RECYCLING

RECYCLING NEWSLETTER

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In This Issue:

Editor's Corner

Wow. Since our last issue, it is not a stretch to say that the world has completely changed. When we published our Q1 magazine on February 27, COVID-19 was not yet a global pandemic. ANTEC 2020 in San Antonio was just around the corner. N-95 face masks were easily available in hardware stores. As we have seen in the days and weeks since, a curious evolution is taking place in real-time: the role of plastics in the modern world. More specifically, the ***understanding*** of the role of plastics in the modern world is evolving.

Personal protective equipment (PPE) has never been so critical to the health and well-being of the public. Since the majority of it is made from polymeric materials, the plastics industry has been at the forefront of the response to the pandemic. Even the much-maligned and humble plastic grocery bag has been given a stay of execution. With all this as backdrop, it would be tempting to focus solely on COVID-related matters. The pace of science, research, and development is slow and steady with incremental improvements. Of course, breakthroughs can and do occur that radically shift the environment.

As the organizers of ANTEC successfully transitioned to a virtual edition, plastics professionals the world over were able to log in and enjoy the vast majority of papers that were originally scheduled for San Antonio. The recycling track offered several new and interesting papers, and we will publish them here over the course of the next year.

Polystyrene has come under pressure in recent times yet there are significant efforts (and successes) to recycle PS in several forms. A US-German team from INEOS presented an overview of chemical recycling techniques, including depolymerization and solvolysis, a process in which "polymer waste is dissolved in special selective solvents, then filtered to remove contaminants."

Moving from the lab to the public square, the SPE Recycling Division will be serializing portions of a new book, "The Plastics Paradox" by Dr. Chris DeArmitt. Written primarily to counter misinformation about plastics and the environment, this book targets a lay audience and uses current news items to focus the reader's attention. Given the ongoing scrutiny of plastics in the environment, including the recent PBS "Plastic Wars" series, recycling is being held up for closer examination. Facts can be annoying things, but narratives also wield enormous power in the public imagination. As our members know, it is incumbent on each of us to engage with our families, friends, and colleagues in a rational manner to explain the realities and the benefits of plastics while not shying away from thorny challenges that we still must tackle.

We are always looking for new and original content, including hi-resolution photos for our digital publication. Thanks to our sponsors such as Midland Compounding & Consulting, we are able to deliver 4 more quarters of recycling-specific information to our members. If you or your company would like to contribute to our continuing success – and reach 1500 readers – take a look at our sponsorship opportunities on p. 12.

Stay healthy, stay safe, and keep involved in the plastics discussion.

(Cover image: Adobe Stock Images: SPE licensed)

Recycling in the News

COVID-19 Shifts Supply and Demand for KW Plastics

By Colin Staub & Jared Paben, *Plastics Recycling* Update April 29, 2020

The coronavirus has disrupted end markets for KW Plastics, moving demand away from industrial applications and toward packaging for essential products.

Troy, Ala.-based KW Plastics, which describes itself as the world's largest plastics recycling company, has 350 employees directly tied to plastics recycling. KW has not laid off any of those workers during the coronavirus pandemic, said Stephanie Baker, director of market development for KW Plastics.

Baker spoke on a recent webinar hosted by the Southeast Recycling Development Council (SERDC) and provided more details in an interview with Plastics Recycling Update.

"We're doing everything we can to keep business as usual so that we can keep PCR flowing to our customers that need it," Baker said.

But the company has seen fast changes in the numerous end markets it supplies.

The automotive sector has essentially shut down, and "we have seen that business come to all but an abrupt stop," Baker said. Automotive manufacturers have floated plans to restart their plants in early May, but for the time being, that end market is closed.

At the same time, however, KW has seen demand increase for its natural HDPE recycled pellets. This resin goes into packaging for personal care products, household cleaning agents, detergents, soaps and more.

"We can't keep that stuff on the shelves," Baker said. KW anticipates shipping 9.5 million pounds of natural HDPE this month.

"That is a significant amount for us in that particular resin, but, overall, that is significantly lower than what we would ship throughout our whole product line," Baker said.

KW has converted several of its extrusion lines over to natural HDPE to meet the demand, Baker said.

Meanwhile, the coronavirus has had impacts upstream, shifting the supply of recyclables that make up KW's raw materials.

Some California MRFs that supply KW shut down recently, but the company continues to purchase bales from its other regular suppliers, Baker said. Still, the company is starting to see a slowdown in bales being produced, she added, not because of collection disruptions, but because MRFs are making internal adjustments to keep employees safe and prevent the spread of the virus, slowing down sorting and baling.

KW was fortunate to have a considerable amount of inventory as the pandemic began to take hold, and the company continues to buy as much material as it can, Baker said.

In a separate shift, KW has noted less activity as far as brand owners experimenting with recycled resin in new applications.

Baker said there has been a large uptick in brand owners making sustainability commitments in the past nine to 16 months, and those pledges have translated to more demand for using recycled plastic in innovative ways within product packaging.

But the coronavirus has shelved that work as companies prioritize responding to the current market.

"All of that has come to a stop right now as we are seeing our suppliers really scale back to producing the items, the products, that are essential right now," Baker said. "They don't have any room to introduce new products or new packaging right now." |

CIRCULAR ECONOMY – New Styrenic Polymer Recycling Concepts

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Editor's Note: *This paper was first presented at v-ANTEC 2020.*

Abstract

Circular economy is a term describing a sustainable way to interact with all major stakeholders of the economic sphere. One basic idea is to minimize waste creation and to use post consumer waste as raw material for new products. This concept stands in contrast to the "linear economy", based on products that end in landfill. Circular economy will play a particularly important role for all materials and goods having a short and mid-term lifetime and will have an implication on how these products are designed and recycled.

Plastics food packaging are examples for goods, providing safety, protection and extended shelf-life and hence allow us to lead our modern life style. They typically have a short-term lifetime and are disposed after use. Within the challenge of "Circular Economy" however, producers of packaging, as well as upstream raw material producers are requested to provide new concepts for re-use in a true circular way, hence re-cycling rather than downcycling or waste dumping in landfills.

Plastics producers, and especially producers of Styrene-based plastics are taking up the challenge and started to "connect the dots" between municipalities, new recycling technology providers, raw material producers and customers. By promoting "chemical recycling" they are pursuing new ways to create high quality, even food grade plastics based on post consumer waste as new raw material.

Introduction

The change from linear to circular economy will be a disruptive change affecting the way we live and the way we organize our good´s value chain. It is a sustainability trend based on the paradigm of avoiding waste by re-cycling goods back into the value chain after use. Although experts are not able to forecast in which way and when circular economy will take off, most of them agree that in the one or another way, circular economy will rather sooner than later affect our daily lives.

We can observe this trend already today: producers of packaging materials are trying to find new ways to recycle them back into their original applications. Examples are PET bottles [1] or "booster resins" [2] for mechanical recycling. Recycling is particularly recommended for all applications that are easy to identify and collect, and that are based on a clearly defined product. Wherever plastics are used for packaging, however we face the challenge of having a multitude of applications (e.g. beakers, foils and films, molded parts) that are based on a multitude of resins. In addition to that, there is also a trend to multilayer packaging, where the combination of layers from different polymers provide enhanced properties and can e.g. prolong the shelf life of food significantly.

Although new sorting technologies enable commercial recycling companies to separate specific polymers out of mixed plastics waste with a high degree of efficiency, still a high variety of different grades is used, with many different additives and fillers, and with dirt and moisture attached. As far as multilayer packaging is concerned, sorting techniques come to their limit as well. Hence the challenge is to develop recycling technologies that address and exploit the specific properties of materials in use. In the following we are focusing on polystyrene as one of the most frequently used plastics in packaging, after polyolefins and PET.

Recycling Technologies for Polystyrene

In order to avoid or reduce landfill, three basic technologies are available to recycle plastics: thermal, mechanical and chemical recycling. Furthermore, there is solvolysis, a special process positioned between mechanical and chemical recycling. While thermal recycling typically uses plastic waste as energy source in municipal waste incineration or as substitute for mineral oil in processes like cement production in kilns, mechanical recycling maintains the integrity of the original polymer chain by melt blending clean waste sources to form a "recycling grade". Chemical recycling goes one step further and cleaves polymer into monomer, being ready to be used – after purification – for the production of so called "virgin" polymers. Solvolysis is the selective solution of polymers from a mixture and consecutive precipitation, so that a separation of polymers takes place which then can be used again.

Thermal recycling, for example in cement kilns, is an attractive way of disposing plastics or even partly hazardous materials, because of [3]:

- The temperatures in the kiln, which are much higher than in other combustion systems (e.g. incinerators), so that hazardous contaminants like flame retardants are destroyed,
- the alkaline conditions in the kiln, afforded by the high-calcium raw mix, which can absorb acidic combustion products,
- the ability of the clinker to absorb heavy metals into its structure and thus incorporate any heavy metal contaminants coming e.g. from the pigmentation or other additives in the plastic.

Nevertheless, this procedure is not fully acknowledged as one that fulfills the requirements of Circular Economy, as it does not fully close the loop, but only utilizes the energy content of the plastic feedstock.

Mechanical recycling is a very effective way to re-use plastics. In many cases however, compromises regarding purity and regulatory status have to be made, and in many cases, the recycling becomes rather a "down-cycling", because contaminants and a mixed input create a product with lower properties compared to virgin polymers.

Chemical recycling is the only method to really close the loop without sacrificing product properties and product quality. Chemical recycling of polystyrene is of particular interest, because polystyrene decomposes back into *styrene monomers under oxygen-free conditions at temperatures higher than 400 °C. First technical and scientific investigations range back to the 70s and 80s of last century [4-5]. The basic principle is depicted in figure 1.*

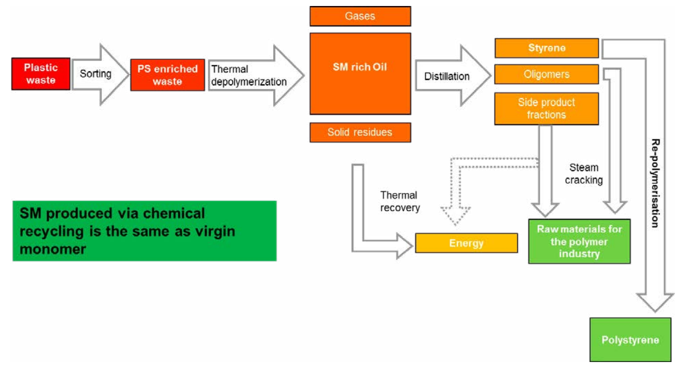


Figure 1: Schematic description of PS Depolymerization

The process to de-polymerize Polystyrene requires temperatures of typically 400-600 °C and a technical aggregate allowing to efficiently transfer external heat into the polymer melt. Such processes have been developed in the past, e.g. by Japan Steel Works [6] or by BASF [7]. The challenge is the low conductivity of polymers, therefore thorough mixing is required to ensure an efficient process. The use of an extruder is one way to quickly heat the polymer melt, as shown in figure 2.

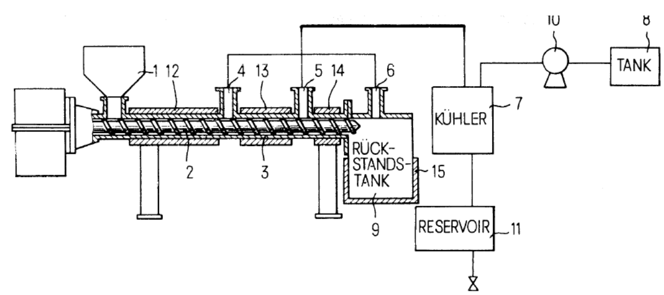


Figure 2: JSW patent from 1973 claims use of extrusion technology for PS de-polymerization

A further option to de-polymerize polystyrene is the use of microwave radiation [8]. As polystyrene is "transparent" to microwave irradiation, typically a microwave absorbing material such as carbon black needs to be added.

Typical de-polymerization products – besides styrene monomer – are: 2,4-diphenyl-1-butene, 2,4,6-triphenyl-1hexen and higher oligomers, benzene, toluene and other aromatics. A representative spectrum of pyrolysis products is listed in table 1 [9]. Besides the challenge of fast heat transfer, it is important to isolate styrene rapidly in order to suppress the [4+2] Diels-Alder reaction to dimers and higher homologues. A standard yield often found in literature is 65 %. The remaining organic material however can be used for example in provisioning the process heat for de-polymerization.

Recently, a few companies with focus on depolymerization became active in approaching producers of polystyrene and other plastics to offer their services in building-up the circular economy value chain [10-11]. Due to the unique value proposition of polystyrene mentioned above – having a moderate decomposition (ceiling) temperature allowing significant cleavage into monomers – PS producers announced collaborations with these depolymerization technology firms [12-14].

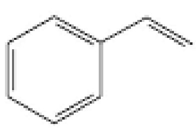
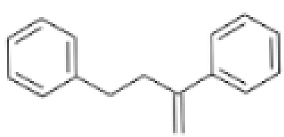
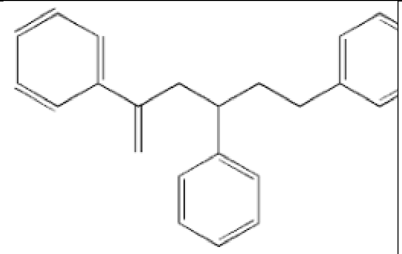
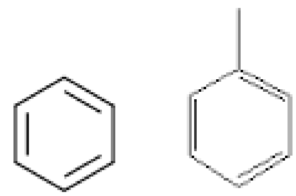
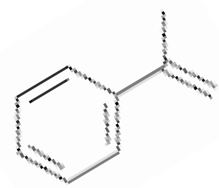
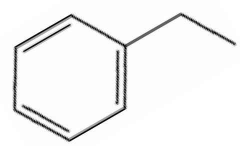
Component	Structural formula	Content
Styrene (Monomer)		63,9 %
2,4-Diphenyl-1-butene (Dimer)		14,0 %
2,4,6-Triphenyl-1-hexene (Trimer)		2,2%
Benzene and Toluene		2,0%
α-Methylstyrene		2,1%
Ethylbenzene		0,5%
Other aromatic compounds		15,3 %

Table 1: Typical PS depolymerization products [9]

Pyrowave uses catalytic microwave de-polymerization with its unique patented microwave technology that unzips plastics back into their initial constituents. The concept is based on placing small, modular units directly onsite at recycling facilities, producers of plastic waste, or users of styrene monomer such as resin producers. Pyrowave has one machine currently in operation producing recycled styrene monomer (RSM) from polystyrene waste.

Agilyx has previously commercialized a technology that converts mixed plastics to high quality vacuum gas oil (VGO) crude. More recently, Agilyx has pivoted to expand their technology to include de-polymerization of PS and retrofitting an existing pilot plant for this purpose. The concept is to scale up and build a large scale plant that uses a proprietary technology based on a non-catalytic process in a continuously fed dual-screw reactor to pyrolyze waste plastic into styrene monomer. Such plants would initially be placed near large metropolitan areas.

Solvolysis

Another approach, closely related to the chemical recycling is the solvolysis. Polymer waste is dissolved in special selective solvent, filtered to remove contaminants and precipitated again. Some companies involved are: Polystyvert, Fraunhofer/CreaSolv and CreaCycle [15-17]. This technology is able to selectively dissolve polymers. The reported yields are higher than in de-polymerization, but one remaining challenge is the purification of the polymers for the use in food contact or medical/ diagnostics.

A SWOT analysis for both technologies – depolymerization and solvolysis – is given below (tables 2 and 3).

Strengths/Opportunities
• Suitable for all PS grades
• Real closing of the loop
• No difference to virgin monomers; use in food contact or medical applications possible
Weaknesses/Challenges
• Logistics needs to be well aligned (from recycler/sorter over de-polymerizing plant to polymer plant)
• Probably requires minimum quality of post consumer waste with defined max. amount of impurities and non-PS polymers

Table 2: "SWOT" analysis de-polymerization

Strengths/Opportunities
• Suitable for multi-component waste
• Polymer chain is retained, no complete conversion to monomers
• Suitable for EPS and XPS foam
Weaknesses/Challenges
• Logistics needs to be well aligned (from recycler/sorter over solvolysis plant to polymer regranulation plant)
• Contaminants are only reduced, but in most cases not completely removed, therefore limited suitability in food contact and medical applications

Table 3: "SWOT" analysis solvolysis

Discussion and Next Steps

We currently witness the first step towards introducing circular economy concepts into the styrenics industry. The excellent reputation of styrenic polymers, especially polystyrene, as a material that is easily processed and efficient for high quality food packaging, requires the introduction of new and truly "circular" recycling methods. Both solvolysis and de-polymerization technologies appear to be well suited for the recycling of polystyrene. On the one hand, polystyrene´s unique value proposition of having a modest decomposition temperature, allowing recuperation of monomer at a comparably high yield, enables efficient de-polymerisation. On the other hand, polystyrene´s solubility in selected organic solvents allows for an efficient solvolysis process. Major polystyrene producers are currently driving the concepts within their industry associations in all regions, with a focus on Americas and Europe [18].

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The Plastics Paradox - Preface

By Chris DeArmitt, PhD, FRSC, CChem

Editor's note: With the author's permission, the SPE Recycling Division will serialize portions of Dr. DeArmitt's book over the next 4-6 issues of our quarterly newsletter.

I once sat next to a young person on a plane. She took a nap and I glanced at a sticker on her laptop that read: "Rise above plastics". I had to smile at the naïvety. Why? Well, the sticker was made of plastic, and so was the adhesive that held it on her laptop, which was also made of plastic. Her backpack was made of nylon plastic, and so were her shoes. She had a PET plastic water bottle in her hand and was cozied up in a polyester (plastic) blanket. In fact, the only thing I could see that wasn't synthetic plastic was her cotton jacket. Later, she woke up and started editing video clips made on her ABS plastic Go-Pro camera—in the video, she was swimming in the ocean in a rubber suit with plastic flippers on. She had no idea that her life would not be possible without the very plastics she claimed to object to.

That incident made me think—there must be many people who are against plastic but who don't fully understand what it would mean to live without it. I have spent my whole career as a plastic materials scientist, so to me it's obvious, but how are the public supposed to know? In fact, how can the public be sure of anything these days when extreme headlines go viral and misinformation spreads at the speed of light? You would think that eventually the truth would come out and public opinion would correct itself, but scientists have studied that, and it turns out that the sensational lies spread faster and farther than the truth. So, when the truth does finally come out, it never catches up with the lie. Why is that? Well, the truth is often not as exciting as the lie was.

Over the last decade or so, there has been a vocal campaign against plastics and the plastics industry has done almost nothing to counter it. Perhaps they assumed it would go away. However, it didn't go away, so now we are ten years on and the public has made up their minds that plastics are bad. Politicians make policies in response to that public opinion, and companies make policies and even create new product lines to address the public's demands. Progress is being made in the war on plastics, and that must be a good thing, right?

I didn't think too much about it until recently when my two daughters came home from school and told me what they had learned that day. To my horror, they had been taught clear, undeniable lies about plastic. I should not have been so surprised—after all, teachers are just members of the public, and they pick up their information from the same online sources we are all exposed to. However, it's a serious problem when we start teaching our children lies. They will grow up and vote for policies based on those lies, and that is likely to have unforeseen—and unfortunate—consequences.

So, what was the lie that triggered me? My kids were told that plastics take a thousand years to degrade. As someone who has spent my whole career as a plastic materials scientist, I know that's a whopping lie. I had a degree, a master's, a PhD and 30 years of experience telling me this was just plain wrong. The fact that plastics degrade is as certain as the sun rising or an apple falling. It's not open for debate. There are thousands of scientific articles on it, and a whole journal called Polymer Degradation and Stability devoted to the topic.

Just how stable are the typical plastics we use today? I had just finished a project as an expert witness for a large class-action lawsuit, which led to appearances on CBS's 60 Minutes, Sky News, and the BBC. It was all about the stability of polypropylene mesh used in the body to repair hernias and other abdominal ailments. I had just read hundreds of peer-reviewed articles on the stability of polypropylene and other plastics, so I had the information at my fingertips. Would you like to guess how long polypropylene lasts at room temperature? Please take a guess…

The answer is that polypropylene (PP) is extremely unstable. They found that out almost as soon as they made PP for the first time. If left at room temperature, it will oxidize and degrade, losing its strength in less than one year.

Does that shock you? That's what the peer-reviewed scientific articles tell us. It's a fact proven in the laboratory. That's a big deal, because polypropylene is the second-most common plastic produced today. You use it every day in household items like shampoo bottle caps (especially the ones with the hinge), pot scrubbers, and string. It's the main plastic used in cars due to its great properties and low weight. It's not just PP, either. Other common plastics degrade rather rapidly too. My kids had been told a blatant lie.

How can it be that this accepted "fact" that plastics take hundreds or thousands of years to degrade has penetrated our minds, our schools, and our policies? It turns out that a lie begins to sounds like the truth if it is repeated enough. Of course, it's still a lie, but everyone will believe it. This is exactly what the plastics industry has allowed to happen. It made me wonder about the other "facts" we all believe about plastic. If this one was a lie, what about the others? The first thing I did was to check whether plastic bags really are bad for the environment. Can you guess what I found? I found several studies from all around the world and every single one of them showed that plastic bags are far greener than either paper or cotton. Shocking, isn't it?

Now, I was even more suspicious. I started downloading articles on plastic waste, litter, microplastics, and other related topics. I spent a year reading several hundred articles so that I could present them to the teachers at my kid's school. Members of the public often make up their mind and then only read articles that confirm what they already believe, but that's not how a professional scientist works. I had to read every article I could find and only then make up my mind, based on the evidence. It was a preposterous amount of work, but that was the only way to get to the bottom of the matter.

You are about to see the evidence from scientists all around the world, as published in peer-reviewed journals. I will cite their work and quote from the studies word-for-word to avoid any "spin". In this book, you will discover that everything you have been told about plastics and the environment is a lie, and you will be left with a choice. Hopefully, you will take the real facts and start fighting for a brighter future. Or, you can continue believing the lies you have been told online, which means you will be fighting for changes that seriously harm, rather than help, our environment. It's that simple.

As I mentioned, this book is based on over 400 scientific articles and reports. It would be cumbersome to list every single one here, so I have provided a comprehensive list at plasticsparadox.com. That way the list can grow as new articles are published.

We are told that plastics are our saviour and our nemesis. That is the "Plastics Paradox". How can they be our friend and our enemy at the same time? How do we know whether to promote or persecute plastics? To discover the answer, we need to present the evidence to you, the jury, the public. Only then can we make an informed decision."

Reduced off-odor of plastic recyclates via separate collection of packaging waste

March 31, 2020 - **Plastic recyclates produced from waste packaging have to meet high sensory requirements in order to be used for new products. Plastic recyclates often have off-odors, some of which have not hitherto been identified. The Fraunhofer Institute for Process Engineering and Packaging IVV has analyzed the sensory properties of post-consumer shopping bags made of low density polyethylene (LDPE) and originating from different collection systems. More than 60 odorous substances were identified using combined chemo-analytical methods. The information gained provides a targeted strategy for avoiding off-odors. The results of this collaborative study with the Chair of Aroma and Smell Research at the Friedrich-Alexander-Universität Erlangen-Nürnberg and the University of Alicante have now been published**

In order to meet the targets of the new EU Packaging and Packaging Waste Directive concerning the recycling of packaging waste, new markets for recyclates produced from waste plastic packaging must be found. Recyclates produced from waste plastic packaging must have no off-odors if they are to be used as secondary raw materials for the manufacture of high-quality consumer products. Indeed, the off-odors in plastic recyclates prevent a closed cycle for the recycling of plastic packaging materials. Currently, there is a particularly high reusage rate for recyclates produced from polyethylene terephthalate (PET) bottles.

LDPE Packaging Waste in Focus

The Sensory Analytics department at the Fraunhofer IVV characterizes and optimizes plastics and recyclates. The odorants in HDPE waste and the recyclates produced from packaging from bodycare products and detergents have already been analyzed. Low density polyethylene (LDPE) is one of the most commonly used plastics. It is widely used for packaging materials such as plastic shopping bags. Via various collection systems these bags end up as packaging waste. Part of the current study on post-consumer LDPE shopping bags concerned the effect of the collection strategy on the sensory impairment of the waste.

Identification of Odorants - The Key Step

Identification of the substances causing off-odors is essential in order to be able to take measures for odor optimization. Most of the odorants identified in the study are typical metabolites of microorganisms. Many of these metabolites had a cheese-like or feceslike odor. The odorants included carboxylic acids and sulfur-containing and nitrogencontaining components. The chemical structures of the odorants gave key insight into their origin. Using this information, the pathways into the packaging waste and via the recycling process into the recyclate were identified. Depending on which process step cannot remove an odorant or even results in a new odorant, targeted measures can be taken to reduce odorants or avoid the formation of new odorants.

Odorant Reduction Via Separate Collection in the Yellow Bag

The study showed that the way the packaging waste is collected has a large bearing on the odor quality of plastic shopping bags. There are significant benefits by separate collection in the yellow bag. Waste collected in this way had a significantly lower overall odor. In contrast, the waste fraction collected in the general household waste had more intense cheesy-like, sulfur-like, and feces-like odors. The higher organic fraction in the general waste favors the formation of these microbial degradation products. It was also demonstrated that the post-consumer LDPE shopping bags from the separate collection that were washed at 60 degrees had fewer odorants and a reduced overall odor than the unwashed bags.

Methods for Odor Identification in Plastic Waste

The Fraunhofer IVV scientists used sensory analytics to identify the odors. Sensory evaluation of the sample materials was first undertaken by a trained sensory panel. The odorants were then identified using chemo-analytical methods such as gas chromatography - olfactometry and with two-dimensional coupling with mass spectrometry. This enabled the chemical structures to be determined and also possible formation pathways and sources of the odorants to be identified. These key findings can now be used to develop customized solutions for optimization of the odor of plastic recyclates, starting at the waste collection stage.

Further Information

Contact person at the Fraunhofer IVV is Dr. Philipp Denk, Phone: +49 8161 491-318, philipp.denk@ivv.fraunhofer.de.

Scientific publication: A. Cabanes, M. Strangl, E. Ortner, A. Fullana, A. Buettner. Odorant composition of post-consumer LDPE bags originating from different collection systems, https://www.sciencedirect.com/science/article/pii/S0956053X20300210.

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Separate collection is beneficial for the sensory properties of the plastic waste and hence the quality of the resulting recyclates. |

Why Join?

It has never been more important to be a member of your professional society than now, in the current climate of change and global growth in the plastics industry. Now, more than ever, the information you access and the personal networks you create can and will directly impact your future and your career.

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SPE RECYCLING NEWSLETTER provides technical and non-technical content aimed directly at the plastics recycling industry and members of the SPE Recycling Division. This professional publication is the perfect platform for your company to get the recognition it deserves!

The Plastics Recycling Division produces four, full-color issues in digital format per year. Circulation includes posting on The Chain and on the SPE Recycling microsite.

Publication measures 8.5 x 11″ with all sponsorship ad spaces in full-color. All submitted files should be a minimum of 150 dpi in EPS, PSD, JPG or PDF format. For more information or questions, contact Conor Carlin, Editor, at ccarlin@4spe.org or 617.771.3321.

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