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Complementary Approaches to Understand the Spreading Behavior on Skin of O/W Emulsions Containing Different Emollients

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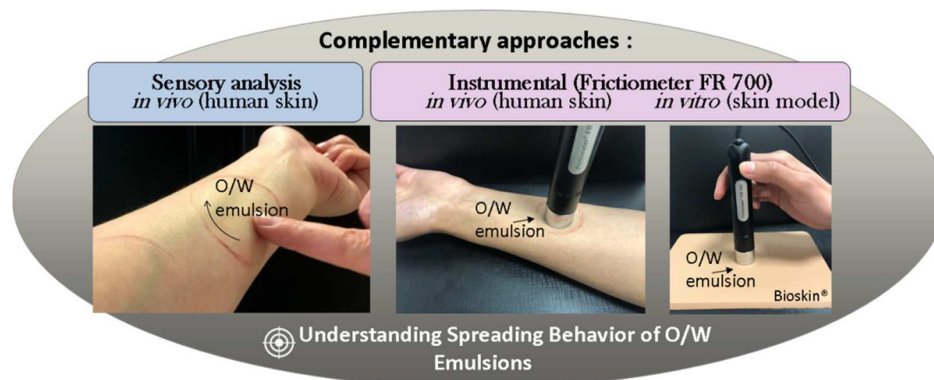
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Abstract

The human skin is a very complex living tissue, in a permanent evolution and self-renewing by constant lipids secretion. The characterization of this biological material is a major concern in dermo-cosmetic and pharmaceuticals fields. Understanding the skin interaction with its environment, during application of skincare products, is consequently of genuine interest to better control the different phenomena occurring. In sensory language, the application of products on the skin is defined as the spreading behavior. Five O/W emulsions were formulated with different ratios of two emollients (isohexadecane and stearic acid). Complementary instrumental and sensory analysis of spreading behavior was carried out *in vivo* on human skin as well as *in vitro* on non-biological skin surface in order to investigate the impact of two emollients, and their mixtures in the spreadability and penetration of O/W emulsions. A first screening was made to link the physico-chemical properties (polarity, physical state and ratio) of emollients with the spreading behavior on human skin. Then, interesting parameters (the plateau value, its length and the increase of the friction value) from the tribological study on skin were considered to allow deepening the product/skin interactions after application of different emulsions and over time. In the last part of the study, an original method, using non-biological surfaces mimicking the human skin, was successfully tested with very good reproducibility of the spreading behavior. This original tool is of great interest to study the efficacy of new formulas on skin, but also for fundamental research and help performing standardized measurements as well as solving the logistic and safety problems of *in vivo* studies.

Keywords: Human Skin; Skin Model; O/W Emulsions; Skin/Product Interaction; Spreading; Emollient; Sensory; Frictiometer

1 Introduction

The skin is the most heaviest and extensive organ of the human body [1]. Through its structure and composition, it plays an essential protective role from unwanted influences from environment as well as to prevent excessive water loss from the body. The uppermost skin layer, the *stratum corneum*, consists of corneocytes embedded in a lipid matrix. This lipid matrix is crucial for the skin barrier function [2]. Also, the *stratum corneum* surface consist in a hydrolipidic film, qualified by some authors as a spontaneous emulsion [3,4]. Depending on the ratio between sebaceous and epidermal lipids, the surface properties of the skin can consequently vary. Moreover, the human skin is a very complex living tissue, in a permanent evolution and self-renewing by constant lipids secretion [1,3]. In this sense, the characterization of this biological material is a major concern in dermo-cosmetic and pharmaceutics fields.

Understanding the skin interaction with its environment, during and after application of skin-care products, is consequently of genuine interest to better control the different phenomena occurring. In sensory language, the application of products on skin is often defined as the spreading behavior. This important property, defined as the force required to spread a product on a given surface, can be influenced by the choice of ingredients, in particular of emollients [5]. Besides their sensory interest, the emollients are an important cosmetic and dermo-cosmetic ingredient, being largely prescribed for their therapeutic virtues in managing eczema or other skin diseases [6–8]. As pure ingredient, their spreading properties were largely evaluated in the literature by using rheology, viscosity, contact angle measurements or sensory analysis [5,9–11]. However, regarding the impact of emollients on the spreading behavior in real complex matrices, like emulsions, few studies have been published. Savary et al. [12] have established that the viscosity and the contact angle of emollients influenced the

spreading properties of emulsions, without trying to understand the interactions between the skin and the product. The study of Gore et al. [13] concluded that the physical state of emollients and their different ratio in the oil phase influence the spreading behavior of emulsions, with some attempts to understand the interaction of the emollients in O/W emulsion with the skin. With respect to this poorly investigated field, further studies are needed to highlight and understand the phenomena occurring during the products application (spreading) between the skin and oil-in-water emulsions. The full understanding of this complex phenomena is highly challenging as it may help innovation by developing optimized ingredients and products, owning specific spreading behavior, penetration or barrier properties. However, comprehensive studies available in the literature remain rare and generally rather former. This is probably explained by the high difficulty to study a living and complex material, subject to large variability [3].

The present work represents an original and transversal study exploring the spreading behavior with different complementary methods. First this study investigated how the physicochemical properties of two emollients - the physical state, the viscosity and the polarity - influence the spreading behavior of five O/W emulsions. To deal with this challenge, complementary instrumental and sensory analysis of spreading behavior was carried out. First, the spreading behavior was studied with a sensory approach to obtain an immediate response of the spreading perception of the products on skin by expert assessors. Secondly, the long term (120s) reaction of the skin to spreading was investigated with the use of a frictionometer in vivo on human skin as well as in vitro on non-biological skin surface. The combination of these comprehensive approaches made possible to explore and understand the way human skin interacts with different skin-care products, and the phenomena occurring during and after application on skin : lubricating length, the initiation of absorption and penetration of the emulsions into the skin.

2 Material and methods

All emulsions were prepared according to the protocol described by Gore et al. (2018) [13]. The content of each emulsion, the International Nomenclature of Cosmetic Ingredients (INCI) and the supplier of raw materials are presented in table 1.

Table 1. INCI¹, supplier and content of the five O/W emulsions formulated

	INCI ¹	Supplier	Content of emulsion (% w/w)				
			I0SA20	I5SA15	I10SA10	I15SA5	I20SA0
Oil phase	Isohexadecane (I)	IMCD	0	5	10	15	20
	Stearic Acid (SA)	Croda	20	15	10	5	0
	Steareth 2	Croda	3.0	3.0	3.0	3.0	3.0
	Steareth 21	Croda	2.0	2.0	2.0	2.0	2.0
Aqueous phase	Distilled water		QS	QS	QS	QS	QS
	Butylene glycol	Acros Organics	4.0	4.0	4.0	4.0	4.0
	Xanthan	Rhodia	0.5	0.5	0.5	0.5	0.5
Preservative	Phenoxyethanol, Methylparaben, Ethylparaben, Propylparaben	Jan Dekker International	0.5	0.5	0.5	0.5	0.5

¹ INCI, International Nomenclature of Cosmetic Ingredients

2.1 Rheological characterization

Rheological behavior of emulsions was analyzed using a stress controlled rheometer (HR-1, TA Instruments), at 25°C using a cone-plate aluminum device with a 40 mm diameter, 1°59'38" cone angle and a 47 μm gap. Measurements were made at last in duplicate and a fresh sample was loaded with a spatula for each run. After loading, the samples rest for 2 minutes for an acclimatization before each analysis.

To characterize the emulsions, the flow and viscoelastic properties were carried out. The continuous shear flow tests were recorded with increasing shear rates ranging from 10⁻² to 10³ s⁻¹, in logarithmic mode, on a duration of 300s. We then focused on the viscosity of emulsions obtained at 0.1 s⁻¹ and 100 s⁻¹, representing the consistency of emulsions at rest and viscosity at a shear rate mimicking its application speed on skin surface, respectively [14].

Viscoelastic behavior was obtained by oscillations strain sweep tests from 0.01 to 100% strain, at a frequency of 1Hz (logarithmic mode). Then, G' (storage) and G'' (loss moduli) on the linear viscoelastic region (LVR) were calculated for each emulsion.

2.2 Sensory analysis

The sensory panel consisted in eighteen expert women assessors, aged from 22 to 29 years, selected among Normandie University (Le Havre, France) employees and students. Two training and two evaluation sessions (one hour each) were performed according to the guidelines in ISO 8586-1 and ISO 13299 [15,16]. Testing took place at the sensory facilities of Normandie University at $21 \pm 2^\circ\text{C}$ and $38 \pm 3\%$ RH. Each product was presented in a 5 mL jar and identified with a randomly assigned three digit code. The code and the presentation order was randomly defined and changed for each session to reduce bias in evaluation.

Emulsions spreading behavior was adapted from the SpectrumTM Descriptive Analysis (SDA) method [17], which provides an accurate sensory description of products by rating each attribute on universal or absolute scales. This study focused on the “ease of spreading” attribute, determined during the rub-out of emulsions on skin. The protocol was developed in order to reproduce and mime the spreading speed of skin care products in normal conditions. Thus, the assessors were asked to draw a circle of 4 cm of diameter on their forearm and to apply 40 μL of product in 20 rotations, by following the beat of the metronome (90 RPM) and by not exceeding the circle area. All these parameters were adopted in order to respect the same film thickness on the skin surface. The ease of spreading was evaluated during the application of the emulsions during the 20 rotations, on a 0-9 scale. Three products were used as reference in order to better discriminate the studied products: Avene Cicalfate Repair Cream at 1, La Roche-Posay Lipikar AP+ Balm at 4 and La Roche-Posay Lipikar Milk at 7. The assessors were allowed to retest the products and the references as many times as necessary.

Both *in vivo* studies presented here, have been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and have been approved by Ethical Committee from Normandie University. All subjects participated only after receiving detailed oral and written information and signing an informed consent agreement.

2.3 In vivo biometrological measurements

Sixteen women volunteers, aged from 20 to 24 years, selected among the Normandie University (Le Havre, France) students, participated in the biometrological investigations. All subjects had no skin disorders at the study sites. No skin care products had been applied to the measured sites for at least 24 h prior to the measurement. The investigation room temperature and relative humidity conditions were: $20 \pm 1^\circ\text{C}$ and $39 \pm 4\%$ RH.

A Frictiometer® FR700 equipped with a plain, smooth Teflon (PTFE) disk with 16 mm of diameter, a Corneometer® CM825 and a skin-pH-Meter® PH905 (Courage-Khazaka electronic GmbH MPA580, Germany) were used to measure the skin friction coefficient, the *stratum corneum* hydration and the pH, respectively. In order to reproduce the sensory evaluation conditions the measurements were made on the same area of application (circle of 4 cm of diameter) on the forearm, with the same quantity of product (40 μL), with circular movements and same speed of application (90 RPM), in duplicate. In order to reduce the bias and to respect the same film thickness on the skin surface, all measurements were made by the same operator.

The conditions of the measurements were as follow:

- Acclimatize the assessor for 20 min with the naked forearms.
- Draw circles of 4 cm of diameter on both forearms.
- Measure the pH and the *stratum corneum* hydration level of the bare skin, at least 5 measurements are made and the mean value is recorded.

- Measure the friction value of the bare skin at 90 RPM during 120 s, with one measure taken per second.
- In order to obtain an homogenous repartition of the product on the skin surface, apply 40 µl of emulsion in the circle with 10 complete rotations at 90 RPM in 6 s and apply Frictiometer® immediately after, in order to measure the friction coefficient for residual film of each emulsion on skin. The computer software readily returned the data in arbitrary units (A.U).
- Each product was tested on both forearms of each volunteer.

2.4 In vitro biometrological measurements

Frictiometer® was used in the same conditions as previously described for the *in vivo* study, on a model standardized non-biological skin surface: the artificial BioSkin® Plate #30 (Beaulax, Co. LTD, Tokyo, Japan). This model is characterized by a 4 mm thickness surface, presenting a multilayer structure composed in two layers of polyurethane elastomer, mimicking elastic and viscoelastic properties of skin [18]. This model was already successfully used to evaluate the properties of thin elastomer films applied on skin [19] and also for skin care products application [3,20].

2.5 Statistical analysis

Statistical analyses of collected data were performed on XLSTAT® software package, version 2018.7 (Addinsoft, France). Single-, two- or three-way analyses of variance (ANOVA) were applied to data series in order to test sensory assessor's performances, product discrimination, time of friction application effect, surface effect or product x surface interaction. When a significant difference was revealed between products or surfaces ($p < 0.05$), groups of emulsions and surfaces were formed by Tukey's multiple comparison test. Results are reported as mean \pm standard deviation (SD). Pearson's correlation coefficients were also calculated between all data in order to determine whether significant linear correlations ($P = 0.05$) between them exist or not.

Table 2. Polarity and physical state of emollients and their impact on the rheological parameters of O/W emulsions

Emollient	Log P ¹	Physical state	η^3 mPa.s (°C)	Density ³ g/cm ³ (°C)	Emulsion	Rheological parameters			
						G' (Pa)	G'' (Pa)	η (0.1 s ⁻¹)	η (100 s ⁻¹)
Stearic Acid (SA)	7.4	Waxy solid <i>Melt.point</i> ² =70.7°C	7.8 (80)	0.839 (80)	I0SA20	1753 ^a ± 206	402 ^a ± 66	281 ^a ± 19	1.1 ^a ± 0.2
					I5SA15	520 ^b ± 27	139 ^b ± 7	215 ^b ± 2	0.8 ^b ± 0.0
					I10SA10	291 ^c ± 1	83 ^c ± 3	172 ^c ± 3	0.5 ^c ± 0.0
Isohexadecane (I)	8.6	Liquid	4.1 (20)	0.791 (20)	I15SA5	229 ^c ± 11	55 ^{cd} ± 3	170 ^c ± 9	0.4 ^c ± 0.0
					I20SA0	53 ^d ± 1	18 ^d ± 0	92 ^d ± 5	0.5 ^c ± 0.0

¹ log P values were obtained or calculated from <http://pubchem.ncbi.nlm.nih.gov>

² As measured by DSC analysis, in duplicate

³ Supplier information

^{a-e} Means in a column sharing common superscripts are similar as tested by Tukey's test (P > 0.05)

Means of replicates ± SD

3 Results and discussions

3.1 Link between physicochemical properties of emollients and spreading properties of emulsions

In order to understand the interactions of emollients with the skin during application, some of their physicochemical parameters were considered as the physical state and the polarity, by formulating emulsions with different ratio between emollients (table 2). This hypothesis will be discussed in this part. According to the literature, IHD and SA are described as non-polar and polar, respectively [21–23], the polarity of SA being attributed to the carboxyl type functions. These two emollients display log P coefficients characteristic for lipophilic substances, lower log P for SA (7.4) and higher for IHD (8.6).

As stipulated in the literature, the polarity of the emollients and their physical state may affect the mechanisms of interaction of the product with skin, the structural organization and the organoleptic characteristics of the emulsion [13,24,25]. When applied on the skin surface, a skin care product strongly interacts with the amphiphilic/monopolar surface components and also penetrates the *stratum corneum*. These interactions depend on the nature and the composition of the emulsion : continuous phase, polar or non-polar emollients, nature of surfactants ... [3]. Since the external layer of the human skin, the *stratum corneum*, is recovered by a polar hydrolipidic film [26,27], it means that polar emollients, such as SA, would have more affinity with the skin comparing with non-polar emollients. Moreover, the human sebum mainly consist in neutral lipids C18 type, like stearic acid, that's why fatty acid is successfully used in the preparation of artificial sebum to better reproduce the skin sebum composition [27,28]. In this way, one could link the polarity of emollients with their affinity for the hydrolipidic skin film. As an illustration, the penetration ability of emollients into the lipophilic *stratum corneum* may depends on polarity, the higher the value of log P, the longer time needed to penetrate into the skin surface [12]. It means, IHD, with higher log P than SA,

will need longer penetration time and for consequence, an easier and longer spreading behavior on skin, because of its weak affinity with the skin surface. Furthermore, in emulsion, at room temperature, SA can be found under a crystallized form. This emollient is known to penetrate into the inter lipid layers of the stratum corneum and its logP impedes the penetration into the skin, except in the wrinkles and follicular ducts [34-35].

Another parameter considered in this study was the physical state of emollients, which can influence the viscoelastic behavior and the viscosity of the emulsions and by consequence their spreadability on skin [9]. Many studies have been led regarding the impact of viscosity in the spreading behavior of emollients or emulsions [9,12,29], but only few considered different physical states and different ratio of emollients in emulsion [13]. Viscoelastic behavior of emulsions is presented in table 2. All products exhibited a predominant elastic behavior ($G' > G''$) within the LVR. The emulsions containing only SA, showed values 30 and 20 times higher G' and G'' , respectively, compared to IHD emulsion. It seems that, only 5% of IHD in an emulsion containing 15% of SA, will have a significant decreasing effect on its viscoelastic behavior.

The viscosity values obtained for the five emulsions (table 2) also showed that the physical state and the ratio of emollients play a significant role, high ratio of liquid emollient (IHD) procured the lower viscosity to the respective emulsions at rest (0.1 s^{-1}). Emulsion obtained with 100% of IHD was three times less viscous than the emulsion obtained with 100% of SA, at 20% of oil phase in emulsion. Interestingly, intermediate viscosities were recorded for the emulsions containing both emollients, with no-significant differences between I15SA5 and I10SA10. According to the literature, the viscosity of the system obtained between 100 s^{-1} and 1000 s^{-1} could be related to the spreading or application speed on a surface [13,14,30]. Thus, viscosities obtained at 100 s^{-1} of shear rate would be associated with the viscosity of the product during application. Since O/W emulsions exhibit a shear-thinning behavior,

viscosities were significantly reduced between 0.1 and 100 s⁻¹ and less difference between products were obtained. Generally, using this rapid rheological measurement, one can observe that the emulsion containing only semi-solid emollient will procure a more viscous emulsion [30, 31], and consequently, more difficult to spread than the one containing only liquid emollient.

In the following section, the spreading of each emulsion has been studied using an objective method of sensory characterization, *in vivo*, in order to determine how the physicochemical properties of the systems influenced their behavior during application on the skin.

3.2 Characterization of spreading behavior by sensory analysis

According to a recent review on skin surface physico-chemistry, understanding the mechanisms for sensory properties modifications induced by product application on the skin is an important key issue to deepen [3]. The spreading behavior of topical products is an important purpose for sensory quality, but also for its efficacy [12]. In order to characterize spreading behavior of the five emulsions on skin, measurements were made by an expert panel. The panel was asked to assign the intensities perceived during the product application on skin for the ease of spreading attribute. Results obtained are presented on figure 1.

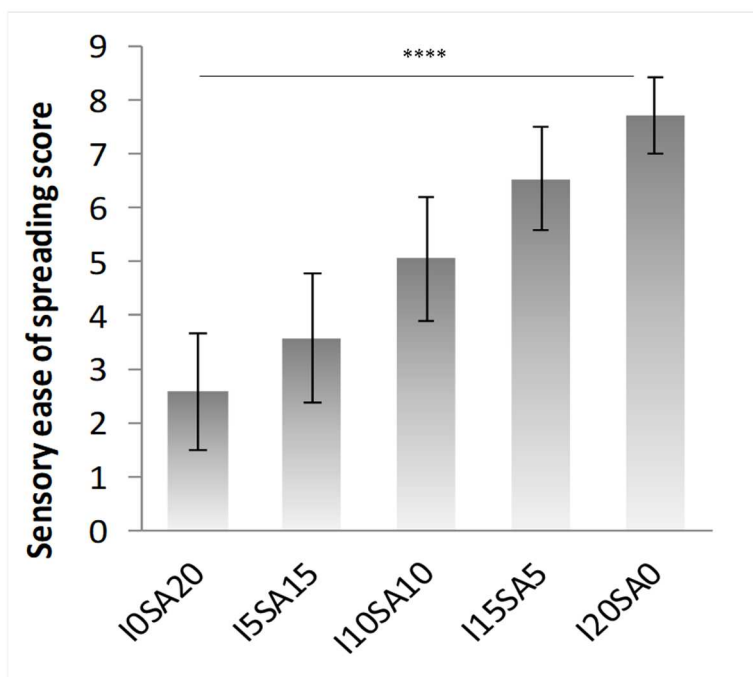


Figure 1. Mean sensory scores obtained for O/W emulsions for the attribute ease of spreading ****, $p < 0.001$, as tested by Tukey's test ($P > 0.05$)

According to the ANOVA, assessors were able to discriminate the five emulsions at a highly significant p-value. Ease of spreading scores obtained are well distributed on the scale, with values comprised between 2.6 for I0SA20 (the more difficult to spread) and 7.6 for I20SA0 (the easiest to spread). A linear relationship between products can be observed in function of the emollients composition (increase of % in IHD and spreading behavior) and the physicochemical properties of the emollients in emulsion (increase of logP and decrease of G' , G'' , η). According to the product x assessor interaction (two-way ANOVA), assessors obtained a non-significant effect ($p = 0.999$), only 2 % of variability between the scores is explained by the assessors notation manner. In other words, only the emollients composition can be considered as the major factor of variation for the spreading behavior on human skin. To conclude this part of the study, the sensory applied approach allowed a good discrimination between products by the panel, and products exhibit well defined spreading behaviors induced by the emollients composition in emulsion during application.

3.3 Comparison with instrumental measurement of spreading on human skin

In order to better understand the spreading phenomena on the skin, and the interactions between skin and residual film formed by the O/W emulsions, a tribological study was conducted on human volunteers as well. In order to reduce bias induced by the age of the volunteers, only young women (20-24 years) were selected for the study. Measurements were done with a frictiometer, which are particularly interesting since they can evidence the skin-product interaction [13]. To this purpose, the conditions of the sensory study were reproduced here: the same quantity of product, application zone and application speed. The results of friction values obtained for 2 minutes after application of the emulsions are presented on figure 2.

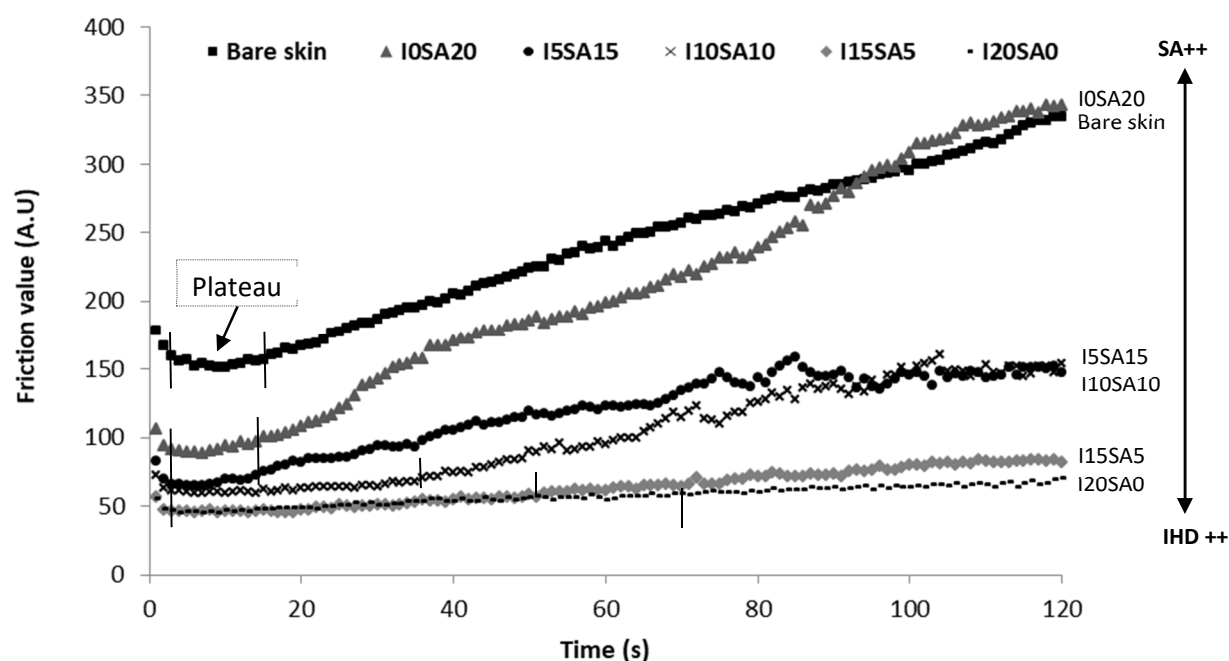


Figure 2. Mean friction value obtained on bare skin (without product) and after application of the five O/W emulsions on the volar forearm of 16 human volunteers

Typically, the friction values on human skin are higher, directly after application of the probe on the studied surface, to gain after around 2 seconds a plateau value [11]. A linear progression of the plateau length is observed in function of the emollient composition in

emulsion (Figure 2). It has been established that the plateau value was very short for emulsions rich in polar and semi-solid emollient (15 and 20% of stearic acid), with no significant difference between both emulsions. A significantly different intermediate plateau length was obtained for the emulsion containing both polar and non-polar emollients in equal ratio and very long for the emulsion with 15 and 20% of non-polar and liquid emollient (IHD), with significant difference between both emulsions (p-value < 0,001). The plateau value also reflects the lubricating effect of the emollients and their mixtures, longer the plateau values longer the lubricating effect [11,13]. For instance, when ratio between IHD and SA were 1:1 the lubricating effect of the emulsions exceeded 30 seconds of application on human skin. Later, the friction values gradually increase after the plateau value. It means that emulsion start to absorb and penetrate into the *stratum corneum* and the hydrating effects overcome the lubricating effect [11,13]. This moderate, for I5SA15 and I10SA10, to high increase in friction value, for I0SA20, early after product application can be interpreted as the SA effect of an immediate hydration produced by the aqueous vehicle and some degree of stickiness, related to the nature of the residue left by the emulsion on skin, which probably produces some occlusive effects [11, 34]. As the occluded skin surface becomes more hydrated, this process overcomes the lubricant effect of the emulsion and a steady increase in friction value is observed. The subsequent steady increase in friction value reflects the slow hydrating effects of a product which acts mainly by occlusion [11]. When the emulsion is still not absorbed into the *stratum corneum* layers, the lubricant effect of emollients allow to keep a stable and a low friction coefficient for long time application of emulsions, as in the case of I15SA5 and I20SA0, showing curves with little evolution over time.

The notable differences between products could also be explained by the polarity of emollients and their affinity for the skin, and more precisely for the lipid layer on the skin surface. It has already been shown that the *stratum corneum* is the main barrier that

anticipates skin penetration. This barrier has to be overcome when skin care products are applied on the skin, in order to deliver an active ingredient to the viable part of the epidermis, for example [22,32]. As a consequence, the polar SA would have more affinity for the polar lipid surface of the skin, would rapidly interact with the skin barrier, resulting in better hydrating effect and gradually increase of the friction value, as described before. As described in the literature, the penetration ability of emollients into the lipophilic *stratum corneum* depends, among others, on the polarity of the molecule, the higher the values of log P, as in the case of IHD, the longer the penetration time [12,22].

To sum up, this part of the study allowed deepening the product/skin interactions after application of different emulsions and over time. It highlights how emulsion composition highly influences the penetration and absorption in the human skin and help to understand the spreading behavior. Moreover, the plateau value, its length and the increase of the friction value appear as very interesting parameters to consider when trying understanding the product-skin interaction. In the last part of this study, the friction measurements were implemented on model skin surface. This material has the interesting property to not absorb the product applied on it. It is thus possible to distinguish the different phenomena occurring during spreading, in particular absorption and formation of the residual film interacting with skin.

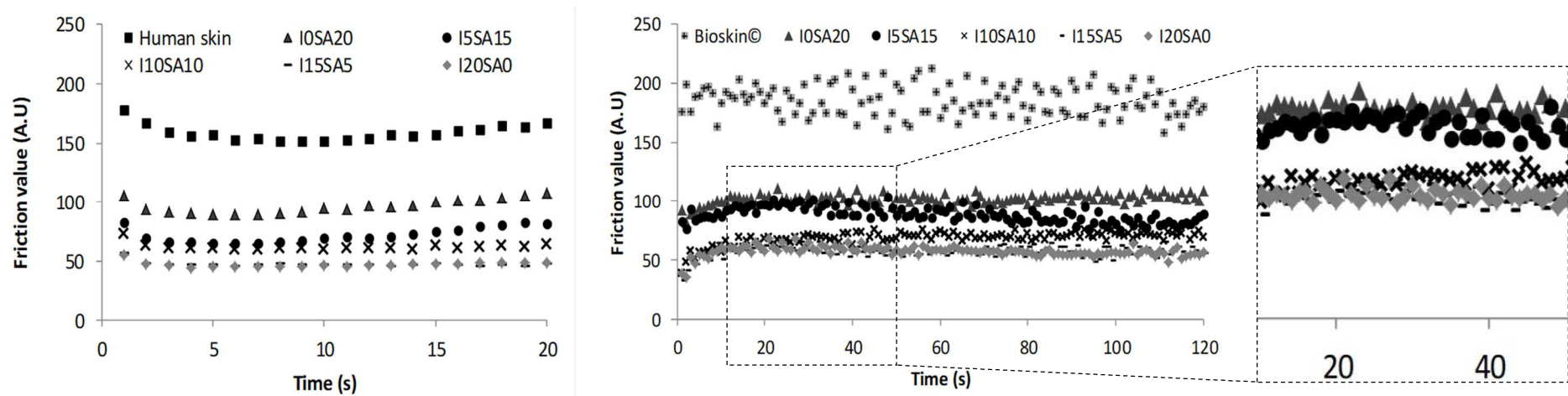


Figure 3. Mean friction values obtained on human skin (left) and Bioskin® (right) after application of the five O/W emulsions

3.4 Model skin surface to reproduce and understand spreading, absorption and formation of O/W emulsion residual film

After a study of the existing skin models on the market, the choice was made mainly on the mechanical properties of the non biological surface Bioskin®. This model is easy to handle, easily affordable, miming skin mechanical and optical properties, its surface belongs to the low energy materials which can be pertinent to characterize residual films properties. This surface has been successfully used to evaluate different properties of residual films left by cosmetic products [19,20,33]. In the present study all conditions of the *in vivo* biotribological measurements were identically reproduced on Bioskin®. Figure 3 shows the comparison between the curves obtained on human skin during 20 s and on Bioskin® during the 2 minutes of test.

Interestingly, in the conditions mentioned above, comparable curves were obtained for both human skin and Bioskin®. The friction curves were explored before absorption of the first emulsion begins, i.e. at 20 s. This figure illustrates the constant spreading behavior of emulsions without absorption and penetration into the *stratum corneum*. On both surfaces, all five emulsions showed friction values ranging from 50 to 100 A.U of frictiometer. The human skin was characterized by a mean friction value around 150 A.U. The most noisy and slightly higher friction value was obtained for bare Bioskin®. Generally, in the conditions applied, it seems that Bioskin® reproduces similar spreading behavior of O/W emulsions as obtained on human skin. This result was not completely surprising, since in a recent physico-chemical study, it was demonstrated that the residual film wettability on Bioskin®, 3 minutes after application of different emulsions, reproduced *in vivo* wettability [3]. This surface model also showed similar spreading behaviors of four emollients with *in vivo* spreading, carried out by contact angle measurements, each emollient interacting with Bioskin® in the same way than with human skin [28].

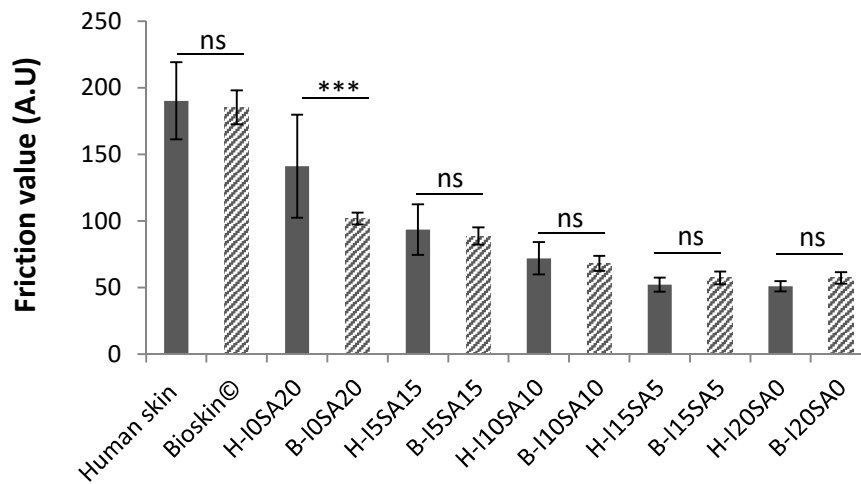


Figure 4. Mean friction values obtained on the bare human skin (dark grey, H prefix) during 60 seconds and on Bioskin® (striped pattern, B prefix) during 120 seconds as well as after application of the five O/W emulsions

To conclude, the last challenge of this work was to consider if Bioskin® would give predictable spreading values comparable to the human skin. In this respect, different ANOVA were applied to the data in order to compare results obtained on both surfaces at different application times (figure 4). Interestingly, it would appear that Bioskin® give predictive results when comparing friction values obtained at 120 s of friction on it and the ones obtained on human skin during 60 s. This applies to both bare human skin and Bioskin® and all four O/W emulsions containing IHD. The only different significant mean friction values were obtained on both surfaces, for the emulsion containing 20% of SA. This last result could be explained by the composition of the emulsion, for which during the spreading, the water was rapidly absorbed into the skin, leaving a consistent part of the oil phase, which is semisolid at room temperature. Because of its crystallized form, SA procure a very viscous emulsion, due to numerous small crystals and consequently a very viscous and difficult to spread residual film on the skin surface [13]. Under these circumstances, for 20% rate of SA in oil phase, the emulsion shows significant difference when applied on both surfaces, human skin during 20 s and Bioskin® during 60 or 120 s, when no absorption of product is

evidenced. The development of this original tool is of large interest and could avoid using *in vivo* methodology, the last being largely limited by both inter and intra individual variability, by the toxicity control, the cost and the time needed for such studies [3].

Conclusion

In conclusion, the study allowed deepening both knowledge and understanding of skin interactions with its environment, after application of different emulsions. It highlights how emulsion composition, and more specifically the emollient content, highly influences the penetration and absorption in the human skin and help to understand the spreading behavior. Moreover, an original method, using non-biological surfaces mimicking the human skin, was successfully tested with very good reproducibility of the spreading behavior. This original tool is of great interest to study the efficacy of new formulas on skin, but also for fundamental research and help performing standardized measurements as well as solving the logistic and safety problems of *in vivo* studies.

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