SÜDPACK White Paper

Chemical Recycling

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SÜDPACK

Table of contents

The SÜDPACK Sustainability Strategy 3

Chemical Recycling – an Overview 5

The Process 5
What Materials Are Suitable for Chemical Recycling? 5
Further Advantages of Chemical Recycling 6

Relevance for SÜDPACK and the Packaging Industry 7

Important, Non-Recyclable Materials Cannot Be Readily Replaced at Present 7
Recyclates From Mechanical Recycling Are Not Suitable for All Applications 8

Circular Economy 9

The Legal Framework Conditions in Germany and the EU ..9
Status Quo 11

A Holistic Approach to Sustainability 12

LCA and Carbon Footprint 12

Ecological Categorization of Granulates From Chemical Recycling 12

Economic Categorization of Chemical Recycling 13

Vision – Recycling From SÜDPACK's Point of View 14

References 17

Contact Information 18

The SÜDPACK Sustainability Strategy

SÜDPACK is a leading manufacturer of high-performance films and packaging materials, which are predominantly used for the packaging of food as well as medical and technical products. Sustainability has been an integral part of our corporate philosophy from the very beginning – and the company group has always been very much aware of its ecological, economic and social responsibility and acts accordingly.

The current roadmap for sustainable film packaging (or packaging, or "sustainable packaging") essentially includes two main lines of action. The first line of action, the continued development of efficient and sustainable packaging solutions that ensure maximum product protection as well as additional features with minimum material input, has always been one of SÜDPACK's key objectives. The objective is to continue to reduce the carbon footprint of our packaging solutions.

At the same time, SÜDPACK is doing its utmost to implement closed loops for plastic packaging. This is because in the future as well, plastics will remain essential for a multitude of applications for different reasons. Compared to other materials, especially in the field of packaging, they continue to provide significant advantages – and do so in terms of functionality, product protection, weight and a low carbon footprint along the entire value chain. In this respect, packaging made from plastics is often the most sensible alternative both ecologically and economically and is superior to packaging made from other material classes. SÜDPACK considers it essential for plastic packaging to no longer be seen as waste after its use, but rather as a valuable resource that should undergo recycling of an appropriately high quality. This is why SÜDPACK is working to ensure the strict and systematic collection and treatment of plastic waste – the defined goal is to prevent the discharge of plastic waste into the environment. The development of packaging concepts that are recyclable and can therefore be converted back into valuable materials after use must be driven forward. Likewise, recycled post-consumer plastics can be used as components in packaging in order to close loops.

The establishment of chemical recycling as a recycling alternative to mechanical recycling is an expedient approach to expanding a circular economy for flexible packaging. The process offers advantages for mixed and contaminated plastics as well as for composite materials that cannot be mechanically recycled using current technology and can therefore not be returned to the closed loop as valuable materials. These materials can be chemically recycled to recover high-quality raw material that can then be used to manufacture high-performance films. Chemical recycling should therefore be viewed as a new, complementary process to traditional mechanical recycling as well as an innovative solution for a sustainable, circular economy.

SÜDPACK has already implemented the first promising concepts in collaboration with BASF and SABIC in recent months. In particular, there was extensive media coverage of the pioneering customer projects with Gutfried and Zott in which PA and PE from chemical recycling were used in high-performance films. The hygienic film composite packaging features the same high level of product protection and performance as new products but is manufactured in a way that uses significantly less resources (1).

The confidence that suppliers and customers placed in SÜDPACK as a partner in technology within the framework of these first projects is both an incentive and an obligation. We will therefore resolutely continue our work on the development of sustainable packaging solutions that meet both current and future demands in terms of sustainability, resource conservation and recyclability. Due to the special, stringent requirements for food packaging, the recognition of these materials would greatly benefit the food industry in particular and presumably make it possible to establish a circular economy in this sector in the first place: To meet the stipulated hygiene and barrier requirements (product protection, shelf life and thus prevention of food spoilage), multilayer film composition is absolutely necessary. As a result, these films cannot generally be mechanically recycled. This is where chemical recycling can offer a solution.

This SÜDPACK white paper provides comprehensive information about the subject of "chemical recycling." In the same manner as the position paper that SÜDPACK published for various stakeholders, this paper is a clear commitment to recognizing chemical recycling as a supplementary component for sustainable waste management and a circular economy.

Chemical Recycling – an Overview

The Process

Chemical recycling is understood to mean different processes that convert plastics into short-chain hydrocarbons, such as hydrocracking, depolymerization, solvolysis or gasification. In the current discussion, however, chemical recycling is mostly used synonymously with another process, namely pyrolysis. The use of pyrolysis for recycling plastic seems reasonable, as the process can have an easier time handling mixed plastic waste and – up to a point – contaminated waste (2).

Pyrolysis produces differently composed hydrocarbon mixtures that, after fractionation and processing, can be used as base materials for the chemical industry, and thus for the packaging industry as well. Pyrolysis itself is a well-tested process – in the absence of oxygen, the materials are decomposed in a high-temperature process and converted into pyrolysis oil and gaseous or also solid products. With gasification, in comparison, a synthesis gas is produced that can only be converted into hydrocarbons in subsequent process steps. Solvolysis, on the other hand, is a technology with which polymer chains are broken down into monomers.

The materials that are recovered using chemical recycling are then used, like fossil-based raw materials, at the beginning of the chemical production chain, which can save on conventional crude oil. In simple terms: The raw materials that are recovered in such a process can be used for the resource-efficient manufacturing of new, high-quality plastics for a variety of uses. This means chemical recycling makes it possible to also indirectly return these materials to the material loop.

What Materials Are Suitable for Chemical Recycling?

Chemical recycling in principle makes it possible to process different plastics into raw materials, including those that are partially contaminated, mixed or other plastics that could not previously be processed with mechanical recycling. The process is also the solution of choice for recycling highly complex multilayer films, which are commonly used in the food industry in particular for packaging a variety of products. Due to their composite structure, these films are highly functional and provide optimal protection for the packaged goods with minimal input volumes (and minimal resource consumption as a result). However, such laminated films are not suitable for mechanical recycling due to this very composition and can therefore only be recycled with chemical recycling. Chemical recycling thus presents itself as a complementary process to established recycling technologies and makes it possible to recycle waste streams, which until now would have primarily undergone thermal recycling, back into plastics.

Further Advantages of Chemical Recycling

The material that is recovered with chemical recycling becomes available in virgin-grade quality for producing high-performance films, which can also be used to package demanding products with high quality and hygiene standards – this is an essential aspect for SÜDPACK, as product protection is always of top priority not only in the interest of protecting the environment and conserving resources on a lasting basis, but also in the interest of mankind.

SÜDPACK is convinced that chemical recycling can make a significant contribution to increasing recycling rates and, particularly when used for food contact applications, to closing the loop between supply and waste management.

The recycled portion itself is allocated to chemical commercial products using what is known as a mass-balance approach according to a method verified by an independent auditor. This approach is necessary, as significant amounts of oil are converted from fossil sources in large chemical industrial facilities, such as crackers. In comparison, the quantities of pyrolysis oil still remain low. Due to the small amount of pyrolysis oil used compared to that of fossil-based naphtha in the start-up phase of chemical recycling, a mass balance approach must be used. This approach records the amounts of fossil oil and pyrolysis oil separately, and the recycled content from pyrolysis oil is then calculated and allocated to the end product. – This is analogous to the green electricity concept, in which it is generally accepted that the electricity a consumer is supplied with is not necessarily sustainable, but instead ensures that more green electricity is fed into the national electricity grid in general.

Abandoning fossil-based carbon sources or at least reducing their use can lead to an improved carbon footprint for packaging as a whole and therefore also to the reduction of greenhouse gases. This is also supported by the fact that plastic products made from chemically recycled material as well as other plastics can be chemically recycled again after use without any loss of quality. This is a core component on the path to the decarbonization of the packaging industry.

Relevance for SÜDPACK and the Packaging Industry

SÜDPACK is pushing for the recognition of chemical recycling in the German Packaging Act because the process is highly relevant for two key reasons:

- Important, non-recyclable materials cannot be readily replaced at present
- Recyclates from mechanical recycling cannot be readily used in food packaging

Important, Non-Recyclable Materials Cannot Be Readily Replaced at Present

As a manufacturer of high-performance films that are used for applications such as food packaging, SÜDPACK cannot forgo the use of important materials such as polyamide (PA) in its structures without having to make compromises, for example in product protection. The polymer PA, for example, is currently classified as not mechanically recyclable, yet it is indispensable for several packaging applications due to its specific properties. When polyamide is used, films provide features such as improved product protection with regard to puncture resistance – a common example concerns the production of puncture-resistant packaging for sharp products. Due to its mechanical properties, polyamide is also used for downgauging films. – This makes it possible to effectively reduce the volume of packaging. These films are therefore an important component, for example in the bags for mozzarella made by the company Zott or the thermoformed vacuum packaging for sausage made by Gutfried.

Structures that contain these materials cannot be mechanically recycled according to their present-day classification and can therefore not be returned to the loop after use. They also cannot be readily replaced with alternative concepts that are classified as mechanically recyclable. Although equivalent packaging concepts (such as films based on PP) represent an alternative, they also entail an increased use of resources and are therefore not comparable in terms of the film thickness, weight, complexity and cost of the packaging as a whole. Moreover, this does not comply with the objective of the European waste management hierarchy, which defines reducing waste volume as the overriding principle.

Chemical recycling, in contrast, makes it possible to produce valuable raw materials from these composite materials, which in turn can be used for the production of high-performance materials. At the same time, it provides an opportunity for closing loops for laminated films that contain materials such as the polymer PA.

Recyclates From Mechanical Recycling Are Not Suitable for All Applications

Due to the strict hygiene standards in the food packaging and medical product industries, the allowed use of recyclates from mechanical recycling in films and other packaging for various products is already very limited. This is because in contrast to chemical recycling, mechanical recycling does not alter the polymeric structure of plastics. The material therefore remains largely intact. The type of feedstock materials and their quality are therefore crucial in determining the quality of this material. Accordingly, the success of mechanical recycling is based above all on the quality of the plastic and on optimal sorting of the individual types of plastic by consumers or also downstream in the sorting facilities of recycling companies.

Also due to the special requirements with regard to product protection and barrier properties, the production of plastic packaging from purely recycled plastic for sensitive goods such as food and medical products is not currently conceivable. At best, PET flakes from EFSA-certified companies are permitted for use in packaging films[1].

Another aspect is the fact that the quality of recyclate products from mechanical recycling is often not sufficient for meeting the requirements of the relevant processing operations for plastics. For example,

[1] In Germany, these PET flakes generally come from the material loop for PET beverage bottles. If recyclate from this loop is used for packaging, no guarantee could be given that the PET from the packaging would be recycled again within the framework of the dual systems. In the interests of a circular economy, this PET recyclate should continue to be used exclusively for PET beverage bottles.

processing problems often arise in the production of films, ranging from inferior product quality to interruption of the process itself.

As a result, plastics that are recovered with mechanical recycling are still most often incorporated into lower quality products. What occurs is “downcycling” instead of “recycling” in the sense of a circular economy. The use of chemical recycling would overcome this obstacle. – Moreover, chemical recycling offers the potential of upcycling, which means turning applications of lesser quality into high-performance plastics.

Circular Economy

In Germany alone, the weight of annual household and industrial plastic waste amounts to a total of 6.3 million tons (3). When compared internationally, Germany performs well – roughly 47 percent of all plastic waste and about 39 percent of post-consumer waste is at least currently recycled (3). 75 percent of plastic packaging is designed by definition to be recyclable (4).

With the tightening of both national and international laws and regulations, the aim is to now systematically counteract the “plastic flood.” Another approach involves the establishment of functioning material loops for plastic packaging. To make sure the progress made in implementing the established objectives can be traced, both the EU and national legislative authorities have defined different volume- and percent-based objectives for the implementation of a circular economy in the packaging industry.

The Legal Framework Conditions in Germany and the EU

The Strategy for Plastics was published by the European Commission in early 2018 and aims, among other things, to

- significantly reduce the use of plastics in the packaging industry,
- improve the recyclability of plastic packaging,

- increase the share of recyclates used in the production of product packaging and
- implement a functioning circular economy for plastic packaging.

These targets have essentially been substantiated and fleshed out in the German Packaging Act and in the EU Packaging Directive 1994/62/EC. Accordingly, an average of roughly 60 percent of the plastic waste that is collected from private households in Germany with yellow sacks or yellow bins must be mechanically recycled. As of January 2022, the rate will increase to 63 percent. For multilayer film composites and composites with plastic content, which are typically used for packaging in the food, pharmaceutical and medical device industries due to their specific properties, the act specifies a recycling rate of 55 percent and, as of 1 January 2022, a rate of 70 percent based on the participation volume.

The EU Green Deal, which was presented in 2019, updates the action plan for the circular economy package from 2015. Within the framework of a voluntary commitment, the aim by 2025 is to use ten million tons of plastic recyclates to produce new products primarily in resource-intensive sectors, such as the textile, construction, electronic and plastic sectors. By 2030, the strategy paper specifies that the plastic packaging placed on the EU market should be reusable or recyclable at a low-cost. In parallel, the aim is to no longer use non-recyclable materials and to gradually replace materials that complicate recycling. The overall aim by 2030 is to increase the current recycling rate across Europe from 39 percent to more than 50 percent and to quadruple the sorting and recycling capacities as compared to 2015.

However, the ambitious rates in the field of recycling cannot be achieved with conventional processes such as mechanical recycling alone – especially because, as has already been pointed out, it is also not currently feasible for a wide range of materials. Simply abandoning materials that are not currently mechanically recyclable is not a sustainable solution on account of the quality, hygiene and technical requirements that were previously mentioned. This means that in addition to mechanical recycling, additional innovative technologies and processes must be established as supplementary measures. This includes chemical recycling. With a combination of different recycling processes, many more types of plastic could be recycled in the future than has been the case, which would also make it possible to fulfill the ambitious legal requirements.

Status Quo

At the European level and in most countries in general, chemical recycling is categorized as material recycling as long as the objective is not to produce fuels, but rather new products such as plastics. This means chemical recycling is generally recognized as a recycling process. It is only in the German Packaging Act (VerpackG) that an exception is made, as it calls for a rate of plastic packaging from household waste to be mechanically recycled. According to current interpretation, chemical recycling does not count towards this rate. Without a doubt, chemical recycling is preferred over thermal recycling or energy recovery.

However, both mechanical recycling and energy recovery (for plastics that could not previously be mechanically recycled) are considered processes that are firmly established and therefore set the standards based on current technology. As a result, new technologies and processes such as chemical recycling must always compete with these standards and confirm their ecological raison d'être in the market with supporting evidence. In this light, their feasibility on an industrial scale and their economic viability in particular are factors that must be urgently resolved. Moreover, the extent to which chemical recycling and the mass-balance approach can contribute to achieving mandatory recycling rates must be defined.

At the European level, chemical recycling is now considered a recognized process. For example, in draft legislation for the British plastic packaging tax, Great Britain is planning exceptions for materials that have been chemically recycled (5). Germany, in contrast, is still lagging behind in this development. Even though chemical recycling is categorized as material recycling in Germany, it does not count towards the mechanical recycling rates.

The common goal of everyone involved in the process on both a national and international level should therefore be to create the necessary technological and regulatory conditions for the recognition of chemical recycling as an equivalent technical alternative to mechanical recycling. In addition to considering holistic life cycle assessments and eco-balances as well as economic feasibility, one of the most relevant aspects is for it to count towards achieving current and future (mechanical) recycling rates in waste legislation.

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A Holistic Approach to Sustainability

Recycling must always be in accordance with the best possible protection of mankind and the environment. For assessing the sustainability and the ecological footprint of materials and packaging concepts, SÜDPACK finds a holistic approach expedient that also includes life cycle assessment (LCA) methodology. Here it should be taken into account that packaging prevents food spoilage worldwide and ensures the necessary level of hygienic protection, particularly for sensitive products. The recyclability of packaging is also intrinsically linked with the existing recycling systems and consumer behavior. It can be assumed that recycling systems in particular will change over time in accordance with the volume flows of the individual materials. A further point to note is that different recycling systems exist within Europe which have different characteristics with regard to volume flows.

LCA and Carbon Footprint

In current discussions regarding sustainability, resource efficiency and reducing the use of plastic, an aspect that is often ignored is that the life cycles of packaging and the packaged goods are closely intertwined. The percentage that packaging makes up of the total carbon footprint for packaged food or other products, however, is comparatively small (6; 7). Its percentage of the cumulative energy demand generally amounts to a mere five to ten percent, whereas 90 percent is generated in the production, transportation, storage and processing of the food itself.

Study results on chemical recycling that are based on a holistic approach are already available and will be briefly outlined here.

Ecological Categorization of Granules from Chemical Recycling

The extractive industry has already presented in-depth life cycle assessments for the ecological categorization of granules from chemical recycling (8; 9; 10). They examine the ecological footprint of these materials in detail and look at their impact from a holistic perspective. From SÜDPACK’s point of view as well, it is of particular importance to assess the value of products over their entire life cycle rather than based solely on their recoverable nature at the end of service life. Taking the food industry as an example, it becomes clear that plastic packaging protects products, makes it possible to process some products in the first place and significantly extends the shelf life in some cases, and can therefore also prevent food spoilage. In the delicate balance between the performance of a packaging material or the packaging made from it and the consideration of sustainability as a whole with a functioning circular economy in mind, it is essential to find solutions that can be viewed positively in their entirety. A relevant component in this context is chemical recycling (11).

A brief overview of the main findings from studies that have been conducted so far follows:

In general, composite materials that cannot be recovered with mechanical recycling are recovered with thermal recycling or energy recovery. This already inherently involves high CO_2 emissions. If plastics are chemically recycled, much lower CO_2 emissions are generated compared to thermal recycling or energy recovery. Expressed in concrete numbers, the pyrolysis of mixed plastic waste emits approximately 50 percent less CO_2 than the thermal recycling of mixed plastic waste (8).

The production of recyclates by means of chemical recycling (pyrolysis) leads to CO_2 emissions that are similar to those from the production of recyclates made by means of mechanical recycling from mixed plastic waste. An aspect that was taken into account in this comparison is that plastics from chemical recycling are generally available in virgin-grade quality, whereas recyclates from mechanical recycling are of lower quality. To illustrate this correlation in the LCA, the “Circular Footprint Formula” (12) was applied, which offers an approach for quantifying the quality of a recyclate in the results of the LCA, thus making it possible to compare materials of different grades (8).

And, as pointed out above, the more often chemical recycling is performed, the more it helps keep carbon in the product loop, which in turn contributes to the decarbonization of the packaging loop. This reduces CO_2 emissions and improves the carbon footprint of a product as a whole.

Economic Categorization of Chemical Recycling

The pilot phase for chemical recycling in the packaging industry has now been successfully concluded. However, because production is currently only conducted on a small scale, chemical recycling is still expensive due to insufficient economies of scale. Moreover, the requirements for chemical recycling are complex, particularly for the process of pyrolysis – even though it is a process that has already been extensively tried and tested in other sectors of industry. What this means for the packaging industry is that the more diverse and heterogeneous the plastic waste is, the more complex the entire process becomes. The composition and condition of the input materials as well as their sorting therefore have a direct impact on the efficiency, process management and, ultimately, the quality of the raw materials that can be recovered from these materials. Nevertheless, chemical recycling offers significant advantages for composite materials that would otherwise be inseparable. In such cases, it makes recycling possible in the first place and the recycling routes of incineration and landfilling can be avoided.

From SÜDPACK's point of view, chemical recycling will only receive widespread acceptance when it can be raised to the same level as mechanical recycling. Only then will it be possible to reach the relevant critical volumes in the market – and to ensure its economic feasibility.

Vision – Recycling From SÜDPACK's Point of View

As a basic principle, plastic recycling should be of the highest possible quality. The goal is to replace fossil-based raw materials at the beginning of the value chain with materials that have been recovered from the waste stream and to either use them as recyclates for suitable applications or convert them into valuable raw materials. That being said, it is only possible to recycle materials that are indeed recyclable and for which the relevant technology is available. Compared to the recycling loops that are already well established and accepted for paper, light metals and glass, however, the variety of materials that are collectively referred to as plastic require different technologies and processes.

There is no doubt today that chemical recycling can contribute to achieving recycling rates just like mechanical recycling. There is also no doubt that an entire package of different measures will be more effective on the path to greater sustainability. Recent trends in the market also demonstrate how different initiatives, innovations and developments can contribute to tackling the current challenges. This includes

- the development of packaging materials and packaging concepts that conserve resources and are also recyclable
- the reduction of the use of material in the production of packaging
- the successful implementation of initial pioneering pilot projects in the field of chemical recycling and, last but not least,
- further technological development of mechanical recycling and an increased use of recyclates from mechanical recycling. Due to hygiene standards, however, these recyclates are not allowed to come in direct contact with food and can therefore – if at all – only be incorporated into laminated films and other packaging for food to a limited extent. In this case, the industry is called upon to develop viable concepts for the use of post-consumer material in food packaging. This could increase the amount of recyclate in the packaging industry as a whole. It also supports the objective of establishing a circular economy for flexible packaging.

If chemical recycling becomes established as a complementary process to mechanical recycling, this will expand recycling to include additional waste fractions that until now could not be appropriately recycled with mechanical technology. Chemical recycling should therefore be seen as a major opportunity to broaden the fields of application and recycle much higher quantities of plastic in the future without downcycling. This is because we will be recovering the raw materials with which plastic is made – and not recyclates, which cannot live up to the high standards of the food packaging industry. The material is of virgin-grade quality and can therefore also be used for products such as food packaging. This needs to be promoted, provided that it is reasonable in terms of eco-balance as well as competitive and suitable for the market.

For chemical recycling be able to contribute to a circular economy in addition to mechanical recycling, however, it is necessary to interpret waste legislation with an open attitude towards technology. It is not necessary to modify legislative texts, because the waste act does not stipulate that material recycling must be technically performed exclusively with mechanical processes that are immediate or direct. Intermediate or indirect processes with a stage of chemical conversion, such as pyrolysis, can also create new plastics and therefore be categorized as material recycling in waste legislation.

With regard to the German Packaging Act, SÜDPACK is of the view that a legal categorization of chemical recycling as a complementary process to mechanical recycling is required as well as a supplementary regulation to the regulation for mechanical recycling.

Another important aspect when assessing the processes to be recognized is, as has already been pointed out, to do so from a holistic point of view that focuses on which process is most sustainable for the different materials. This should be performed based on eco-balances, life cycle assessments and an assessment of the technological development and economic competitiveness of each process.

As part of an entire value chain and as a leader in innovation and technology, SÜDPACK feels particularly committed to developing new concepts, technologies and concrete solutions to protect the environment. This includes chemical recycling – which is why it is being promoted with the utmost vigor.

“It is precisely this kind of innovation that we will need in the future if we want to make plastic an even more sustainable raw material. We are a technological leader in the coextrusion of high-performance films. But above all else, we are a sustainable company. And that is why for every one of our packaging solutions, we must also have a recycling solution. Chemical recycling does indeed have the potential to alleviate the issues surrounding plastic packaging – provided that our recycling loops are truly closed,” emphasized Carolin Grimbacher, who is Managing Partner of SÜDPACK and also responsible for Research & Development.

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