# Polymer Materials

## *On the Image of Plastics and their Responsible Use*

Polymer materials, including synthetic polymers, have a bad reputation. These image problems do not just arise from the current environmental debate but also have earlier origins. In the past, too, polymer materials were subject to unjustified criticism. This often stemmed from non-scientists and frequently betrayed a lack of scientific knowledge.

Many changes to this earth are now man-made. The present epoch is therefore sometimes already being called the Anthropocene

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Plastics have a massive image problem. They are often seen as a symbol of environmental pollution. In addition, they are still considered by many consumers to be an inferior, cheap material used as a substitute for supposedly higher-quality materials. These currently widespread views are no new phenomenon but have long been associated with these materials and to some extent have historical origins. There are also some difficulties in defining the term plastics. That is why it is better to refer to this material group as "polymer materials" (poms).

Polymer materials is the generic term for:

- biogenic polymers (natural polymers) such as cellulose, starch, proteins, natural resins, natural rubber,
- modified biogenic polymers (semi-synthetic plastics, chemically modified natural polymers), for example vulcanized natural rubber, cellulose nitrate, cellulose acetate, casein formaldehyde,
- synthetic polymers (synthetic plastics) such as thermosets, thermoplastics, elastomers, and thermoplastic elastomers (TPE),
- biopolymers such as biotechnological polymers (enzymatically produced or genetically engineered, e.g. polyhydroxybutyrate and proteins similar to

spider silk) and bio-based polymers, in which the starting materials or monomers are biogenetically or biotechnically accessed and then synthetically polymerized, such as bio-based polyethylene (PE).

There are some difficulties in defining the term plastics. On the one hand, the term also covers resins (natural and synthetic) and even polymer emulsions and dispersions (International Organization for Standardization ISPO 468/3-Part 3, Terminology of Resins, 1999) [1], on the other, rubbers are not included. The term plastics has acquired a negative connotation in the constant debate about "plastics waste", the "plastics dilemma", and the "plastics catastrophe".

There has often been controversy over plastics in the past – it is nothing new. Topics that have triggered concern include plasticizers, colorants, and other constituents, when toxic. At present, debate centers mainly around the global spread of macro- and microplastics. This has given rise to a massive image problem and hostility to the material, frequently referred to as "plastics bashing". This is now having an impact on the use of plastics and composite materials indispensable to our lives in the technical, medical, and sports sectors.

However, this image problem can also be traced back in large part to historical origins. Since the first production of semi-synthetic plastics such as cellulose nitrate (Celluloid, John W. Hyatt, 1868/70), they were used, among other purposes, to imitate and substitute for ivory, horn, tortoiseshell, coral, and mother-of-pearl. But, of course, not just for that, since from very early on unique patterns and colors were achieved with Celluloid that had no models in nature. Nevertheless, students of art history are still taught that the early plastics just fulfilled a substitute role and carried the taint of being artificial, inferior, cheap, and mass-produced. In Germany, this image was propagated in particular by members of the Deutscher Werkbund, in English German Association of Craftsmen (artists, designers, architects and industrialist).

One of the protagonists of the Werkbund, the art historian Gustav E. Pazaurek [2], created a "classification system for esthetic aberrations" and fought for the dissemination of good taste in arts and crafts, since imitations were anathema to him. Through this, he had a lasting influence on the attitude of the Werkbund. As far as the new plastics were concerned, the members of the Werkbund neglected to see the new coloration and patterning opportunities they offered, of which there were enough examples. Neither were they able to grasp the potential technical uses of the new materials because of their fixation on art and crafts. They failed to recognize the possibilities of, for example, vulcanized rubber for raincoats (Charles Macintosh), electrical insulation, bicycle or car tires, and as a hard rubber for the electrical industry, telephone receivers, hammers, clarinet mouthpieces, and fountain pens; cellulose nitrate (Celluloid) and cellulose acetate (Cellon) for paints and films; and casein formaldehyde (Galalith) as a low-frequency insulator. The entire subsequent development of the electrical industry was only made possible by phenolic resins (Bakelite), which served as an insulating and construction material.

The actual use of plastics as substitutes during the raw material blockade in The First World War dealt another blow to their image, especially in Germany. Inferior-quality viscose staple fibers were not particularly popular. The first synthetic methyl rubber was laborious to produce, had low productivity, and its soft rubber properties were neither very reproducible nor comparable with those of natural rubber. It only found adequate use as a hard rubber. In this time of emergency, materials such as "artificial fiber" and "artificial silk" – just like "artificial honey", "artificial pepper" and "artificial cinnamon" – were branded in the collective memory as cheap surrogates. Outside professional circles, they could never fully shed the image of inferior quality.

Equally influential and detrimental to the image of plastics among art critics and art historians was an essay on "Plastic" by the French philosopher Roland Barthes in 1957 [3]. Among other things, he writes that: "Despite having names of Greek shepherds (polystyrene, phenoplastic, polyvinyl, polyethylene), plastic, the products of which have just been gathered in an exhibition, is in essence the stuff of alchemy. […] So, more than a substance, plastic is the very idea of its infinite transformation. […] whatever its final state [...] the mind does not cease from considering the original matter as an enigma."

In his words, Barthes clearly shows his ignorance of natural sciences and chemistry. This is betrayed by his "naïve" surprise. He is obviously not aware, either, that his description of the material also applies exactly to the age-old cultural material glass. To this day, Barthes is readily and extensively quoted in liberal arts circles, particularly among art historians.

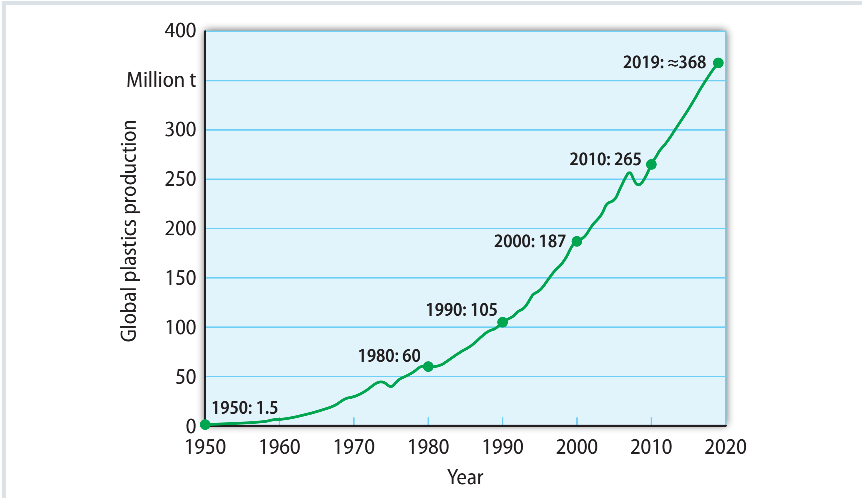


**Fig. 1.** Global plastics production (million t per year) is increasing exponentially since 1950

Source: PlasticsEurope; grafic: © Hanser

## *Microplastics and the Anthropocene*

To these virulent, historical taints that still plague the image of plastics, new ones have also continued to be added more recently. Around 2000, the biologist Eugene Stoermer and the meteorologist and Nobel prizewinner Paul Crutzen »

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mit besonderer Berücksichtigung von Kunstseide und anderen Kunstfasern, von vulkanisiertem, devulkanisiertem (wiedergewonnenem) und künstlichem Kautschuk, Guttapercha usw. sowie Ersatzstoffen, von Zellhorn (Zelluloid) und ähnlichen Zellstofferzeugnissen, von künstlichem Leder und Ledertuchen (Linoleum), von Kunstharzen, Kasein-Erzeugnissen usw.

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herausgegeben von Dr. Richard Escales (München).

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**Fig. 2.** The first edition of ***Kunststoffe*** magazine in 1911 "with special focus" on biogenic and modified biogenic polymer materials © Hanser

proposed that the latest period of the Holocene epoch should be named the Anthropocene, i.e. the Age of Man (**Title figure**). The basis for this was the geological deposits from the first atomic bomb tests [4–6]. Now, the remains of plastics waste are also often regarded as an identifier for the Anthropocene. Microplastics are verifiable globally according to geological standards. However, it appears this is not unspecific plastic waste but, measured by weight, is mostly the remains of packaging (films, bottles and containers).

At the present time, some 370 million t of plastics are produced annually worldwide. The increase is exponential (**Fig. 1**). Packaging accounts for more than one-third of all plastics production. Of the approximately 8300 million t of plastics produced globally between 1950 and 2015, about 6 % has been recycled, 8 % incinerated, and 55 % sent for waste disposal. Around one-third is still in use. In 2017, some 2 % of the 350 million t or so of plastic produced, i.e. about 7 million t, ended up in the sea.

Approximately 99 % of this waste is initially invisible, since it is degraded by slow weathering and fragmentation processes into plastic particles less than 5 mm in diameter – so-called secondary microplastics. The proportion not absorbed by marine organisms sinks to the bottom of the oceans, is deposited there, becomes embedded in the sediments, and gradually forms a new geological layer, the "plastics horizon". As previously mentioned, this is seen as a further sign of the Anthropocene.

Of these secondary microplastics, a distinction is made between "primary microplastics" type A and type B. Type A includes deliberately manufactured small plastics particles for specific products such as cosmetics, polymer abrasives, laser sintering powder for 3D printing and semi-finished product powder. Type B microplastics originate through usage or abrasion processes, e.g. abrasion of rubber tires (highest share of 81 %), textile fiber fragments released during laundering of textiles, weathering of colorants and paints and agricultural plastics such as films. Deposition and layering of these microplastics also takes place on land – via global air pollution – in remote regions such as the High Alps, the Tibetan Highlands, and on Greenland ice.

## *Plastics: A Material with History*

Biogenic polymer materials (poms) such as amber, natural rubber, Asian lacquer, Chinese silk, paper and paper pulp, composite materials such as leather, horn and tortoiseshell, but also gelatine glue, casein- and egg white-treated painting grounds, shellac, linoleum, and the chemically modified biogenic polymer materials have an age-old history. They have all contributed significantly to the cultural development of mankind. ***Kunststoffe*** (the Journal for Plastics Technology), the world's first trade magazine for the plastics industry, also included such polymer materials as part of its field of publication in the first edition of 1911 (**Fig. 2**).

The countless synthetic plastics show a potential for exploitation of their tailored properties that is far from being exhausted. They and modern biopolymers represent only a small proportion of all polymer materials; they form part of a very long line of polymers that have played an important role in the history of materials, technology and culture in terms of their properties, behavior, processing and use. Polymer materials (poms) are at any one time not just "substitute materials", "cheap plastics", "toxic", and "ocean-polluting" but also a gateway to technical innovations and artistic possibilities – which is no different from ceramics, glass, and metals. For all these materials, the same thing applies: their advantages and disadvantages must always be carefully weighed up by producers, trade and consumers to achieve an optimum environment-friendly, sustainable use. ■

## The Author

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## Service

### References & Digital Version

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