

# Aluminium – a much-discussed element

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For some time past there has been much discussion on aluminium containing anti-perspirants and deodorants. Many of us are not aware that aluminium also is a component of hygiene products and many other cosmetic preparations and that it is ubiquitous in our environment – literally wherever we go.

**A**luminium is associated with lightweight constructions such as airplanes, cars or bicycles, with conductor elements, aluminium wrap, food packaging or aluminium tubes. Just to mention some examples for the versatile use of aluminium. The silvery and matte light metal seems to be indestructible as it protects itself by a thin oxide layer and it doesn't corrode like iron. The non-metallic compounds of aluminium in the form of oxides and salts determine the shape of our earth unlike any other element. Aluminium is the most frequent element in the Earth's crust.

## Attributes range from rock-hard to healing

Aluminosilicates are the silicic acid salts of aluminium. They are the base substance for feldspar and mica and both together with quartz form huge mountain ranges such as the Central Alps where they constitute the primary rocks as for instance granite and gneiss. Weathering through water and carbon dioxide leads to the formation of clay of which the main components also are aqueous aluminosilicates. Kaolin is a very pure variant and used for the manufacturing of porcelain and pottery (earthenware) by means of shaping and firing. The most part of the mined kaolin is used as a bulking agent in the paper production and in paints and plastics. A smaller part is used in white pigments for make-up preparations.

Clay is an essential component of marl and silt whereas the latter one is a key feature in fertile loess soils and used either as a breathable building material (mud brick) or in its fired form as conventional brick. Another important construction material, cement, consists of a mixture of clay and lime (chalk).

Silt in very pure quality is sold on the market as so-called terra sana (healing earth). Healing earth in cosmetic packs and masks absorbs the natural substances of the body and penetrates the integrated active agent components into the skin in a controlled manner. The specific feature of clay as an ion exchanger is particularly marked in zeolites, i.e. crystalline aluminosilicates; they occur naturally but they also are chemically produced. On a limited

scale they can be used as water softening agent.

Alumina, unlike clay, consists of aqueous aluminium oxide; the natural mineral bauxite serves for the manufacturing of aluminium. Alumina is soluble in acids and bases. It reacts with acetic acid to form basic aluminium acetate (aluminium diacetate) that, in analogy to aluminium chloride, has antiseptic and astringent characteristics or in other words, it eliminates pathogenic germs and has dehydrating, hemostatic and anti-inflammatory features. It is well-known in the traditional folk medicine.

In combination with tartaric acid, basic aluminium acetate forms an aqueous solution which in the official German pharmaceutical catalogue (Rote Liste) still is mentioned as aluminium acetate tartrate solution<sup>2</sup>; it has soothing effects in the case of hyperhidrosis, sun burns, swellings and insect bites. By the way, corundum, sapphire and ruby are the compact forms of aluminium oxide. These minerals are used for jewellery or also as abrasive materials due to their hardness.

Speaking of mica: The powder gained from mica schist (INCI: Mica, CI 77019) has particular optical features and adds an extra gloss effect to powders or other decorative cosmetic products that still can be intensified by coating.

## Aluminium chloride

Similar to sodium chloride in the kitchen, aluminium chloride (INCI: Aluminium Chlorohydrate) is a salt of the hydrochloric acid. As a hydrate, it contains water and is water-soluble similar to the aluminium acetate tartrate for medical purposes.

## Aluminium absorption

Publications and media primarily discuss the aluminium content in particular products because it is associated with health risks. It has to be mentioned though that there are scientific studies – above all those concerned with statistics – which do not comply with the required standards. The media-informed public however often experiences difficulties in distinguishing

between valuable and non-viable studies. It is not a problem though as faulty results and hypotheses will be invalidated later on by other scientists. This also applies for all the reports on the health risks of aluminium chloride. The different hypotheses on Alzheimer disease or breast cancer (women) causing effects of aluminium in antiperspirants and deodorants had all been disproved later on. Moreover, the studies have neglected other components of the deodorants such as the chlorophenol triclosan which is a bacteriostatic active agent.

EFSA (European Food Safety Authority), WHO (World Health Organization) and FAO (Food and Agriculture Organization of the United Nations) have different concepts on the threshold value for the daily oral intake of aluminium. The most unfavorable value is defined with 1 mg/kg bodyweight per week. Converted to a bodyweight of about 60 kg for women it corresponds to 60 mg aluminium per week. The resorption of soluble aluminium however is extremely low since the ion forms insoluble compounds with the proteins and acids of the body such as for instance with the palmitic acid of the skin barrier. This also applies for the mechanism of action in deodorants and the astringent (dehydrating, hemostatic and anti-inflammatory) effects. The body releases aluminium via kidneys. In order to keep the resorption at a low level, the German Federal Institute for Risk Assessment (BfR (Bundesinstitut für Risikobewertung) advises the public to refrain from applying deodorants on a clean-shaven skin.

### Alum – the substitute material

The negative media reports have led to the fact that some of the manufacturers developed and advertised aluminium chloride free antiperspirants. So far, so good. Nevertheless, in cases where the preparations with the substitute alum (INCI: Potassium Aluminium Sulphate or Potassium Alum) are advertised with the term "0% aluminium chlorohdrate", the customers might think that the products are aluminium free. A wrong conclusion though. Alum and the therein contained aluminium sulphate have been used in hemostatics, alum sticks and shaving pencils for a long time, particularly to treat minor lesions caused by wet shaving.

### Cosmetic applications

In this context let's focus on the multitude of other products that contain aluminium. Not only beverage cans, but also aluminium tubes, aluminium dispensers or aluminium fingertip dispensers in the cosmetic field belong to this group for instance. Aluminium and aluminium

oxide slowly dissolve either through the exposure to the acids contained in the products as for instance fruit acids, through a low pH level or through bases with a high pH level with the effect that the aluminium then is released into the products. The corrosion process still is accelerated by chelating agents. This is the reason why the interior surfaces of the containers have to be coated and must be completely intact. Coating materials are epoxy or polyester resins.

Aluminium fluoride which is used in tooth pastes for the caries prevention for instance also belongs to the soluble aluminium compounds. Since tooth paste remainders are rinsed out, the aluminium absorption is low. Apart from that, aluminium fluorides can be replaced by other fluorides in this case.

Other aluminium compounds that mostly are used as cosmetic additives are non-soluble: The following substances belong to this group:

- Bentonite, an aluminosilicate, forms inorganic gels with water which then are the base material for the mixture of liquid make-ups to which pigments, glycols and oils are added.
- Aluminium hydroxide serves for the coating of titanium dioxide in sun protection and make-up products. Coating impedes the radical formation in titanium dioxide after radiation. There is a fluent passage between aqueous aluminium oxide (alumina) and aluminium hydroxide. The chemical features are nearly identical though.
- Aluminium stearate is a component of powders and stabilizes W/O emulsions similar to magnesium stearate. Aluminium stearate improves the viscosity of fatty and non-aqueous preparations. Other salts as for instance Aluminium Starch Octenyl Succinate (INCI; E 1452) have similar properties.
- Argilla (INCI) is the Italian term for clay which has already been described above.
- Kaolin is a component of pigment-containing products such as lip sticks and concealers as well as powders and foundations.
- The sulphurous aluminosilicate ultramarine is a blue pigment.
- Sodium Potassium Aluminium Silicate (INCI) is a component of powders, eye shadows and concealer creams. Its composition is equivalent to the composition of natural Mica (INCI). Consequently the optical features are similar too.

- Zeolite and similar porous aluminosilicate particles serve for the incorporation of amorphous active agents and their use in nanodispersions. Particle diameters of less than 100 nm have to be declared as nanomaterial. They are non-biodegradable.

### ...and thinking outside the box

Besides the broad discussion about the use of aluminium in cosmetic products, its wide application in daily household products should not be neglected as the contact with food is even more intense. Just to mention some examples:

- Unglazed pottery such as stoneware and earthenware which are affected by the fruit acids of brandied fruit (rum pot) for instance. Fruits and sour dishes such as pickled cabbage (sauerkraut) with its lactic acid still are more activated under the effect of heat (clay pot cooking). Porcelain and glazed pottery by contrast are largely inert whereas the glaze could be affected through frequent dishwasher use.
- Baking sheets can be affected by lye and baking soda when baking lye pretzels for instance or by the fruit juice after baking fruit pies. The same applies for instant meals in aluminium packaging and for the use of aluminium pans and pots. Experience shows that the original coating with Teflon becomes damaged after a certain while.
- Juice extractors, scoops or Italian coffee pots often are manufactured with pure aluminium. The same applies for beverage vats.
- Food as for instance tea, cocoa and chocolate also contains aluminium compounds. E 173 is a food colour used for the coating of dragées. It consists of pure aluminium. The use of sodium aluminosilicate, potassium aluminium silicate and aluminium varnishes in food has been restricted since 1. August 2014<sup>1</sup>. Further food additives are aluminium sulphate (E 520), aluminium sodium sulphate (E 521), aluminium potassium sulphate (E 522), aluminium ammonium sulphate (E

523) and sodium aluminium phosphate (E 541).

- Antacids<sup>2</sup>, i.e. drugs that neutralise stomach acid (medical drugs) may contain aluminium magnesium silicate. Antiseptic gargle solutions to treat infections in the mouth cavity – also medical drugs – contain diluted aluminium chloride solutions<sup>2</sup>.

### Conclusion

In our daily life, we are constantly confronted with the light metal – whether we are outdoors, read newspapers, work in the kitchen, eat a chocolate bar or just apply make-up. As for many other substances, the health organizations have determined threshold values for aluminium and, as yesterday so today, compliance with these values is difficult to check though. Good news is that there has not yet been found valid evidence to prove harmful secondary effects.

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<sup>1</sup> Bundesinstitut für Risikobewertung, Fragen und Antworten zu Aluminium in Lebensmitteln und verbrauchernahen Produkten, revision on 20. February 2015

<sup>2</sup> Rote Liste, volume 2015