

Taskforce TEWL – for a healthy skin barrier

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The water balance in the skin is extremely important not only for the skin but for the whole body. In the evolutionary process it was vital to survival to build up a barrier against dehydration. Keeping this protective skin barrier in a healthy and intact state still is one of the major tasks of skin care.

The skin is a masterpiece of nature. Besides the transmission of pain-, temperature- and tactile stimuli, it forms a barrier against foreign substances and microorganisms, protects the body against sun radiation, atmospheric radicals and mechanic stress, and ensures the heat and water exchange with the external world.

Water balance of the skin

Important elements of the water balance are:

- evaporation of water vapour via skin,
- urinary excretion via kidneys,
- sweat production,
- oral water intake and
- water production during the burning of fatty acids and carbohydrates

The water balance also influences the complexion of the skin:

- The elasticity of the skin is mainly influenced by the skin turgor. A reduction of elasticity here finally results in a loose and sunken skin.
- Insufficient hydration of the epidermis (skin hydration) leads to a dry and cracked condition of the skin which then is prone to the penetration of microorganisms and foreign substances.
- Skin hydration depends on how well the water is bound in the skin. The water-binding mainly is effected by means of the NMF (Natural Moisturising Factor) consisting of amino acids, urea, salts (e.g. lactates), glucosamine and various other compounds.
- The skin hydration additionally is influenced by the activity of the sebum glands that excrete the sebum consisting of squalene, triglycerides, fatty acids, wax-like compounds and cholesterol. The lipids form a film-like layer on the skin surface and thus limit the evaporation of water through the skin.

- The skin flora also contributes to the lipid film of the skin by its synthesis of fatty acids (acid mantle).

A deficient skin hydration mostly appears in the context of a disordered skin barrier. The skin barrier is a lamellar structure consisting of a bilayer array of long-chained fatty acids, ceramides and cholesterol. While previously a ratio of 1 : 1 : 1 was assumed, today the molar ratio ceramides/cholesterol/long-chained fatty acids of 1 : 0.9 : 0,4 is mentioned¹. Barrier disorders develop when the amounts differ from the above-mentioned ratio or when the barrier formation is insufficient – as for instance in the case of atopic skin.

The TEWL – a variable

The discharge of evaporating water from the epidermis into the external atmosphere is called transepidermal water loss, abbreviated with the capitals TEWL. Apart from the already mentioned endogenous factors, the TEWL is influenced by the following external parameters:

- Along with the external temperature, in particular with the direct impact of the infrared fraction of the sun radiation, the TEWL increases and the sweat glands are activated.
- With falling atmospheric pressure, as for instance in the airplane or in the mountains, the TEWL increases. In order to balance this phenomenon, the skin requires more lipid substances.
- With falling atmospheric humidity the TEWL also increases and the skin needs skin care preparations with a comparably higher lipid ratio. The other way round, the lipid content in skin care preparations can be lowered or skin care can even be completely spared in areas with high atmospheric

¹ I. Plasencia, L. Norlén und L. A. Bagatolli, Biophysical Journal 2007 (93), 3142-3155

humidity (as for instance in the tropical regions).

- With increasing wind force the evaporation of water vapour also increases which can be recognized with the sensation of cold on the skin (wind chill effect). During the dry NE weather conditions that are typical for Central Europe in mid-February, the perceived external temperature can be around 5-10 °C lower than the measured temperature. This is due to the high evaporation enthalpy of water („evaporation chill“) that drains heat from the body.

As the condition of the skin barrier determines the transepidermal water loss, a measuring of the TEWL can, vice versa, inform on the condition of the skin barrier.

- In the case of atopic skin the skin hydration is low and the TEWL increased. Analogous conditions can be found in the skin that is sensitive to external impacts since a high TEWL is no one-way road. If the skin barrier is more permeable from the inside out, then this also applies, vice versa, to the permeability for allergens, irritants and microorganisms.
- The same applies to impaired skin. Impaired skin can already occur with tight, rubbing and, possibly, coated textiles.
- In the course of acute dermatitis conditions, both the skin hydration and TEWL are increased and during the following healing process the skin hydration is low and the TEWL high.
- Attention should also be paid to the fact that the TEWL varies according to the body area and the skin temperature. It even depends on the hours of the day, e.g. it increases in the evenings.

Measuring the TEWL

TEWL measurements not only inform on the function of the skin barrier but also on the efficacy of the individual skin care. By means of comparative measuring of the skin hydration and the TEWL in the context of the application of different formulations, moisturizer products can be optimized during their developmental process. Since the tensides contained in cleansing products impair the skin barrier, partly have irritant effects like Sodium Lauryl Sulfate [SLS] and additionally tend to increase the TEWL measurements also can help select gentle cleansing components.

Reliable TEWL measurements only are possible after test persons stayed for a certain span of time in air-conditioned rooms. Otherwise, among other influences, the sweat secretions would falsify the measuring results.

Recommended are a temperature of 22 °C and an atmospheric humidity of 40-60%. Such precisely defined conditions² can hardly be realised in cosmetic institutes. In cases where the efficacy of a product is in the foreground and not the skin diagnosis, manufacturers rather avoid such kind of measurements in summer (warm) and in winter (frosty days, bad skin condition).

Among other procedures the TEWL is measured by applying a weighted amount of hygroscopic (water-binding) salt on a defined skin area. After a certain period of time the salt is removed and again weighed. The difference in weight reveals the TEWL in gram per square meter and hour [g/m²/h].

The most frequently used measuring tools today are electronic “open chamber” probes. They are open cylinders that are placed on the skin. The cylinder contains up to 30 pairs of sensors that measure atmospheric humidity and temperature (Fig. 1). Based on the measured humidity gradient appearing shortly after placing the probe on the skin, the device identifies the TEWL value. In order to increase the precision of the measurements, the average value is taken out of a series of different measurements.



Fig. 1: Cross-section of an open-chamber probe (enlarged)
(Tewameter; Foto: Courage & Khazaka, Cologne)

² E. Berardesca, M. Loden, J. Serup, P. Masson und L. M. Rodrigues, *Skin Res Technol.* 2018 (24), 351-358

In case that the pure barrier function shall be measured, it is necessary to cleanse the skin before in order to remove remainders of skin care products, among others. The cleansing preparations used should not contain any substances that leave traces on the skin such as lipid replenishing substances. Since the cleansing also removes part of the sebum and the skin barrier it is necessary to wait for a defined period of time of at least several hours of regeneration in order to rebuild the natural skin balance.

TEWL measurements of the well-nurtured skin allow for a validation and optimization of the individual skin care. The measuring result then comprises in part the natural effects of the skin barrier and the exogenous skin care. That way not enough skin care (TEWL too high) and overdone skin care (TEWL too low) can be distinguished and avoided. Extremely low TEWL values are caused by non-resorbed lipophilic substances that act on the skin surface like an occlusive plaster. They down-regulate the natural regenerative capacity of the skin. Consumers using preparations with a high mineral oil- and mineral wax content hence complain very soon of particularly dry skin after missing their skin care product.

The requirements for cosmetic products to achieve a "natural" TEWL value are:

- Physiologically compatible, resorbable and biodegradable skin care components.
- Emulsifiers should be biodegradable or substituted by barrier-active components such as phospholipids, ceramides and fatty acids.
- Besides the chemical composition also the physical structure of the preparations should be similar to the structure of the skin barrier. This applies to lamellar preparations.

Estimating the TEWL

Whoever does not have a device for measuring the TEWL but is experienced enough in skin care can estimate the TEWL by measuring skin hydration and sebum:

- Low skin hydration, low sebum – high TEWL,
- Maximum skin hydration and extremely high lipid value (sebum & product lipids) – very low TEWL (occlusive conditions),
- Average skin hydration- and sebum values: normal TEWL.

Unlike the pH level that tends to increase, changes in the TEWL of older skin are the subject of controversial discussions. Since it is a matter of statistical survey it is rather difficult to estimate whether we are dealing here with changes in the physiological conditions or culture- and behaviour-related impacts.

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