

# Water – more than just wet

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An old saying goes where there is water, there is life. During evolution the first forms of life developed in water. They adapted to the different water conditions.

To become independent from dry seasons and salt- and freshwater, many organisms developed a technique called osmoregulation that allowed for a constant salt concentration in the body associated with a steady osmotic pressure. Today the salt concentrations in the blood of terrestrial mammals are around 0.9 percent. In comparison to the 3.5 percent salt concentration on average of the oceanic waters the marine creatures also have a lower salt concentration. To maintain the osmotic or in other words isotonic pressure in our body we have to ingest water and salt when required and/or egest both via kidneys, sweat glands and lungs (water vapour). This guarantees optimal working conditions for the regulatory circuits of the body.

## NMF and TEWL

The osmoregulation also plays an essential part in our skin. Salts, amino acids and other water-soluble components of the NMF (Natural Moisturizing Factor) are called osmolytes. Both together, the transepidermal water loss (TEWL) and the NMF determine whether the skin is hydrated or dehydrating. During cosmetic treatments it is important to maintain an intact NMF and to support the TEWL with barrier-active components and filmogenic substances. Hyaluronic acid is such a substance with a high water-binding property.

## Why H<sub>2</sub>O is so exceptional

With its low molar mass of 18 Da (Dalton) water actually should exist as a gas – similar to the weightier nitrogen molecule (N<sub>2</sub>, 28 Da) or the oxygen molecule (O<sub>2</sub>; 32 Da). But it doesn't. Instead it is a liquid that, at standard pressure, boils at 100 °C and freezes to ice at 0° C. By way of comparison: Acetone (C<sub>3</sub>H<sub>6</sub>O), a solvent, with its 58 Da or in other words, more than triple the molar mass, has a lower boiling point of 56 °C and a still lower melting point of -95 °C.

The clue to the riddle is the polymer-like structure of water in liquid and all the more in solid state. The hydrogen atoms of the water molecules form bridges to the oxygen atoms of

neighbouring water molecules (H<sub>2</sub>O...H-O-H...OH<sub>2</sub>). These „hydrogen bridge bonds“ are of vital importance in nature. They occur in proteins between the carboxyl groups >C=O and the H-N< groups of amino acid components and determine the secondary structures of the proteins as well as the DNA and RNA in particular.

## Water reservoir

Also the glycosidic structures of many polysaccharides are stabilised in this way. The lightly tightening effect of hyaluronic acid is ascribed to the hydrogen bridges between its N-acetylglucosamine units and the keratin of the skin. This is the reason why hyaluronic acid adheres better to the skin surface than other polysaccharides as for instance hydroxyethyl cellulose or carboxymethyl cellulose. The moisture-retaining capacity of hyaluronic acid is based on a similar principle: water molecules are fastened by the H-O- and H-N< groups of the acid.

Hydrogen bridge bonds are weaker than atomic bonds since they only result from the attraction of uneven electric charge distributions of the water dipoles. They break up in extreme conditions such as low atmospheric humidity and below atmospheric pressure as occurs in the mountains or in airplanes. Water evaporates and the skin dehydrates unless lipid substances are topically applied and the NMF is supported with the administration of amino acids and possibly stronger hygroscopic substances such as ectoin. The hygroscopic or in other words water-absorbing effects are technically utilized in desiccants as for instance silica gel (amorphous silicic acid) or calcium chloride. Calcium chloride absorbs water into its crystal structure („crystal water“). The superabsorbent substances in baby diapers are the sodium salts of polyacrylic acid that absorb water through their hydrogen bridges on the one hand and on the other hand have a strong capillary action. The esters of polyacrylic acid in turn are widely used as filmogenic substances in cosmetic preparations.

## Skin hydration

The high dielectric constant of water (80.4) is the direct consequence of its high dipole moment. The dielectric constant measuring is relatively simple and implemented with condenser-like probes; it allows for a measuring of the water content in the near-surface skin. In the skin diagnostic field this technique has become known as corneometry. The probe alias corneometer is pressed onto the skin surface and immediately shows the skin hydration value.

## Water transport

Aquaporins are peptide structures which control the passage of water in the cell membranes. The water channels are opened after stimulation through mesoporation- or radiofrequency techniques. Apart from that there are substances which have a stimulating effect on the aquaporins such as Glyceryl Glucoside (INCI). This effect still is supported with penetration-enhancing liposomal carrier systems. In this context it has to be mentioned that only non-aqueous, lipophilic glide gels and active agents can be used for bi- and multipolar radio frequency treatments since the application of water as a medium can cause short circuits.

## Water in cosmetic products

The osmotic pressure of an aqueous solution, an aqueous gel or also the water phase of an emulsion alias cream is determined by the concentration of the substances dissolved therein. The aqueous phase of O/W emulsions frequently is hypertonic in order to impede the life of unwanted microorganisms. At the latest when the water of an emulsion evaporates on the skin, the water-soluble components concentrate and the osmotic pressure continues to rise. This process is not substance-specific and can cause irritations in individuals with disposition to rosacea-like symptoms. In this particular case the skin cannot adequately adjust the high concentrations.

## Water qualities

It somehow sank into oblivion that rainwater is one of the best skin care remedies and together with the self-cleansing programme of the skin it can provide for a gentle cleansing of impurities. Hard tap water already is less appropriate in case of a skin barrier disorder. The disorder still is aggravated through the bonding of the natural fatty acids of the skin to the calcium- and magnesium ions (hardening agents). What is considered as good features for drink-

ing water and for the skeletal system is not necessarily beneficial for the skin.

Specifically levitated, oxygen-enriched, ionised, colloidal, structured, magnetised waters including super-, ultra- and moon waters display a lot of phantasy however little substance. In his book „Chemische Leckerbissen, published by Wiley-VCH, Weinheim (2014), p. 2-16, Professor Klaus Roth, Ph.D., wrote an enjoyable article worth reading, entitled „H<sub>2</sub>O – Jo mei!“. In a further article entitled „Dehydrierung: Die Angst geht um“ in the specialist journal „Chemie in unserer Zeit 48, 332-340 (2014), he covered the water balance in marathon runners and describes that too much water can even be fatal.

Beneficial for the skin are externally applied saline waters. Marine waters and above all the high salt contents of the Dead Sea bring relief to neurodermatitis patients and reduce the cell proliferation in the case of psoriasis. They also can be used as a therapeutic measure in the bathtub. Only recently the features of thermal waters have been covered in the article „Thermal springs – an overview on thermal waters“, in Beauty Forum 2021 (1), 70-72.

By the way: the oxygen of vegetable origin in the terrestrial atmosphere comes from water. The photosynthesis utilizes the carbon dioxide of the air, also suitable for the purpose, only for the formation of oxygen-containing organic compounds.

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