CO_2 – more than just a greenhouse gas

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There is not a single day without the horror stories on climate change and its consequences, be it in newspapers, broadcasts or TV. One of the main polluters is carbon dioxide or abbreviated CO_2. Many of its useful properties however get caught up in the maelstrom of the negative communication. The following paper is intended to partially rehabilitate the agent, among others also in the areas cosmetics and healthiness.

Day after day we produce it in the power stations of our body. Via lungs we participate with a share of about 4 percent in the worldwide production. There is talk of carbon dioxide, the unavoidable end- and waste product of our conventional energy generation based on carbon and carbon compounds like crude oil and natural gas.
With all our attempts to find alternatives: transitions towards a production of electrical energy in our human bodies at the best sound like material for science fiction series. That's the bad news. The good news is that CO_2 participates in many beneficial functions of our daily life without our knowing it.

Protection & preservation

The basic concept of a CO_2 fire extinguisher still is easy to understand. It eliminates the oxygen which is essential for a fire and thus quenches the flames. It gets more complicated when it comes to the mechanisms around food preservation. Quite a number of our food is oxygen-sensitive and hence stored or packed in protective atmosphere. Also the ripening process of fruit and vegetables can be retarded which allows for a longer storage period. This way we can enjoy fresh apples in winter, without having transported them from the southern hemisphere to our regions.
Carbon dioxide not only protects sensitive organic material against direct oxidation but also against microbial degradation, in particular through aerobic germs. They produce the essential energy they need for proliferation through oxidative metabolisation of organic substances.
Even anaerobic germs that prefer a non-oxygen atmosphere do not like a pressurized CO_2 atmosphere. In other words there is a preservation method on hand without having to resort to the typical and potentially allergenic preservatives listed in the German Cosmetic Directive (Kosmetikverordnung – KVO).
The cosmetic industry uses spray cans in which also mixtures of CO_2 with other inert gases such as propane and butane are compounded. However, such kind of packaging can only be used for low consistent formulations to be extracted in the form of foams. Foams are perfectly spreadable on the skin. One of the advantages of the usually sterile products is that the number of cosmetic additives can be reduced which can affect the microbiome of the skin. CO_2 is rarely contained in aerosols used for spray cans with deodorants, hair spray & co., though.
By the way, also yeasts live in anaerobic conditions. They reduce oxygen-containing compounds and produce carbon dioxide which forms a protective layer over the mash during the alcoholic fermentation and bubbles unpressurized out of the tank via airlock with barrier liquid. Wine and beer production is controlled by yeast enzymes. Saccharides such as glucose are converted into alcohol and carbon dioxide. Similar conditions can be found with yeast cakes. The formed leavening CO_2 makes the cake rise.
Concerning the energy generation in the mitochondria of our cells it should be mentioned that fatty acids or glucose are oxidised with simultaneous formation of CO_2. In addition to that, harmless water is released during the radical reactions occurring in the background. The performance of the mitochondria can be adapted during manual work or physical exercises.
With the help of sunlight, the flora does the exact opposite of it and produces carbohydrates (saccharides) from carbon dioxide and water. Hence it is hardly surprising that plant growth is stimulated with growing CO_2 content in the atmosphere.

Leavening

An alternative to the enzymatic formation of CO_2 during baking processes are chemicals in which the gas is bound. Mainly sodium carbonate (soda) but also small amounts of potassium carbonate (potash) belong to this group. These compounds are ground to pow-

der and mixed with powdered acids like tartaric acid for instance. In the presence of water the acids react with the carbonates with release of CO_2. To ensure a controlled reaction, separating agents in the form of starch or flour are added.
Similar conditions can be found with bath tablets; their components are pressed to form tablets. As soon as the fizzy tablets come into contact with water they are busted by the gas formation and their other ingredients such as essential oils, perfumes or dyes can spread in the bath water.
Without the addition of acid, sodium hydrogen carbonate (natron alias baking soda) develops carbon dioxide at about 50 °C and converts into sodium carbonate. Hence it can also be used as a bakery improver. The situation is similar with ammonium hydrogen carbonate (baker's ammonia alias hartshorn). Sodium hydrogen carbonate in the form of suppositories is used as a "leavening" laxative.

Carbon dioxide & water hardness

The already mentioned carbonates are ubiquitous in the environment. Carbonates are the salts of carbonic acid with metals such as sodium, potassium, calcium and magnesium. While free carbonic acid has a very short lifespan and immediately separates into carbon dioxide and water, its salts are quite stable and form huge mountain ranges (limestone, dolomite, Jura Mountains, corals). The major part of the terrestrial carbon is solidly bound there. Only when carbonates get in contact with acids they decompose with release of CO_2 as already mentioned above. For a long time this particular feature has been used for soap production by cooking animal or herbal lipids with soda- or potash solutions. In this process the lipids are decomposed into fatty acids and glycerin. The fatty acids on their part eliminate the carbonic acid from their salts and form fatty acid salts (soaps). Curd soap forms from soda and soft soap from potash. For a long time, the cosmetic industry has mainly used soaps as emulsifiers in O/W emulsions; still today small amounts of them are mixed into components such as the self-emulsifying mono diglycerides. Carbonic acid can react with its own salts. In the presence of water, carbonates assimilate carbon dioxide and form hydrogen carbonates which again release CO_2 in the case of high temperature (see baking powder) or with the evaporation of water. The latter mentioned occurs with the erosion of mountains (karst) and the formation of dripstone caves when it is a matter of calcium- or magnesium hydrogen carbonate. Both the hydrogen carbonates are water-soluble and also responsible for the temporary hardness of drinking water. The presence of these salts can be identified by the scale (tartar) in the water boiler and the flocculation when using soap bars for washing purposes. The flocculation is due to a reaction with the fatty acids of the soap bars.
Something of the sort also happens with a barrier disturbed skin. The fatty acids of the skin are bound as so-called lime soaps which further harm the skin barrier. Hence in the case of atopic skin, water softening measures are part of the therapy. By contrast, calcium and magnesium hydrogen carbonate-containing mineral waters are beneficial for the health, in particular for the bone structure.

Gentle extracting agent

At room temperature carbon dioxide is a gas and at low temperatures it is a solid material (dry ice, -78.5 °C), well-known from the smoke machines of theatre stages.
A particular aggregate phase is the so-called supercritical carbon dioxide; it is highly pressurized and has gas- but also liquid properties. Supercritical CO_2 is used as a solvent for the extraction of cosmetic active agents from plants and other organic material. Also polar, heat- and oxygen-sensitive substances can be extracted in a very gentle way. The solvent escapes without any residues after the extraction and can be reused. By the way, this method can also be applied for an ecologically-friendly commercial cleaning of textiles.

Cosmetic active agents

Humans mainly discharge the carbon dioxide via lungs. A very small portion also is diffused via skin. High concentrations of the colourless and unscented gas in the air have a narcotic effect on animals and humans and finally can be lethal.
There is a finely tuned balance between oxygen and carbon dioxide in the body. If the CO_2 content rises in the blood vessels an opposite regulation in the form of intensified lung activity and blood circulation in the vessels starts. The alternative medicine uses this process by subcutaneously injecting carbon dioxide (subcutaneous carboxytherapy). Fields of application are the stimulation of the blood flow and the relief of pain and tensions.
The cosmetic field tried to adapt the procedure to cosmetic purposes in the form of carboxytherapy. Instead of the gas, sodium hydrogen carbonate containing preparations or in other words preparations that contain chemically bound carbon dioxide (see above) are used. It should however be mentioned that the related or promised effects mainly are due to the additionally contained active agents. Terms like sodium hydrocarbon for sodium hydrogen

carbonate found in the product descriptions rather are fantasy terms here.
Also the alkaline skin care uses natron, in other words sodium hydrogen carbonate, since dissolved in water or integrated into creams it shows a minor alkaline reaction. Alkaline skin care claims to have de-acidifying effects. This means that long-chained fatty acids are dissolved out of the skin barrier which stimulates the endogenous new synthesis of fatty acids on the one hand but also intensifies already existing barrier disorders.
A very frequently used carbonic acid derivative is urea alias carbonic (acid) diamide. Urea is a component of the NMF (Natural Moisturizing Factor) of the skin and has hygroscopic characteristics. In higher concentrations it has penetration-enhancing features for other active agents and in very high concentrations it has keratolytic effects. The enzyme urease degrades urea into CO_2 and ammonia. The smell of ammonia can be found around poorly maintained urinals.
Dicaprylyl carbonate is a representative of the carbonic acid esters and used as a skin care component in the lipid phase of emulsions. Polycarbonates are thermoplastics. Polyurethane simultaneously is a polymer ester and amide of carbonic acid. The ground plastic can be found as a scrubbing agent in professional hand wash pastes.

CO_2-Laser

CO_2-Lasers emit infrared radiation which, among others, is applied for facial anti-aging treatments (resurfing). The laser facilitates a two-dimensional abrasion of the epidermis on the one hand and on the other hand a treatment of scars, tattoos, wrinkles and age spots.

Dr Hans Lautenschläger