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CircuTray-UP – Circular economy for PET trays in food packaging

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The "CircuTray-UP" research team is working on new sorting and processing technologies for PET trays. The aim is to produce new, safe food packaging from this food and non-food packaging. On a technical scale, "CircuTray-UP" is demonstrating a process for recycling PET packaging.

The project is being funded as part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept "Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

Circulation for post-consumer PET trays

PET trays are used in everyday life for packaging foodstuffs such as meat, fish, fruit and vegetables or takeaway products, but they are also widely used in the non-food sector. The trays are made from the same material as beverage bottles: polyethylene terephthalate (PET). There is a widespread, well-established, and successful recycling scheme for this plastic.

At present, PET trays are not recycled to a high standard using current technology. This applies to both mono material and multi-layer composites with PE or other polymers. They are sorted into PET fractions in lightweight packaging sorting plants (LVP). A considerable proportion of this material then ends up in energy recovery and is lost to the PET cycle.

The low level of processing of post-consumer PET trays is mainly due to the high proportion of foreign plastics (PE, EVOH, EVA, PUR) and tray-specific material properties. These have a detrimental effect on processing plants that are geared towards PET bottles. In addition, food and non-food trays are collected together via the dual systems. This calls into question the food compliance of reuse in the food sector.

Recycling through optimised separation technology

The "CircuTray-UP" researchers' approach: The implementation phase starts with currently available PET tray fractions, which are obtained in modern waste sorting plants. They contain far too much foreign material for direct reutilization. The three project partners – the Fraunhofer Institute for Process Engineering and Packaging IVV, SRH Kunststoffe and Unisensor – are working on the positive sorting of mono-PET trays and subsequent optimized mechanical processing. In the further course of the project, Fraunhofer IVV and LÖMI will produce PET recyclates from residue fractions with a high proportion of multi-layer PET sorting fractions and process residues – using physical solvent-based recycling. The Öko-Institut is analyzing the innovative products and processes and assessing their sustainability.

PET trays are used in the food and non-food sectors.

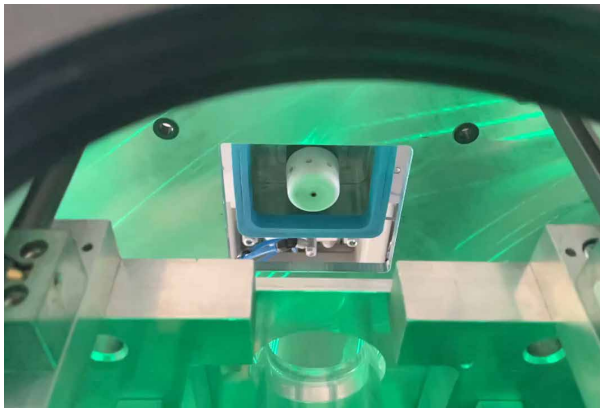
In a further step, the companies Reifenhäuser and silver plastics will process the PET recyclates into films, laminate them with a migration barrier made of virgin PET and thermoform trays.

Fraunhofer IVV will test the function of the barrier, thus guaranteeing the safe use and recyclability of the trays at the end of their life.

Great potential for circularity

The concept has great potential for the circular economy: around 430 kilotonnes of PET recyclates are currently produced each year, of which only 162 kilotonnes are reused in food packaging in the form of PET bottles. If the PET trays collected by the dual systems in Germany – around 120 kilotonnes – could be processed into high-quality PET and made food-safe, the yield could be almost doubled. In addition, the comprehensive recycling of PET trays is currently the only way to provide PET recyclates for the production of PET trays without disrupting the established PET bottle cycle.

The PET processor SRH and the PET tray manufacturer silver plastics are responsible for implementing the project results. The plant manufacturers Reifenhäuser and LÖMI will provide the necessary equipment for the closed-loop value chain. Accompanying communication of the results with other participants in the value chain is intended to support the rapid and comprehensive implementation of the technologies in the European economic area.



A thermoforming test rig for PET recycling.

Funding initiative
Resource-efficient Circular Economy –
Plastic Recycling Technologies (KuRT)

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CircuTray-UP – Innovative technologies for implementing a circular economy for PET trays in food packaging

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Contact
Dr. Martin Schlummer
Fraunhofer Institute for Process Engineering and Packaging IVV
Giggenhauser Str. 35
85354 Freising, Germany
Phone: +49 8161 491750
E-mail: martin.schlummer@ivv.fraunhofer.de

Project partners
SRH Kunststoffe; silver plastics GmbH & Co. Kommanditgesellschaft; Reifenhäuser Cast Sheet Coating GmbH & Co. KG; UNISENSOR Sensorsysteme GmbH; LÖMI GmbH Großostheim; Öko-Institut. Institut für angewandte Ökologie e. V.

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HydroCycling – Chemical recycling of plastic waste into petrochemical base and raw materials

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The "HydroCycling" project team is developing an integrated, petrochemical value-added cycle for various mixed plastic wastestreams. Catalytic treatment of waste plastics with hydrogen produces petrochemical raw materials and basic chemicals. "HydroCycling" thus complements current technical solutions such as pyrolysis or gasification processes.

The project is being funded as part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept "Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

Raw material utilization of plastic waste

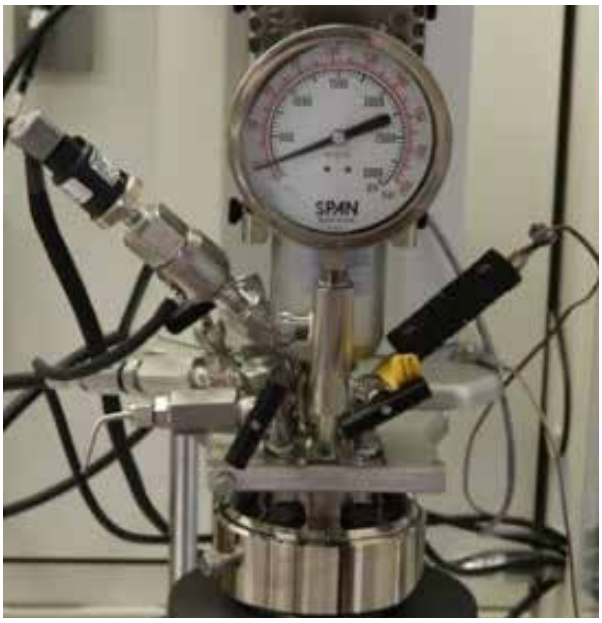
In the mechanical recycling of plastics materials, polymer damage, the combination of several polymers into "blends" and composite materials such as multi-layer films, or non-polymer substances including fillers, dyes, plasticizers and product adhesives limit the number of recycling cycles.

An innovative addition is, thus, feedstock or chemical recycling – the chemical decomposition into small molecules and their subsequent conversion into new polymer products. Chemically recycled used plastics can be utilized as raw materials to produce new plastic articles. The combination and complementarity of raw material and mechanical processes can significantly increase the quantity of recycled used plastics and the quality of the recyclates.

Chemical recycling processes can be applied to e. g. by-products of scrap metal recycling, so-called shredder light fractions. Waste plastics from the construction sector, e.g. bromine-containing expanded polystyrene, or fractions from the recovery of waste electrical and electronic equipment may also be chemically recycled. For these and other fractions, the "HydroCycling" project is developing concepts for their mechanical processing and subsequent catalytic conversion into petrochemical raw materials and basic chemicals.

HydroCycling – from laboratory to demonstrator

The industry currently favors two chemical recycling routes: One is via the pyrolysis of used plastics and the use of the pyrolysis oils as petrochemical raw materials. The second route is gasification and the production of petrochemical polymer building blocks from synthesis gas. "HydroCycling" also attempts to largely preserve the molecular structures of used plastics and use hydrogenation to obtain petrochemical raw materials and basic chemicals.



Lab autoclave for hydrogenation tests on plastic waste and model mixtures.

Catalytic hydrogenation of polymers has been scientifically described many times. Depending on the catalysts used and the operating conditions, different polymers have been converted in pure form or in mixtures, e. g. with refinery streams. In "HydroCycling", the influence of the composition of available, real plastic waste on hydrogenation will also be investigated. Pre-processing steps will be developed experimentally. The aim is to

remove interfering foreign substances from the plastic waste to obtain usable input materials for the "HydroCycling" process. These will be converted into hydrocarbon mixtures by catalytic hydrogenation on a laboratory scale. Product work-up and utilization will be simulated in combination with a commercial "HydroCycling" plant at a refinery or petrochemical site. An important objective is to develop a concept for a demonstrator in a follow-up project. The process developed in individual steps at laboratory scale could be combined, its operation could be demonstrated and first product samples be produced.

Realization and holistic assessment

In addition to this work, a comprehensive assessment of the "HydroCycling" concept from a techno-economic, ecological, regulatory, and patent law perspective is being carried out as part of the project. This is a prerequisite for industrial implementation of the new process.

"HydroCycling" starting material.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

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HydroCycling – Chemical recycling of plastic waste into petrochemical raw materials and base chemicals

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Contact
Dr. Michael Bender
BASF SE
Carl-Bosch-Str. 38
67056 Ludwigshafen, Germany
Phone: +49 626 05 6235
E-mail: michael.bender@basf.com

Project partners
BP Europa SE; DBI Gastechnologisches Institut gGmbH Freiberg; Theo Steil GmbH; Technische Universität Berlin (TUB), participating institutes PTK: Dept. polymer materials and -technologies; EVUR: Dept. for Energy Process Engineering and Conversion Technologies for Renewable Energies; and BasCat, UniCat BASF JointLab

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pool-in-loop – depolymerisation process for polyolefin-containing plastic waste

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The joint project "pool-in-loop" is working on the development of a sustainable chemical recycling process for a future-oriented carbon cycle economy. Specially formulated catalysts convert plastic waste, which has previously been thermally utilized, directly into short-chain olefins. This process can be used to produce the basic chemicals for new plastics without the need for complex intermediate steps.

The project is part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept "Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

The innovation approach

The nine partners of "pool-in-loop" have joined forces to chemically recycle polyolefin plastic waste, which is currently being thermally recycled. The target products are monomers. These can be reused for the production of plastics immediately after the plastic waste has been converted, without the need for complex intermediate steps.

This recycling process is an innovation for waste management and plastics production. On the one hand, low-grade residual material fractions can be recycled as raw materials. On the other hand, low-carbon recycled base chemicals can be provided for plastics production. During the project, the technology maturity level will be increased from the current four - laboratory scale - to seven - operational prototype. The "pool-in-loop" research team will accompany this development by continuously analyzing possible development paths. The analyses also consider the economic and environmental conditions.

The degree of innovation

In order to develop this sustainable process, the researchers are developing a product-specific adaptation and a special formulation of these catalysts. Their use produces gases of varying composition, with short-chain olefins such as ethene, propene and butenes as the main components. These in turn can be easily purified from interfering heteroatoms such as chlorine, nitrogen, sulphur and oxygen components using suitable processes. The usual purification of the pyrolysis products by hydrogenation and the associated loss of the olefins, as well as cracking in a steam cracker furnace, can thus be dispensed with.

The "pool-in-loop" test facility: a rotary kiln reactor.

The "pool-in-loop" researchers are using laboratory-scale tests to calculate the yield of valuable products from this process. They estimate that a significant increase in yield of 46 percent is possible. Greenhouse gas emissions could also be reduced by 44 percent.
A further reduction in greenhouse gas emissions can be achieved by so-called load-flexible operation. Depending on the supply of renewable energy, the "pool-in-loop" test facility: a rotary kiln reactor. Depending on the amount of energy available from renewable sources, the corresponding sorting fractions can be converted into products with different compositions by adjusting the operating mode.

Social added value

Catalytic cracking has the potential to become established as a sustainable and energy-efficient method of chemical recycling for polyolefin-rich plastic fractions. It targets residual material (post-consumer) fractions that previously had to be thermally utilized and provides feedstock materials for the chemical and plastics industries.

The process promoted by "pool-in-loop" thus complements mechanical recycling and enables material cycles to be closed efficiently. By recycling plastic waste that was previously only thermally utilized, previously lost material flows are included in the plastics cycle. The priority objectives of the "KuRT" funding measure – improved recycling of plastics and the associated increase in economic efficiency – are thus directly addressed and pursued with this project. The planned collaborative project aims to transfer the innovative catalytic cracking technology to an industrial scale, involving partners along the entire value chain.

Agglomerated film residues are used in laboratory operations.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

Project title
pool-in-loop: Development of an energy-efficient depolymerisation process for polyolefin-containing plastic waste using catalysts for the direct production of polymers for new plastics.

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Contact
Mathias Seitz
Hochschule Merseburg University of Applied Sciences
Eberhard-Leibnitz-Str. 2
06217 Merseburg, Germany
Phone: +49 3461 462104
E-mail: mathias.seitz@hs-merseburg.de

Project partner
Braskem Europe GmbH; Chemiewerk Bad Köstritz GmbH; EurA AG; Fraunhofer-Institut für Windenergiesysteme IWES; Hallesche Wasser und Stadtwirtschaft GmbH; MIBRAG GmbH; MVV Umwelt GmbH; Polymer Service GmbH Merseburg

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ProGeo-UP – product stewardship through closed-loop geosynthetics

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The research team behind the "ProGeo-UP" project wants to pave the way for a complete cycle for geosynthetics. These high-quality materials for earthworks, hydraulic engineering, transport routes and landfill sites are currently mainly disposed of in waste incineration plants after demolition.

The project is part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept " Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

Geosynthetics gain in importance

In addition to mineral building materials, plastics have been increasingly used in construction worldwide since the 1960s. One relevant segment is geosynthetics (GEOK), which are mainly used in hydraulic engineering, earthworks, and foundations, as well as in landfill and tunnel construction and groundwater protection – in various functions such as filtration, sealing or stabilization.

They account for less than five percent of the total mass of a structure and have a high sustainability potential. For example, leaner construction methods can replace large quantities of mineral fractions, concrete and steel, and use locally available building materials of inferior quality. For example, CO_2 emissions can be reduced by up to 90 percent. Construction time is also reduced. As GEOK mineral mixes are currently still disposed of in incinerators after deconstruction, there is a great need for recycling.

Closing the loop completely

The project "ProGeo-UP" aims to create the conditions for full recycling within five years. In addition to the re-use of selected products, the aim is to achieve recycling at the highest quality level. This means that new GEOK products will be made from recycled materials.

To this end, dismantling techniques for recovering the installed GEOK are being developed and tested based on three large-scale trials. In addition, the logistics systems, and processes to enable the material recycling of GEOK will be developed. The cycle will be set up in a robust manner to ensure a high, homogeneous, and standardized quality level of GEOK from secondary

Deconstruction of a geosynthetic.

materials in the long term. To this end, the necessary administrative and regulatory framework, such as standardization, will be developed. Based on a standardized knowledge on the life cycle of the products, quality assurance mechanisms will be established to enable the comprehensive recycling and use of high quality secondary materials from GEOK. Economic and environmental indicators developed during the project will be used to establish sustainable business models for this product group.

Wide range of applications for the solutions

The "ProGeo-UP" researchers work in the following division of labour: The Resources working group of IWARU coordinates the overall project and deals with the processing technology and the analysis of the material flows generated at the various stages of the value chain. The infrastructure working group of IWARU will look at the dismantling process and analyze the environmental and economic indicators over the life cycle

to develop a business model. The RUB is responsible for setting up structures to collect relevant data on the value creation stages (material passport) and linking them to the relevant stakeholders. Two of Europe's leading manufacturers of GEOK, NAUE and HUESKER, are participating in the joint project.

IBH provides access to specific construction projects, including design details. TIBATEK specializes in attachments for the installation and removal of geosynthetics. TAILORLUX GmbH develops marking materials and sensor technology for quality and process assurance of plastics, and LINDNER & USG, two renowned manufacturers of processing units, complete the joint project. Other associated partners, such as the Institute for Materials Applications at the TH Köln, are also providing support.

The concept developed in "ProGeo-UP" is intended to be universally applicable for plastic products in contact with the ground in the construction sector, for example also for green roofs and artificial turf pitches, as these have similar framework conditions.

Geogrid reinforcement in a bridge construction.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

Project title
ProGeo-UP: Implementation of product stewardship through closed-loop geosynthetics

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Contact
Sabine Flamme
FH Münster | Institute for Infrastructure • Water • Resources • Environment (IWARU)
Corrensstraße 25 | 48149 Münster, Germany
Phone: +49 251 8365264
E-mail: flamme@fh-muenster.de

Project partner
Ruhr Universität Bochum, Lehrstuhl für Informatik im Bauwesen; Herold & Partner Ingenieure mbH; TAILORLUX GmbH; TIBATEK GmbH; HUESKER Synthetic GmbH; NAUE GmbH & Co. KG; assoziierte Beteiligte: TH Köln, Institut für Werkstoffanwendungen; STRABAG AG; BAUVERBÄNDE NRW e. V.; Hubert EING Kunststoffverwertung GmbH; RCS Rohstoffverwertung GmbH; Bundesanstalt für Gewässerkunde; LINDNER Recyclingtech GmbH; USG Umweltservice GmbH & CO. KG

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ReVise-UP – Recycling of plastic waste through intelligent material flow management

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The "ReVise-UP" project consortium is using sensor technology to accurately track the recycling of post-consumer plastic packaging. The aim is to develop perspectives and incentives for improved collection and recyclate quality. It also aims to increase process efficiency: sorting, processing, and plastic conversion processes shall be better adapted to fluctuating material flow characteristics, and the entire life cycle shall be optimized both ecologically and economically.

The project is part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept " Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

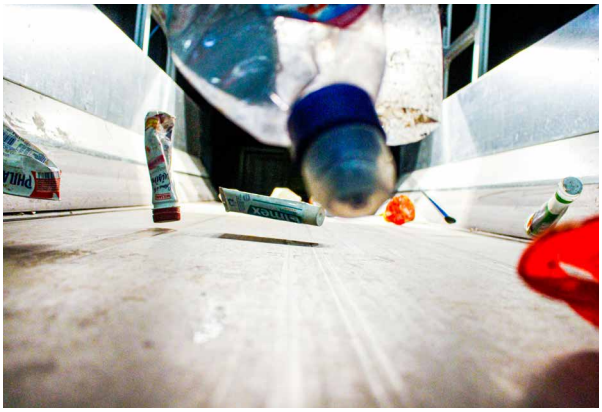
Innovative sensor technologies

At 3.2 million tonnes per year, post-consumer packaging waste is the largest plastic waste stream in Germany. However, the recycling rate is low: In 2021, only around 27 percent of post-consumer plastics were converted into recyclates, while only around 12 percent were used to substitute virgin plastics. One of the main reasons is that the recycling process often lacks information on process-relevant material flow characteristics. This is due to the high cost of manual, sampling-based material flow characterization.

The "ReVise-UP" researchers are using in-line sensor technology to automatically characterize post-consumer material flows. The aim is to improve collection and recyclate quality through more accurate material flow characterization; to efficiently adapt sorting, processing, and plastic conversion processes to fluctuating material flow characteristics and to create a solid database for a holistic assessment of plastic waste to better allocate technical investments, where they create the largest environmental and economic benefits.

Increasing transparency

"ReVise-UP" seeks to develop sensor-based monitoring for various process steps in plastic recycling. Using near and mid-infrared spectroscopy in combination with artificial intelligence methods, researchers in "ReVise-UP" aim to enable an automatic inline material flow characterization. In contrast to traditional, sampling-based characterization methods, the aim here is to achieve continuous monitoring of pre-concentrates from sorting plants. Based on this monitoring data, the aim is to promote optimized sorting and ultimately contribute to an improved overall quality of the plastic recyclates.



Plastic packaging is detected by sensors.

Higher yield through adaptive process parameterization

In addition, the researchers in ReVise-UP aim at developing the first prototypes of adaptive process parameterization in sorting, processing, and plastic conversion plants. Improved process feeding and adaptive parameterization of preconditioning units shall increase process efficiency in sorting plants. In addition, sensor-based material flow monitoring in plastic processing plants shall enable more precise addition of additives and optimized fine-tuning during compounding.

With view to the entire life cycle, it is being investigated which sorting and processing depths in sub-processes

– for example, sensor-based sorting – are ecologically and economically advantageous. A particular focus will be on how the targeted coordination of processes can minimize the overall energy consumption and operating costs. The researchers are also interested in the influence of product design on the respective process. In addition, "ReVise-UP" will develop an incentive model to implement the optimization steps throughout the value chain.

The "ReVise-UP" research project, coordinated by the Department of Anthropogenic Material Cycles at RWTH Aachen University, involves eight partners from academia and industry.

ReVise-UP increases the recycling of post-consumer plastic packaging waste.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

Project title
ReVise-UP: Improving the process efficiency of mechanical recycling of post-consumer plastic packaging waste through intelligent material flow management.

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Contact
Univ.-Prof. Dr. Kathrin Greiff
Department of Anthropogenic Material Cycles (ANTS),
RWTH Aachen University
Wüllnerstr. 2
52062 Aachen, Germany
Phone: +49 241 8095700
E-mail: kathrin.greiff@ants.rwth-aachen.de

Project partner
Deutsches Forschungszentrum für Künstliche Intelligenz GmbH; DIN Deutsches Institut für Normung e. V.; Hündgen Entsorgungs GmbH & Co. KG; Krones AG; Kunststoff Recycling Grünstadt GmbH; SKZ – KFE gGmbH; STADLER Anlagenbau GmbH; Wuppertal Institut für Klima, Umwelt, Energie, Forschungsinstitut GmbH

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SmellStop – Odour reduction as a key technology for the use of recycled polyethylene

Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

The "SmellStop" joint project is pursuing a holistic approach to reducing the odour of polyethylene film recycles through process engineering. This is because the strong odour is one of the biggest obstacles to the widespread use of these post-consumer recycles in packaging films. The "SmellStop" innovation covers the entire material cycle – from pre-treatment through to film production. It also identifies odour-causing substances so that they can be avoided right from the packaging design stage.

The project is part of the funding initiative "Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)". "KuRT" is part of the BMBF research concept "Resource-efficient Circular Economy" and is aimed at high-quality recycling of plastics.

Use of recyclates in new packaging

The packaging sector processes the largest amount of plastic of any industrial sector. Compared to durable products in the construction and automotive sectors, packaging such as films, cups and bottles have a short lifespan. Currently, most plastic packaging is made from fossil-based virgin materials. This linear use of plastic products leads to high greenhouse gas emissions and significant environmental pollution. New laws and regulations in Germany and the EU require increased use of recyclates in new packaging. Until now, the majority of recyclates have been used for lower value products or thermally utilised.

During the conception phase of the project, the "SmellStop" research team identified the strong odour of recyclates as a major obstacle to the widespread use of high levels of recyclates in packaging products, especially during processing. "SmellStop" aims to minimize the odour of PCR materials to increase product acceptance and achieve a sustainable, resource-efficient circular economy in the field of lightweight packaging.

Reducing odour via process engineering

The aim of the project is to reduce the odour activity of the recyclates via process engineering as well as preventing it in the long term by specifically adapting the printing inks. The odour reduction of the post-consumer polyethylene films is planned in several steps:

In "SmellStop" the use of recycled materials for films is to be increased.

thermal pre-treatment in the infrared rotary drum; targeted degassing in the twin-screw extruder; decontamination under the influence of temperature and water vapour, and optimised process parameters during film extrusion.

The odour is analysed at all stages of the process using gas chromatography-mass spectrometry (GC-MS) to identify the odour-causing substances and to avoid them in the production of the primary packaging. Targeted contamination of virgin material will also be used to draw conclusions about odour-active compounds in recycled materials. The focus is primarily on printing inks, adhesives, and biotic contaminants. The GC-MS analysis is further used to calibrate mobile sensors that can detect odours during production operations, and in the product.

Potential for a truly circular economy

The results have a major impact on the circular economy of lightweight packaging. By establishing the developed processes, recyclates can be used in a variety of products.

The Institute of Plastics Processing (IKV) at RWTH Aachen University will initially carry out laboratory-scale processing tests and GC-MS analyses of the odour-causing substances. In scale-up trials, the companies Coperion GmbH (regranulation), Kreyenborg GmbH & Co. KG (thermal pre-treatment in an infrared rotary kiln), Reifenhäuser Cast Sheet Coating GmbH & Co. KG (flat film production) and RKW SE (blown film production) validate the results on an industrial scale. Siegwerk Druckfarben AG & Co. KGaA supply contaminants in the form of printing inks and adhesives and continuously optimizes the formulations to achieve low odour levels in the recycling process. 3S GmbH optimizes and calibrate the sensors for the inline detection of odours in recyclate processing, enabling the quick and easy quantification of odours during processing and in the product.

In total, the entire odour reduction process will be performed twice, with the odour measurement and odour reduction strategies being further optimised in the second run.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

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SmellStop: Odour reduction as a key technology for the use of recycled post-consumer polyethylene

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Contact
Lisa Leuchtenberger-Engel
Association of Sponsors for the Promotion of the IKV – Institute for Plastics Processing in Industry and Craft at RWTH Aachen University of Technology e. V.
Seffenter Weg 201
52074 Aachen, Germany
Phone: +49 241 8028372
E-mail: lisa.leuchtenberger@ikv.rwth-aachen.de

Project partner
3S GmbH; Coperion GmbH; Kreyenborg GmbH & Co. KG; Reifenhäuser Cast Sheet Coating GmbH & Co. KG; RKW SE; Siegwerk Druckfarben AG & Co. KGaA

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KuRT_Plus – Networking and transfer project for “Plastic Recycling Technologies”

Resource-efficient Circular Economy– Plastic Recycling Technologies (KuRT)

The networking and transfer project “KuRT_Plus” provides targeted networking support for the research projects of the BMBF funding measure “Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)” and supports the transfer of the research results towards practical implementation in industry.

The project is part of the funding initiative “Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)”. “KuRT” is part of the BMBF research concept “ Resource-efficient Circular Economy” and is aimed at high-quality recycling of plastics.

Sustainable plastics recycling

We encounter plastics in many areas of our daily lives. In Germany alone, around 14 million tonnes of plastic are produced every year. Recycling these plastics after use is a challenge. Too much plastic waste is still lost to the cycle.

The Federal Ministry of Education and Research (BMBF) supports the development of innovative approaches and technologies for high-quality plastics recycling through its funding measure “Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)”. The aim is to significantly increase the actual recycling and recycled content rates and the economic efficiency of plastics recycling through intelligent utilization concepts for plastics, improved logistics, collection and sorting as well as innovative recycling processes and the high-quality use of recycled plastics.

Together for greater resource efficiency

Over the next few years, six research teams will work together in “KuRT” to promote the economic and resource-efficient recycling of plastics and thus pave the way for the sustainable use of plastics. They will receive support from the team of the networking and transfer project “KuRT_Plus”. “KuRT_Plus” promotes the dialogue between all project participants. The aim is to identify potential synergies at an early stage and to generate synergy effects in the projects. Among other things, cross-sectoral and cross-technology issues are to be defined and discussed in working groups.

Exchange and networking: tasks of “KuRT_Plus”.

In addition, “KuRT_Plus” supports the networking of the funded projects with experts from industry and science as well as with the interested public. The aim is to support the transfer of the project results into commercial practice. This is achieved, among other things, through cross-project public relations work and the provision of up-to-date information material. In addition, various target group-specific events are organized, such as status conferences, discussion forums, political dialogues, and a final transfer conference.

In addition, networking with related national, European, and international initiatives and the presentation of the funding measure at specialist events are planned. The aim is to inform all relevant stakeholders in the value chain and target groups representing businesses, politics, scientific organizations, as well as environmental and social interest groups about the developments in the funding measure, and to involve them into a dialogue with the research teams in the funding measure.

Partner for networking and exchange

DECHEMA is the competent network for chemical engineering and biotechnology in Germany. As a non-profit professional society, it represents these fields in science, industry, politics, and society and promotes the technical-scientific exchange of experts from different disciplines and organizations. "KuRT_Plus" profits from DECHEMA's many years of experience in coordinating research and development projects as well as networking and transfer projects, supporting those projects with their networking and public relations work.

"KuRT_Plus" organises conferences for "KuRT" researchers.

Funding initiative
Resource-efficient Circular Economy – Plastic Recycling Technologies (KuRT)

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KuRT_Plus: Networking and transfer project for the BMBF funding measure "Resource-efficient Circular Economy – Plastic Recycling Technologies"

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Contact
Katja Wendler
DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e. V.
Theodor-Heuss-Allee 25
60486 Frankfurt am Main, Germany
Phone: +49 6975 64-425
E-mail: katja.wendler@dechema.de

Project partner
DECHEMA e. V.

Internet
bmbf-kurt.de

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