The pH value of the skin and of cosmetic preparations

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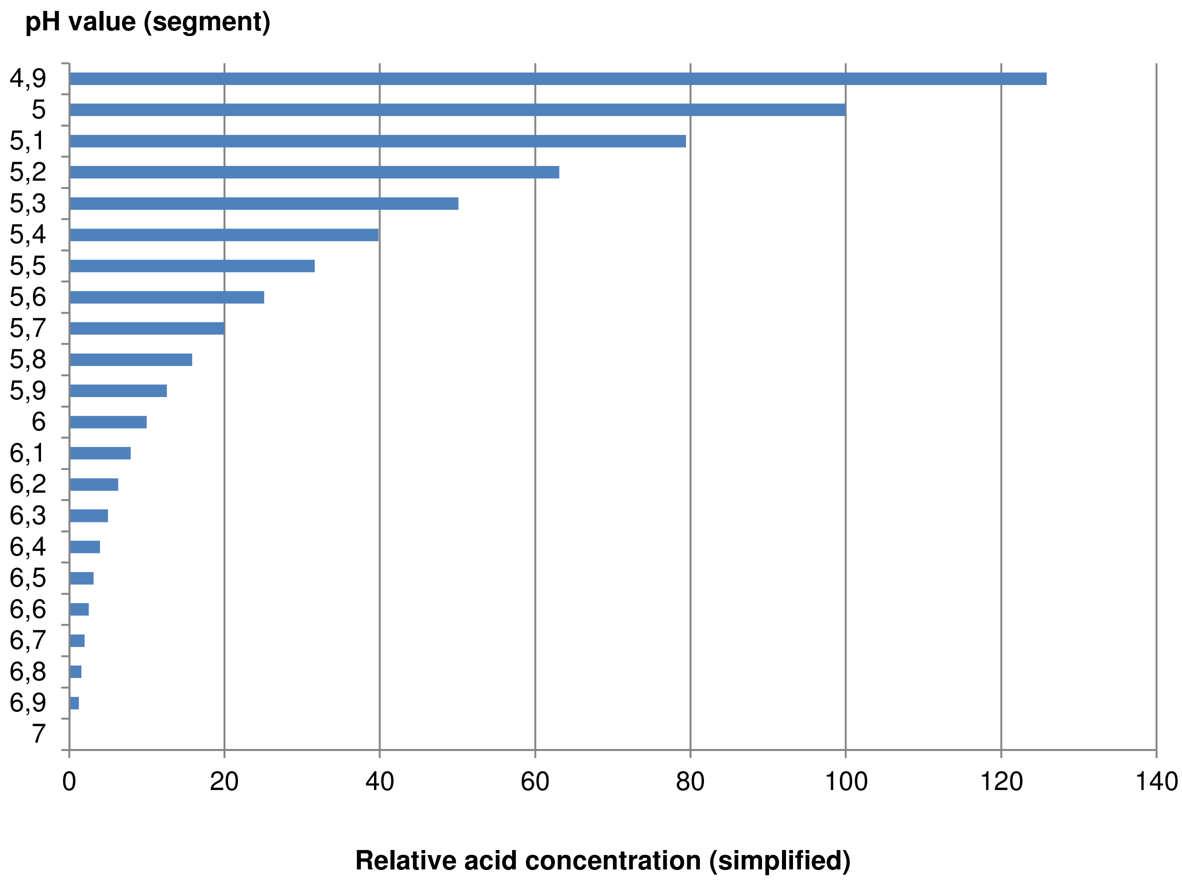
Many of the processes in physics and chemistry are non-linear processes. The following rule of thumb for the shelf life of cosmetic preparations can here be quoted as an example: The shelf life of a cosmetic cream (emulsion) halves when the temperature is raised by 10 °C while it doubles when the temperature is dropped by 10 °C. Similar applies to the pH value where an increase or a drop has a considerable impact on biochemical reactions and the activity of epidermal enzymes. How does the pH work?

The pH value is a measure for the concentration of an acid – or in other words, it informs on the acidity of an aqueous solution. So far, so good! It is precisely defined as the negative decadic logarithm of the hydrogen ion concentration however the cosmetic practice has little use for this complex explanation. Far clearer is the relative acid concentration as shown in the following diagram and explained with text samples.

- An aqueous solution – as for instance the aqueous phase of a cream – is **neutral when the pH value is 7**, i.e. neither **acidic (pH lower than 7)** nor **basic (pH higher than 7).**
- Aqueous solutions with a pH value of 5 are 10 times more acidic in comparison to pH 6 and about 100 times more acidic in comparison to pH 6.9. **With respect to the acid concentration there always is a factor of 10 between the full pH values.**



- Aqueous solutions with a pH value of 6 are considered to be mildly acidic.
- Gastric acid has a pH value of about 1 just like diluted hydrochloric acid. This corresponds to a 100,000-fold concentration of the acid in comparison to pH 6.
- Lemon juice and vinegar have pH values of about 2.4 to 2.5.

Acid mantle of the skin

While blood with its pH value of 7.4 shows a weak basic reaction, the hydrolipid film of the skin surface is lightly acidic with pH values of about 4.5 up to 5.5, depending on the person and the body area. The low pH value of the skin results from the oxidative breakdown of skin barrier substances by the skin flora. Acids are formed in this process. The thus developed “acid mantle” of the skin protects the skin and in particular the locally adapted resident germ populations against exogenous microorganisms. From this point of view the uncritical use of strong antioxidants in skin care preparations may be counterproductive as it has an impact on the oxidative activities of the skin microbiome. It should also be mentioned that the pH value is increased in the case of barrier disorders such as atopic skin and irritative contact dermatoses.

Buffer effects of the skin

Acids can be neutralised with bases. In the case of a continuous neutralisation of acids with bases the pH value also continuously rises up to a pH value of 7. And to mention an example: hydrochloric acid and soda lye form common salt (sodium chloride) as known from the kitchen. Aqueous solutions of common salt are “pH neutral”.
Every single day the skin surface gets in contact with varying acidic and basic substances. Such contacts would continuously modify the dermal pH value and hence interfere with the physiological, frequently enzymatic processes that require a specific pH value. Such modifications are impeded with a specific composition of the skin surface: to a certain extent it keeps the pH value of the skin at a constant level regardless of the impact of exogenous substances. The technical term for these specific compositions is „buffer “. The so associated buffer capacity of the skin or in other words, the capacity to compensate external influences is relatively small in amount however sufficient to such an extent that skin care creams with pH value <7 and water with pH value of 7 cannot modify the regular pH level of the skin. In other words: It makes no difference whether a cream with a value of pH 6.5 or pH 5 is applied: it does not necessarily have to be “pH skin neutral” (pH 5.5).

Skin irritations

The situation is quite different when preparations or chemical substances with high buffer capacity are applied on the skin. This frequently occurs with working substances. In these cases often an extended contact with a medium with pH value of 8 is enough to seriously affect the skin. The same applies to pH values lower than 4 as for instance with concentrated fruit acids which thus have keratolytic effects (fruit acid peelings). This leads to corrosive injuries in case that the recommended treatment times are exceeded. The same peeling effect could of course be achieved with diluted hydrochloric acid but this idea is hard to sell due to its name.
Such kind of targeted irritations are tied to subsequent regenerative efforts of the skin. What makes sense when once-only administered after diagnosed dermatological indications and cosmetic conditions, is related to long-term side effects such as rosacea and perioral dermatitis when applied regularly and over an extended period of time. In other words, the skin reacts in a cumulative way similar to radiation damages – the skin will not forget a thing.
Not only liquids but also solid substances can destroy the acid mantle of the skin after extended exposure. A typical example is the calcium carbonate used as a bulking agent in cardboard packages. It reacts with the natural fatty acids of the skin and forms calcium soaps while the packages as such additionally have degreasing effects. Unless protective skin care is applied or gloves are worn during the daily work with packages, dermatoses are likely to develop. The skin-damaging risks are still much higher when working with lime and cement at construction sites.

Elderly skin

Statistics says that the elderly skin has a higher pH value (pH 6) than young skin. With adequate preparations buffered to a pH value of 4.5 the cosmetic industry tries to down-regulate the pH value on a permanent basis. The idea behind is to optimally maintain the enzyme-controlled skin metabolism. In how far this strategy proves successful depends on several, still unanswered questions:

- Is the higher pH level of the skin surface culture-bound or rather a pathologic symptom of old age?

- Can age-related pH modifications also be found in the deeper skin layers with their metabolic activities?
- In how far does the pH value of the skin surface also influence the areas with enzyme activity?
- What is the part of the microbiome in the pH of elderly skin?

There still is need for comprehensive studies regarding the actual causalities.

Cosmetic preparations

Cosmetic products usually are buffered with partly neutralized salts of phosphoric- and citric acid or mixtures of both (INCI: disodium phosphate, potassium phosphate, disodium citrate etc.). Sometimes these salts also are directly formed during the manufacturing process of the cosmetics. The list of ingredients then specifies e.g. citric acid and the neutralizing agents (bases) sodium hydroxide and potassium hydroxide. The latter mentioned, both hazardous substances, of course are no longer contained in the end product.
Traditional soap bars consist of fatty acid salts, in the simplest case these are sodium stearate or sodium palmitate (hard soap alias Marseille soap). During the washing process they cause a pH value of far more than 7 since salts of a strong base and a weak acid are involved. This high pH value is not really beneficial for the skin. That is why hard soaps were exchanged for pH neutral and lightly acidic liquid soaps. In tap waters with high permanent or temporary hardness, small (!) amounts of hard soap (short dips) can help softening the water and reducing the surface tension. The thus forming flocculating lime soaps are a rather annoying side effect, although the water then is appropriate for barrier disturbed skin since the hardening agents no longer can further damage the skin barrier.
Many of the preservatives listed in the annex of the German Cosmetic Regulation (Kosmetikverordnung) are optimally efficient in the lightly acidic pH range. This of course applies to the acids listed in the annex. An interesting fact in this context is that there are active agents that show higher oxidation stability at lower pH-values. This applies, for instance, to the main ingredient of green tea, epigallocatechin gallate (EGCG). EGCG is a polyphenol and responsible for the dark colouring of tea after brewing. EGCG stimulates the filaggrin formation and has collagenase-inhibiting effects. In combination with fumaric- or citric acid it remains pale and stable.

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