# Titanium dioxide – the whitener

**published in Beauty Forum medical 2022 (3), 16-17**

Until now, the use of titanium dioxide as an excipient in food, medicines, cosmetics and many other articles of daily life was considered harmless to health. But for some time now, concerns and restrictions have been increasing. We have compiled the background information for you.

Titanium (Ti) is a light metal. It occurs in the earth's crust in the form of mixed oxides associated with calcium, silicon and iron or as pure titanium dioxide.
Elemental titanium is used to produce high-strength alloys where light weight, physical toughness and chemical stability are important. Devices and implants with a long service life and high physiological compatibility and aircraft construction are examples of common applications.

**Gemstones**

The titanium dioxide ($TiO_2$) resulting from the oxidation of elemental titanium crystallises in several modifications, of which the minerals rutile and anastas in particular are processed into gemstones with varying colouring. The oxide, which is ground into powder, takes on a pure white colour and is used in many ways as a pigment. Areas of application are foodstuffs, medicines, coatings, paints, varnishes, detergents and cosmetics.
Since the beginning of the 20th century, titanium dioxide has replaced lead salts such as lead sulphate and lead carbonate, which are also white and harmful to the environment and health. Above all, the higher chemical stability of the pigment proved to be an advantage over the lead salts, which in the presence of hydrogen sulphide, which occurs everywhere in traces, darkened over time to form lead sulphide.
The pigment is obtained by treating titanium dioxide ores containing more or less iron with concentrated sulphuric acid. The process made negative headlines in Germany due to the (later discontinued) dumping of dilute acid in the North Sea. In the meantime, a cycle process with titanium tetrachloride as an intermediate stage is gaining in importance.

**Cleaning semiconductor**

Titanium dioxide particles can be coated with other substances. This changes the optical properties. In cosmetics, for example, they then have a core of titanium dioxide (INCI: CI 77891) and a coating of aluminium hydroxide (INCI: Aluminium Hydroxide).
The coating has the advantage of further increasing the chemical stability of $TiO_2$ dispersions. This is because titanium dioxide has semiconductor properties. This means that radiation in the near UV range releases reducing electrons from the crystal lattice. Conversely, electron gaps remain, which have a high oxidative potential and can generate radicals. A typical example are hydroxyl radicals ($OH•$), which are formed from the hydroxide anions ($OH^-$) of water. They attack practically all organic substances and ultimately degrade them. The photocatalytic cleaning of nano-titanium dioxide-coated surfaces is based on this principle.

**Questionable sun protection**

From the point of view of photocatalysis, the earlier use of the untreated (non-coated) oxide as a mineral component in sunscreens appears to be more than counterproductive, although at the time reference was always made to the physical reflection of the radiation.
With the introduction of colourless nanoparticles at the latest, this argumentation was reduced to absurdity, because the readiness to react described above increases as the diameter of the particles decreases. Nano-dispersions were then consequently withdrawn from circulation again, but actually for a different reason: It could not be ruled out that the biologically non-biodegradable nanoparticles could possibly enter the bloodstream through the intact skin and even more so through the barrier-disrupted skin. This suspicion could not be confirmed until today.

**Dusts and aerosols**

As a white pigment, titanium dioxide is not only used in cosmetic powders but also in aerosol-generating hair care products. Aerosols are also produced when dispersion paints are sprayed and even when applied with a paint roller. While the oxide is firmly bound in plastics and paper when used, the absorption of

particularly small particles in the lungs must be expected when dusts and aerosol mists are inhaled. In the lungs, titanium dioxide leads to inflammatory immune responses.
Since it is not degraded, it probably behaves similarly to comparable mineral dusts such as cement, quartz and coal dust. Inhalation has been classified as potentially carcinogenic in this respect.

The Technical Rule for Hazardous Substances "TRGS 559 - Mineral Dust" of February 2010 describes in detail the effects of dusts and the protective measures to be taken. However, TRGS 559 only applies to production in the case of cosmetic powders containing minerals. Upon enquiry with the Industrieverband Körperpflege- und Waschmittel e. V. (IKW), it was confirmed that there are currently (as of January 2022) no efforts to provide cosmetic powders with a warning label.

**Titanium dioxide in food**

Until recently, titanium dioxide was considered a safe lightening component in foods such as chewing gum, instant sauces, baking agents, cheese and pastille-shaped sweets. In the meantime, animal studies have shown that the food additive E 171 can cause intestinal inflammation. A carcinogenic potential is also suspected there. In addition, studies with water fleas (daphnia) revealed indications of aquatic toxicity and associated mutagenicity.
The European Commission banned the use of E 171 in food on 14 January 2022. The implementation of the ban in Germany is expected to take place in mid-2022. In neighbouring France, titanium dioxide was already withdrawn from circulation in 2020.

**Lipsticks, tablets and the like**

Against this background, lipsticks and toothpastes containing $TiO_2$ will presumably also have to be viewed more critically in future, as a considerable part of the composition is swallowed during use.
It should also be noted that titanium dioxide is a popular excipient of tablets and dragées in the pharmaceutical sector and in medical devices. Here, too, restrictions can be expected sooner or later, if the data available so far are confirmed.

Dr Hans Lautenschläger