Small but mean – plastics and microplastics in cosmetic products

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Plastic materials with their partly harmful additives such as plasticisers, antioxidants and Co. continue to be criticised because of the ecological problems they implicate. Mainly the outer packaging, the containers but also the ingredients of cosmetic products are involved, in particular, if it is a matter of small particles or, in other words, microplastics.

The term polymer stands for a substance consisting of a multitude of serial subunits also called monomers. Glucose (alias grape sugar) is naturally occurring as a (bio) monomer and the basis for many (bio) polymers such as cellulose, starch, glycogen and xanthan gum. Hyaluronic acid, alginic acid and pectins also are typical biopolymers. The more resistant among them are wood, cotton, wool, silk, hairs, fingernails and chitin; finally also the non-degradable mineral oils and ceresin waxes belong to this group.
Synthetic polymers (plastics) occur in a multitude of variants that, depending on their specific use, either degrade rapidly, slowly or are non-degradable. Analogous to the biopolymers, they can be water-soluble or non-soluble in water. As regards their properties, in many respects they are superior to biopolymers. It is differentiated between linear polymers, linked cross polymers and copolymers that consist of several different kinds of monomers.

Disposal & recycling

During the past decades the production of plastics has skyrocketed and thus has led to global-scale disposal problems and water pollution, above all with respect to the non-degradable polymers.
In Germany the cosmetic manufacturers pay fees to organizations involved in the proper disposal of containers as for instance Grüner Punkt (dual system) or similar organizations. While the typical icon for “Grüner Punkt” formerly was printed on the packaging, it is no longer shown today. The mentioned disposal practice led to the fact that the fraction of cosmetic packaging of European origin polluting the global oceans is vanishingly small.
The synthetic materials used for container production mainly are polypropylene (PP), polyethylene terephthalate (PET), polyethylene (PE), styrene acrylonitrile resin (SAN), nitrile butadiene rubber (NBR) and caoutchouc (alias Indian rubber, gum elastic). Other frequently applied synthetic materials such as polyvinyl chloride (PVC), polystyrene (PS) and polytetrafluoroethylene (PTFE) are practically not utilized in the cosmetic field.
Used plastics partly are recycled and re-used for the production of new containers, also in the cosmetic field. Such recycled materials however can involve problems due to the different origin and composition of the plastics but also because residues of harmful additives and other pollution cannot be completely excluded. Containers made of recycled materials can be identified by the certificates supplied with the containers. In contrast to the pure or non-recycled synthetic materials such certificates are rather comprehensive and contain ample information on threshold values and measurement data of potential pollution.
Apart from the mentioned traces of harmful substances the analytical technique can only find what it explicitly searches for. In other words: additional substances can be present and there is the risk that the ingredients of the preparations will release such substances from the containers and trigger reactions on the skin after the products are applied. Hence special attention should be paid with respect to imported materials.

Microplastics

Besides proper recycling or refuse incineration, often after single use only, a small fraction of the materials finds its way into the soil and water bodies, either by neglect or criminal energy. Only in exceptional cases they are degraded by specialized organisms – as examples can be mentioned the digestion of PE foils through particular moth species or the enzymatic degradation of polyamides (nylon) through proteases.
Usually the synthetic materials are quite persistent and at the utmost are subject to a gradual comminution due to the impact of mechanical or atmospheric influences such as UV radiation and aggressive oxygen radicals. The

particles become brittle after a longer period of time and gradually disintegrate into smaller and smaller particles. In this way microplastics forms which the European Chemical Agency defines as following: particles in a size of one nanometer (10^{-9} m = 10^{-7} cm) up to 5 millimeters (mm) including fibers of 3 nanometers up to 15 millimeters of length.
During this disintegration, harmful and partly endocrine disruptive stabilisers (e.g. bisphenol A) and plasticisers (e.g. phthalic acid esters) are released from the plastic materials. Fortunately the cosmetic and pharmaceutical packaging is free of such substances since the risk of product contamination would be too high. By the same token however microplastics that found its way into water bodies absorbs on its surface lipophilic organic substances just like a microfiber cloth. These substances can be pesticides or harmful substances of crude oil origin.
Including the adhering harmful substances the microplastics is ingested by micro-organisms, fish and birds and in this way ends up in the food chain where it causes serious disorders.

Solid particles in cosmetic preparations

Rinse-off preparations or in other words hand cleansers for professional use (e.g. shop floors), mechanical peelings and tooth pastes can contain small plastic scrubbing particles (micro beads). These particles mainly consist of linear (PU) and interlinked (PUR) polyurethane and find their way into the waste water immediately after use. Based on a self-commitment of the cosmetic industry such particles have been completely withdrawn from circulation by end of 2020. By 2028 further self-commitment is planned regarding the elimination of such particles in leave-on products. This commitment involves for instance powders (nylon particles), hair treatment preparations and components of decorative products.

Water-soluble polymers

Besides solid plastic particles, solutions of biopolymers and synthetic polymers are used in cosmetic preparations. Consistency agents belong to this substance group. They help control the viscosity and physical stability of cosmetic products in order to ensure that the lipid- and water phase will not separate even with longer storage periods. Apart from that they can form open-porous films on the skin.
Among the soluble synthetic consistency agents, polyacrylates alias carbomers and their copolymers are the mostly used substances. These polymer concentrations are comparably low, mostly below one percent. Toxic effects can be excluded. In the sewage treatment plants they are separated from the waste water and very slowly degraded by microorganisms due to their ester structure. Being polymers they often have been associated with microplastics, however, they show completely different behaviour and are not involved in water pollution. Apart from that there is no adsorption of harmful substances which for instance occurs with microplastics. The situation is similar with polyethylene glycols (PEG) that also are administered as laxatives in the pharmaceutical field (macrogols).
INCI (partial-) terms of water-soluble polymers are for instance: Sodium Carbomer, Acrylates Copolymer, Acrylates Crosspolymer, Polyethylene Glycol, Polypropylene Glycol (PPG). In the context of crosspolymers also the abbreviation VP can be found that refers to vinyl pyrrolidone. In the form of polyvinyl pyrrolidone it is also used to control the consistency in cosmetic products and it serves as a disintegrant in the pill production.

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