SPECIAL:
PLASTIC TRENDS

[VEHICLE ENGINEERING] [MEDICAL TECHNOLOGY] [PACKAGING] [ELECTRICAL & ELECTRONICS] [CONSTRUCTION] [CONSUMER GOODS] [LEISURE & SPORTS] [OPTIC]

Strong in Medicine and Sanitary Applications

Polyethylene (PE)

In recent years, society's view of plastics has shifted. The actual material advantages have been overshadowed by the plastics waste debate. Uncommon times, such as the Covid-19 pandemic, remind society of the outstanding contribution of plastics materials. Polyethylene is particularly strong in medical and hygiene applications.

PE ensures cost and weight savings in medical technology. For containers, the material also facilitates sterilization © Adobe Stock; Sudok1

Polyethylene (PE) has replaced and continues to replace more traditional materials, (i.e. glass) as it relates to sterile fluid holding containers. Obvious reasons for the replacement in primary packaging applications are cost and weight reduction. But there is another aspect which is probably less known outside the community of professionals. While glass needs to be sterilized before filling, PE is the material of choice when it comes to manufacturing pre-filled bottles by the aseptic "Blow Fill and Seal", or BFS, process. In an integrated process, the bottle is manufactured by extrusion-blow-molding, aseptically filled and sealed using the same machine. The filled bottle then goes into an autoclave to be steam-sterilized at temperatures of up to 115 °C.

A typical polyethylene for this type of application is a LDPE (low density PE) of the Purell portfolio from LyondellBasell, Rotterdam, Netherlands, a selection of products which are strictly manufactured according to "good manufacturing practices" (GMP) and commercialized following a very stringent medical protocol that is in accordance with ISO 15378. The intrinsic properties, such as contact transparency, flexibility and a high enough melting point to withstand critical sterilization temperatures make this material most suitable for medical fluid containers, especially when produced by the BFS process.

Prior to each treatment, specific and sensitive diagnostic methods are key to allow doctors to define the next steps for their patients. Specifically, in the case of pandemics, high-throughput testing is of utmost importance not only for the individual diagnosis, but also for the screening and tracing of infection chains. Modern diagnostic devices are based on very high throughput methods. Key to their success is a proper sample preparation, as well as the minute cleaning of the device to avoid cross-contamination and possibly incorrect results. Reagents and rinsing liquids are made available using containers that are blow-molded from PE that has to fulfill a number of requirements. Apart from the right mechanical properties like stiffness and resistance to chemicals, it is important to avoid possible interactions with the test that could result from leaching of additives into the reagents and cleaning liquids.

In addition to medical technology, PE also plays an important role in food packaging. In Germany alone, every year, around 12 million t of food end up in the garbage can according to the German ministry of nutrition and agriculture. Apart from the food waste along the supply chain, from the producer to the wholesaler to the retailer, end-consumers alone throw away about 75 kg of food per capita every year. Plastic packaging, such as containers, not only help to protect sensitive food such as grapes, strawberries and other fruits during their transportation, but they also keep the food more hygienic on the shelf. Once the food has arrived in our households, PE cling films have become a very common and adopted packaging material to keep unpacked food or food remainders fresh for longer (**Fig. 1**), which increases the likelihood of being eaten, consequently helping to reduce food waste.

Fig. 1. The importance of the shelf life of food products became more important again during the corona crisis. Plastics such as PE make an important contribution as packaging material and prevent food waste © Adobe Stock; Goffkein

Packaging Made from Renewable Resources

By using PE products made from renewable resources that contribute to a lower carbon footprint, society can enjoy the positive primary purpose of packaging materials. In 2019, plastic producer LyondellBasell conducted its first large-scale industrial trial using bio-based raw materials. This trial indicated that there are no differences in physical properties between products produced from fossil-based versus renewable-based resources. As such, consumers can help minimize food waste with less impact to CO_2 emissions.

Hygiene articles are also an important area of application for PE (**Fig. 2**). Women have high demands for hygiene products. These products have to fulfill their primary purpose of being hygienic and comfortable to use and wear, while also being safe, hygienic and as discretely transportable as possible. While most products are packed in bulk without individual protection, more and more our modern and mobile lifestyle requires sanitary articles to be packed as individual pouches. Sanitary items have strict hygiene standards, and these same standards apply to the pouches they are stored in. Additionally, safety and discretion are important. The pouches should not tear open unintentionally while being transported, and when opened intentionally, it should not make crackling noises which draw the attention of others. As an added preference, most women want a pleasant look and feel for these packaging materials, which translates into material properties, such as softness and printability.

Conflicting Goals and Preferences

Consumers tend to prefer individual packaging solutions, while brand owners are striving for very light-weight mono-material solutions in order to reduce the plastic waste and hopefully make it recyclable, if possible. There is an apparent »

Fig. 2. For hygiene products such as tampons and bandages, pleasant and at the same time inconspicuous packaging is required. Due to the increasing mobility of many people, the demand for individually packaged products is also growing © Adobe Stock; Studio KIVI

Fig. 3. PE is increasingly used for drinking water supply pipes. The plastic is particularly in demand in countries with a high proportion of chemicals used to kill germs in drinking water © Shutterstock; T.W. van Urk

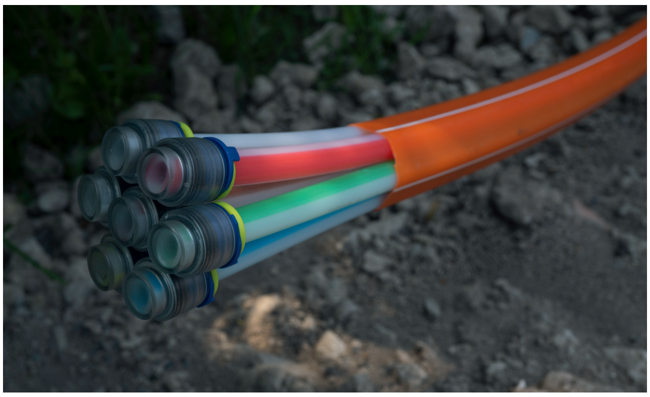

Fig. 4. Due to the increasing demands on data rates and volumes, fiber optic networks are becoming more and more widespread. Microducts made of HDPE are suitable for protecting the sensitive fibers © Adobe Stock; Gabort

disconnect between end-user preferences and brand-owner desires, which make it very difficult to find the right balance between material properties.

First, the thinner the packaging film gets, the more difficult the processing becomes on high-speed machines, since the thin film tends to tear easily. Therefore, thinner films have to be printed at slower speeds, which ultimately makes these products more expensive to produce, although less material is consumed. High-performance products like metallocene-based and bi-modal polyethylene grades enable the solution. These PE resins combine high-molecular-weight (HMW) and low-molecular-weight (LMW) resins to improve the balance of processability and mechanical properties. Modern flexible packaging materials for hygienic articles offer superior tear resistance and make them suitable to be processed at high speeds without the risk of tearing.

PE has also become a firmly established pipe material for water supply (**Fig. 3**). The material helps to ensure drinking water quality. This quality can be impaired by the infestation with germs. The quality of drinking water can be impaired for many reasons, bacteria being one of them. Bacteria grow more easily and faster with rising water temperatures. This is why warmer climate countries like those in Southern Europe, use higher concentrations of disinfectants in their drinking water grids, such as chlorine dioxide or hypochlorite. These very aggressive disinfectants cause oxidative damages to normal steel water pipegrids, therefore shortening the lifetime much more than expected by their design. Polyethylene pipes have become state-of-the-art in pressure pipes used for drinking water distribution systems especially with the new class of polyethylene materials (Resist-RD materials) which combines chemical resistance with improved resistance to stress cracking. This allows for unconventional laying including in demanding environments, thereby reducing installation cost and maintaining the lifetime of these pressure pipe installations. Outside of Europe a similar approach is taken. For example, in Australia where high soil temperatures heat up the distributed water, bacterial growth is common and therefore calls for polyethylene materials with improved resistance to disinfectants.

PE is also increasingly used in other infrastructure areas, such as communications infrastructure. Modern communication and entertainment increasingly take place via the Internet. The amount of data transmitted increases steadily, which not only requires constant technology upgrades, but also the best possible telecommunication cables such as optical fiber cables. "Fiber to the Home" (FttH) cables provide these Gigabit Internet connections using glass fibers that are very fragile by nature and therefore need protection. Microducts (**Fig. 4**) are typically small-diameter, flexible, or semi-flexible ducts designed to provide clean, continuous, low-friction paths for placing optical fiber cables that have relatively low pulling tension limits. These cables have a size ranging from typically 3 to 16 mm and are installed as bundles in larger ducts with a thin flexible outer jacket.

For microducts typically HDPE is used due to its low temperature performance, flexibility, impact balance, low friction for laying and its pressure resistance of up to10 bars. These HDPE ducts have great suitability for a large variety of laying techniques, including trenchless technology for the household connections. The basic types of ducts are smooth-walled, corrugated, and ribbed. The need for a specific characteristic or combination of characteristics such as pulling strength, flexibility, or the lowest coefficient of friction will dictate the type of duct required.

Liquid chemicals and dangerous goods have been transported for several decades in large containers. These Intermediate Bulk Containers (IBC), as well as drums and jerry cans, are typically made from high-molecular weight HDPE. The majority of them are still monolayer containers, however the number of multi-layer containers is increasing.

Protection for Sensitive Glass Fibers

Unlike usual consumer product packaging, these containers have two func- »

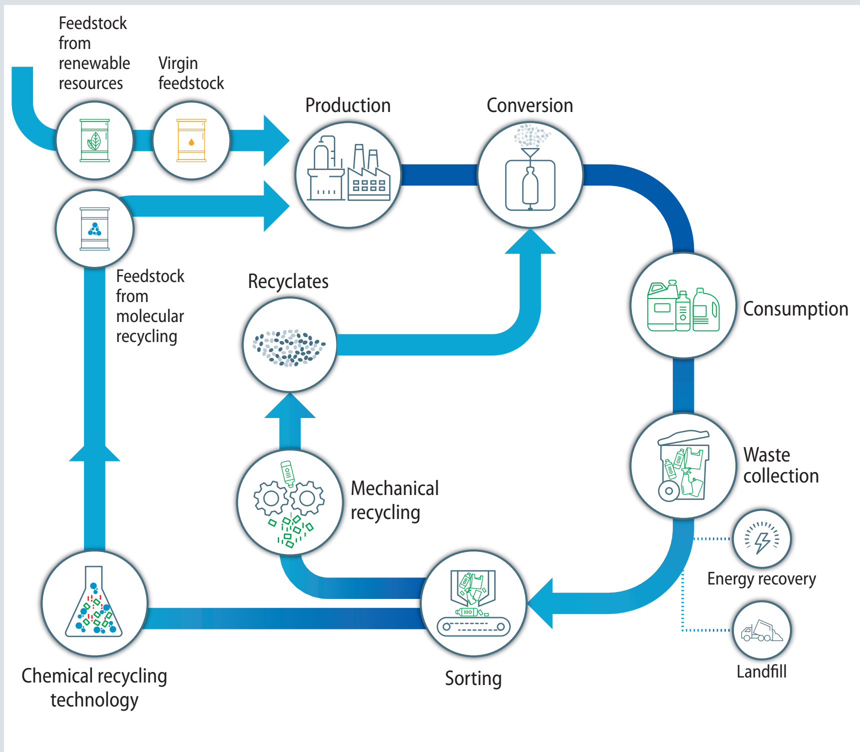

Fig. 5. Depending on the original application, both mechanical and chemical recycling of PE waste is possible Source: LyondellBasell; grafphic: © Hanser

tions. Firstly, protect the content from being contaminated and, secondly, protect the environment from these dangerous fillings. The recent strong demand for disinfectants associated with hand and surface cleaning show the importance of such packaging materials. IBCs are used for the chemical products which are key building blocks to make the disinfectant. Jerry cans and blow-molded bottles are preferred for the transport of the finished disinfectant to the retailer and then to the consumer or hospitals.

While the aforementioned products and trends illustrate the important contribution to modern society, they will at one point come to their end of life. Whether applications go into durable or consumer goods will determine their lifetime. Investment goods or durables are designed to have the longest lifetime possible. Pipe applications, for example, are reaching 50 years and more of service life. In contrast, consumer goods have typically very short life cycles, from production to consumption, before they become waste material. This waste material, in fact, should be considered as potential feedstock material to be reused as part of closed circle recycling loops. Once articles are being collected for recycling, two options exist (**Fig. 5**).

Mechanical or Chemical Recycling?

Mechanical recycling benefits from the intrinsic thermoplastic properties of most plastics materials, and therefore is the shortest cycle back into the value chain: plastics to plastics. However, there are qualifications for the waste materials to be used in mechanical recycling. These waste materials undergo a very stringent selection and cleaning process before being recycled. Different polymer families must be separated from each other. Past design trends aimed at combining different polymer families to benefit the best of both worlds' properties need to be revised in order to take advantage of mechanical recycling. Instead of multi-material or multi-layer solutions, mono material designs need to be developed in order to make articles more recyclable. In addition, residual contaminations cannot be completely excluded. This limits the ability of mechanically recycled materials. For applications which call for the highest standards of purity, such is the case of medical, hygiene and also food applications, mechanically recycled materials are not a viable option.

These limitations can potentially be overcome by the second option: chemical or molecular recycling. Currently, the chemical industry is putting forth substantial effort into the development of chemical recycling technologies for plastic waste streams, e.g. in a joint project between the Karlsruhe Institute of Technology, VCI, PlasticsEurope Deutschland, BKV and major polymer producers. One of these technologies is currently being developed further by polyolefin manufacturer LyondellBasell. This particular molecular recycling technology (MoReTec) uses a proprietary catalyst-based approach in a pyrolysis process that targets converting mixed plastic waste into hydrocarbon liquids. After an upgrading process, these hydrocarbon liquids are very similar to naphtha, a feedstock which is typically used in steam crackers for the production of ethylene and propylene monomers. The monomers which originate from this naphtha-like feedstock can be used for the production of any PE or PP. ■

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Service

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