Versatile use – alcohols in skin care products

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What do you understand by the term alcohol or alcohols? What are the functions associated with it? Imagining cosmetic products without this substance class is almost impossible, except for powders.

The term alcohol originates from the Arabic language and has a checkered history behind it. But it was only in connection with wine making that the spirit of wine came up which is the characteristic component of the beverage. In this context, the chemical terminology uses the word ethanol and defines the term alcohol more comprehensively. According to it, alcohol is a hydrocarbon linked with a hydroxy group (-OH) just like the one we know from plain water:

Water (H_2O): H-OH
Alcohols: R-OH (R symbolizes hydrocarbon)

From basic to aromatic alcohols

The most basic alcohols are:

- **Methanol (CH_3-OH):** has 1 carbon atom. Time and again, methanol appears in the media in connection with fatalities caused by adulterated alcohol.
- **Ethanol (C_2H_5-OH):** contains 2 carbon atoms.
- **Propanol (C_3H_7OH)** and isopropyl alcohol: with 3 carbon atoms each.

These basic alcohols are liquids similar to water. Cetyl alcohol (hexadecanol) which is an alcohol with 16 carbon atoms is solid, though. Due to the water-like hydroxy group and the lipophilic hydrocarbon residues, the alcohols with short carbon chains are used as **solubilizers** while the long-chained ones are used as **emulsifying additives**.
One hydrocarbon may have several "alcoholic hydroxy groups". Well-known examples are glycols with 2, glycerin with 3, glucose (grape sugar) with 5 and the sugar substitute sorbitol (E 420) with 6 OH groups. They are also called **bivalent, trivalent, pentavalent and hexavalent alcohols**. With the number of OH-groups also the sweet taste intensifies – with a few exceptions though.
Aromatic alcohols constitute a specific group which is known under the collective term phenols. The hydroxy group here is linked with an aromatic hydrocarbon ring. Phenol (C_6H_5-OH) itself is a toxic solid material. Other phenols are strong **preservatives** or **antioxidants** like flavones and isoflavones (phytohormones) for example.
The human organism degrades alcohols by means of oxidation – ethanol for example is degraded via acetaldehyde and acetic acid into carbon dioxide which is exhaled.

Function of specific exponents

Ethanol: Basic alcohol is not considered as a preservative. In concentrations of more than 10 percent, however, it has bacteriostatic effects. That is the reason why it is frequently used in preservative free products. There is no reason to assume that these concentrations dehydrate the skin, though. More of a problem are shaving and facial tonics with more than a 20 percent content of ethanol. A factor in this context is its interaction with emulsifiers that may support barrier disorders in form of dry skin. Combined with other alcohols like glycerin and sorbitol already a few percent of it will microbiologically stabilize the products. An advantage is that alcohol has no sensitizing potential.
As ethanol belongs to the group of semi luxury foods and is subject to taxes, the cosmetic industry uses denaturants for cost saving purposes. In the INCI these additives can be identified with the term alcohol denat. For detailed information on this subject please refer to Kosmetische Praxis 2009 (5), 10-13.

Isopropyl alcohol: It is an alternative to ethanol, when it comes to disinfecting purposes in the beauty institute. This specific alcohol is inexpensive and its characteristic smell reminds of hair tonics in which it is still widely used.

Propylene glycol: Similar to ethanol moderate concentrations of this bivalent alcohol prevent the growth of microorganisms. Propylene glycol too is not listed as a preservative in the Cosmetic Decree. According to reports of Professor Gloor of the University of Karlsruhe there is no evidence for a sensitizing potential of propylene glycol despite of the fact that it is intensely used and despite former reports to the contrary. This feature could be ascribed to modifications regarding the purity of the sub-

stance. Similar effects have other glycols like butylene glycol, pentylene glycol, hexylene glycol and decylene glycol which altogether only differ in the length of their carbon chain. Polyethylene glycols contain one or few alcoholic hydroxy groups only. This compound class has been covered in detail in Kosmetische Praxis 2009 (1), 12-15.

Glycerin: It is classified as a trivalent alcohol and generates during enzymatic degradation of natural fats and lipids (triglycerides), among others. It is a component of the NMF (natural moisturizing factor) of the skin and that is why it is frequently found in the INCI. Similar to ethanol it is often reported to have dehydrating effects. This is a rather subjective sensation when using hand creams with a high content of glycerin for instance. At first, the skin hydration is substantially increased. If the hands then are cleansed, a major part of the water soluble glycerin is washed out of the skin. That is the reason why the hands feel rather dry afterwards. Hence, it is recommended to use hand creams with a high lipid but moderate glycerin content. The higher the protective lipid content, the less glycerin is washed out of the skin.
Today, glycerin is either produced by saponification of natural oils or synthetically manufactured. The discussion among representatives of natural cosmetics which glycerin is supposed to be the better product now, is hard to comprehend from the chemical point of view. What actually counts is the purity of the product.

Sorbitol (Sorbit): The hexavalent alcohol occurs as sugar substitute in food products. Like glycerin it has water-binding characteristics. The so-called sugar alcohol is contained in plants and gained from starch by reduction of the intermediary glucose (grape sugar). In combinations with ethanol, glycols or glycerin, sorbitol has antimicrobial effects in preservative-free products. Similar properties have mannitol which occurs in algae, beach and tideland plants and the natural inositol of the body which is an annular hexavalent alcohol.

Saccharides (sugars): These polyvalent alcohols are frequently used in cosmetic products. A survey can be found in Kosmetische Praxis 2009 (49) 12-15.

Benzyl alcohol (C_6H_5-CH_2-OH): The liquid has a bitter almond scent and is used as a preservative not only in cosmetics but also in watery medical products. A rose-like scent has **phenyl ethanol (C_6H_5-CH_2-CH_2-OH)**, which is equipped with an additional carbon atom and which is the main component of rose water that also serves as a preservative. **Phenoxy ethanol (C_6H_5-O-CH_2-CH_2-OH)** with its almost identical name contains an additional oxygen atom and when combined with parabens, it is a very popular preservative.

Cetyl alcohol (hexadecanol) und **stearyl alcohol (octadecanol)** are popular co-emulsifiers in O/W emulsions where they increase the stability of the compounds. They are also used as mixtures (cetylstearyl alcohol). They are reported to have comedogenic effects although this characteristic is not sufficiently documented and may be ascribed to the solid consistency, a fact which has to be evaluated in relation to the other components in the product. Similar conditions can be observed with stearic acid; in this context also unspecific physical effects play their part and have to be considered with regard to the dosage of the substance.

2-Octyldodecanol is a typical exponent of the so-called Guerbet alcohols which are chemically synthesized and have a branched carbon chain. They are used like cetyl alcohol and its relatives. They are not solid but have liquid consistency and because of the above mentioned reasons beneficial for the use in emulsions.

Wool fat (adeps lanae): It is a mixture of animal sterols (main component: cholesterol) and long chained alcohols (“wool fat alcohols”) partly esterified with fatty acids (for the definition of esters please refer to “covert alcohols” in the following). They contain a multitude of different compounds which serve as emulsifiers for creamy W/O emulsions due to the free hydroxy groups of the sterols and fatty alcohols. The mixture of 65 % wool fat, 15% paraffin oil and 20% water (lanolin) is used as a cream base to be mixed with pharmaceutical active agents.

12-Hydroxy stearic acid: Just like the related unsaturated **ricinoleic acid** (12-Hydroxy-oleic acid) this substance has a very interesting feature if the alcoholic hydroxy group is located in the center of a carbon chain: it has an extremely strong adhesive property on skin and mucous membranes which can be referred to the formation of intermolecular hydrogen bridges of the OH group. This also applies for **castor oil** which is the triglyceride of ricinoleic acid. Like wool fat it is used in W/O emulsions and also a frequent component in lipsticks, make-up foundations and medical suppositories.

Aromatic alcohols

Chlorphenols and chlorkresols: Both the aromatic alcohols with preserving effects have sensitizing potential. The antiseptic triclosan (5-Chlor-2-(2,4-dichlorphenoxy)-phenol) also belongs to this substance group. UV radiation or combustion processes of these compounds may result in the formation of toxic polychlorinated dibenzodioxins and dibenzofurans.

Hydroxybenzoic acid ester: The abbreviation for this substance group is parabens. They constitute the largest group of preservatives in cosmetic products. The active principle is mainly ascribed to the aromatic hydroxy group.

Flavones and isoflavones (phytohormones) are polyphenols whereas the term already insinuates that they contain several hydroxy groups linked to aromatic rings. They are prevalent in natural surroundings. Due to the sensitivity of the aromatic ring systems to oxygen they are used as radical scavengers.

Vitamin E: A multitude of other natural substances belongs to the phenol compounds as e.g. vitamin E which is a popular antioxidant.

Covert alcohols

Covert alcohols occur in many natural substances. The main components of vegetable oils, the triglycerides, consist of glycerin and 3 fatty acids. Triglycerides are an exception within the large group of **esters**. This is the term for substances which generate from alcohol and fatty acids while releasing water. And vice versa, esters may again be separated by reacting with water. This reaction is called saponification process referring to the formerly widespread manufacturing of soaps on the base of vegetable oils, water and sodium bicarbonate or potassium carbonate. Esters are widely used as fattening components, spreading agents and odorants.
Ethers resulting from the reaction of two alcohols with release of water also belong to the group of odorants. Related substances are acetals and ketals as well as combinations of sugar molecules in oligo and poly saccharides.
If a keton or aldehyde function is located next to an alcoholic hydroxy group then strongly reducing compounds (antioxidants) will generate which may even have acidic features. The most popular representative of this group is **ascorbic acid** (**vitamin C**).

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