SUSTAINABLE PRODUCTION

Unbreakable, chemically resistant, sterilizable - high-performance plastics such as polytetrafluoroethylene (PTFE) have many outstanding material properties and are therefore indispensable in the laboratories of this world. However, the most important raw material of all fluoroplastics, fluorspar, is one of the finite resources available. We at BOHLENDER see it as our responsibility to use these resources carefully, to save material and energy wherever possible, and to exploit all recycling possibilities. Various recycling options have long existed for fluoropolymers - both for processing waste and for products that have reached the end of their useful life. These are presented by Dr. Michael Schlipf, a chemist with a doctorate in expert in the field of fluoropolymers, in the technical presentation on page XXX.

OUR FOUR COLUMNS

1. Thought ahead from the start

For us, saving resources begins with development and design. Our products are designed in such a way that they can be used several times and, if possible, for years. At the same time, we pay attention to minimal material use and maximum reduction of production waste. For example, chip-generating work steps are not necessary in the production of compression moulded parts. In addition to the savings in PTFE powder, less energy is also consumed.

2. Recovery in view

We first process fluoropolymers, especially PTFE, into semi-finished products. The main products are tubes, rods or special pressed bodies. From these, we produce customised end products in well thought-out machining processes.

Chips produced during drilling, turning, milling or similar operations are extracted and collected directly at the machine via a pipe system. This way they are not contaminated. We store them sorted clean and free of contamination until we send them to external recycling companies. This also applies to residual pieces of semi-finished products. It may be that the processed, sintered PTFE waste comes back to us. We process them into suitable products.

3. Natural energy in use

We rely on solar energy in the production of our products. Back in 2012, we installed an almost two thousand square meter photovoltaic system on the roof for this purpose, which not only provides us with sufficient electricity, but also saves around 150 tons of CO2 emissions per year in the process.

4. Safe use and disposal

Products made of the most common fluoroplastics such as PFA, FEP, ETFE or PVDF are free from plasticizers and solvents. No harmful substances are released into the environment through them.

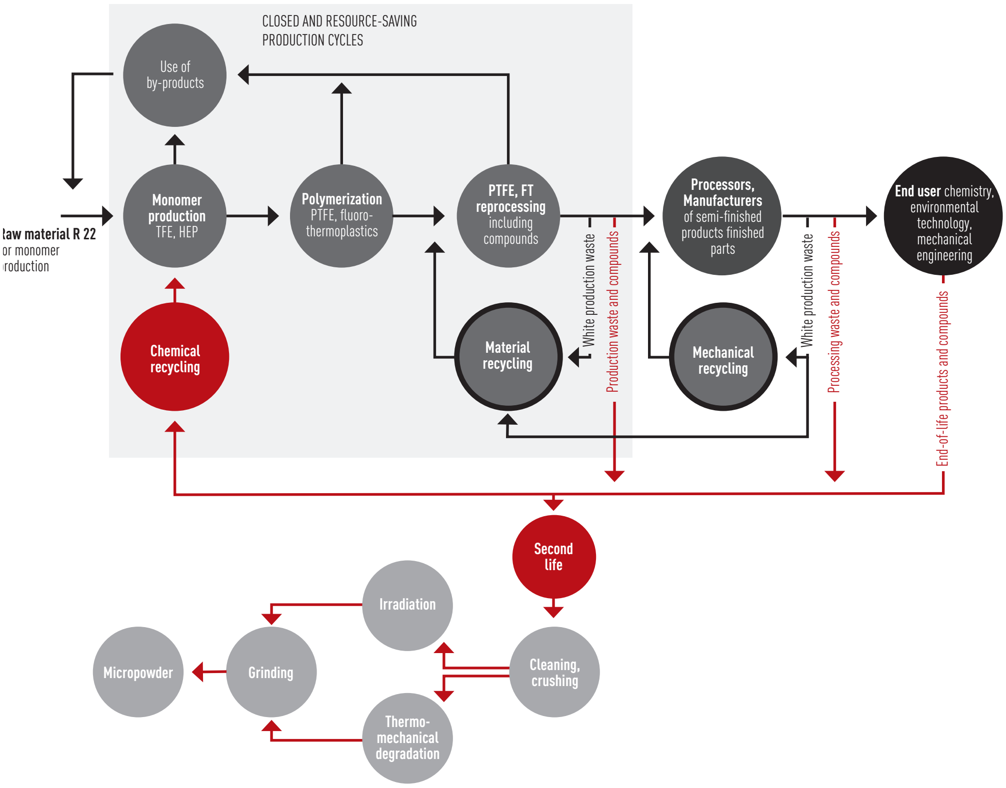
Until 2015, the auxiliary substances PFOA and APFO were used for the production of PTFE. However, both substances could be almost completely removed from the product during reprocessing and recovered for the most part. Nevertheless, well-known PTFE manufacturers have committed themselves to completely renouncing their use. This guarantees that no harmful substances are released to humans or the environment either during the use or disposal of our products.

Recycling of fluoropolymers and other plastics

Dr. Michael Schlipf

With more than 50 percent, polytetrafluoroethylene (PTFE) is the most important representative of the fluoropolymers. For PTFE and other fully fluorinated fluoropolymers, the same applies from the beginning of their use: The material costs are comparatively high and the most important raw material, fluorspar (CaF2), is one of the finitely available resources. Reasons enough why various recycling cycles for fluoropolymers were developed early on and integrated into their life cycle. Today, they are general practice (Fig. 1).

Established cycles during production, processing and use of fluoropolymers



Waste incineration with recovery

If waste from monomer production and polymerisation is incinerated, integrated lime flue gas purification (Ca(OH)2) enables the recovery of fluorspar. This can then be used again as a raw material for monomer production.

Beginning of a "second life"

It is also possible to extend the life cycle. For this purpose off-spec batches from polymer production are converted into PTFE micropowder by thermomechanical degradation of the molecules. This is then used as an additive in paints, printing inks or lubricants.

The thermomechanical degradation of fluoropolymers is particularly environmentally friendly: New, stricter purity regulations, which stipulate low-molecular „fragment" content of less than 25 ppb, are easily complied with.

Mechanical recycling

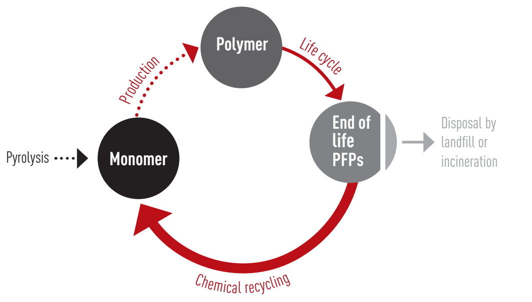
Machining waste from the production of semi-finished and finished parts is collected, cleaned and ground. This can then be used to produce semi-finished products such as rods, tubes or sheets by means of ram extrusion. It is also possible to break down polymers by high-energy irradiation and reuse the resulting PTFE micro powder.

If products are easy to clean at the end of their life cycle, they too can be ground and used either as a raw material for Ram-extrusion or, after radiation degradation, as PTFE micro powder in additive applications. The reprocessing is done by companies specialised in this. They deliver the recycled products back to their point of origin, where they are processed again.
Fluorothermoplastics such as PFA, FEP, ETFE or PVDF can be used in injection moulding or extrusion after state-of-the-art processes such as grinding, cleaning and reuse. The fact that these thermoplastics are usually marketed without the use of fillers makes recycling particularly easy.

Chemical recycling

Chemical recycling, also referred to as upcycling in the case of fully fluorinated fluoroplastics, is a new technology (Figure 2). It has been developed on an industrial scale since 2015 in an experimental industrial plant with a capacity of one thousand tons per year. In the meantime, it is ready for market launch. The fully fluorinated polymers, PTFE, modified PTFE, PFA and FEP, as well as some PTFE compounds can be recycled. The monomer recovery rate is around 85 percent.

Figure 2: In the upcycling process, the products are not incinerated after reaching the end of their life, but are returned to the cycle. The polymers produced again in this way polymers produced in this way show no loss of quality.



For the upcycling process, too, the products are collected after reaching the end of their lives, cleaned and then mechanically shredded. This is followed by thermal splitting back into the monomers at over 600 °C. Reaction products are primarily tetrafluoroethylene (TFE) mixed with a little hexafluoropropene (HFP). After purification of the raw gas mixture by distillation and special washing processes, high-purity monomers are recovered. These can be reused for the polymerisation of new fluoropolymers.

Polymers produced with this process show no reduction in quality compared to the original polymers. Upcycling thus transforms „old" into „new" materials. The quality is thereby raised to the initial level. Fears that the properties of upcycled products are inferior to those of new products do not apply.

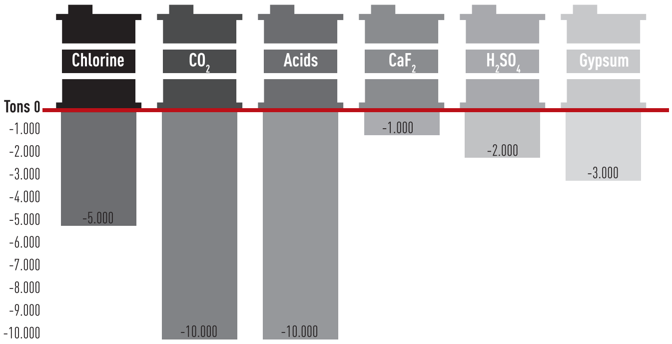
Raw-material saving by upcycling

The raw materials for fluoropolymers are fluorspar, crude oil/natural gas, methane and common salt (NaCl). From these, first the fluorocarbon intermediate R22 and finally tetrafluoroethylene (TFE) are produced in a multi-stage process. All fluoropolymers are made from this raw material. Besides a high energy demand, waste products are also produced, especially hydrochloric acid (HCl). These have to be reprocessed or recycled in complex processes. In addition, all the raw materials mentioned are only available in limited quantities. Once these resources are used up, substitute products will be in short supply.

However, if fluoropolymers that have reached the end of their useful life or machining waste are used instead of these finite resources, the raw material and waste savings that can be achieved are enormous. Figure 3 shows the environmental relief per 1,000 tonnes of fully fluorinated polymer returned to the cycle through upcycling. The amounts of „waste acid" or saved carbon dioxide (CO2) are about ten times the weight of the recycled fluoropolymers. The CO2 footprint („carbon footprint") of fluoropolymers is thus significantly reduced via the upcycling process to better values.

Figure 3: The environmental impact per 1,000 tonnes of upcycled monomer TFE is enormous. Unwanted by-products of the regular monomer production process, such as CO2 and hydrochloric acid, are even completely avoided.

Environmental relief per 1.000 t of recovered TFE



Re-use of PE and PP

Two important representatives of the „standard plastics" are polyethylene (PE) and polypropylene (PP). Due to the comparatively low raw material prices of virgin materials, only low-cost recycling processes are used here; chemical recycling is not possible because of the comparatively high costs.

PE and PP in the production of laboratory supplies are essentially chips or remnants. These are collected, shredded, cleaned and then converted back into new products via thermoplastic processing methods. The preferred recycling method for PE is film production. Recycled PP is reused by means of injection moulding mainly for technical products, for example bumpers or lamp housings for motor vehicles. In these applications, the material cycles can also be passed through several times. About 14 per cent of the plastics currently used in Germany come from such recycling processes.

Plastic mixtures collected via the „yellow bag", for example, provide a „PE-rich fraction" and a „PP-rich fraction" in automated processes. These are then also suitable for further processing by extrusion or injection moulding. Non-separable municipal plastic waste ends up in so-called „energy recycling" as substitute fuel in coal-fired power plants and thus replaces lignite or hard coal.