-soluble UV filters

As the SPF booster has no significant impact on the skin feel, the incorporation in formulations well accepted by consumers is simplified.

Conclusion

In search of a solution for the increasing challenges in the field of cosmetic and sunscreen formulations the UV protection booster SymEffect™ UV offers a way to increase efficacy in many kinds of applications. As it is fully based on renewable and biodegradable ingredients SymEffect™ UV can be considered a sustainable solution to increase the SPF in a natural way. It can be easily incorporated into the oil phase of creams and lotions without significant impact on the final sensorial profile. Working well with different emulsion types and UV filter systems this wax blend can be used in cosmetic products with sun protection factors, such as beach products, daily face creams and care products for children, while maintaining the balance of protection against UVA and UVB irradiation.

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The Skin Microbiota Photoprotection: Crossing Frontiers in Skin Photoageing

Ò. Expósito, A. Guirado, M. Buchholz, A. Gallego, M. Mas, P. Riera, D. Luna, S. Laplana, T. Ruiz, S. Ruiz, M. Gibert, M. Molné

In the last years, the role of skin microbiota in modulating the skin homeostasis has been described. Less known is the microbiota role in the protection of skin against sun radiation. While a healthy and balanced skin microbiota helps protect the skin in front of the harmful effects of sun exposure, a microbiota having lost the correct equilibrium generates metabolites which affect the aspect of skin, worsening the photo-induced ageing.

The active Photobiome™ protects the microorganisms involved in skin photo-protection, boosting the good metabolites (antioxidants, soothing compounds, etc.) which help our skin defend itself in front of harmful radiation. Made from *Punica granatum* and *Gossypium herbaceum* stem cells, it contains a skin photo-protecting cocktail. It is a new active with anti-photo-ageing activity backed by a complete panel of *in vitro* and *in vivo* tests.

Introduction

A new player in skin photoageing: The Photobiome Factor

The skin microbiota plays a key role in skin homeostasis and the skin microbial ecosystem evolves with age [1,2,3]. Furthermore, the microbiome is highly relevant regarding the regulation of skin functions when the skin is exposed to sun radiation.

Various microorganisms of the skin microbiota have been identified for having especially important functions in protecting the skin in front of UV radiation [4,5]: *Staphylococcus epidermidis*, *Micrococcus luteus*, *Bifidobacterium spp*. and *Malassezia furfur*. The metabolism of these microorganisms contributes in the protection of our skin against the exposure to sun radiation.

S. epidermidis can produce Short Chain Fatty Acids (SCFA) which inhibit the sun erythema, reducing the pro-inflammatory cytokine IL-6, as well as increasing the collagen expression in fribroblasts [6], thus improving the skin firmness and elasticity.

M. luteus can resist high dosages of UV radiation thanks to the production of a high amount of carotenoids [7,8], at the same time it synthesizes UV endonuclease, which eliminates Cyclo-Pyrimidine Dimers (CPD) in damaged DNA, repairing it [9].

Bifidobacterium spp. also produce SCFA, such as lactate, which protect from free radicals (Reactive Oxygen Species, ROS) [10], preventing UV radiation-induced damage in collagen [11], as well as reducing pro-inflammatory cytokines (IL-6, IL-1b and TNFα) and modulating metalloproteases MMP-1, MMP-3 and MMP-9 which degrade skin collagen. Finally, these bacteria synthesize urolithins [12], natural microbial antioxidants highly beneficial for the skin [13,14,15,16].

M. furfur, and other species of *Malasseziaceae*, can produce melanin and melanin-like pigments [17,18,19].

These microorganisms are affected by the sun radiation, and if their environment is not the most suitable, the loss of homeostasis will impact our skin, potentially leaving it defenseless in front of the harmful effect of sun exposure. The skin microbiota and its state in front of sun radiation, including the microbial metabolic behaviour, is the **Photobiome Factor**. These microorganisms can interact with sun radiation and produce specific metabolites: **the solar postbiotics (metabiotics)**.

Among these postbiotics, **microbial melanin and urolithins** stand out. **Both compounds photo-protect cutaneous microbiota and are part of the skin's natural photo-defense system.** If the conditions are not favourable, like with an excessive sun exposure, the population of these protecting microbes is dramatically reduced, the production of urolithins and melanin is decreased, and the cutaneous synthesis of harmful metabolites (ROS, IL-6) gets higher, worsening the skin photo-induced damage and the photo-ageing.

Therefore, we present a **new axis in cosmetics**: **Sun-Microbiota-Skin**. This biological axis allows tackling the photo-ageing with a totally innovative approach: we can **combat the photo-ageing from excessive sun radiation exposure by protecting our skin microbiota**.

Preventing photo-ageing through skin microbiota

Photobiome™ is a 100% natural active ingredient from stem cells of pomegranate (*Punica granatum*) and cotton from desertic and semi-arid regions of the Near and the Middle East (*Gossypium herbaceum*). Through a new technological platform of **Phyto-Cell Fusions**, we combine a Phyto-Lipidic Fraction (PLF) of *P. granatum* with a Plasma Rich in Cell Factors (PRCF) of *G. herbaceum*. This way, we obtain a **synergistic effect of prevention from photo-ageing by photo-protecting the skin microbiota (Figure 1)**.

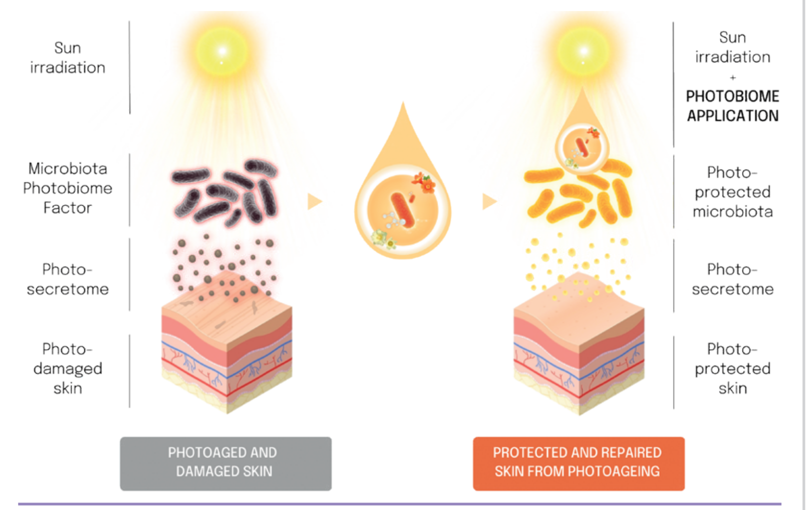

Fig. 1 Mechanism of action of Photobiome™

The **membrane lipids of de *P. granatum*** (phospholipids, glycolipids, etc.) have been maximized in this active ingredient, together with the plant's antioxidants, the **polyphenols** and the **hydroxybenzoic acids like ellagic acid**. Furthermore, the **Phyto-Lipidic Fraction helps to encapsulate these antioxidants**, and by **fusing** this fraction with the **PRCF of *G. herbaceum***, the **active molecules** of this extremophile cotton (mainly, **plant chromophores** like polyphenols and other defense molecules) **are also encapsulated in the lipids from *P. granatum***.

This **Phyto-Cell Fusion is complemented with two more plant-derived substances**: the **fructooligosaccharides** and the **trehalose**, sugars that help protecting the cell membranes of the skin microbiome against adverse conditions like dehydration. Therefore, the fructoologisaccharides and the trehalose **also contribute to protecting the microbiota in front of sun radiation and as a consequence, to protecting our skin against its harmful effects**.

Biological activity

In vitro

Protection of skin microbiota against sun radiation

The bacterial population (CFU) of different microorganisms was quantified (*S. epidermidis*, *M. luteus* and *B. pseudocatenolatum*), each cultured in its specific culture medium in Petri plates (serial dilutions followed by CFU count), in different conditions: non irradiated, and irradiating at 6J (broad spectrum: UV, visible and IR) in absence or presence of the active (at a 20% dosage, as the bacterial populations were very high, between 200,000 and 5,000,000 CFU).

The sun radiation reduced the bacterial populations, while the active could maintain higher rates of survival. *S. epidermidis* was the bacteria with highest CFU count reduction in front of sun radiation, and in this case the ingredient increased the bacterial survival by 7-fold versus the irradiated untreated control. With *M. luteus* and *B. pseudocatenolatum*, more than the 100% of the CFU count was recovered compared to the irradiated untreated control.

In another assay, the effect of sun radiation on a co-culture of various microorganisms in plates was analysed. The microorganisms cultured were: *S. epidermidis*, *Staphylococcus capitis*, *Streptococcus mitis*, *Corynebacterium tuberculostearicum*, *Corynebacterium simulans*, *Cutibacterium acnes*, *Malassezia pachydermatis*). A total reduction of the microbiota was observed when irradiating 2.69J (UV) and applying a lotion without any SPF. But with the same irradiation plus a lotion with a 3% of Photobiome™, the co-culture could maintain a 43% of survival **(Figure 2)**.

Effect of the sun radiation, and the active, in the microbial metabolism

Vytrus has carried out, for the first time, research to understand the effects of sun radiation in the microbial metabolism of skin microbiome, and to study the effect of microbial secretome after sun exposure (photo-secretome, PS) on keratinocytes.

When irradiating *B. pseudocatenolatum* (6J; UV, visible and IR), a reduction by 29% in the production of urolithins com-

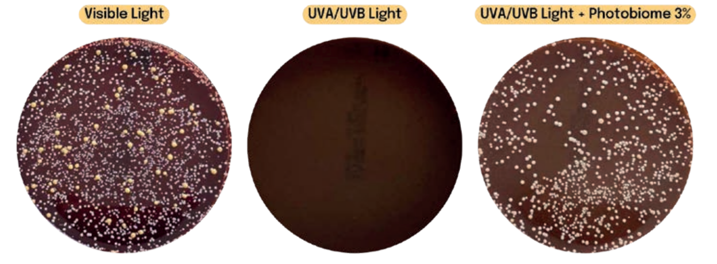

Fig. 2 Protection of the model skin microbiota co-culture by Photobiome™ 3%. UV exposure reduces the count to zero, while the active achieves 43% survival of the microbiota.

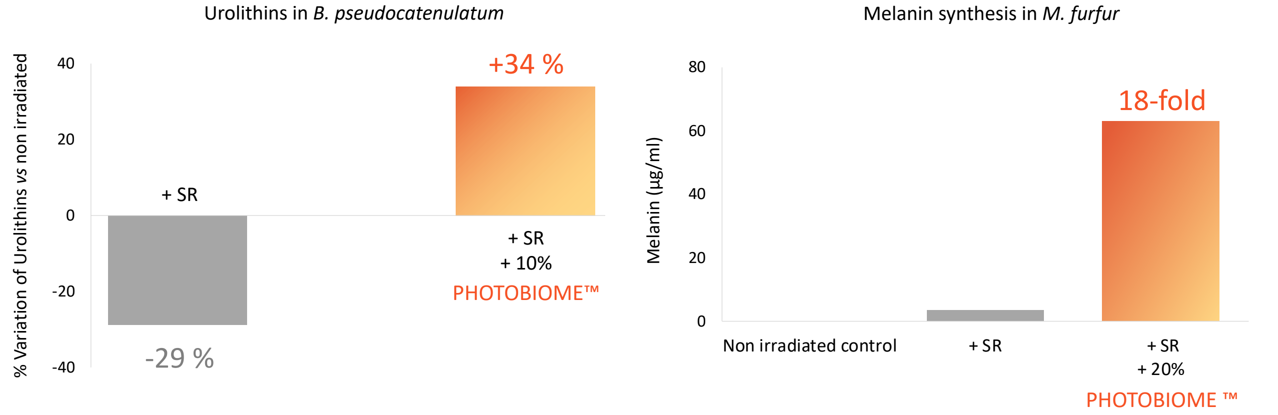

Fig. 3 Increased production of urolithins in *B. pseudocatenolatum* and melanin in *M. furfur* with Photobiome™ (SR = Solar Radiation).

pared to the non-irradiated control was observed (quantification by UPLC in the bacterial supernatant, i.e., the photo-secretome, PS). With the same irradiation in the presence of a 10% of the active, though, the opposite effect was obtained: the synthesis of urolithins increased by 34% versus the non-irradiated control **(Figure 3)**.

In parallel, we observed that sun radiation caused some increase in the melanin production in *M. furfur*, but if in addition to sun radiation, the *M. furfur* culture is treated with 20% of the ingredient, the increase is 18-fold higher **(Figure 3)**. In a flow cytometry assay, cultures of *S. epidermidis* and *M. luteus* exposed to sun radiation produced more ROS than their non-irradiated controls. But under the same exposure in the presence of 20% of the active, a reduction of ROS production was observed, by 67% in *S. epidermidis*, and by 19% in *M. luteus*, compared to the irradiated controls which were not treated with the ingredient.

Finally, we analysed the effect of the microbial photo-secretome (PS) on ROS and IL-6 production on keratinocytes, in different condition: effect of the treatment of keratinocytes with 1% of each PS, effect of irradiating the keratinocytes at the same time they were treated with 1% of each PS, and effect of the active on keratinocytes irradiated and at the same time treated with 1% of each PS **(Figure 4)**.

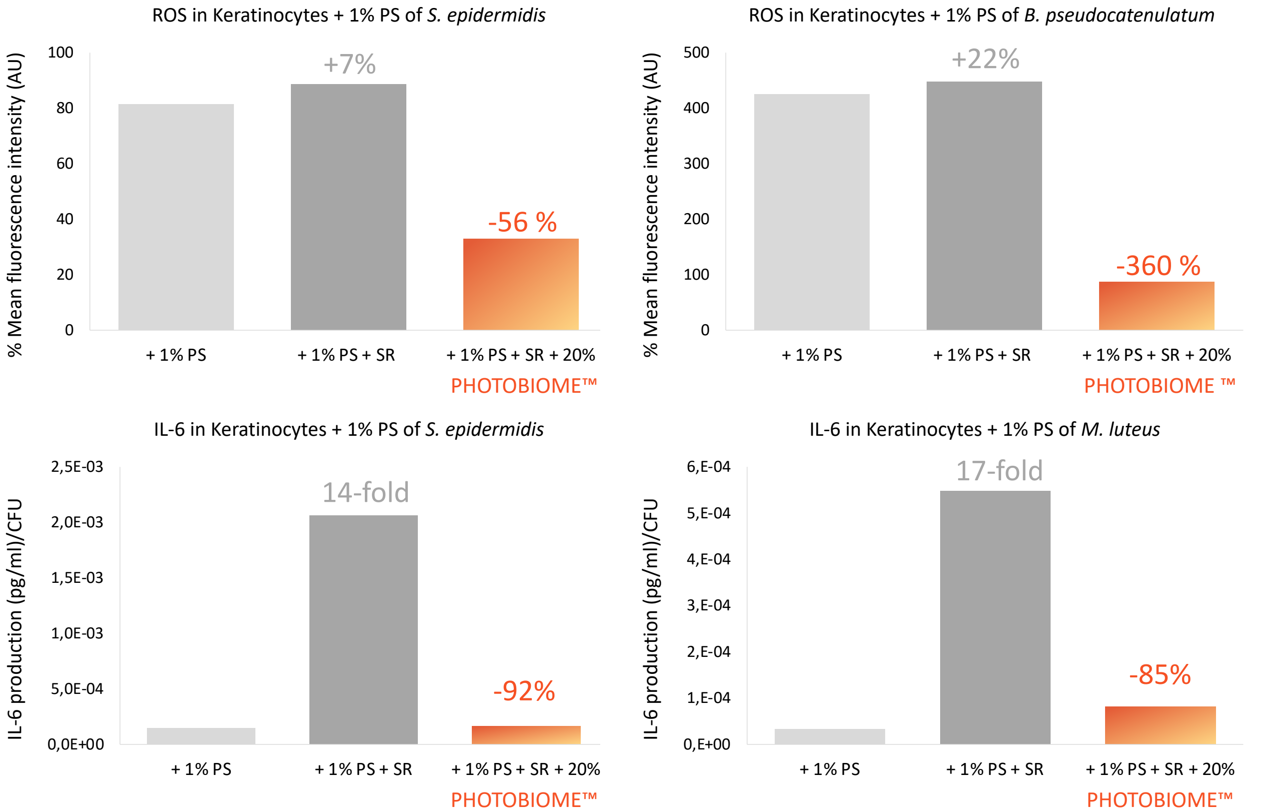

Fig. 4 Effect of different microbial photosecretomes (PS) on ROS (PS from *S. epidermidis* and *B. pseudocatenolatum*) and IL-6 (PS from *S. epidermidis* and *M. luteus*) production in keratinocytes. Photobiome™ reduced ROS and IL-6 production in keratinocytes exposed to solar radiation (SR) as well as microbial photosecretomes (PS).

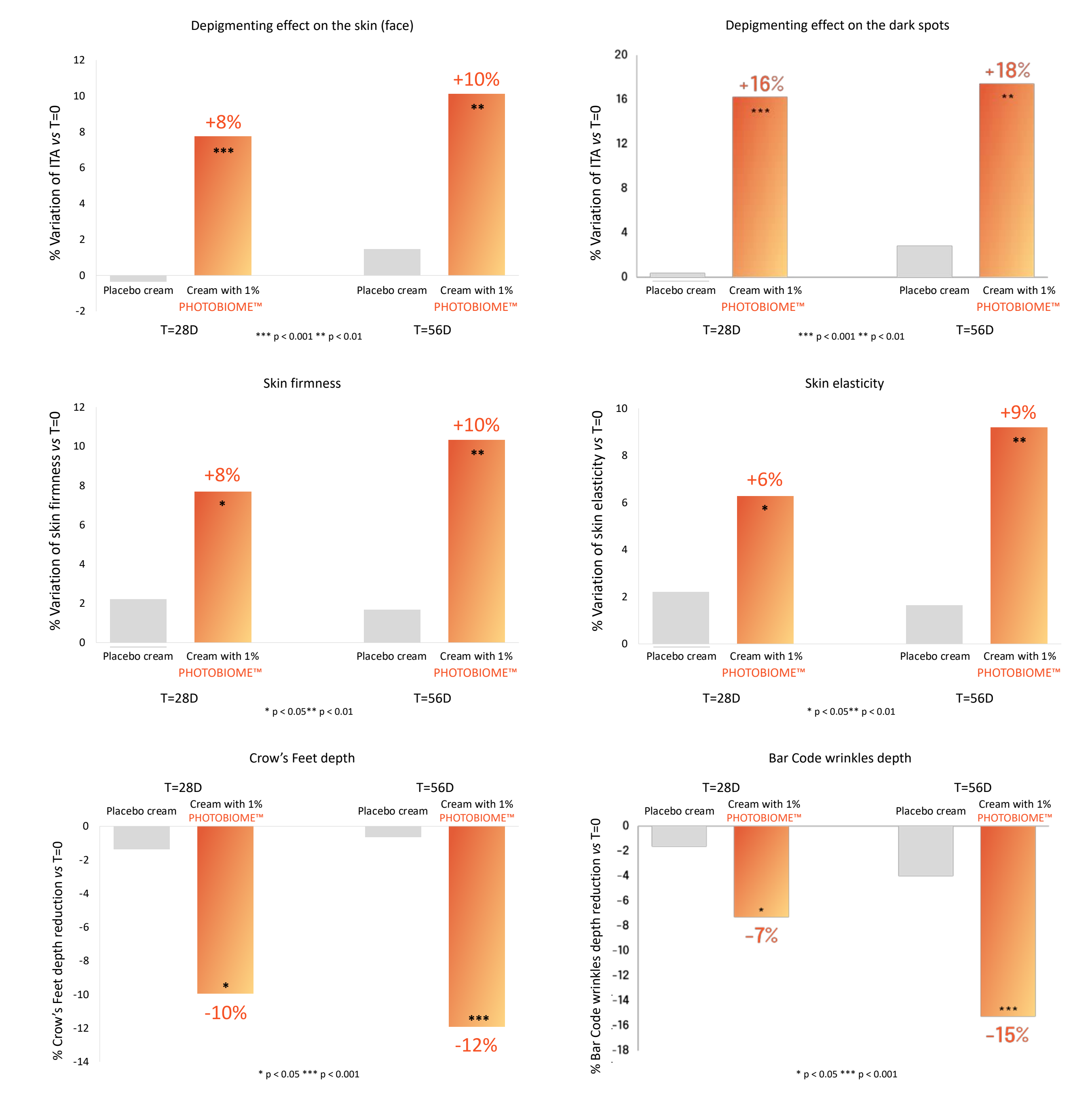

Fig. 5 Photobiome™ significantly increased, with respect to placebo, ITA on face and spots, as well as skin firmness and elasticity, at 28 and 56 days of treatment. The active also significantly reduced the depth of wrinkles in the crow's feet and nasolabial area (barcode) at both 28 and 56 days.

Clinical evaluation

In vivo test performed with 20 volunteers with signs of photo-ageing, summer tan and ages between 49 and 67. Double-blind and placebo-controlled assay, hemi-facial application, 1% Photobiome™ dosage, with two daily applications during 28 and 56 days. The test was carried out in Italy in the end of the summer season so the sun exposure and the damage on the volunteers' skin were maximized.

The variation in the Individual Tipology Angle (ITA) was measured in order to study the skin pigmentation during the treatment, both in the face and in the dark hyperpigmented spots (CM-700D colorimeter from Konica Minolta). Furthermore, the skin firmness and elasticity were assessed by cutometry, and by skin profilometry and PRIMOS 3D analysis, the variation in wrinkle depth in the crow's feet and in the nasolabial regions (eye contour and bar code areas) were also analysed **(Figures 5** and **6)**.

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Conclusion

The active ingredient Photobiome protects the cutaneous microbiota involved in fighting the sings of photo-ageing, at the same time it stimulates the antioxidant and photo-protecting microbial metabolism under sun exposure. This allows a new approach in skin care and in the prevention of the photo-ageing, where taking care of the skin microbiome we can recover a more smooth, luminous, firm and elastic skin even during and after the sun exposure.

With this 100% natural active from pomegranate and extremophile cotton stem cells, we obtain a **well-ageing effect even under sun radiation exposure**, through the positive modulation of the cutaneous microbiota involved in reinforcing the natural skin defense under sun exposure: wrinkles reduction, skin firmness and elasticity increase, and reduction of post-sun exposure hyperpigmentation on skin and on dark spots.

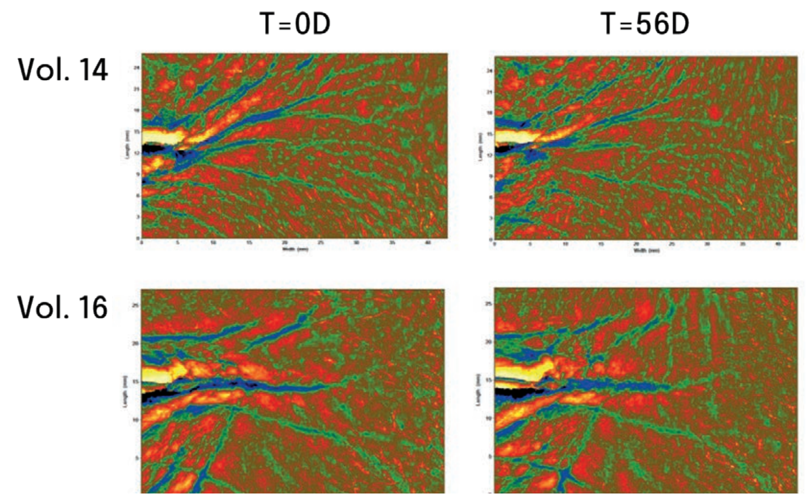

Fig. 6 Photobiome™ significantly reduced crow's feet depth following treatment

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VINCENTZ

Natural Photoprotective Antioxidants from *Garcinia indica* Fruit Rinds: An Approach Beyond Sunscreen

P. Dhawal, M. Deodhar

abstract

Objective: Recent articles have emphasized that sun protection factors (SPF) and UV-A protection factors (UVAPF) are not sufficient parameters for measuring photoprotection. An approach 'Beyond Sunscreen' is currently being explored that involves adding antioxidants and antiaging actives to sunscreens to give holistic protection from UV rays. Herbal extracts containing polyphenols have antioxidative and UV-protective abilities including a class of natural benzophenones. In the current study, ethyl acetate, a green solvent, was employed in the extraction of 62.6% garcinol-enriched fraction from *G. indica* dried fruits rinds and was explored for non-sunscreen benefits apart from its previously reported SPF and anti-aging applications.
Methods: Several *in-vitro* assays were adopted to decipher the mechanistic activity of TEAE such as protection against the ultraviolet rays and/or hydrogen peroxide-induced toxicity, endogenous restoration of superoxide dismutase (SOD), and glutathione (GSH) antioxidants in the 3T3 mice fibroblasts, and geno-protective ability in pBR322 plasmid DNA. The effect of TEAE on UV-induced melanogenesis in B16F10 melanoma cells was also studied.
Results: TEAE revealed cell protective effect against damage caused by different doses of UV-A and UV-B and hydrogen peroxide (H_2O_2) alone and in combination. TEAE also showed UV-H_2O_2-induced DNA damage protection activity. TEAE exhibited protection by elevating the endogenous levels of GSH and SOD. TEAE showed melanin reduction that was induced by exposure to UV rays.
Conclusion: Garcinol-enriched *G. indica* dried fruit rinds extract serves as a potentially ideal sun-protective candidate by virtue of its previously reported sunscreen and currently highlighted non-sunscreen benefits.

Introduction

Considering the complexity of exposure to ultraviolet (UV) rays, canceling them using chemical and physical blockers may not be the only strategy to develop UV-protecting cosmetic formulations. Also, recent research suggests that protection from sun damage can be further reinforced by supplementing sunscreen with antioxidant and antiaging actives referred to as "non-sunscreen" or "non-SPF" actives [1,2].

UV exposure induces ROS production that disrupts the balance between cellular ROS and endogenous antioxidant levels, evoking damage. Thus, restoration of balance seems apparent to provide holistic UV protection, making the use of antioxidants in sunscreens imperative [1,2]. Hence, apart from using organic-chemical or physical sunscreen actives, other non-sunscreen UV protection strategies developed are using antioxidants to exhibit anti-mutagenic, anti-inflammatory ability, and anti-aging and anti-melanogenic potential against UV-induced damage [2,3].

Nowadays, interest has risen in the health benefits of safe and biocompatible botanical extracts in the field of cosmetics and a few reported extracts for non-sunscreen benefits are *Tanacetum parthenium, green tea polyphenols, Sophora japonica* flowers extract, among others [1]. Natural benzophenones extracted from *Garcinia indica* species are well documented for their anti-aging ability by virtue of their anti-hyaluronidase and anti-elastase potential [4]. Additionally, the SPF activity for *G. indica* fresh fruit rinds extract has been studied by *Dike & Deodhar*, 2015 [5]. The dried fruit rinds extract (TEAE) is also reported to have an SPF of 3.68 at 2.5% and acted synergistically with 3% octyl methoxycinnamate (SPF 8.05) to give an SPF of 14 [6].

To date, only the SPF and anti-aging potential of *G.indica* was reported by the team. But its non-sunscreen photoprotective mechanism in cells exposed to UV (ROS aggressor) and hydrogen peroxide (marker of UV-induced oxidative stress) remains underexplored. According to our knowledge, we are the first to report the mechanism of this garcinol-enriched fraction extracted from dried fruit rinds of *G. indica* (TEAE) revealing its *in-vitro* non-sunscreen benefits.

Materials and Methods

Mice embryo fibroblast cell line 3T3/NIH ATCC 1640 and B16F10 mice melanoma cells were procured from National Centre for Cell Science (NCCS), Pune. All the cell culture chemicals were procured from Himedia laboratories or Thermo Fischer USA. All the laboratory chemicals were of analytical grade

Extraction

The extract, TEAE, was prepared as mentioned in our previous study [6].

Cell-based assays

The ability of the extract to protect the cells from free radicals generated by UV rays, H_2O_2 alone, or in combination was studied. The cells were seeded with a cell density of $0.5x10^4$ cells/well in DMEM and 10% FBS followed by incubation at 37°C in a CO_2 incubator for 24 hours. After the incubation period, the media was removed and the cells were treated with different concentrations of the extract prepared in DMEM without FBS and were exposed to various conditions as given below:

1. No treatment was given to the cells to determine the effect of TEAE on cell viability [7]
2. Exposed to 0.5 J/cm^2 and 1.08 J/cm^2 of UV-A rays [8]
3. Exposed to 0.5 J/cm^2 and 1.0 J/cm^2 of UV-B rays [8]
4. Different concentrations of H_2O_2 (0, 10, 25, 50, and 100 µM) [9]
5. H_2O_2 at different concentrations (0, 10, 25, 50, and 100 µM) in the presence of UV rays (exposed to UV-A and UV-B tubes with a combined intensity of 1 J/cm^2)

Following different experimental treatments, the plates were further incubated at 37°C in a CO_2 incubator for 24 hours. All the plates were processed by SRB staining to determine percent cell viability [10].

Effect on GSH and SOD levels

After exposing the cells treated with 10 µM H_2O_2 for 24 hours in the presence and absence of TEAE and after incubation for 24 hours the plates were further processed to determine GSH and SOD levels as per the instructions given in the kit Elabscience Biochemical Assay Kit for GSH (E-BC-K030-M) and SOD (E-BC-K022-M) [11].

DNA damage protection assay

The assay was performed as per the methodology mentioned in *Kakodkar et al.* (2019). A mixture of intact DNA plasmid pBR322 was exposed to H_2O_2 and UV rays in the presence and absence of 10-50 µg/mL of the TEAE. The DNA was processed on 1% agarose gel, electrophoresed, and visualized under an Alpha imager. Images were captured and screened for the intensity of supercoiled and open circular bands using Image J software [12].

Anti-melanogenic against UV-induced hyperpigmentation

The effect on cell viability in mice melanoma cells was carried out using the SRB-staining method [7,10]. The non-toxic concentrations were used to determine the effect of melanin reduction on hyperpigmentation induced by UV-A and UV-B rays. The T-flasks with B16F10 cells containing TEAE and media alone were exposed to UV-A and UV-B (1.0 J/cm^2). The cells were incubated for 24 hours and post-incubation the melanin content was estimated via the methodology given by *Mainkar et al.*, 2022 [10].

Statistical Analysis

All the measurements were compiled in the triplicate data set and processed as mean ± standard deviation using Microsoft Excel. The results obtained were subjected to Analysis of Variance, ANOVA, and $p<0.05$ was considered to be statistically significant.

Results and discussions

This is the first study to report cell-based non-sunscreen mechanisms of garcinol-enriched *G. indica* fruit rind extract standardized to 62.6% garcinol content [6].

TEAE promoted cell viability of mice fibroblast cells

As seen in **Figure 1**. TEAE exhibited cell proliferative benefits at the concentrations 5-15 µg/mL as the cell viability was significantly higher than the media control (100%).
The most significant increase in cell proliferation was observed at 5 µg/mL with cell viability 133.16 ± 0.05% ($p<0.01$).

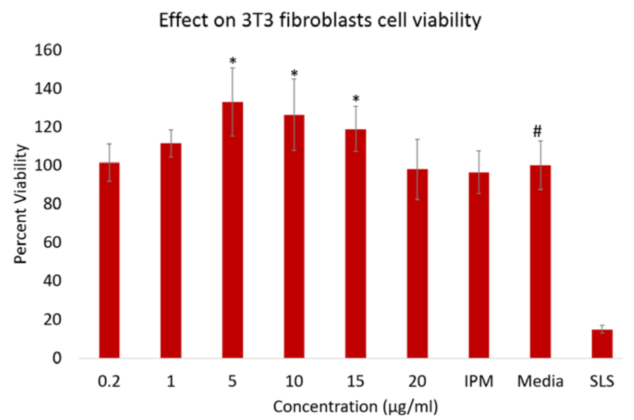

Fig. 1 Effect of TEAE on the viability of 3T3/NIH fibroblast cells

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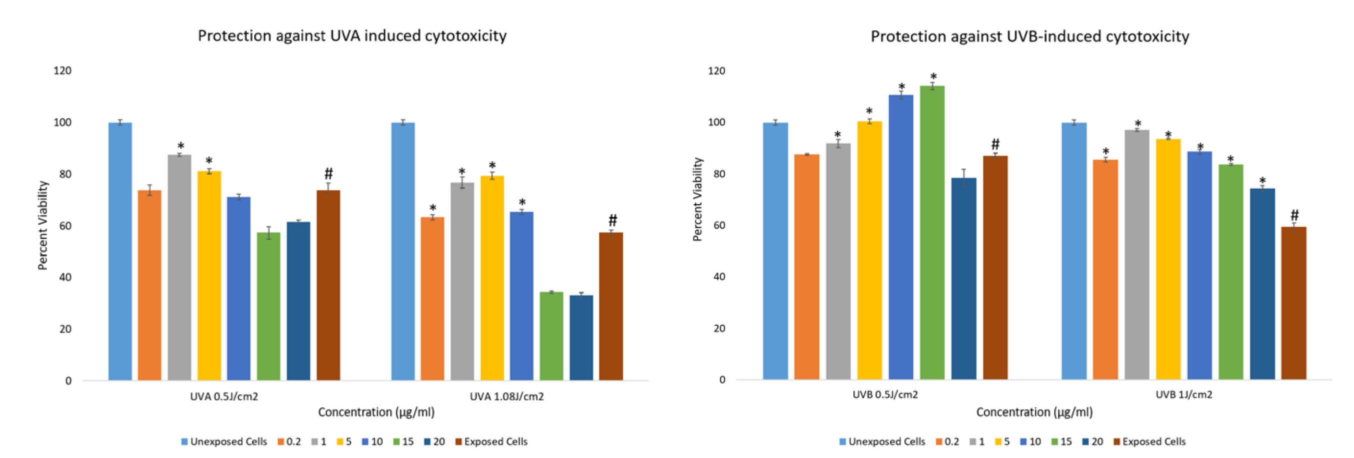

Fig. 2 Protective effect of TEAE against cytotoxicity caused by UV-A and UV-B rays

Cytoprotective ability of TEAE against UV-induced cell damage

The proliferative concentrations 0.2 – 20 µg/mL were chosen to determine the protection against UV-A and UV-B induced cell cytotoxicity. The extract showed statistically significant ($p<0.05$) cell protective effects against the harmful effects of UV rays in 3T3 mice fibroblast cells **(Figure 2)**.

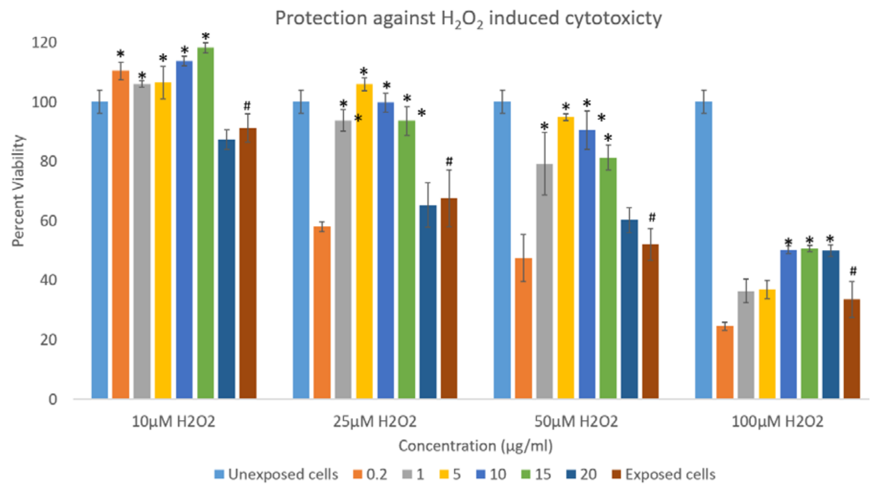

Fig. 3 Protective effect of TEAE against cytotoxicity induced by H_2O_2 (10-100 µM)

Cytoprotective ability of TEAE against H_2O_2-induced cell damage

There was a concentration-dependent decrease in cell viability when exposed to hydrogen peroxide. TEAE exhibited a statistically significant ($p<0.05$) cell protective effect against cell toxicity induced by different concentrations of H_2O_2 (10 – 100µM) in 3T3 mice fibroblast cells **(Figure 3)**.

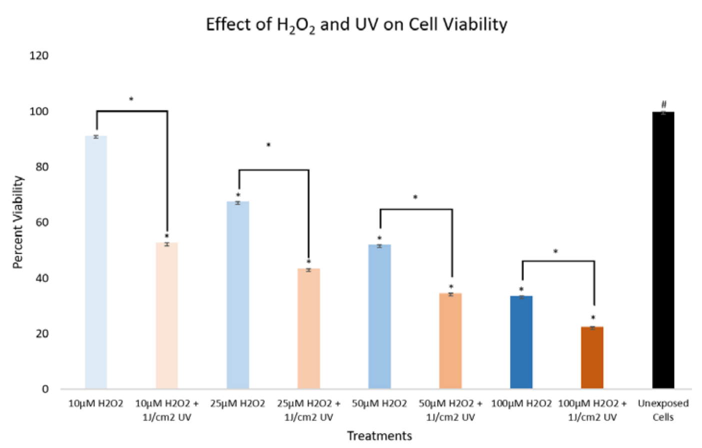

Fig. 4 Combined cell cytotoxic effects of UV rays (UV-A and -B) and H_2O_2

Cytoprotective ability of TEAE against UV-H_2O_2-induced cell damage

As per our knowledge, no data exists for the UV-H_2O_2 protective ability of the *Garcinia* benzophenones *in-vitro* on mice fibroblasts cell line. We are the first to report the UV-H_2O_2 protective ability of *Garcinia* benzophenones, TEAE, *in-vitro* in mice fibroblast cell lines using this mechanism. There was a significantly higher cell death observed when exposed to UV-A and-B, and H_2O_2 together versus when used alone **(Figure 4)**.

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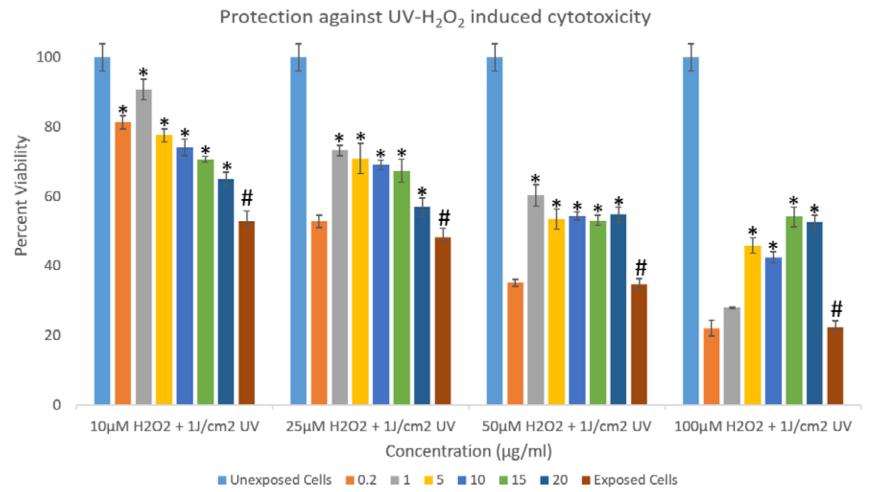

Fig. 5 Cell Protective ability of TEAE against oxidative stress induced by UV and Hydrogen Peroxide

DNA affected by free radicals generated due to UV-H_2O_2 insults where the intensity of supercoiled DNA (SC) is decreased and the intensity of open circular DNA (OC) is increased.

As seen in **lane 3**, TEAE at a very low concentration of 10 µg/mL is responsible for the reversal of DNA damage caused by H_2O_2 and UV-induced free radicals with higher intensity of SC and lesser intensity of OC conferring protection. TEAE when added at higher concentrations of 30 **(lane 4)** showed little protection and 50 µg/mL **(lane 5)** showed no protection **(Figure 7)**.

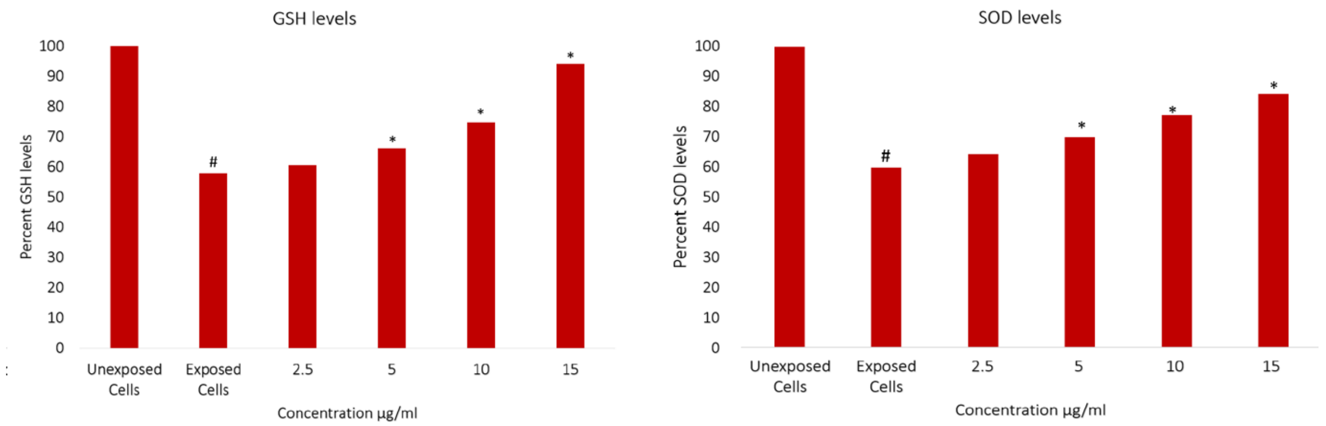

Fig. 6 Protective effect of TEAE on oxidative stress induced by hydrogen peroxide

The extract showed protection against oxidative stress induced by the combined effect of UV-H_2O_2 by canceling the cytotoxic effects **(Figure 5)**.

TEAE elevated GSH and SOD levels

The extract exhibited antioxidant ability *in-vitro* by increasing the endogenous antioxidant levels in the 3T3 fibroblast cells viz., SOD and GSH in a dose-dependent manner **(Figure 6)**.

DNA damage protection activity of TEAE

TEAE showed protection ability **(Figure 7)** against DNA damage induced by UV and H_2O_2. **Lane 1** represents the supercoiled form of untreated plasmid DNA control. **Lane 2** and **lane 6** represent

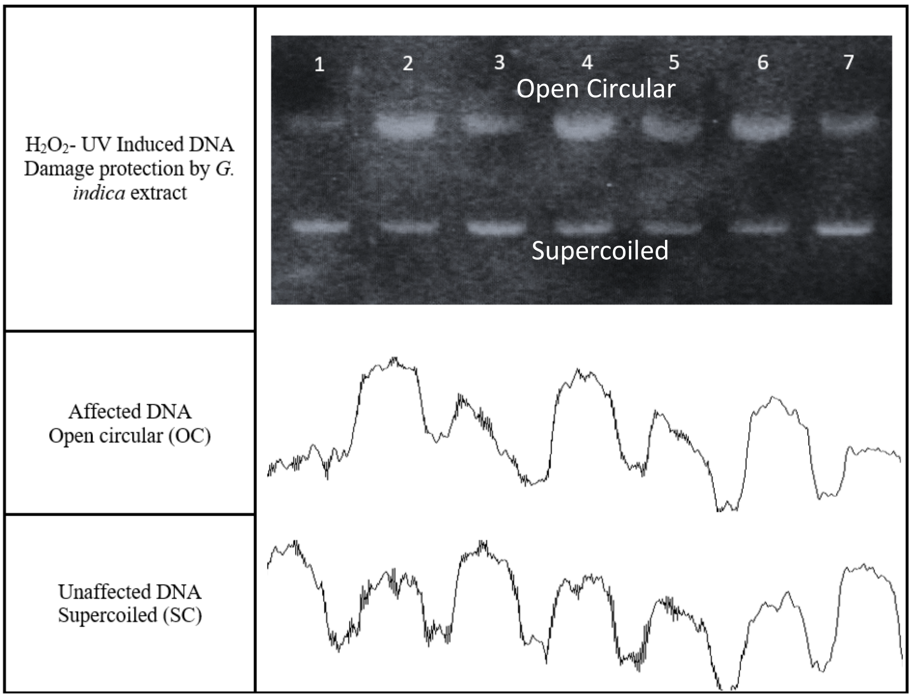

Fig. 7 Protective effect of TEAE against DNA damage induced by UV and hydrogen peroxide

Anti-melanogenic activity against UV-induced hyperpigmentation

No reduction in melanin content was seen in the cells treated with TEAE in the absence of UV exposure. However, TEAE showed a potent photoprotective effect on melanoma cells by restoring a 100% melanin level at 2.5 µg/ml ($p<0.05$) which increased to 150% upon UV exposure **(Figure 8)**.

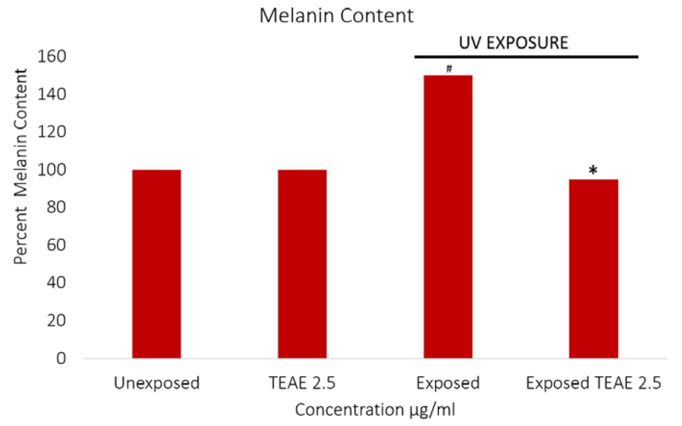

Fig. 8 Reduction in UV-A, -B induced- melanin content in TEAE-treated cells

Discussion

As mentioned earlier, canceling UV rays is not sufficient to protect the skin from sun damage. Reports suggest that UV exposure can build up concentrations of H_2O_2 in the skin causing depletion of vitamins and glutathione as well as native antioxidant enzymes such as SOD, glutathione peroxidase, and catalase. ROS plays a major role in aging and melanogenesis. Hence, the supplementation of sunscreens with antioxidant actives has become apparent. Two major approaches to combat these issues reported by *Lintner* (2017) are either to protect the innate enzymes from depletion or fortification of these antioxidant enzymes in sunscreens [1].

In the current study, the garcinol-enriched extract showed non-sunscreen benefits by protecting the cells against the oxidative stress induced by UV and H_2O_2 and further inhibited the depletion of essential endogenous antioxidants such as GSH and SOD [3]. Depletion of antioxidant reserves in the skin is strongly associated with premature aging. Additionally, a cascade of reactions occurs when UV rays and ROS radicals together act on the DNA of the cells to induce breaks resulting in inflammation and p53 mutations in addition to visible erythema [2]. Pigmentary disorders such as freckles, melasma, and age spots are frequently associated with exposure to UV rays [8]. In the current study, a garcinol-enriched extract of *G. indica* dried fruit rinds (TEAE) serves as an interesting photoprotective candidate with holistic benefits.

Conclusion

Multiple shreds of evidence support the concept of non-sunscreen materials such as antioxidants, extracts, and DNA repair enzymes to be added to SPF products that exhibit protection via mechanisms different than SPF or UVAPF actives. The SPF and UVAPF properties of the active TEAE are already reported. However, the current study reports for the first time the non-sunscreen benefits of this botanical extract. TEAE showed *in-vitro* antioxidant potential against the harmful effects of UV and/or H_2O_2 in mice fibroblasts and plasmid pBR322 DNA, and UV-A and -B-induced melanogenesis via the probable mechanism of replenishing innate antioxidant reserves of cells (GSH and SOD). TEAE can thus contribute to anti-aging and anti-hyperpigmentation non-sunscreen benefits in sunscreens.

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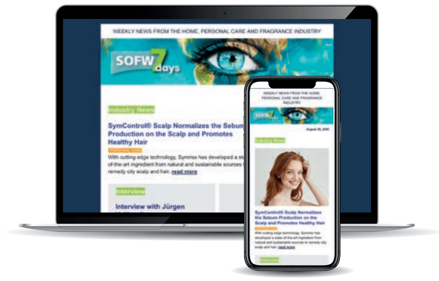

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The Skin's Microbiome: Establishing a Quality Seal for Cosmetics & Consumer Expectations

M. Brandt, K. Unbereit, G. Springmann, S. Bielfeldt

abstract

Quality seals being precisely defined, transparent and validated could help consumers in their decision making. This applies particularly for new categories of cosmetics e.g. those related to the human skin microbiome

The knowledge on the human skin's microbiome grows rapidly and a huge number of cosmetic products with 'microbiome' claims are now seen on the global market.

Developing a credible and valid quality seal for supporting approved claims on skin microbiome is challenging.

Here we propose standards for a quality seal for cosmetic products claiming to be 'microbiome friendly'.

We assume that such a claim can be made if: there is no significant change in microbial diversity as measured by e.g. the Shannon Index and there is also no significant dissimilarity between untreated and treated skin as measured by main component analysis (e.g. Unifrac distances); Also, it should be controlled that there is no strong increase or decrease in the abundance of single microbe genera. Further, evaluation of the skin in terms of clinical safety, skin pH and barrier integrity should also be performed.

Introduction

The introduction of seals (and labels) to promote and endorse cosmetic products is a growing market. Seals are primarily used to help the consumer with the 'informed decision' making when they purchase a product. However with the observed inflation of labels of different quality, only quality seals being precisely defined, transparent and validated could avoid confusion and help consumers in their decision making.

One category of cosmetics that has seen almost exponential growth in recent times is those addressing the skin's microbiome. The human skin's microbiome as a field of dermatology continues to grow rapidly alongside new knowledge of the human microbiome in general. As the field has developed markedly, so has a marketing need for making a variety of competitive 'microbiome' claims. The requirement to make these claims not only legal, but also credible in the eyes of the consumer and authorities, quality specialist seals are a way to help the consumer make an informed decision when purchasing such products.

It is important to emphasize that the skins microbiome is not just made up of 'bacteria' – bacteriome [1]. It also comprises a mycobiome – yeasts and fungi [2], as well as a virome – viruses [3], and actual living creatures or mites, especially the demodex [4], which reside near and in the skins hair follicles. Moreover, the skin's microbiome contributes to our overall health, and plays a role in protecting the body against a wide range of infections [5].

In this paper, in which we focus on the skin's bacteriome, we describe the development and integrity of a microbiome quality seal for the validation of cosmetic claims. We present an understanding of the variations in the skins microbial family, and some of the challenges in testing and evaluation in this category. We also stress the importance of consumer expectations in relation to development of credible quality seals for claim support.

Consumer Expectations

When it comes to the use of quality seals on cosmetic products [6,7], in the eyes of the consumer, expectations are high. This is driven by the growing saturation of the market with so-called seals of approval which have no real bearing on the credibility of the actual product itself. Moreover, some seals or labels, give the consumer the impression of an endorsement which does not actually exist. The most common examples would be 'Greenwashing' [8,9]. In a consumer insight study sponsored by SGS proderm (unpublished data, 699 participants, October 2021), it was found that quality seals can help consumers with purchasing decisions, and companies are perceived to be more trustworthy, and therefore an increased willingness to spend more money on a product bearing a quality seal. However, the large variety of seals and labels currently available is perceived as confusing, and consumers' knowledge about seals is not very well developed despite the willingness to actively find out more about seals. The majority of consumers studied, consider quality seals for cosmetics as very important, and positively influence purchasing. Importantly, background information on the 'seal' needs to be easily accessible, especially since consumer expectations for quality seals are high, including being awarded independently. Among consumer expectations are that, a product bearing a credible quality seal has to have good skin tolerability; proven efficacy; safety evaluation involves medical specialists; and the products are environmentally friendly. Moreover, they want quality statement truthfulness to be provided by an independent organization, with thorough testing, transparent consumer information, and thus provide them an assured safe and good feeling when purchasing a product.

Skin Microbiome Uniqueness

The skin is naturally covered with its own microbiome and these are unique to each individual, with no two peoples' microbiomes being exactly identical [10-12]. The human skin microbiome, which acts as part of the body's first line of defense against the external environment, comprises hundreds of diverse microbial species. Including the hair follicles, the skin is reported to be approximately 25 sqm and each square centimeter of skin possesses around 1 million to 1 billion microbes [5]. The microbiome of the skin contributes to overall health and plays a role in protecting the body against a wide range of infections. Each individual's microbiome exists in symbiosis with the body. As our primary connection with the external environment, the skin's microbiome biodiversity is heavily influenced by many external factors, including the biodiversity of our intimate external and internal environments, lifestyle habits and exposures [13]. These include poor diet, disease, hygiene, smoking, cosmetics, pollution, UV, drugs, etc. [14,15]. Our individual skin's microbiome also plays a key role in the maturation and homeostatic regulation of keratinocytes and the immune system with dysfunction of both implicated in ageing processes and disease [16]. It is the consequences of microbiome disturbances and composition that will also lead to increased skin (oxidative) stress, and thus an increase in certain defined ageing parameters [17]. Recent findings highlight the role of the skin microbiome in modulating immune function and inflammatory response, and this is likely to have wider implications in not only the understanding of sensitive skin but also in how cosmetic products play a role [16,18]. Dysbiosis is related to a plethora of diseases, including skin, inflammatory, metabolic and neurological disorders [19].

Skin Microbiome – The Bad, Good, and Ugly

There is a high diversity of the microbiome both in and on the human body There are mainly four different phyla found on the skin, the *Actinobacteria*, e.g., *Cutibacterium acnes* and the malodorous *Corynebacteria*; *Fermicutes*, e.g., *Staphylo-*

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Challenges in the Production of Food-Grade Packaging for Cosmetic Products

by Nelly Freitag
Fraunhofer-Institut für Verfahrenstechnik und Verpackung (IVV)
Wednesday, 25 Oct 2023

Although the use of non-food compliant recyclates is possible under certain circumstances, in the leave-on sector, for example, **many post-consumer recyclates (PCR) have so far not achieved the necessary purity to ensure safe use.** Food-grade PCR packaging for cosmetic products would be the solution here. However, the production of high-quality polyethylene recyclates faces various challenges, such as the purity of the waste stream, the change in material properties or the development of odors. These challenges are being addressed in the EU Horizon 2020 project CIRCULAR FoodPack, in which **novel monomaterial packaging** is being developed **that meets design-for-recycling guidelines, solving multiple challenges along the value chain.**

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coccus epidermidis; and the *Bacteriodetes* and *Proteobacteria* [5,20]. Depending on the location, body areas will have very location-specific microbiome such as the gut, the skin, the scalp, the oral cavity, and the vagina. Furthermore, variability in these areas occurs – since the skin is composed of sebum rich regions, dry regions and moist regions – including, inter-individual variability which is very high; time driven variability such as on the face and hands. Not all microbes are variable, transient and resident microbes exist. Variations appear when the skin is diseased such as atopic dermatitis [16,21]; and there is seasonal variation of microbes on the skin [15].

'Bad' bacteria are also present at times on the skin [22]. These are pathogens which require eradication when the skin's (and body) health is at risk and danger. Disinfectants and antibiotics are employed to remove these pathogens and promote skin healing. However, the challenge faced in the approach undertaken in their usage, is normally developed through traditional cell culture methods which are not only highly selective for a particular pathogen(s), but importantly are also unable to explore their impact on the complete microbiome itself.

So-called 'Good' bacteria present on the skin are those that help the skin stay 'healthy'.

The 'Ugly' bacteria at worse are those pathogens which become resistant to antibiotics and disinfectants. However, pathogens are usually rare and are controlled by the skin and its 'normal' microbial community. It is important to note that most skin bacterial species former were disregarded as they do not grow readily on culture plates. Based on the new genetic methods it is understood that each skin location where these microbes live (e.g.forearm-skin) is a balanced complex ecological system. Most species are harmless commensals in that they share the "dining table" [5].

Characterisation of the Skin Microbiome – Parameters and Indices

In the field of cosmetics, methods are available for the evaluation of the skins microbiome. The diversity of species can be divided into alpha and beta diversity. Alpha diversity is the diversity of a specific region e.g. the human cheek. Beta diversity describes the differences between e.g. two body regions. Differences found in one region at different times or differences caused by e.g. cosmetic treatments also belong to beta diversity.

Since healthy skin microbiotas have a specific biodiversity and evenness of microbes' distribution, for alpha diversity e.g. the Shannon Diversity Index [23] is a suitable objective parameter. It is characterized by the number of different species and the evenness of abundance of the counted species. The higher the number and the more even the distribution of species, the higher the Shannon Index. It is important to note that each area of the skin has its own specific Shannon Index. No changes to the Shannon Index after a cosmetic skin treatment is an important indicator that the microbiome is still in good health, whereas a significant change (mainly a drop) in the Shannon Index, is a robust indicator for a modified and perhaps impaired microbiome **(Figure 1)**.

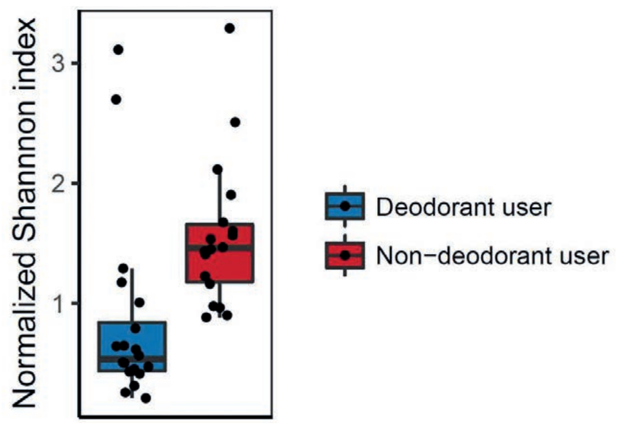

Fig. 1 The Shannon index (Mann-Whitney U test, $p < 0.0001$) is significantly higher in non-deodorant compared to deodorant users. The deodorant clearly reduced the biodiversity

Calculation of UniFrac distances [24] is a well established main component analysis to quantify beta diversity. It is used to quantitatively detect the genetic similarity of two microbiotas. For example, the microbiota of the arm axillae of deodorant or antiperspirant users, can be very different from that of non-deodorant users **(Figure 2)**. A test statistics is given to proof for significant differences.

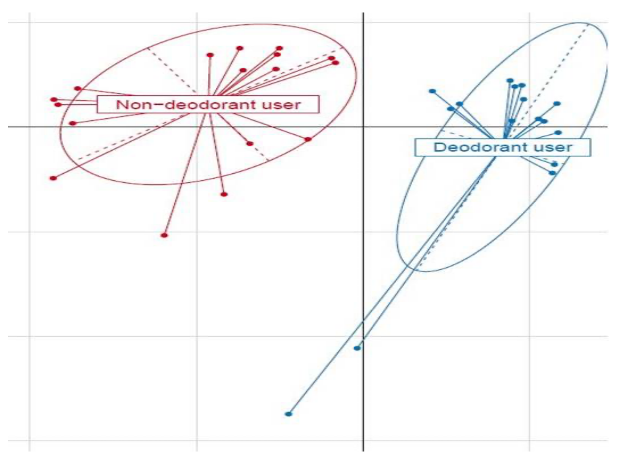

Fig. 2 Principal coordinates analysis plot of generalized UniFrac distances comparing non-deodorant and deodorant users. There is a significant difference between the two groups (Adonis, $p = 0.001$)

Without doubt, advances in gene sequencing have advanced our knowledge of the microbiome considerably. The microbiome is generally characterized using a 16S rRNA method amplified by PCR [25]. The library molarity of DNA is then sequenced and the microbiome analyzed by the 16S phylogenetic profiling method based on sequencing the 16S rRNA gene. It is a common and widely accepted method for studying bacterial phylogeny and taxonomy [26]. Since this gene consists of both – highly conserved as well as hyper-variable regions – it probably is the most established genetic marker used for bacterial identification and classification. Many sequences of the gene are now available in public databases, and the method is considered by many as the gold standard for microbial analysis. The relative abundance of and biodiversity of the microbiome in the controlled and treated skin areas can be calculated and identified. Microbes with a similarity of at least 97% regarding 16S rRNA-gene sequence are clustered into separate operational taxonomic units (OTUs). The relative abundance of all OTUs and bacterial taxa are then presented from phyla to genera. Instead of OTUs, newer methods work with ASV (Amplicon Sequential Variants) that provide improved processing of unknown gene sequences. 16SrRNA gene data is specific for taxonomic assignment of bacteria down to the genus level, and is quantitative in that the number of genes can be counted and then from this the diversity and relative frequency of the microbiota can be assessed. Advantages of gene sequencing include characterization of non-cultivable bacteria; studies of complex microbiomes; identification of low-abundance bacteria; and provides faster and more accurate classification than traditional identification methods.

Establishing a Quality Microbiome Seal (Figure 3)

Developing a credible and valid quality seal for supporting approved claims for cosmetic purposes is challenging. With respect to the microbiome, care needs to be taken given that policies, regulations and guidelines surrounding microbiome claims are either vague, non-harmonized, or non-existent [27-29]. Also, a so-called disturbed microbiome may be or may become a pathologic one, and therefore not in the remit of cosmetics but of medicine. Aiming for a 'healthier' microbiome is a goal to be achieved in overall wellness of humans, yet all effects and statements of effects have to be 'cosmetic' rather than 'curative'. The wide use of terms such as 'probiotic', 'prebiotic' and 'post-biotic' have been scrutinized, since the addition of live bacteria to the skin (probiotic) may well be non-complaint to e.g. cosmetic preservation regulations; bacterial extracts (prebiotic) will have to show they are safe and do not cause any imbalance in the natural microbiome of a given individual; and likewise with post-biotic actives, produced by living bacteria claiming to have a 'positive effect on the microbiome'. Moreover, while a number of methods have been published claiming to provide 'approval' for microbiome claims, investigations of these methods highlight a lack of consistency, which might result in issues if claims are challenged.

Fig. 3 The SGS proderm Microbiome seal

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At SGS proderm we have executed and published a number of studies [30-33] in the microbiome arena, and our method for developing a 'quality seal' specifically for a 'microbiome-friendly' claim so far has been well recognized by the scientific community. In brief, the method comprises clinical *in vivo* assessments on human skin in the appropriate skin location of a sufficient number of human subjects. Additionally, clinical parameters and measurements are performed to assess tolerability. As an example, for a 'microbiome friendly' claim for a leave-on body care product, a clinical study is performed on the body (normally intra-individual) with a minimum of 30 subjects with healthy skin (male and/or female). A wash-out period of 2 weeks is undertaken (no usage of any cosmetic products including cleansers) on the test-site (volar forearms for example). The test areas are then swabbed and 16SrRNA microbiome assessed. The test product is applied twice daily to one arm only for a period of 4 weeks. The swabbing procedure is then repeated with 16rRNA microbiome assessment, and a comparison of the status of the microbiome is made treated versus untreated at baseline and 24 hours post final treatment. We have been able to show that this method provides consistent statistically significant data **(Figure 2)** for products that impair the microbiome.

It is our understanding that a 'microbiome friendly' claim is only possible if: there is no significant change in microbial diversity as measured e.g. by the Shannon Index and there is also no significant dissimilarity between untreated and treated skin a measured e.g. by Unifrac distances. Also, it has to be controlled that there is no strong increase or decrease in the abundance of single microbe genera.

Furthermore, In order for the 'quality seal' to be granted for a 'microbiome friendly' claim, at least three other additional parameters have to be met. These are: full dermatological evaluation of the skin in terms of safety; barrier function and integrity; and skin pH. These parameters are important since the skins microbiome is sensitive to changes in these and can exacerbate poor barrier function and alterations in pH. Moreover, given consumer demands for credibility and transparency of seals and labels, this quality seal as with all SGS proderm quality seals has its own consumer information platform. The benefit to both the product and consumer are high: provision of testimonial and in-depth quality statement; claims made are always based on guidelines and/or quality publications; re-testing of the product takes place when the formulation is changed; a products safety is additionally reviewed from market data; provides a certificate of approval; transparency of communication with the consumer and thus assured 'Informed Decision' making.

Making Cosmetic Claims - Compliance and Validation

While the methods to evaluate the effects of cosmetic products on the skin's microbiome, issues arise when providing evidence to comply with the claims legislation and to provide validation for those claims. Moreover without a clear understanding of the skin's microbiome difficulties will arise. For example, concerns have been raised that preservatives will affect the microbiome. This however must not be the case since preservatives are utilized to protect the product, and are used at relatively low concentrations [35]. The wording of so-called microbiome claims have also come under scrutiny, an example being 'nourishes the microbiome'. In the UK, the Advertising Standards Authority ruled against this claim since: the evidence provided was insufficient for such breakthrough claims; *in vitro* studies needed to be backed up with human studies; and human studies are required to reflect the target population [36]. The claim itself however was not criticized, but the ASA had higher expectations.

Concluding Remarks

In the past, the skin microbiome research predominantly focused on dangerous and pathogenic bacteria – combated by washing, disinfection and even antibiotics. Today however the cosmetic industry, in particular, has moved this focus to the care and maintenance of an intact skin microbiome, in order to maintain the skin in good condition. Influencing the microbiome to an individual's healthy state has encouraged the use of a variety of ingredients to keep the skins microbiome harmonious. This has led to a plethora of varying claims, and generated confusion within the industry, as well as the consumer. Since transparency is absolutely key when making an informed decision to purchase a product, the employment of quality seals has been shown to be very important to consumers. As described in our paper, we have argued a case for the importance of quality seals when supporting microbiome friendly claims, in light of the controversy that not only surrounds confusing cosmetic seals and labels, but also 'microbiome' claims in general. In this regard we believe we have raised the bar for achieving a quality seal by instigating high fulfilment of the criteria we set to achieve this and addressed the demands of consumers for absolute transparency when it comes to cosmetic claims. These are strong stand alone features for such a specific and consumer-centric award.

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ADVERTISEMENT

How Germany Cleans: Housework between Social Norms and Sustainability

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abstract

Housework is much more than “just cleaning”. The way cleaning is done allows conclusions to be drawn about social norms, behavioural patterns, the current emotional state and about the state of society. In this context, the Industrieverband Körperpflege- und Waschmittel e. V. (German Cosmetic, Toiletry, Perfumery and Detergent Association, IKW) commissioned a study from INNOFACT AG that examined the topic of housework from a holistic perspective.

The two-part study (1. qualitative part with 50 in-depth interviews, 2. quantitative part with approx. 1,500 persons, cf. **Figure 1**) provides an insight into the „cleaning behaviour“ in private households with more than two people. In each case, people’s self-perception, and the perception of others with regard to housework and the family and socio-cultural influences on cleaning behaviour were to be examined. The questions were, among others: What were and are role models? What motivations are there and how are the activities and roles in housework evaluated? Are there changes in the evaluation of cleaning compared to the past? It was also important to analyse the meaning and understanding of the ubiquitous term of sustainability in the context of housework.

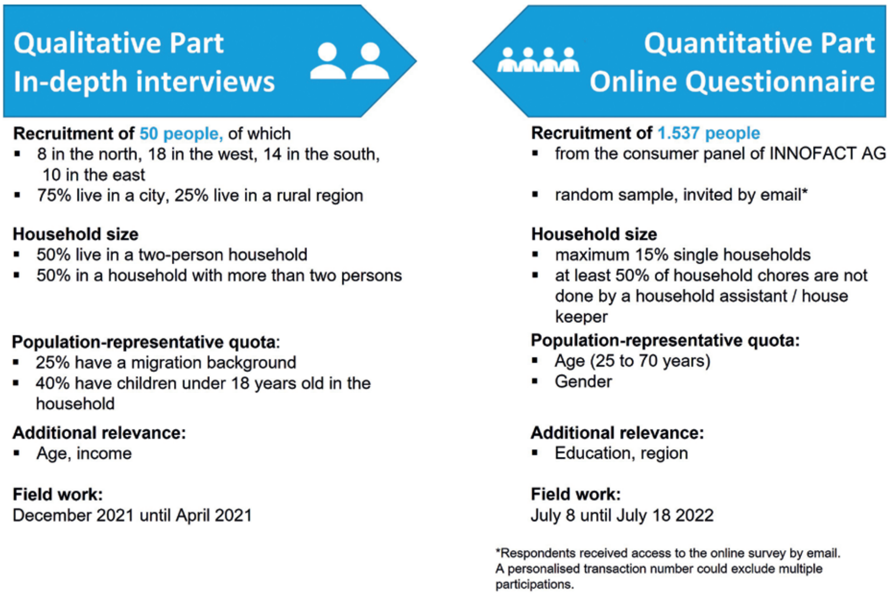

Fig. 1 shows the methodology and the most important data of the study “So putzt Deutschland” (“How Germany cleans”), which was conducted by INNOFACT AG on behalf of IKW.

Respondents were selected from the consumer panel based on the criteria and then by random sampling and invited by email. Access to the survey was personalised by a transaction number, so that multiple participations were not possible.

How the topic of cleaning is anchored in people’s minds

The assumption that each generation finds its own interpretation of everyday activities was not confirmed. In fact, “order” and “cleanliness” are deeply ingrained in the DNA of society (cf. **Figure 2**). Clean-

Fig. 2 Relevance of order and cleanliness in the parental home compared to one’s own household are almost identical.

liness (82%) and order (72%) were already very important or important in the parental home for a large proportion of the respondents. There was also virtually no change in the current household. Both are relevant to an almost identical extent (cleanliness: 83%, order: 77%). Almost half of the respondents adopted many or all of the cleaning habits from their parent's home, and in the age group 25 to 34 years the number is as high as 62 per cent. In comparison, in the age group 50 years and older, "only" 41 per cent adopt parental habits. One reason for this may be that people learn primarily from role models.

We tend to notice people in the same household cleaning more often than friends or acquaintances. Mostly, the transfer of knowledge about housework and the associated habits therefore takes place from parents to children. From a sociological point of view, today's 25- to 34-year-olds also have a more friendly relationship with their parents than previous generations and one that is far less characterised by critical distance. This could result in an even stronger imitation of the cleaning behaviour by the younger age group.

Lessons learnt – children's help in the household

The topic „children's helping out in the household" has hardly changed from "then" (in the parental home) to "now" (in one's own household). Even as children, most respondents (around 87%) were involved in household chores and 85 per cent now assign specific household tasks to their children (e.g., emptying the dishwasher). Only a quarter of the respondents had fixed cleaning days in childhood, especially the female respondents. At 84 per cent, boys had to help the main person in charge with housework at home somewhat less than girls (89%).

Imprinting and motivation – cleaning has an emotional component

Cleaning contributes to a sense of well-being. This is confirmed by 78 per cent of respondents who say that they feel they have accomplished something after cleaning. 70 per cent enjoy the cleanliness after the housework. 61 per cent of the cleaning behaviour in the household is intrinsically determined and controlled, i.e., it is mainly determined by one's own internal motivation. Especially the 25 to-34-year-olds show higher values for intrinsic motivation.

About half (51%) of the respondents are extrinsically motivated to do the housework, e.g., by the desire to be able to receive guests in a clean home (cf. **Figure 3**). For slightly less than half (42%), a visit is the immediate trigger to clean. In this context, it was repeatedly pointed out in the

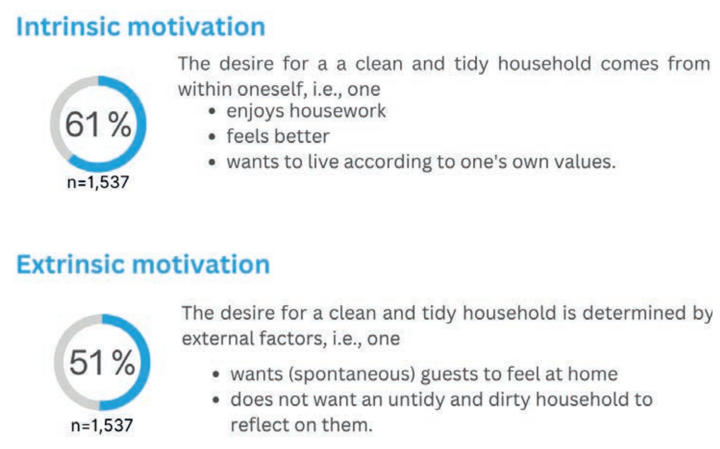

Fig. 3 Slightly more than half (61%) of the respondents say that their motivation to clean is largely self-driven, while 51 per cent need external factors as motivation for housework.

DGK cosmetic science
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Fortbildungskurs:
Kanzerogenese und Mutagenese
13. – 14. Juli 2023, Berlin
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in-depth interviews that order and cleanliness are expected by society. As a conclusion, it can be stated: Housework is perceived as a duty, but overall the intrinsic motivation clearly outweighs the extrinsic motivation – both in the in-depth interviews and in the quantitative online survey.

Social norms: The understanding of roles changes slowly

On average, 64 per cent of respondents from private households with more than one person do all the housework, with women (79%) significantly more likely to do so than men (48%). Apart from the fact that the respondents either overstate or understate (the figures do not add up to 100 per cent), the numbers suggest that the main burden lies with women.

As expected, this classic division of roles in cleaning was still very strongly cemented in the parents' generation. For about half (51%) of those who grew up in a home with a father and a mother, one parent took care of all the housework, mostly the mother (98%). This circumstance is found especially among the older respondents aged 50 and above. Among younger respondents, both parents shared duties significantly more often (62%). The subdivision into individual age segments shows that the understanding of roles is weakening in small steps: In the generation aged 50 and above, 99 per cent stated that the mother did the housework alone, and in the 25- to 34-year-olds it was 96% (cf. **Figure 4**).

Sharing household care: Younger people and East Germans distribute housework more evenly

A different picture emerges among the younger generations and in East Germany. If the results are broken down by East and West, striking differences emerge: two-thirds of respondents (68%) from the new federal states say that both parents have taken on household tasks – in 28 per cent even in equal shares. In the old federal states, on the other hand, less than half (45%) say they do the housework together – and in equal shares only 15 per cent. Encouragingly, for the vast majority (70%) cleaning is rarely or never a topic of dispute in the household (cf. **Figure 5**).

Cleaning changes over times

Social norms have shaped roles and habits, which rarely change, and when they do, more than half (54%) say it is due to a change in life situation. The main reasons given were the acquisition of a pet (18%), followed by an addition to the family or a relocation (14% each). The in-depth interviews showed that the relevance of „cleanliness" increases, and "order" decreases when a child moves in. For 12 per cent, the coronavirus pandemic caused a change in cleaning behaviour between 2020 and 2022, and for half of this group, it became established. Mainly cleanliness and order have gained in importance. However, a different or clear distribution of tasks played only a small role in the change in cleaning behaviour.

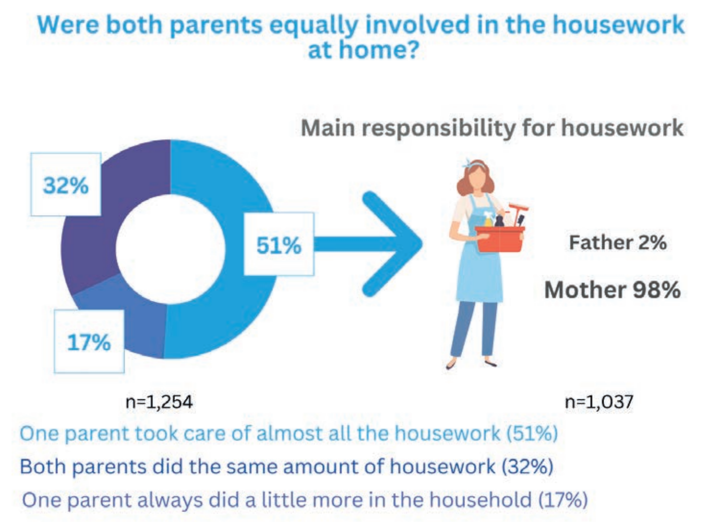

Fig. 4 The social norms: It was deeply anchored in the parent's generation that the mother looked after the house. 98 per cent of the respondents stated that it was predominantly the mother who took care of the housework.

Sustainability between relevance and implementation

In recent years, no topic has gained as much importance as sustainability. But what does "sustainability" mean in the individual areas of life, specifically in housework? For most respondents, sustainability means above all "using environmentally friendly products". The in-depth interviews also show that the consumption of products, purchasing, the reduction of

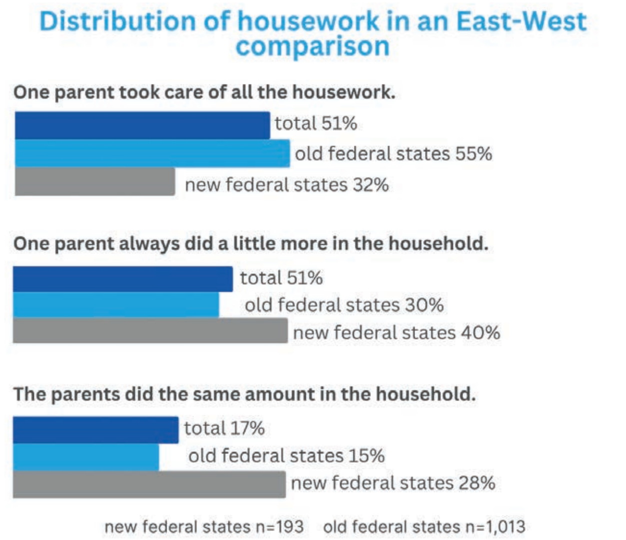

Fig. 5 In the new federal states, 68 per cent of the housework in the parental home was done by both parents, in 28 per cent of the cases equally. In the old federal states, 45 per cent did the housework together and 15 per cent equally.

packaging waste or the use of energy-efficient technical devices are considered relevant. The priorities are clearly distributed here: Sustainable behaviour comes easiest to the interviewees where they have the most influence – while shopping and doing housework, and least in the topic of mobility. Respondents pay the most attention to the economical use of washing and cleaning products (74%) and the use of energy-saving programmes (73%). The main motive for sustainable behaviour in the household is a long-term cost saving, followed by preserving the value of objects in the household (72%) and a contribution to environmental protection (64%). A possible social contribution, such as adequate remuneration of employees at cleaning product manufacturers, follows with 60 per cent. Higher costs are cited as the biggest barrier to more sustainable behaviour, especially among respondents under the age of 35. Young people in particular often have tighter budgets. Furthermore, this age group has doubts about "green" product claims (whether these are in fact true) and whether individual sustainable impacts can be achieved at all.

Digital aids for housework only relevant in certain areas

While digitalisation has long been a true reality in banking transactions or everyday communication, it seems to play a subordinate role in housework.

Digitalisation makes its way to housework – through the back door

The use of a cleaning schedule is not relevant for most multi-person households. Only just under 20 per cent follow a strict cleaning schedule with a concrete distribution of tasks; the majority loosely divide up tasks that arise (over 80%). Among those who do have a cleaning schedule, 89% have it on paper (cf. **Figure 6**). The in-depth interviews revealed the following explanation: It is obvious when something or a certain room needs to be cleaned, so digital tools are not needed for this. However, the benefit is seen sporadically, e.g., when parents want to remind their children of assigned chores.

Mopping and vacuuming robots – what is used for cleaning?

In principle, digitalisation has made its way into housework. Household appliances have been upgraded in the development of smart homes, e.g. washing machines and dishwashers that can be controlled by

Fig. 6 Only 20 per cent of the respondents in the study "So putzt Deutschland" ("How Germany cleans") use a cleaning schedule, which is either strictly or rather loosely adhered to. Of this group, 89 per cent create it in paper form, 11 per cent use an app.

smartphone. People think about vacuuming and mopping robots, but they do not yet have broad acceptance. In the in-depth interviews, respondents stated that they are unsure whether the robots actually clean everything as they had wished.

The assessment that cleaning agents and household appliances are indispensable correlates, as expected, with the frequency of their use. For the majority of respondents, dishwashing detergent (85%), toilet cleaner (84%) and glass cleaner (72%) are indispensable. The top household appliance is the washing machine with 92%, closely followed by the dishwasher (71%). The top tool is the cleaning bucket.

The report on the study "So putzt Deutschland" ("How Germany cleans") can be accessed via *https://www.ikw.org/services/ikw-studien/so-putzt-deutschland-haushaltspflege-zwischen-sozialisierung-und-nachhaltigkeit* or scan the QR code:

The QR code leads directly to the IKW homepage from where the results can be opened or downloaded as pdf file or a presentation.

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PRODUCT LAUNCH

The ELEMENTS COLLECTION

Kao
Kirei–Making Life Beautiful

Kao Chemicals Europe's new fragrance collection, THE ELEMENTS COLLECTION, is based on nature-inspired elements -air, water, earth and botanicals- capturing the inner beauty of the natural world.

This nature-inspired concept takes us on a journey, starting with the lightness and delicate floral fragrances that represent the element of air. It then transitions to refreshing aquatic notes with hints of green, connecting us to the concept of water. Finally, the collection concludes with earthy and woody tones, evoking a warm feeling associated with the element of earth. These creations comply with the EU-Ecolabel standards and utilize 100% readily biodegradable ingredients, presenting a creative challenge for our expert perfumers.

As for the concept of the botanicals, we believe Cosmos fragrance's claim perfectly aligns with the more natural aspects while also caring about the ingredients used. That is why we have chosen this claim to represent combinations of botanicals herbs like mint and geranium, fennel and thyme or herbs and ginger to be part of our collection.

The ELEMENTS COLLECTION is designed for your personal care formulations: body washes, hair shampoos, and facial cleansers. Our latest collection with pleasant scents while being friendlier with the environment.

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FRAGRANCE CREATIONS FOR A FRIENDLIER FUTURE

At KAO, sustainability is at the core of our business. Our fragrance creations elevate every scented moment, striving to be in harmony with the environment. We actively promote the use of natural-based or biodegradable ingredients and take pride in ensuring that our fragrances meet the highest eco-certifications in the fragrance industry.

For more information, scan the QR code to connect with Kao.

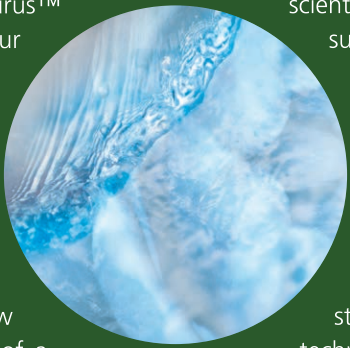
FRAGRANCES

Dive into Givaudan's Long-Lasting Freshness!

P. Arnoux

Performance and long-lastingness. Those two key ever present consumer expectations for fragranced products. Consumers want no compromise on performance, long-lastingness and of course hedonics they love, because it "makes them feel fresh all day, every day".

At Givaudan, to help our customers meet these needs, our R&D teams continuously innovate by shaping new and sustainable solutions. Our Scentaurus™ palette of precursors and our fragrance encapsulation systems, such as PlanetCaps™ are part of a number of solutions that can be used by Perfumers to craft beautiful yet performant and long-lasting fresh fragrances for various types of end products for laundry cleaning and softening, hair and many others..



Precursors, like our biodegradable Scentaurus™ Clean and Scentaurus™ Melrose, are low odour molecules that release fragrant molecules when they are naturally activated by external triggers such as oxygen or the humidity in the air. This patented technology allows Perfumers to reinvent the architecture of a fragrance, the way it is built and how it delivers long last freshness. It is also a way to fight odour habituation by bringing unique new perfume notes during the life and evolution of a fragrance. Givaudan has been the first company to introduce, in 2006, a fragrance precursor activated by light with Scentaurus™ Tonkarose, a molecule that releases two different hedonics when activated. Today Givaudan offers the largest palette of fragrance precursors in the industry and continues to expand the portfolio and in doing so provides new and exclusive tools, with a high level of versatility, to craft long-lasting freshness that will delight consumers all around the world.

Encapsulation systems, like Givaudan's PlanetCaps™, are another way to deliver stronger performance and a long-lasting character: the scented accord is contained in a capsule that can be activated by friction. During the last six years, Givaudan scientists have been striving to ensure fragrances capsules both deliver outstanding scent release and are kind to nature. It resulted in PlanetCaps™, introduced at the end of 2021, this breakthrough innovation is the first-to-market fragrance encapsulation system with a biodegradable and bio-sourced structure for fabric softeners, offering a long-lasting and delightful fragrance experience at different stages of formula evolution. These breakthrough technologies complement traditional perfumery ingredients and allow perfumers to push the boundaries of their creativity by having access to an unmatched portfolio, supporting the formulation of fragrances solutions that consumers crave for.

Designed with sustainability in mind, Scentaurus™ and PlanetCaps™ strongly contribute to our Company's purpose of "Creating for happier, healthier lives with love for nature" and support our customers in meeting both their sustainability ambitions and consumers' expectations for performance and long-lastingness.

Pierre Arnoux
Science & Technology
Marketing Manager,
Givaudan

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"The Situation is Becoming More Challenging, Expensive and Complex"

Perfumer **Sarah Brajic (Düllberg-Konzentra)** talks with **SOFW** about sustainability in the perfume oil industry: the challenges and how the industry can address them in a constructive way.

Time flies! This advert was published in 1957 in "Seifen-Öle-Fette-Wachse" (SOFW Journal = Soaps, Oils, Fats, Waxes Journal). What are the greatest challenges in the perfume oil industry today?

One of the biggest challenges – alongside increasingly restrictive regulations and supply chain issues – is the topic of sustainability. The perfume oil industry needs to adapt in order to meet the needs of our customers as well as those of our planet. To achieve this, we need greater transparency along the supply chain and a new perspective on our product portfolio. It's a highly complex issue. What sustainability aspects should, and can we look at? How can we generate comparable data and values to transform our processes and resources sustainably in tandem with other industries?

How do you deal with the issue of the circular economy?

As in many other sectors, the circular economy is a complex topic in the perfume oil industry. There are numerous different aspects we can engage with, such as incorporating returnable containers and optimizing transport routes in the B2B segment. For perfume oil – which is used in consumer products such as shower gels or eau de parfums – we have ingredients that can end up in wastewater; here, biodegradability is an important factor. When it comes to recycling, our focus is on packaging. We can also optimize internal processes to ensure that waste is reduced to a minimum, a target we are always striving to achieve.

However, we believe that the greatest lever for change lies in optimizing our product range to include more sustainable product alternatives, such as using upcycled products obtained from waste products from other industries or developing new methods for obtaining natural isolates – without using more acreage to grow raw materials. There are so many different possibilities, all of which need to be weighed up in terms of their sustainability impact.

What are your customers' requirements in this context?

Our customers face the same challenges as we do. Everyone wants maximum sustainability; consumers want products that do not harm the environment and are produced in a socially responsible manner. Ideally, they should be local, vegan, upcycled and biodegradable – and, in addition to all this, they should, of course, smell good. Implementing all these factors is not an easy undertaking. An average perfume oil contains between 20 and 100 raw ingredients from all over the world, such as ginger oil from India or neroli oil from Tunisia; these ingredients are made with the byproducts of other industries or petrochemical processes. Each individual ingredient needs to be scrutinized and evaluated from multiple highly complex angles. In some cases, synthetic alternatives may be more sustainable than the natural substances.

One topic is the endocrine effect and declaration of perfume oils. How do you deal with this issue?

Any issue that involves the safety of our customers and products is a top priority for us. Our extensively skilled, professional team for quality management, safety and regulatory matters works proactively on anticipating and addressing new issues and develops the appropriate safety profiles. This gives me the liberty to focus on creating appealing, suitable, and successful fragrances for our customers, secure in the knowledge that the perfume oils fully comply with the current regulatory standards and the requirements of our customers.

Last, but not least: more expensive raw materials, higher energy costs, supply chains. What impact do these factors have on the perfume oil market?

Although we all hoped the situation would become easier, this has unfortunately not been the case. In fact, it is apparent that in the long term the situation is set to become even more challenging, more expensive, and more complex, particularly in terms of sustainability.

The current situation and the difficulties sparked by the pandemic continue to present a great challenge to the industry. At the same time, these conditions also opened up the opportunity and the necessity to adapt to the circumstances. Those who, like us as a fragrance house, have seized the opportunity and worked to implement innovative improvements – for example, to ensure faster responsiveness, optimized processes, higher inventory levels and better supplier relationships – can build on this and will be better able to deal with the stricter requirements of the future.

www.duellberg-konzentra.de

DÜLLBERG KONZENTRA

Sarah Ajumah Brajic, Senior Perfumer at Düllberg-Konzentra, has over ten years of professional experience and specializes in Fine Fragrance, Personal Care and Natural Fragrances. She has an M.Sc., MBM and European Fragrance and Cosmetic Master from ISIPCA, and received her perfumery training at Drom. Her favorite fragrance is the scent of bitter orange blossom.

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Fun in the Sun – the Safe Way

Group interview with **BASF, Sun Protection Facilitator GmbH** and **Symrise**

Sunscreen products, containing UV-filters, are used worldwide to protect from the negative effects of sunlight. However, in order to provide this photoprotective function, sun screen products need to be photostable and be retained by the skin.

How do you make your UV/UVA filters photostable?

Marcel Schnyder, Head of Global Technical Center Sun Care, BASF:
The photostability of a sunscreen is predominantly linked to the photostability of the individual UV filters and their combination used in a sunscreen. The most efficient way to achieve a photostable sunscreen is by the selection of UV filters with inherent photostability. In case UV filters with a limited photostability are used (i.e., Avobenzone/BMDBM), they need to be stabilized to avoid degradation of the UV filter function under irradiation. Some UV filters are used that can also act as a stabilizer (typically Octocrylene or BEMT). In contrast the use of stabilizers which have an inherent UV absorbing function, but are not registered as UV filters, is critical as the safety assessment for UV filters is more comprehensive than for other cosmetic ingredients.

Uli Osterwalder, Owner and Principal,
Sun Protection Facilitator GmbH:
Some UV filters are inherently photostable, so we do not have to worry about them. The best-known example of a photolabile UV Filter is Avobenzone (ButylMethoxy diBenzoyl Methane, BMBM). Formulators do know how to stabilize it in sunscreens. In the future, for a UV Filter not to be completely photostable could prove to be beneficial. From an environmental impact point of view, BMBM is found in lower quantities in the sea, compared to other UV Filters although it is used more often in sunscreens. This is an indication and almost a proof that photo instability in beneficial.

Ev Suess, Vice President Business Unit Sun Protection, Functionals & Colors and Marek Busch, Project Manager Business Unit Sun Protection, Functionals & Colors, Symrise:
Most of our UV filters are photostable in themselves and don't need stabilization. We stabilize the UV filter Avobenzone (Neo Heliopan® 357), which is not photostable per se, by combination with other UV filters such as Octocrylene (Neo Heliopan® 303) and Bemotrizinol (Neo Heliopan® BMT) or, alternatively, with our emollient Corapan® TQ (Diethylhexyl 2,6-Naphthalate) which also protects Avobenzone from degradation.
In addition, the final UV filter combinations must always be tested for photostability.

What are your testing methods for photostability?

Marcel Schnyder: The ISO method 24443 to evaluate the UVA Protection Factor (UVA-PF) of a sunscreen includes an irradiation step and indirectly include the photostability requirement. A photoinstable sunscreen would therefore not meet the European Commission (EC) recommendation for UVA protection because it would degrade significantly during irradiation.
In addition, there are alternative methods where a defined film of a sunscreen is irradiated by a defined UV dose, and the remaining UV filter amount is detected by using High Performance Liquid Chromatography (HPLC).

Uli Osterwalder: If the conventional SPF-method ISO 24444 is used to test the performance, photostability is inherently tested with it. Not sufficiently photo-stabilized formulations would lead to an inferior SPF. To consider photostability, the emerging alternative test methods which are all non-invasive contain an extra irradiation step on a PMMA plate that is mimicking skin, similar to the UVA-PF method ISO 24443. Hence, photostability is an integral part of SPF and UVA-PF testing. For research purposes photostability can be tested by analyzing the remaining UV filter content of a sunscreen by analytical methods, e.g. HPLC.

Ev Suess and Marek Busch: We formulate the UV filters individually with a realistic maximum usage concentration in a basic sunscreen formulation and apply it at 1.3mg/cm² (according to Colipa guidelines 2011 and based on ISO 24443:2021) on PMMA plates with a defined roughness.
After 30 minutes of drying time in the dark, the absorption of the sunscreens in the UVA and UVB range is measured. Subsequently, at an irradiance of 10 MED, the absorption of the sunscreen is measured again.
The ratio between the absorption before and after irradiation gives the photostability of the sunscreen formulation, which may contain single or combinations of UV filters.
To demonstrate a photostabilizing effect in, which we saw in the absorbance curve, the same formulation is applied to PMMA plates and tested via HPLC. Samples for irradiation

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and non-irradiation are prepared and washed in a solvent suitable for HPLC evaluation. Finally, the HPLC measurement shows us that the photoinstable UV filter is protected, when the same or a similar concentration of the molecule is found both in the samples before and after irradiation.

How do you test a sunscreen's protection factor?

Marcel Schnyder: The sun protection factor is measured in vivo on 10 human subjects (ISO 24444). The endpoint of measurement is the erythema of the individual subjects. The SPF claim indicates the length of self-protection time for an individual without them getting sunburnt. For example, an SPF of 30 protects a person with fair skin and self-protection time of 10 minutes (without sunscreen) for up to 300 minutes (5 hours). However, the measurement is done with an application rate of 2 mg/cm^2. Compared to these standard conditions, in real world applications, the application amount is in the area of only 1 mg/cm^2. This means the real protection is reduced by around 50%. In addition, it has to be taken into account that the application of a sunscreen is never homogeneous and there are areas with lower protection where sunburn can thus occur. Moreover, mechanical treatment, sweat or water exposure remove some of the sunscreen and reduce its protection. Due to all these factors, the recommendation is to use a sunscreen with a higher SPF (SPF 30-50+) depending on the self-protection time (the darker the skin tone, the longer the self-protection time). In addition, the sunscreen should be reapplied regularly and especially after contact with water.

Uli Osterwalder: The various SPF testing methods all have their merit. It depends what phase of development a sunscreen is in. Before thinking about going to the laboratory, ideas and concepts of sunscreens can already be tested in-silico. BASF and DSM-Firmenich provide reliable SPF simulation tools on their respective websites. To improve an existing sunscreen formulation, an *in-vitro* transmission method may be used for relative assessment of the improvement. There is now also a non-invasive *in-vivo* method available. The hybrid method HDRS measures the UVA part *in-vivo* and extrapolates into the UVB part by attaching *in-vitro* results. Finally, once a sunscreen is fully developed, a conventional *in-vivo* test according to ISO 24444 is still advisable.

Ev Suess and Marek Busch: Before determining a sun protection factor for a sunscreen formulation, the following three steps must be followed:

1. Calculation of the sun protection factor.
Since UV filters differ in their absorption efficacy when compared at the same concentration, we calculate a specific SPF value for each percentage of UV filter. In this way, we obtain an initial estimate.

2. *In-vitro* SPF
In this method, UV transmittance is measured through a thin film of a sunscreen sample applied to a roughened substrate before and after exposure to a controlled dose of radiation. This is another indication of the SPF.

3. *In-vivo* SPF
In a final step, we verify our formulation in an in-vivo study based on the determination of sun protection by hybrid diffuse reflectance spectroscopy, a non-invasive method as it does not induce an erythematous skin response from UV irradiation. This method has been extensively tested to correlate with the ISO 24444:2019 standard for the measurement of sun protection factors and provides us with a SPF based on screening.

In the area of sunscreens, regulations can vary widely, affecting both formulation and measurement of sunscreens. We measure formulations developed specifically for North America according to FDA monograph standard 21CFR201.327, which includes UVA protection requirements. While the European Union requires a UVA protection factor that is at least 1/3 of the stated SPF, the FDA requires a critical wavelength of at least 370 nm to indicate broad spectrum protection.

In the media, we read of concerns about the potential toxicity of sunscreens to marine and freshwater aquatic organisms such as coral, as well as the concern about nano particles. How do you address these issues and educate consumers?

Marcel Schnyder: The human and environmental safety of sunscreens is tested prior to approval. Registered UV filters are seen as safe and efficient for human life and the environment. However, the eco toxicological and human toxicological data sets are different for the individual UV filters. Currently, we see a trend toward UV filters based on conventional chemistry being formulated out from sunscreens due to their ecotoxicological and/or human toxicological data sets. The efficacy of UV-filters is adding to this trend, as there are newer UV filter molecules with higher efficiencies. In older sunscreens, formulations required more than 30% UV filter composition to reach an SPF 50, but with more efficient UV filters, this can be reduced to 10-15% leading to less environmental impact at identical performance.
BASF established a new methodology especially developed for sun protection products – evaluating the environmental compatibility of UV filter systems in sunscreens. The methodology supports the transparent assessment of UV filters based on internationally recognized criteria and comprises eight different parameters, from biodegradation and aquatic toxicity to endocrine disruption potential. It not only considers environmental factors for individual UV filters but provides a comprehensive environmental evaluation of filter systems. This open access tool is called EcoSun Pass.

Uli Osterwalder: Yes, the discussion about the environmental impact of sunscreens, in particular their UV filters started in 2008 and again in 2015, which resulted in the ban of some UV filters on some Pacific Islands, including Hawaii. In recent years, claims like "reef-safe" also became popular in Europe. In my view this issue should be handled scientifically, similar to human safety. Because it has not been a big issue until recently, the authorities, e.g. ECHA in Helsinki have not yet concluded their studies. In the meantime, UV filter suppliers did step in and provide help with their scientific assessment, e.g. BASF with their EcoSun Pass and DSM-Firmenich with their Ecoprofiling, which is built into their Sunscreen-Optimizer.
Regarding concerns about nano-particles, my opinion is very simple: Nano means BIG, i.e. there should be no concern (see next question on human safety).

Ev Suess and Marek Busch: To address these concerns, we need to consider a few points:

1. The entire formulation should be evaluated, as UV filters are not individually released to the water when consumers go swimming in open waters.
2. Where is your sunscreen actually being released into the environment? If you wear your daily sunscreen and end up washing it off at home, the sunscreen will be washed down the drain and end up in the sewer system where the water gets cleaned, cleared and treated. In these occasions the sunscreen is not directly released in open waters.
3. Testing of the effects of UV filters on marine and freshwater organisms is still being evaluated to have validated and agreed upon test methods, while previous studies often showed a lack of methodology.
4. While we want to keep aquatic ecosystems intact, there is a serious risk of skin cancer from too much UV radiation from the sun because it damages the DNA in our skin cells. To protect your skin and minimize the impact on marine life, we recommend using a sunscreen that has been tested to be very water resistant and letting it dry for at least 20 minutes after application to allow a protective film to form, making it more resistant when you go swimming in open waters.

Mineral sunscreen vs. chemical sunscreen: which is safer? This has been an issue for some time. What is your opinion?

Marcel Schnyder: Mineral (inorganic) as well as organic UV filters which are listed on the positive list of the EC Cosmetic Directive can be used and are safe for use in sunscreens. The regulation also informs about the maximum concentration that can be used. The list of approved UV filters is constantly being monitored and updated by the EU commission in relation to the latest findings in regard of environmental and human safety.
Therefore, both organic and inorganic sunscreens are safe for the end consumer, however differences exist with respect to their efficiency. Organic molecules are designed to achieve the highest possible performance and photostability, and therefore the UV filter amount needed for high performance is less in the case of organic UV filters. In addition, inorganic UV filters are neither soluble in oil nor in water and are therefore used as particles. This results in a white painting effect which needs special measures to be reduced e.g., by manufacturing nano particle size.

For sunscreens with light texture and low/no white painting effect, organic UV filters are preferred.

Uli Osterwalder: Now we talk about human safety. The distinction mineral vs chemical sunscreen is misleading, e.g. Titanium Dioxide and Zinc Oxide are of course also chemicals, as well as are their coatings. I prefer the distinction Particulate UV filters *vs* Soluble UV filters. BTW the term Sunscreen refers to the final product in the American understanding. Generally, when a UV filter is approved by an authority, e.g. the EU Commission or the US FDA, it is by definition safe. If this were not the case we would all expect the authority to remove such an unsafe UV filter from the positive list. In the US there are currently only TiO_2 and ZnO on the category I list (GRAS/E, generally recognized as safe and effective), all other filters in use are on the category III list (more safety data required), but they can be used for the time being.
However, one may or even should assess the potential risk of using sunscreens, especially if one belongs to a potentially vulnerable group (children, pregnant woman, breastfeeding mothers...). The major concern is skin permeation and the resulting bioavailability of organic, soluble UV filters. The inorganic, particulate UV filters, mostly in Nano form do not permeate into the skin, and are thus considered inherently safe (except for the potential airborne route via lungs; therefore, the restrictions in sprays). So, my recommendation: if you want absolutely no foreign UV filters in your body, look out for the (Nano) declaration and make sure that there are no other organic (soluble) UV filters in the INCI list.

Ev Suess and Marek Busch: Regarding the safety of UV filters to humans when applied topically to the skin, the European Commission's Scientific Committee on Consumer Safety (SCCS) evaluates safety based on available scientific data and recommends maximum concentrations for each UV filter. There is only anecdotal evidence that mineral sunscreens are less likely to cause skin reactions, which is why they are preferred for sensitive skin. However, sunscreens containing chemical UV filters can also be formulated for sensitive skin, as shown by tolerance tests of the final products. In addition, any cosmetic product, including sunscreens, entering the cosmetics market (whether in Europe, the U.S. or other regions) must be safe, as manufacturers must ensure that products undergo scientific safety evaluation by experts before they are sold.

What country-specific features are there to consider in the production of sunscreens?

Marcel Schnyder: Each region has its own registration status of UV filters. In the US, sunscreens are considered as Over the Counter (OTC) drugs, while in Europe, sunscreens fall under the cosmetic regulation. In the EU, new and improved molecules are registered and approved by the authorities, while in the USA, the FDA has not approved any new UV filters in the last 20 years. Authorities in Asia and LATAM mainly follow the EU registration, with some adaptations. Due to the main differences of approved UV filters in the EU and the USA, it is not possible to have one formulation that suits the end consumer globally.

Uli Osterwalder: I have already mentioned that there is difference between the US and the rest of the world, when it comes to sunscreen. For sunscreens to go on the US market, they have to be produced according to Pharma standards (GMP). Each region may also have a bit a different positive list for the UV filters. Making a global sunscreen, thus means that the formulation has to meet the lowest common denominator. As you can imagine, such a sunscreen may then be available everywhere, but it will less likely be the best in the world.

Ev Suess and Marek Busch: In general, lists of approved UV filters differ by region, but also in terms of the maximum allowable concentration for the same UV filter. This may vary by region depending on formulation type, as aerosol products sometimes have special restrictions on allowable UV filter concentrations.
The declaration of nano pigments is required in the European Union if the average diameter is below 100 nm, which is not provided for in the FDA guidelines. This declaration applies to insoluble UV filters and is placed in brackets: [NANO]
When testing water resistance in the EU, sunscreens can be tested as water resistant or very water resistant. For the first statement, the sunscreens must develop at least half of their protective properties based on the sun protection factor after two immersions in water for 20 minutes each time. In order for a sunscreen to be described as very water-resistant, it must have at least half the original sun protection factor after four 20-minute exposures. This is in contrast to the method used for sunscreens in the United States, where the FDA can only report the SPF for water-resistant sunscreens, which is measured after immersion in water.
Finally, the way the UVA protective properties of sunscreens are measured differs between the EU and the US. For the EU and as an international standard ISO 24443:2021, the assessment of an *in-vitro* UVA protection factor is acceptable, while the FDA requires the measurement of a critical wavelength that defines at which point the range below the absorption curve reaches 90%. The higher the critical wavelength, the more the absorption curve covers the UVA spectrum.

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Interview with Sven Klare

Technical Manager Applied Innovation Sensory Additives, Cosmetic Solutions at **Evonik**


Sven Klare

For several years, sustainability has been an important topic in the development and marketing of cosmetic products. However, this trend has not been as prevalent in sun care products. Film formers are indispensable in sunscreen products because they enable long-lasting and water-resistant protection against UV rays. They also play an important role in formulation by improving the aesthetics, texture and feel on the skin. Most film formers are made from synthetic polymers which do not biodegrade. We asked Evonik's Sven Klare about film formers and the challenges of creating biodegradable sunscreen products from natural, renewable raw materials.

What are film formers and why are they needed?
As the name suggests, film formers are substances that can create a film or layer on a surface when applied. The term "film former" is often used in different contexts. For example, film formers can be categorized as hydrophobic or hydrophilic. Hydrophobic film formers are oil thickening ingredients used in sunscreens, color cosmetics or skin care. Hydrophilic film formers are used in applications such as hair care.

In sunscreen products, film formers create a uniform film of UV filters on the skin, empowering their effective protection against harmful UV rays. When formulating a sunscreen, a film former can also improve the look and feel for consumers. Most film formers used in sunscreen products today are made from fossil and non-biodegradable polymers. Many companies have recognized the need to create alternatives that are sourced from renewable raw materials and are biodegradable. At Evonik, one of our latest innovations is a novel natural biodegradable and biobased film former called TEGO® FILMSTAR One MB.

Creating biodegradable sunscreen products from natural, renewable raw materials remains a challenge. Why is this?
Sunscreen products are made up of many different components such as UV filters, emulsifiers, thickeners, emollients and film formers. The good news is that for many of these components, biobased and biodegradable alternatives are now available. Some examples include Evonik's polyglycerol emulsifiers or enzymatic emollients. Unfortunately, it is still difficult to replace organic UV filters with such alternatives. The reason is that these organic UV filters contain aromatic molecules like aromatic esters. Natural building blocks are still not available at commercial scale. Another hurdle is that newly developed UV filters require time-consuming registrations for worldwide use.

The majority of film formers are made from synthetic polymers which do not biodegrade. What is Evonik doing to address this challenge?
Our life sciences division at Evonik has adopted sustainability as its guiding business principle. This is reflected in some of our latest innovations like in TEGO® FILMSTAR One MB. We are pleased that this film former offers customers a biobased and biodegradable alternative. Benefits include a level of water resistance in sunscreen formulations comparable to synthetic polymers. Our innovative film former can also be easily formulated by simply adding to the oil phase. We have observed good stability and no significant thickening effect in o/w formulations.

How do you ensure strong performance for biodegradable film formers?
Our first investigations always include in-depth studies on the formulation range with emphasis on stability, viscosity and sensory profile. In our experience, *in vivo* tests are still the gold standard to ensure strong performance with regards to SPF and water resistance. We also include fossil-based, non-biodegradable market benchmarks in the comparison.

What is your strategy for film formers? Where do you see film formers in five years' time?
Perhaps this is clear from the name of our film former: TEGO® FILMSTAR One MB! We plan to offer a full family of film formers that will address multiple applications and benefits. In five years, I see the development of in vitro tests for both SPF and water resistance with good correlation to in vivo studies, helping to find the best customized film former solution for each individual formulation at short notice. Also, I would like to see film formers based on next generation raw materials like side streams or CO_2. These are topics we are already targeting with a new program in Cosmetic Solutions at Evonik called ECOHANCE®. This program focuses on developing personal care ingredients derived from beyond biobased feedstocks.

www.evonik.com

Sun Care beyond Filter

Interview with Stanisław Kruś, Senior Technology Manger Sun Care and Senior Lab Leader at Global Technical Center Sun Care, **BASF Grenzach GmbH**

BASF We create chemistry

You are part of the BASF's team at the Global Technical Center for sun care. What are your responsibilities?
I'm leading the technical service laboratories at the Global Technical Center of BASF.

We're providing technical support to sun care producers, sharing our experience and know-how on formulating and performance aspects of sunscreens.


Stanisław Kruś

What are the recent tendencies – where is the sun care market heading?
Developing new sunscreens today, has turned out to be highly challenging due to both the unclear fate of some approved UV filters mainly in Europe and, also other regions, as well as the hurdles to register new UV filter molecules. From the UV filters under scrutiny, the widely used UVB filters Ethylhexyl Methoxycinnamate (EHMC) and Octocrylene (OCR) are being heavily discussed due to rising concerns regarding their safety profile for humans and the environment.

In addition to the issues put forward by official authority bodies, sunscreen manufacturers must also consider the perceptions of the end consumers, who are more concerned than ever of how they personally impact the environment. And they are increasingly adjusting their consumption accordingly. On the other hand, consumers are also more and more aware about the need for UV protection and they expect products with high performance and high-end sensory profiles.

The uncertainty regarding the legal fate, in addition to the reticence of consumers, explains the willingness of sunscreen manufacturers to pro-actively remove some widely used UV filters such as EHMC and OCR from their new sunscreen developments. This removal results in a real challenge in terms of the performance achievement of sunscreen formulations.

How does BASF manage this challenging situation?
Formulating new sun care products under these circumstances isn't easy. Not only are there fewer UV filters to choose from that the market will accept, but the right combination of the UV filters must also be selected. This is where we offer our expertise.

What does that mean?

As mentioned before, OCR and EHMC are less and less used in sunscreens nowadays. UV absorbers such as Ethylhexyl Triazone (EHT) and Bis-Ethylhexyloxyphenol Methoxyphenyl Triazine (BEMT) are promising ones, which could be used in modern sun care products. They are characterized by their high molecular weight, they have very good safety profiles, and they show high photostability. When they are used, however, in combination with the common UVA filter: Butyl Methoxydibenzoylmethane (BMDBM), their photostability decreases. One of the consequences of photoinstability is the generation of free radicals in formulation, what can lead to adverse skin reactions.

When we combine EHT and BEMT with an alternative UVA filter, Diethylamino Hydroxybenzoyl Hexyl Benzoate (DHHB) we do not observe that phenomenon. DHHB and its combination with EHT and BEMT are fully photostable.

Therefore, the combination of EHT and BEMT with DHHB is a good choice when creating modern sun care formulations, without UV filters under discussion.

Can the formulation of the base / chassis help to achieve improved protection?

Sunscreen performance depends on the UV filters used – their absorbance, their concentration and combination, but also on the type of vehicle used.

Indeed, in terms of SPF, we found that the efficacy of the sunscreens depends on the sunscreen formulation chassis, relating to the film thickness distribution of applied sun care products.

In the SPF enhancement study, we found that a water-in-oil emulsion has the highest SPF and highest film thickness, followed by an oil-in-water cream, an oil-in-water gel cream, an oil-in-water spray, and an alcoholic spray formulation, with all the formulations containing the same filter combination.

We are looking further into that topic and we are trying to identify ingredients which can have a positive impact on sunscreen performance, such as emulsifiers in oil-in-water emulsions or hydrophobic waxes such as hydrogenated castor oil (Cutina HR Flakes). That group of ingredients may impact the film thickness and its homogeneity, and thus have a positive influence on the SPF value.

What about "magic ingredients" such as boosters? Are they on the rise and what exactly is it that they are doing?

One essential requirement for high SPF is the presence of a UVA filter in the filter combination.

Enhanced photoprotection can also be achieved by the combination of organic oil-soluble UV filters with water dispersible UV absorbers in the form of microfine particles such as MBBT (Tinosorb M) and /or TBPT (Tinosorb A2B). Those materials not only absorb but also reflect and scatter UV radiation, and therefore lengthen the efficacy of soluble UV filters used together in a formulation.

It is interesting to observe that in the EU market other ingredients which provide protection (absorption) of UV light have not been registered as UV filters. They are marketed as stabilizers of an instable UV filter (BMDBM). They contain the same UV absorbing chromophores as registered UV filters, but they have not gone through the registration process and were not evaluated for human safety.

This is a paradox because on one side, the UV filters have been re-evaluated in respect of their safety and the legislation has been adapted (e.g., the maximum concentration of Homosalate reduced to 0.5% for body sun care) and on the other side, there are those materials that are used without the same safety evaluation as required by UV filters.

The EU Regulation clearly states that in cosmetic products claiming UV protection, this must be provided by the UV filters listed in ANNEX VI of the Cosmetic Regulation 1223/2009.

Therefore, it is not in line with the Cosmetics Regulation to use ingredients with inherent UV absorbency that are not listed in Annex VI.

The right decision is to select ingredients which have no own absorbance but can enhance the protection of sunscreen when used in combination with UV filters.

Such an effect can be achieved by using particles which lengthen the UV radiation path in the sunscreen film when applied to the skin. This phenomenon increases the chance that UV radiation will hit the molecule of the UV filters and enhance their efficacy.

We were pleased to present such a product at this year's in-cosmetics in Barcelona. The natural-based, functionalized calcium carbonate and hydroxyapatite particle is dimensioned in micrometers.

It is of natural origin, not polymer-based, and does not leave a white cast on the skin. It improves the SPF and UVA-PF values as shown in several formulations using *in vivo* and *in vitro* studies.

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