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Literature List

MoistureMap

The MoistureMap is licenced worldwide under the L'Oréal patent for the Skin Chip® (EP 1 438 922 B1). A variety of articles on the capacitance imaging measurement principle has been published.

*C. Uhl, D. Khazaka, **Skin sensitization in pandemic times**, PERSONAL CARE MAGAZINE, June 2021*

For almost a year and a half, an unprecedented pandemic has had us in its grip worldwide, forcing us to abandon many cherished activities and realign our entire daily lives. It is particularly important in these times to prevent the spread of the pandemic through protective measures, distance and significantly increased requirements for hygiene measures such as the wearing of protective mouth-nose masks and the frequent use of sanitisers on all kinds of surfaces and naturally also on the skin.

*C. Uhl, D. Khazaka, A. Pouladi, **“Classic” biophysical methods for hair & scalp**, PERSONAL CARE, March 2021, p. 23-26 and **Métodos biofísicos ‘clásicos’ de análisis capilar**, Revista técnica de la Industria Cosmética, Perfumería e Higiene Personal, Primavera 2021 No. 018, p. 34-37*

Hair is not only strands of horn made mainly of keratin. Hair indicates someone's personal beliefs or social status. The matter of hair care / grooming is not entirely all about women. For men, a well-kept, thick head of hair brings added good looks. However, there is more to it. Nowadays, social media, most of all Instagram, influences different generations. Besides skin, hair is the characteristic attribute for health, youth and attraction. Hair can even be a communication and political instrument. Just take as an example the men who let grow a moustache of their own style every November of a year, the so called Movember, to raise funds for men's health. Plenty of products and treatments are ready to fit the modern hair care market for thin, thick, curly, dry, oily, blonde, coloured, ethnic, young, or old hair. Imagine a claim, the product is already invented. As hair is unique, personalised products flood the hair care market. Respectively, a great number of claims around the various products exists. Hair care rituals can be complemented with food supplements and treatment devices.

Además de la piel, el cabello representa un atributo social característico de la salud, la juventud y la atracción. Multitud de productos y tratamientos están listos para ser adaptados al nuevo mercado de cuidado del cabello, específicamente para tratar cabellos finos, gruesos, rizados, secos, grasos, coloreados, jóvenes, envejecidos... Existe un gran número de afirmaciones en torno a los distintos productos existentes en el ámbito del cuidado capilar.

*A. Charpentier, **Clinically supporting ‘antiage’ and ‘pro-age’ claims**, Personal Care Europe, June 2020*

Claims of personal care evolve following trends and various innovations in the field of the active ingredient development, the finished product formulation and the way both are evaluated, demonstrating their performances. Since 2014, the cosmetics industry is gradually leaving the era of anti-ageing behind. Today, most consumers are more in the mood for a well ageing, slow ageing or pro ageing approach. The philosophy of the 'pro-ageing' movement has sought to remove all 'anti' claims because, according to this concept, women over 50 are not interested in looking younger; they want to look healthy and be honest about their age. Some brands have used the idea of "improves the appearance of skin quality", and "restore the skin comfort", for example. A new vocabulary of renewal, regeneration, plumpness and "glow" now dominates the language of the beauty industry.

*C. Uhl, D. Khazaka, **Measuring skin's “true age”**, PERSONAL CARE June 2020, p. 66-68*

The human desire to look young is as old as mankind and our skin plays central role in this craving. Even in ancient civilizations, people developed formulations for creams, tonics and bath additives to keep skin young and beautiful. The physiological process of skin ageing involves structural, biochemical and functional changes. Starting at approximately age 25, the content of collagen and other components of the connective tissue, such as elastin or hyaluronic acid, in the skin continuously decreases. This gradually results in a loss of bound water, leading to a deterioration of the water-protein interaction and an alteration of the overall protein stability.

*C. d'Erceville-Dumond, I. Bonnet, Solene Mine, F. Trombini, C. Kalem, V. Andre-Frei, **Rambutan bioactives for hair and skin***, PERSONAL CARE EUROPE. September 2019

BASF is sourcing the raw materials for three new highly effective natural skin and hair care ingredients from two of Vietnam's first organic-certified rambutan gardens. The bioactives are extracted from the fruit's peels, leaves and seeds- potential byproducts of fruit cultivation that are usually discarded. This form of upcycling benefits both the environment and local rural communities.

*M. Benvegnu, C. D'Erceville, I. Bonnet, D. Hérault, A. Mine Solène, V. Frei, **The Sustainable Rambutan Program: A Multiple Valorization to Foster a Better Local Impact***, presentation at the 25th IFSCC Conference Milan, October 2019

In the global trend of responsible living, consumer's beauty routine is one key field where consumers seek for products with ecological and social engagements. The future cosmetic solutions should be developed with an environmental consciousness while keeping the same high level of in vitro demonstrated biological efficacy and clinical performance. Responsible living is a daily challenge, women and men want to give their skin and hair special care to counter environmental impacts, but not to the detriment of the planet. Consumers are now searching for more ethical cosmetic products, which are as healthy for them as they are for the earth. Consequently, the cosmetic industry has taken up the trends of the demand of modern consumers and their growing environmental awareness to continue developing sustainable solutions. This industry expects more responsible cosmetic ingredients from suppliers who can assure a reliable supply chain and social commitment, and who will not compromise on the level of effectiveness. This is the starting point of our work. Capitalizing on our experience acquired with a previous Argan program, we identified a plant and built a new specific supply chain in cooperation with a long-standing local partner in Vietnam. We identified rambutan, also called *Nephelium lappaceum*, a well-known tree in Asia, that grows in the humid tropics. Out of the fruit itself, we discovered that other by-products of the rambutan plant may possess interesting properties for our skin's health and beauty.

*A. Charpentier, **Soothing effect dedicated to sensitive skin***, PERSONAL CARE EUROPE, April 2019, p. 76-77

The skin plays multiple roles of protection, perception, immunity, regulation of blood and lymphatic reservoir for the whole body. Thanks to several mechanical, chemical or biological (sebum, biofilm...) reactions, the skin ensures its integrity according to the various endogenous or exogenous environmental variations. Today, the increase in the fragile phenomena of skin is a major issue in the development of dermo-cosmetics.

*C. Uhl, **Efficacy testing of microbiome skin care***, PERSONAL CARE EUROPE, April 2019, p. 41-45, PERSONAL CARE ASIA, May 2019, p. 51-55, косметолог 2 [94] 2019 (in Ukrainian), Cosmetics & Toiletries Brasil, Vol. 31, Mai-June, 2019, p. 22-27 (in Portuguese)

For years now, we have accepted the idea that we can nourish our intestinal tract with dedicated bacterial ingredients from food supplements and thereby improve our general health. Books written on this subject have become bestsellers. But why should we focus only on our intestinal tract? There are so many different microbial communities that can be found on and inside our body. Especially the colonization of the skin being our largest organ, tangible to the hands, visible to the eye, and in constant contact with the outside environment has moved to the front of cosmetic research. The idea of being a complex ecosystem is adding to the existing trend of personalised cosmetics, and will confirm the customer in their feeling of uniqueness.

В течение многих лет мы принимали идею о том, что можем обогащать наш кишечный тракт специальными бактериальными ингредиентами из пищевых добавок и тем самым улучшать общее состояние здоровья. Книги, написанные на эту тему, стали бестселлерами. Но можем ли мы сосредотачиваться только на нашем кишечном тракте?

O microbioma cutâneo é a população de microrganismos que habita a pele. Neste trabalho, o autor apresenta uma breve descrição da importância da atividade do microbioma e dos meios analíticos instrumentais para medir a eficácia de produtos cosméticos de interesse do microbioma cutâneo.

*V. Brancato, A. Ratti, K. Tudisco, **Valutazione dell'efficacia idratante**, Cosmetic Technology, Gennaio-Febbraio, 2019 - 22(1) (article in Italian language)*

Hydration is a key factor for skin health. Our largest organ, the skin, is composed by two main layers: the dermis, the inner layer, and the epidermis, the outer layer. Epidermal water content has a gradient: 70% in the viable epidermis which decays to 15-30% at the skin surface. In order to prevent any change of skin moisture, skin aging and other kind of alterations, a daily hydrating routine is needed. Choosing the best product is not so simple, skin hydration is a complex process and different molecules can regulate the water content in several ways. In the present study, we show the *in vivo* hydrating efficacy (instrumentally assessed) of three emulsions containing different concentration of snail slime against a blank formulation. This secret contains several components: allantoin, collagen, elastin, mucopolysaccharides, and glycolic acid among others, conferring to the slime hydrating, regenerating, nourishing and exfoliating effects when applied onto the skin.

*E. Berardesca, M. Loden, J. Serup, P. Masson, L. Monteiro Rodrigues, **The revised EEMCO guidance for the *in vivo* measurement of water in the skin***, Skin Res Technol. 2018; 24: p. 351-35

Background: Non-invasive quantification of stratum corneum water content is widely used in skin research and topical product development. Methods: The original EEMCO guidelines on measurements of skin hydration by electrical methods and transepidermal water loss (TEWL) by evaporimeter published in 1997 and 2001 have been revisited and updated with the incorporation of recently available technologies. Results: Electrical methods and open-chamber evaporimeters for measurement of TEWL are still the preferred techniques to measure the water balance in the stratum corneum. The background technology and biophysics of these instruments remain relevant and valid. However, new methods that can image surface hydration and measure depth profiles of dermal water content now available. Open-chamber measurement of TEWL has been supplemented with semi-open and closed chamber probes, which are more robust to environmental influence and therefore convenient to use and more applicable to field studies. However, closed chamber methods interfere with the evaporation of water, and the methods cannot be used for continuous monitoring. Validation of methods with respect to intra- and inter-instrument variation remains challenging. No validation standard or test phantom is available. Results and Conclusions: The established methods for measurement of epidermal water content and TEWL have been supplemented with important new technologies including methods that allow imaging of epidermal water distribution and water depth profiles. A much more complete and sophisticated characterization of the various aspects of the dermal water barrier has been accomplished by means of today's non-invasive techniques; however, instrument standardization and validation remain a challenge.

*U. van Daele, P. Moortgat, R. Clijsen, J. Meirte, M. Anthonissen, K. Maertens, P. Clarys, **Bioavailability of scarred skin during application of a vaso-active substance***, Poster Presentation, 17th European Burn Association Congress EBA, Barcelona, September 2017

Objectives: The skin acts as a mechanical or insulation barrier in physiotherapy interventions. The evidence of topical applications in physiotherapy is poor or lacking in skin and (burn) scar research. In this study, non-invasive skin measurements will be used to evaluate bioavailability of scarred skin during application of a vaso-active substance. Methods: Two groups consisting of 14 scar sites and 8 healthy skin sites are selected based upon predefined inclusion and exclusion criteria. Baseline measurements on a 6cm² scar/skin site include skin color, trans epidermal water loss, skin hydration and epidermal and dermal thickness. A filter disk saturated with a Methylnicotinate (MN) solution (0.005M) is applied for 30 seconds on the marked scar/skin site. Bioavailability is assessed by quantification of an MN-induced skin redness observed with the Chromameter® over 65 minutes after the MN application by a standardised protocol. Change in skin color is compared using a repeated measures ANOVA. Spearman correlations between skin color and all independent variables are calculated. Between group differences are tested by the Mann-Whitney. Spearman correlation coefficients between skin hydration outcome measures are calculated. Results: A significant group x time effect for chroma a^* values is demonstrated ($p=0,044$). A significant difference between both groups is found for the sum of total color change ($p=0,02$) and for dermal thickness ($p=0,044$). A significant difference between both groups is found for the sum of total color change ($p=0,02$) and for dermal thickness ($p<0,0001$). A correlation between the latter parameters is significant ($r=,587$, $p=0,004$). Hydration values of the Corneometer correlate significantly with the Grey Index T of the Moisture Map® ($r=0,427$, $p=0,047$). Conclusion: The dermal thickness is a determining factor for bioavailability of MN in scars. Epidermal thickness and TEWL were

no significant factors of influence on skin color within the current study. The Moisture Map® can be used as an assessment tool for skin hydration, especially the Grey Index T seems a valuable parameter based upon the current primary study results.

S. Mac-Mary, J.-M. Sainthillier, P. Humbert, Mesure instrumentale de l'hydratation cutanée, EMC - Cosmétologie et Dermatologie esthétique, June 2017

L'eau joue un rôle fondamental dans les propriétés physiques de la peau en permettant d'assurer sa solidité, sa flexibilité et une perméabilité minimale pour que l'eau endogène puisse jusqu'à la surface cutanée activer les enzymes responsables de la desquamation. Dans la couche cornée, elle est fixée sur des substances hydrosolubles et hygroscopiques intracellulaires appelées *natural moisturizing factors*. Cette eau représente l'aspect statique de l'hydratation cutanée.

A.-M. Pensé-Lhéritier, A. Sirvent, Objectivation des produits antitranspirants et déodorants, in: A.-M. Pénse-Lhéritier (Editor): Évaluation des produits cosmétiques, Lavoisier Paris, Tec & Doc, chapter 9, p. 144-157, 2016

Longtemps délaissée, le produit affichant une activité déodorante et antitranspirante fait actuellement l'objet de nombreuses innovations et de communication de la part des entreprises. En effet, ce produit s'est vendu en 2015 à 4 milliard d'unités soit le troisième dans la catégorie hygiène après le gel douche et le dentifrice. Au-delà des nouvelles propositions d'emballage compressé, les marques ont fixé leur innovation: - sur la substitution des ingrédients pour le marché féminin: matières premières naturelles et minérales moins agressives; - sur des produits techniques pour les hommes: capteurs d'odeurs par exemples. Afin de ne pas décevoir ces populations quant à l'efficacité des produits, ce qui entraînerait automatiquement l'absence de ré-achat, il est très important de pouvoir offrir des méthodes d'évaluations efficaces pour tester ces produits s'affichant comme déodorants et/ou antitranspirant. Sous ces noms se cachent en fait deux modes d'action bien différents. Le déodorant ne perturbe pas la sudation et se contente de masquer l'odeur. Quant à l'antitranspirant (ou antiperspirant), son rôle premier est avant tout de bloquer l'écoulement du flux sudoral et il revendique des effets absorbants, antihumidité et neutralisants.

V. Mengeaud, Évaluation de l'effet hydratant, in: A.-M. Pénse-Lhéritier (Editor): Évaluation des produits cosmétiques, Lavoisier Paris, Tec & Doc, chapter 3, p. 32-57, 2016

La peau constitue l'interface principale entre l'environnement extérieur et notre organisme, qui est équipée à son extrême surface d'une très fine couche tissulaire appelée *stratum corneum* (SC) dont la fonction spécifique de «barrière» est indispensable à notre survie terrestre. Elle est non seulement protectrice vis-à-vis des agressions extérieures qu'elles soient physiques, chimiques ou microbiologiques, mais aussi capable de limiter les pertes hydriques corporelles. Ainsi, l'une des fonctions majeures de la peau est d'assurer son rôle de barrière entre l'organisme et le milieu extérieur tout en préservant des échanges avec celui-ci. La fonctionnalité de cette barrière dépend donc d'un équilibre dynamique. En effet, au niveau de cette interface, sont mis en jeu des mécanismes régulés de manière dynamique et réactive, qui concourent au maintien d'un milieu interne stable alors que l'environnement extérieur subit des variations: ces mécanismes garantissent l'homéostasie cutanée.

C. Uhl, D. Khazaka, Claims and measurement methods for hair and scalp, Personal Care March 2015

Hair diversity (style, shape, growth pattern or colour) is one of the most important features to define us physically. Therefore, it is no surprise that the market of hair care products with a value of US\$39 billion is one of the most important sectors in the complete area of cosmetic products. Hair care products for women are the most frequently bought and used cosmetic products of all. Shampoos and conditioners are leading in the field. For men, hair care is the most important and favoured sector of all cosmetics.

J.L. Lévêque, Skin Capacitance Imaging, Non Invasive Diagnostic Techniques in Clinical Dermatology; Springer Berlin Heidelberg 2014; ISBN 978-3-642-32108-5

Introduction: Before the 1980s, skin was the only organ of the human body impossible to explore and study quantitatively, in vivo, in its three dimensions. Since then, two types of methods were developed and are now routinely used. The first ones are dedicated to the visualisation and characterisation of the different structural layers of the skin (ultrasounds, magnetic resonant imaging, confocal microscopy, optical coherent tomography, multiphoton imaging). These are based on the recording of either vertical or horizontal virtual sections of the different skin layers. Other types of methods are dedicated to skin surface imaging. Skin colour, temperature, micro-relief and blood flow can now be recorded, pixel by pixel, with a high 2D resolution.

C. Piérard-Franchimont, G.E. Piérard, Ustekinumab biotherapy and real-time psoriasis capacitance mapping: a pilot study, J Biomed Biotechnol. Article ID 870194, 5 pages (2012)

In recent years, the treatment of moderate to severe psoriasis has benefited from the development of targeted biologicals. Assessing this new class of drugs calls for precise modalities of severity/improvement ratings of the disease. Bioengineering-driven dermometry aims at improving objective and quantitative assessments of disease severity and treatment efficacy. Skin capacitance mapping/imaging is one of those emerging methods. Among its clinical applications, psoriasis capacitance mapping (PCM) was introduced in order to assess both skin scaliness and water trapping inside the stratum corneum (inflammatory serum deposits) on lesional skin. PCM was used for assessing the therapeutic effects of ustekinumab on target lesions of 5 psoriatic patients. The reduction in the inflammatory dampness of the stratum corneum was conveniently seen after a 1-month ustekinumab treatment. The present pilot study suggests that PCM could be used as a fast and convenient method for assessing the anti-inflammatory efficacy of ustekinumab and other biotherapies.

H. Qiu, X. Long, J.C. Ye, J. Hou, J. Senee, A. Laurent, R. Bazin, F. Flament, A. Adam, J. Coutet, B. Piot, Influence of season on some skin properties: Winter vs. summer, as experienced by 354 Shanghai women of various ages, International Journal of Cosmetic Science, March 2011

The facial skin of 354 women, aged 18–80, living in Shanghai, was investigated over two successive 6 months periods, summer and winter. Results from clinical assessments indicate that aging signs, such as wrinkling and sagging, are unaffected over such period. However, physical measurements revealed alterations in some functional criteria of the skin, such as sebum output, skin colour, melanin content of pigmented spots, skin hydration, all being increased during summer. The relationships between all criteria, as well as technical or applied inferences/consequences from this study, are discussed.

C. Piérard-Franchimont, G.E. Piérard, Hair Weathering and Hair Capacitance Mapping: a Pilot Study, Journal of Cosmetic Dermatology 11:179-182, 2012

Background: Currently, there is no reported objective method allowing confident assessment of hair hydration mapping. Thus, assessing hair moisture kinetics and versatility according to hair shaft damages and hair care products is difficult to perform. Aim: To explore a new method for assessing hair moisture. Method: A new method of hair capacitance mapping (HCM) is introduced for monitoring hair surface damage and hydration. This study was performed on intact and weathered hair locks. Samples were soaked in 10% solutions of regular shampoos or in tap water alone. HCM was performed using the SkinChip® device based on a semiconductor image sensor technology. Time to complete water desorption from cuticular cells was recorded.

E. Xhaufaire-Uhoda, G. Mayeux, P. Quatresooz, A. Scheen, G.E. Piérard, Facing up to the imperceptible perspiration. Modulatory influences by diabetic neuropathy, physical exercise and antiperspirant, Skin Research and Technology 2011; 17: p. 487-493

Eccrine Sweating is under the control of the cholinergic sympathetic innervation. It plays an essential role in regulating body temperature in physiologic and pathologic conditions. This function is altered by some systemic diseases including diabetic neuropathy, which commonly involves the distal sensorimotor innervation. The resulting peripheral sweating deficit is often responsible for unequivocal abnormalities of length-dependent thermoregulatory sweating. Hence, the legs affected by diabetic neuropathy most often present hypohidrosis that has been thought to be compensated by hyperhidrosis on the upper body regions. Other sweating changes in diabetes include segmental hypohidrosis and more rarely isolated dermatome involvement.

E. Xhaufaire-Uhoda, G.E. Piérard, P. Quatresooz, The skin landscape following nonoptical capacitance imaging, J Clin Dermatol 11(2): 89-94 (2010)

Skin capacitance is an electrical property measurable at the level of the stratum corneum. Values are related to the moisture content of the tissue. Using the silicon image sensor technology, it has recently become possible to measure capacitance at 50 micrometer intervals on the skin surface. The resulting non-optical picture corresponds to skin capacitance imaging. This novel tool for dermatologists highlights with precision the hollow skin surface patterns, including dermatoglyphics, the patterns of the shallow skin lines, and wrinkles. The topographic heterogeneity in skin surface hydration is made visible. In addition, the sweat gland and follicular openings are disclosed. Skin disorders induced by surfactants or presenting as hyperkeratotic areas, including some neoplasms, may show typical aspects. It is concluded that skin capacitance imaging brings added value to the clinical assessment performed by dermatologists.

*E. Xhaufflaire-Uhoda, P. Paquet, P. Quatresooz, G.E. Piérard, **Characterization of the skin using capacitance imaging.** Expert Review of Dermatology 5(2): 149-158 (2010)*

Abstract: Skin capacitance imaging is a high-resolution real-time nonoptical image acquisition of electrometric properties of the stratum corneum. The method is useful for assessing the uneven hydration of the stratum corneum, and recording dermatoglyphics and other hollow lines and wrinkles, and pilosebaceous and sweat duct openings. In physiology, skin aging is highlighted by the reorientation of the skin lines and by the increased heterogeneity in the skin surface capacitance. The activity of the sweat glands is conveniently scrutinized under different conditions of stimulation or neuropathic inhibition. In pathology, the method is well suited to assess the effects of moisturizers, antiperspirants and surfactants. Skin tumors exhibit peculiar aspects depending on the presence of hyperkeratosis. Skin capacitance imaging represents a promising method for studying some details of the skin physiopathology and the effects of treatments.

*R. Bazin, S. Laquieze, A. Rosillo, J.-L. Lévêque, **Photoaging of the chest analyzed by capacitance imaging,** Skin Research & Technologie. 2010 Feb, 16(1), 23-9*

*J.L. Lévêque, S. Laquieze, A. Piquet, R. Bazin, **Complémentarité de deux methods d'imagerie de surface pour l'étude de la peau sèche et de ses traitements,** Congrès SF2IC, Bordeaux 2010*

*L. Caisey, E. Gubanova, D. Baras, J.-L. Lévêque, **Unexpected distribution of surface hydration level of the lip,** J Euer Acad Dermatol Venereol 2008 Nov, 22(10): 1159-62*

The functional properties of human lips depend on their hydration level. Limited data are, however, available. To investigate water distribution through the lower lip surface. Images from the surface of the lip were recorded using a new capacitance imaging technique. Capacitance and conductance measurements were also carried out in various points of lower lip and on adjacent skin. Data clearly show that the closest part of the mucosa of the lip is less hydrated than the external part. These unexpected findings could be related to the presence of a premucosa area whose structure is clearly different from that of vermilion zone.

*L. Caisey, E. Gubanova, C. Camus, N. Lapatina, V. Smetnik, J.-L. Lévêque, **Influence of age and hormonal therapy on the functional therapy of lips,** Skin Research & Technologie, 2008 May, 14(2), 220-5*

Aim: To investigate the influence of age and hormonal status on some functional properties of the lips of women. Lips properties were measured and compared through four groups of women (young with normal menses, aged with normal menses, aged and menopausal, aged, menopausal receiving hormonal replacement therapy). The following parameters were recorded: sebum excretion rate on the forehead. On the lower lip: TEWL, mechanical damping, color, tactile acuity. Moreover, capacitance images of each lips were recorded and the mean capacitance measured. Changes in TEWL, mechanical damping and tactile acuity appear clearly linked to age while the increase in lip darkness could be due to hormones. Sebum excretion rate is also clearly linked to hormonal status. Surprisingly, no changes of lips capacitance were detected vs. age or hormonal status. This study confirms that upper lip is more hydrated than the lower one. Most of the parameters measured on the lips have similar variations than the same parameters measured on the skin. Only sebum and color appear being dependant on the hormonal status.

*S. Diridollou, J. de Rigal, B. Querleux, F. Leroy, V. Holloway Barbosa, **Comparative study of the hydration of the stratum corneum between four ethnic groups: influence of age,** Int J Dermatol. 2007 Oct, 46 Suppl 1, 11-4.*

Several recent overviews have reported that significant work remains to be performed to understand and quantify the ethnic differences in skin properties. In this way, we have carried out a set of in vivo biophysical experiments on the skin of American women from different ethnic populations living in the same environment. Inter- and intraethnic skin micro relief results were already published, skin hydration differences are now reported here. The skin water content was evaluated taking advantage of the new skin capacitance imaging technique which allows to study stratum corneum hydration without suffering of the influence of the skin micro-relief and hair on the measurement. Three hundred and eleven American women from four ethnic groups were enrolled in this study. The investigation was performed during the summer season of 2004 on the major relatively distinct ethnic groups of Chicago, which is to say: African American, Chinese, Caucasian and Mexican. The hydration of the skin was investigated on the dorsal and ventral forearm sites as a function of ethnicity and age. Skin dryness is higher on sun exposed sites for lighter skin tones, such as in Chinese and Caucasian women, than on

sites that are primarily out of the sun; while, no skin dryness differences are seen on either site for African American and Mexican women whose skin is darker. The skin dryness does not change as a function of ethnicity for the younger group for either the ventral and dorsal site of the forearm. With age, however, the dryness of the skin is higher for African American and Caucasian women than for the two other ethnic groups, with a higher percentage increase in Caucasian women. This study has revealed that the hydration of the skin is different according to ethnicity and that the age effects are influenced by ethnicity, suggesting anatomical or physiological property differences in ethnic skin. This study has also pointed out that the SkinChip seems to be a convenient and fast way to investigate both the micro relief as previously published and the dryness of the skin on a large number of subjects, and in this way will be very useful to improve our knowledge about skin of people from different ethnic groups and helping to develop specific products that are customized to all these populations.

*E. Xhaufnaire-Uhoda, G.E. Piérard, **Skin capacitance imaging of acne lesions**, Skin Research & Technologie. 2007, 13, 9-12*

Little information is available about specific functional characteristics of skin in acneic patients. To determine a capacitance mapping of lesional skin in acne in order to predict drug affinity according to the hydrophilic-lipophilic characteristics. Skin capacitance imaging based on silicon image sensor technology was used with the SkinChip device. The non-optical images obtained by this means clearly identified low capacitance comedones contrasting with a perifollicular rim of high capacitance in inflammatory papules. This method also showed sweating and the follicular pores distributed in a pinpoint pattern. The objective mapping of skin surface capacitance showed large differences between acne lesions and the surrounding skin. The low capacitance of comedones contrasted with the high capacitance of the perifollicular area in inflammatory papules. These electrometric characteristics reflecting the corneocyte hydration may influence drug affinity to acne lesions.

*G.E. Piérard, **Skin capacitance imaging for dermatologists**, Eur Dermatol Rev: 62-3 (2006)*

Dermatologists perceive the skin aspect through its optical properties. The use of a magnifying lens or dermoscopy increases the sensitivity of the observations. However, some characteristics remain invisible to the human eye. Bioengineering is working in this field to help visualizing and quantifying some of these aspects in a non-invasive way. For instance, our laboratory worked on the ultraviolet light-enhanced visualization (ULEV) method showing the skin with otherwise imperceptible details of its melanization patchwork. In very recent years a considerable progress has been made by the access of nonoptical images of the skin surface capacitance showing a high-resolution map of the stratum corneum hydration. A series of dermatological disorders exhibit some surprising aspects that can be interpreted in terms of disease evolution and improvement of treatments. This new era in skin bioengineering is named skin capacitance imaging (SCI) based on silicon image sensor (SIS) technique. The dedicated device is called SkinChip®.

*E. Xhaufnaire-Uhoda, G. Loussouarn, C. Haubrechts, D.S. Léger, G.E. Piérard, **Skin capacitance imaging and corneosurfametry. A comparative assessment of the impact of surfactants on stratum corneum**, Contact Dermatitis 54(5): 249-53 (2006)*

Abstract: Silicon image sensor (SIS) technology was recently introduced as an innovative tool (SkinChip, L'Oréal) providing sensitive imaging of the skin capacitance. This method can detect discrete focal variations in skin surface hydration, and thus early discrete manifestations of skin irritation induced by surfactants. In the present in vivo study, 2 neat and diluted shampoos, and 5% and 10% sodium laurylsulfate solutions were tested on human skin. Each surfactant solution was gently rubbed on the skin using wet hair wicks mimicking the casual use of a shampoo on the scalp. Clinical and SIS evaluations were carried out. In addition, the same products were tested using the ex vivo corneosurfametry bioassay performed on human stratum corneum (SC) harvested by cyanoacrylate skin surface strippings. The colourimetric index of mildness (CIM) was measured on these samples. The product reactivity with the SC was recognized by darker skin capacitance images, and by both lowered SkinChip-generated values and lowered CIM values. The extent in changes varied according to the nature of the test products and their concentrations. The SkinChip image changes likely corresponded to the acute surfactant-induced water swelling of the corneocytes. Skin capacitance imaging and corneosurfametry allow to disclose discrete surfactant-induced alterations of corneocytes.

*E. Xhaufnaire-Uhoda, J.F. Hermanns, C. Piérard-Franchimont, G.E. Piérard, **Highlighting the rim of the perifollicular epidermal unit**, Eur J Dermatol 16(3): 225-9 (2006)*

Abstract: The perifollicular and interfollicular areas of normal skin may look similar. However, some physiological and pathological processes may specifically involve a thin perifollicular rim. This review illustrates some of the methods available for highlighting the rim of the perifollicular epidermal

unit. Non-invasive methods rely on dermoscopy, ultraviolet light enhanced visualization (ULEV), skin capacitance imaging and cyanoacrylate skin surface strippings (CSSS). Conventional histology and immunohistochemistry may also show specific perifollicular features without, however, revealing the aspects highlighted by the specific non invasive methods. The clinically relevant modifications consist of pigmentary and hyperkeratotic perifollicular changes.

*E. Xhaufnaire-Uhoda, C. Piérard-Franchimont, G.E. Piérard, **Skin capacitance mapping of psoriasis**, J Eur Acad Dermatol, Venereol, 2006, 20, 1261-5*

The pathobiological dynamics of psoriatic lesions are complex and difficult to perceive by clinical inspection alone. Non-invasive bioengineering methods may prove to be useful in this field. To identify some subtle capacitance variations in the stratum corneum of chronic psoriasis lesions. The newly developed method of skin capacitance imaging was used to provide nonoptical images of the hydration of the superficial layers of the stratum corneum. Compared to the uninvolved skin, psoriatic lesions usually showed an overall lowered capacitance, admixed with foci of moderately higher capacitance. Still other sharply circumscribed blotches with higher capacitance were present. The latter aspect corresponded to inflammatory areas. Sweating appeared markedly impaired inside the lesions. The fingerprint of some patients was altered, thus potentially interfering with the current biometric security procedures using the same method. Skin capacitance imaging is a non-invasive, non-optical method that distinguishes three contrasting levels of stratum corneum hydration in psoriatic lesions. The lowest capacitance level probably corresponded to xerotic orthokeratosis. The medium capacitance level presumably identified foci of parakeratosis and clumps of neutrophils. The highest capacitance level suggested exudation at the site of prominent vessel dilation and dermal inflammation. Impaired sweating in the psoriatic lesions may potentially interfere with body thermoregulation.

*D. Batisse, F. Giron, J.L. Lévêque, **Capacitance imaging of the skin surface**, Skin Research & Technology 2006 May, 12(2):99-104*

A new device allowing recording capacitance images of the skin surface was recently presented. Parameters, extracted from the gray-level histogram of the images, are tested for a new approach of skin surface hydration measurement in comparison with the classical capacitance method. Illustration of the interest of having both images and parameters for studying the homogeneity and the level of skin surface hydration are presented. Software for selecting a region of interest from an image and measuring the parameters derived from its gray-level histogram was used to characterize skin hydration. There is a very close correlation between a Corneometer and the parameters extracted from the SkinChip measurements. The importance of having capacitance images of skin is demonstrated in case of non-homogeneity of the skin hydration, either because of photoaging or following an inflammation process. Capacitance imaging is a necessary tool for both completely describing and quantifying skin surface hydration.

*J.-L. Lévêque, E. Xhaufnaire-Uhoda, G.E. Piérard, **Skin capacitance imaging, a new technique for investigating the skin surface**, Eur J Dermatologie, 2006, 16(5), 500-6*

Thanks to the recently introduced silicone image sensor technology, skin capacitance imaging has now been made possible. The dedicated device is called SkinChip. This method is easy to handle and provides information about the skin microrelief, the level of stratum corneum hydration and the sweat gland activity. The apparatus sees and measures these parameters with a 50 microm resolution. A series of conditions have been explored using skin capacitance imaging. This review summarizes relevant findings about regional variability on the body, changes occurring with ageing, effects of a hydrating formulation, reactivity kinetics of corneocytes to surfactants, acne and skin pores characteristics, as well as hyperkeratotic dermatoses and tumours.

*E. Xhaufnaire-Uhoda, G.E. Piérard, **Contrasted skin capacitance imaging of seborrheic keratoses and melanocytic nevi**, Dermatolog, 2006, 212(4), 394-7*

The epidermis of common melanocytic nevi may look normal or shows changes including hyperkeratosis. Seborrheic keratosis are characterized by hyperplasia of the epidermis, particularly of the stratum corneum compartment. Clinically, some pigmented seborrheic keratoses may closely resemble melanocytic nevi. Inflamed lesions can even render the distinction more difficult. There are, however, dermoscopic criteria that allow distinguishing them with confidence [1, 2]. Presently, there is no information about most of the functional characteristics of the epidermis in these benign neoplasms.

*J.-L. Lévêque, **Capacitance imaging of the skin surface**, in K.-P. Wilhelm, E. Berardesca, P. Elsner, H.I. Maibach (Editors): Bioengineering of the Skin, Skin Imaging and Analysis, Informa Healthcare, New York 2006, 331-7*

Means for representing the skin surface according to its optical and thermal properties exist for years, even if great improvements have appeared recently. The same is true for the 3-D representation of the skin micro relief by the relatively recent so-called "fringe projection method." The last innovation in skin imaging is probably "capacitance imaging." It is a new technology allowing the skin surface to be imaged according to its capacitance measured even, '50pm. It is based on the use of pixel-sensing technology developed by some big electronic companies for an automatic detection and characterization (for security reasons) of the fingerprints. The present chapter deals with the presentation of the technical aspects of this method with examples of its utilization in skin research.

*E. Uhoda, J.-L. Lévêque, G.E. Piérard, **Silicon image sensor technology for in vivo detection of surfactant-induced corneocyte swelling and drying**, Dermatol 210(3): 184-8 (2005)*

Abstract: Background: Several instrumental methods can indirectly assess some specific aspects of cutaneous irritation at the level of the stratum corneum (SC). Objective: There is a need for developing more sensitive approaches in this field. Methods: We assessed a recently introduced innovative tool (SkinChip®) based on capacitive pixel-sensing technology in its potential to detect early discrete manifestations of skin irritation. The sensor generates a detailed non-optical picture corresponding to a capacitance map of the skin surface reaching 50 µm pixel resolution. Some topographical details can be easily disclosed and the SC hydration as well. Two surfactant solutions were tested on volunteers. These solutions were applied under test patches for 2 days on the volar forearms. Clinical and SkinChip assessments were performed 3 h after removing the patch. Results: The generated images allowed a precise observation of skin irritation which appeared as a two-step process. Early changes consisted of darker pixels corresponding to overhydrated swollen corneocytes at the irritated sites. Two days later, the same area appeared as white pixels, indicating the loss of corneocyte hydration. Conclusion: The SkinChip device appears to be a very sensitive tool for detecting the early steps of surfactant-induced skin irritation affecting the SC.

*S. Diridollou, J. de Rigal, B. Querleux, T. Baldeweck, D. Batisse, F. Leroy, V. Holloway, **Skin topography in different ethnic populations and vs. age**, Presentation on the ISBS Meeting 2005 in Philadelphia and Skin Research and Technology 2005, 11 (abstracts)*

The skin micro-relief of African American, Caucasian, Chinese and Mexican women was investigated during the summer of 2004 in Chicago. Results obtained on skin micro-relief, in terms of line density and line orientation according to the age and ethnicity of the women studied will be presented. Materials and Methods: 310 females participated in this study and each ethnic population was divided into 5 age groups: ([18–30]; [31– 40]; [41–50]; [51–60]; and [461]. The dorsal and ventral forearm skin sites were analyzed to represent sun-exposed and sun-protected areas, respectively. The skin micro-relief was investigated using a new device called SkinChips that is based on an active capacitive pixel-sensing technology. The sensor is composed of an array of more 92,000 micro-sensors located on a 18 mm 12.8 mm surface. This apparatus can map out the topography of skin in real-time. Dedicated image analysis software was used to quantify the skin micro-relief, the angles of the main orientations and the density of the micro-relief lines. Results: It was observed that the two main directions of the microrelief became closer together and the density of the intersection of the micro-relief decreased as the age of the skin increased. Skin differences in terms of ethnicity, sun-exposed and sun-protected areas will also be reported. Conclusion: The SkinChips is a non-invasive real-time imaging apparatus and its analysis of the skin appears to be a convenient way to investigate a large number of subjects to improve our knowledge of skin as a function of ethnicity and age.

*E. Berardesca, G. Primavera, H. Zahouani, J.L. Lévêque, **Capacitance imaging of the skin: new parameters for characterizing the skin surface texture**, Presentation on the ISBS Meeting 2005 in Philadelphia and Skin Research and Technology 2005, 11 (abstracts)*

Most of the knowledge we have about the skin surface texture comes from studies carried out by means of skin surface replicas characterized by profilometry or image analysis. These methods are good and precise and supply parameters relative to the 3D dimensions of the skin surface. The complete process for analyzing one zone on the skin is however very time consuming. The aim of the present study was to examine if capacitance images of the skin surface, given by the SkinChip technique, would allow the determination of new parameters for a fast and precise characterization of the skin surface texture. Skin capacitance images are coded in 255 gray levels (the darker pixel representing high capacitance, the clearer, the low one). With this technology, primary lines of the microrelief appear as clear lines because their bottoms are not in contact with the measuring window. It is therefore possible, by using image analysis thresholding techniques, to calculate the number of 'crossings' of the lines. This parameter, called 'Comer Density* (CD), is directly related to the density of the primary lines which is considered as a good parameter for describing skin ageing. This new parameter was first compared

with the usual parameters (SPmx and SPmy) supplied by classical image analysis package (toposurf). It was also compared to other parameters ('Mean Pattern Area' or MPA), extracted from the images by using the 'watershed' technique. These parameters were extracted from images obtained from two cohorts of volunteers of different mean ages and compared. Results show that all the parameters illustrate changes occurring at the skin surface during ageing, but with different relative amplitudes. A second study shows that skin treatment by an efficient moisturizer induces some recovery in the lines density. Causes of such a phenomenon will be discussed.

*I. Sadiq, J.-L. Lévêque, T. Stoudemaver, A.M. Kligman, **Assessment of sun damage of the V-Neck area of the chest by the skinchip device**, Presentation on the ISBS Meeting 2005 in Philadelphia and Skin Research and Technology 2005, 11 (abstracts)*

A new instrument called SkinChip has been developed to characterize skin micro-relief and measure skin surface hydration. A digital sensor consisting of a large number of capacitor elements, arranged in a rectangular grid, was used. Each of these capacitor elements can assess the hydration level of a specific point on a variably hydrated surface. When this sensor is in contact with skin it produces a capacitance map of the skin. The areas of skin which are moist and in contact with the sensor glass plate, appear dark and the areas which are dry or moist but away from the glass plate, appear bright. This produces an image of the skin micro-relief showing the skin surface features along with hairs, pores etc. The hydration level at a specific point on the skin is proportional to the darkness level of that point in the SkinChip image i.e. Inverse of the gray value of that pixel. Analysis of this capacitance image can be used to assess structural changes in skin due to life-long exposure to sun.

*J.L. Lévêque, E. Gubanova, **Influence of age on lips and perioral skin**. *Dermatology*: 2004, 208, 307-13*

Background: There are few objective descriptions of the age-related changes taking place on the lips and perioral skin. This zone, however, has great importance in relational functions. Objectives: To describe quantitatively the age-related changes in dimension of the lips and the appearance of the perioral wrinkles, to revisit, thanks to a new method, the pattern of the lip furrows, to compare the hydration states of the upper and lower lips. Methods: On 100 women, we clinically scored wrinkles, dryness of the lips and the general photoageing of the facial skin. We used a Corneometer® for measuring dryness of the lips and SkinChip® for recording lip surface patterns. Results: The upper lip is more hydrated than the lower one, and there is no correlation between lip capacitance and the clinical score of lip dryness. The surface pattern can be classified into 3 main groups with no relation to age. Wrinkle number and visibility are linearly related to age, becoming visible during the fifth decade. The intercommissural distance increases with age, whereas lip height decreases. Conclusions: Both lips are different in terms of dryness. Inversely to their surface pattern, their dimensions are markedly changed with age. The time of apparition of vertical wrinkles suggests a possible influence of hormones.

*G.E. Piérard, J.L. Lévêque, **What is SkinChip? From silicon image sensor technology to SkinChip**, *Dermatology*, 2004, 208(4):291-2*

This issue of *Dermatology* welcomes a new development of high technology meeting some aspirations of dermatologists [1], SkinChip® is born. It represents a significant progress for a quarter of a century when non-invasive biometrological methods were progressively launched for better assessing skin structures and functions [2]. Some of these numerous objective and quantitative methods are conceptually quite simple. Others including skin imaging are much more sophisticated.

*A. Bevilacqua, A. Gherardi, **Age-related Skin Analysis by Capacitance Images**, Proc 17th Intl Conf Pattern Recogn (ICPR'04)*

The skin surface characterization has a great importance for dermatologists as well as for cosmetic scientists in order to evaluate the effectiveness of medical or cosmetic treatments. Skin topography characterization has been faced by using profilometers and skin replicas to achieve some measurements related to either skin 3D profile or wrinkles. So far, no in vivo measurements regarding skin topography changes have been achieved to evaluate skin ageing. This work describes how a portable capacitive device, normally used for fingerprint acquisition, can be utilized to achieve measures of skin ageing routinely. The capacitive images give a high resolution representation of skin topography, in terms of wrinkles and cells. In this work we have addressed the latter: cells have been segmented using the watershed approach and a feature related to their area distribution has been generated. Accurate experiments accomplished in vivo show how the feature we conceived is linearly related to skin ageing.

*G.E. Piérard, E. Uhoda, C. Piérard-Franchimont, **From skin microrelief to wrinkles: an area ripe for***

investigations, J Cosmet Dermatol 2: 21-8 (2003)

Abstract: Skin microrelief alters progressively with age. Wrinkles do not result from these changes but are superimposed upon them. Wrinkles result from structural changes in the epidermis, dermis and hypodermis. Four types of wrinkles can be recognized. Type 1 wrinkles are atrophic. Type 2 wrinkles are elastotic. Type 3 wrinkles are expressional. Type 4 wrinkles are gravitational. Each type of wrinkle is characterized by distinct microanatomical changes and each type of wrinkle develops in specific skin regions. Each is likely to respond differently to treatment. Skin microrelief and skin folds can be identified on histological examination. By contrast, only minimal dermal changes are found beneath permanent or reducible wrinkles compared with immediately adjacent skin. A series of objective and non-invasive methods is available to quantify the severity of wrinkling.

*J.-L. Lévêque, B. Querleux, **Skin Chip, a new tool for investigating the skin surface in vivo***, Skin Research and Technology 2003; 9: 343-347

Characterizing the skin surface has, for obvious reasons, a great importance in the cosmetic science. For skin physiologists, this interface between the environment and the biological medium has several important functions (barrier, mechanical, thermal, sensitive, etc) that, all together, justify the efforts undertaken during these 20 last years by physicists and bioengineers in developing new techniques for measuring, in vivo, some physical properties of the skin.

*P. Corcuff, O. de Lacharrière, J.-L. Lévêque, **Extension-induced changes in the microrelief of the human volar forearm with age***, J Gerontol, 1991 Nov, 46(6), M223-7

The skin microrelief can be assessed in vivo using a noninvasive method based on the image analysis of negative replicas, shadowed by oblique illumination. This technique was used to study changes in the surface furrows of the human volar forearm, related to the degree of extension, in volunteers of three age groups. Results confirmed that the skin in elderly subjects can be characterized by the lack of one of the two perpendicular furrow orientations observed in the young. During extension of the arm, the response of the microrelief in young subjects was clearly different from that in the elderly. Young skin buffered strain through a progressive shift in line density and furrow depth from one orientation to the other, whereas in the elderly, a progressive rotation of the single furrow orientation occurred. These differences would appear to be related to changes in the architecture and physical properties of the dermis. Microrelief, in the elderly subjects, showed a mean line density of 24/cm, regardless of the degree of extension. This constancy may reflect the ultimate stage in the chronological aging of the skin and may be characteristic of a loosened and relaxed dermis.