

Solvent-Based Recycling Processes

Recycling of Laminated Films

Composite films are successfully used in the packaging industry to reduce the weight of the packaging material and to increase the product shelf life. Thus, they contribute significantly to CO₂ reduction. However, due to functional requirements, composite structures often use incompatible plastics, which prevent recycling in proven mechanical re-extrusion processes. Solvent-based recycling processes offer an attractive and technically mature solution to tackle the challenge.

The CreaSolv technology enables recycling of laminated films.

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Flexible packaging materials have become indispensable in food and household goods packaging, for example for sausages, cheese, snacks or detergents and soap products. For optimum product protection, multi-layer structures are composed of different polymers, thus significantly extending the shelf life of food packaged in this way. Good sealability, light protection and water vapor barrier of polyolefins are combined with the good oxygen barrier or stiffness of EVOH, PET or PA. In terms of weight, the polyolefin content usually dominates in composite packaging, but such composite film structures also contain other

intermediate layers as well as printing inks and aluminum – either as aluminum foil or as a vapor-deposited aluminum layer.

Physical Dissolution of Plastics from Composite Structures

From a recycling point of view, multilayer packaging is almost impossible to integrate into a circular economy due to the material heterogeneity, so that today's models for assessing recyclability only attest good recyclability to composite packaging in exceptional cases. Instead they advise the use of mono-material multilayer composites made of combi-

nations of PE and PP with small amounts of barrier layers. Whether these materials offer the same product protection as conventional packaging and whether real waste management is able to collect, sort and process these novel composites into high-quality recyclates with high yields is currently still subject of research and development activities.

For two decades the Fraunhofer Institute for Process Engineering and Packaging IVV has been working on innovative technical solutions for the recycling of complex plastic waste based on the physical dissolution of target plastics from compounds and composite

structures. Compared to mechanical recycling, this achieves a very high cleaning potential. This is where CreaSolv comes into play, a registered trademark of Creacycle GmbH. The process is based on old patents describing the dissolution of polyolefins and combines these approaches with innovative and technically highly efficient cleaning technologies. The process was already developed in the early 2000s for various packaging wastes. Since that time it has been continuously optimized technically and economically, scaled up and repeatedly validated with industry partners. Due to its high cleaning capability, the process is particularly suitable for flexible packaging, both for composite films from industrial waste and for post-consumer waste of flexible packaging materials.

Successful Field Test: Industrial Pilot Plant Running in Indonesia

As early as the beginning of the 2010s, Unilever became aware of the CreaSolv process and evaluated it, first in the laboratory and then on a small-technical scale. The preferred application of the process was primarily small-volume multilayer film bags, so-called sachets, which have a high market share in Southeast Asia and are not subjected to adequate waste management there. Instead, they end up, at best, in large landfills, but realistically, unfortunately, far too often in the environment and ultimately contribute to the plastic pollution of waters and oceans. In cooperation with Unilever and Lömi GmbH, the process developers at the IVV designed an industrial CreaSolv plant, which was built in Germany and, after a short test phase, shipped to the site in Indonesia. After commissioning in 2018 and a ramp-up phase in early 2019, the plant has since been producing LDPE recyclate. Post-consumer multilayer film

waste is used as input material, which is collected by waste pickers at Indonesian landfills and pre-cleaned. The recyclate is now successfully applied in new composite film packaging for detergents (Fig. 1).

The European MultiCycle Project

Based on this successful initial plant, the European H2020 project MultiCycle was initiated at the end of 2018. As part of the project, it was intended to prove that the CreaSolv technology can be applied to other target polymers in multilayer packaging and plastic composites (including PP, PA, PA-GF or PET). For this purpose, a flexibly adaptable demonstrator plant was set up at a Lömi site. The plant is designed for alternating demonstration operation for different waste and plastic fractions and reaches a capacity of up to 25 kg/h, depending on the operating mode (Fig. 2).

MultiCycle Plant for a Wide Variety of Plastic Fractions

At the above-mentioned Multicycle plant, post-consumer composite films as well as production waste from various composite films were processed into LDPE and PP recyclates. The table lists realistic product characteristics of the recyclates that are currently being sampled by Multicycle project partners and used for the production of non-food packaging demonstrators due to their virgin-like property profile.

After the end of the project, the demonstration plant will be available from the beginning of 2022 for further sampling trials with research and industry partners who want to test or evaluate solvent-based recycling on a pre-commercial scale. Recyclate quantities of 500 to 1000 kg can be produced at the plant under representative process conditions.

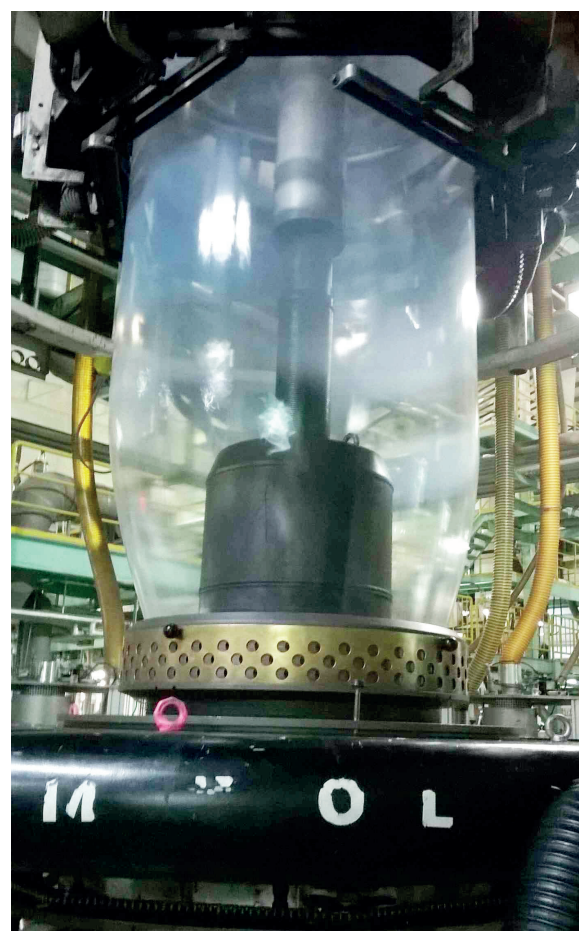


Fig. 1. Blow film production in Indonesia based on recycled LDPE. © Fraunhofer IVV

The plant is not only used for the preparation and conceptual testing of new commercial plant projects, but can also help to prove the recyclability of plastic packaging. In order to be able to meet the numerous enquiries from industry, a second comparable demonstration capacity is currently being set up at the Fraunhofer IVV in Freising, Germany.

Circular Packaging Funding Project

The industrial implementation of the CreaSolv technology is also being driven forward rapidly on a national basis. The data available from the aforementioned projects clearly prove the technical and economic attractiveness of the process on an industrial scale. This is shown by model calculations and business plans for large-scale industrial plants, which are based on the respective national framework conditions, site conditions and waste specifications. Against this background, the commercialization of CreaSolv is currently being investigated in »

Table 1. Typical properties of a LDPE PCR compared to LDPE and LLDPE virgin material
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	LDPE	rPE	LLDPE
Density	0.921 g/cm ³	0.925 g/cm ³	0.940 g/cm ³
Melt flow rate (MFR)	2.1 g/10 min	1.1 g/10 min	1.0 g/10 min
Melting point	109 °C	124 °C	120 – 125 °C
Tensile strength	21 MPa	27 MPa	44 MPa
Elongation at break	280 %	680 %	690 %
Secant modulus 2 %	177 MPa	274 MPa	270 MPa



Fig. 2. The demonstration plant of Lömi GmbH processes up to 25 kg of different waste fractions per hour. © Lömi

Info

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more detail and continued in the r+ impuls Circular Packaging project funded by the German BMBF. For a site in north-eastern Bavaria, the project partners Lömi, Fraunhofer IVV and Lober GmbH & Co. Abfallentsorgungs KG are currently working on a commercial plant concept for flexible post-consumer packaging. The envisaged technology scale-up is accompanied by technical optimization tests on the one hand and results in detailed engineering for a commercial recycling plant on the other.

Economical Plant Operation from 8000 t/a

For Germany and Central Europe, current calculations indicate economical plant operation from capacities of around 8000 t/a. Common waste fractions from the sorting plants of the German dual systems can be used as input, such as fractions 323 or 352.

Current product samples of LDPE and PP recyclates achieve a quality that allows their use in new packaging films with a high proportion of post-consumer recyclate (PCR). This depends on the film structure and area of application, but a PCR content of over 50 % is certainly achievable. The sample productions reveal that the maturity of the technology meets industrial requirements and that only a few technical

details remain to be solved for commercial and technical scale-up.

Available test data, calculations and market developments confirm the team of process developers, plant engineers and waste management experts in their assumption that the solvent-based CreaSolv process can make a substantial contribution to the circular economy of complex plastic waste in the future, especially in the area of flexible packaging. The volume of this waste is immense and amounts to around 1 million t per year in Germany alone, which is currently mainly recycled as secondary fuel and thus removed from a plastics cycle. If solvent-based processes achieve only a market share of 20 % despite their significantly higher cleaning performance compared to mechanical recycling, this results in a potential of 10 to 20 processing plants with capacities of 10,000 to 20,000 t/a each. The development team will implement the technology in commercial industrial plants in close cooperation with investors and potential plant operators. Fraunhofer is acting as the process provider, while Lömi, together with its sister company GAW Technologies GmbH, is acting as the plant construction partner. As the operator of the first commercial CreaSolv plant for packaging plastics in Germany, Lober GmbH & Co. Abfallentsorgungs KG in Neuburg vorm Wald, Germany, stands at the forefront. ■