An Initiative of the German Federal Ministry of Education and Research

Plastics in the Environment

sources · sinks · solutions

New plastic waste recycling method

A technology to support the transition to a circular plastics economy

Sorted polystyrene waste is the starting material for the depolymerization process.

"Even after 90 years on the market, polystyrene surprises with its unique properties and facilitates the transition to a full circular economy."

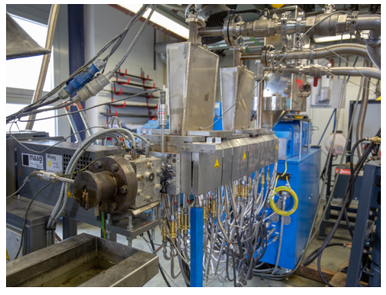
Franziska Nosić,
INEOS Styrolution Group GmbH

It is impossible to imagine the automotive, construction, medical, household and electronics sectors without polystyrene (PS). Polystyrene has numerous advantages and has been making our lives more comfortable for almost a century. However, the transition to a circular economy is crucial for the future. This requires the development and introduction of new recycling technologies. In the ResolVe project, various types of PS waste were processed, depolymerized, the reaction concentrate purified and successfully polymerized again.

Thermal depolymerization of polystyrene

The process investigated here utilizes a special property of polystyrene, namely depolymerization, i.e. the breakdown of PS into its constituent parts - individual styrene monomers.
In the ResolVe project, the process used ("thermal degradation in a twin-screw extruder") has shown that this reactor technology supports a continuous process with a condensate yield of about 78%. Volatile components can be separated by a multi-stage degassing system. Remaining impurities can be fed to thermal recycling.

The investigated extruder process for recycling PS waste streams and producing styrene monomers makes sense not only from an ecological point of view, as it greatly reduces CO_2 emissions as well as the consumption of water and fossil raw materials – it also provides economic benefits due to lower energy costs.



Laboratory set-up for chemical recycling of polystyrene in a twin-screw extruder.

Processing the condensate by distillation

The condensate obtained by depolymerizing polystyrene contains other compounds next to styrene monomers. These can be separated by distillation, resulting in styrene monomers of comparable quality to conventionally produced petroleum-based monomers. This allows re-polymerization to food-grade polystyrene, thus closing the cycle.

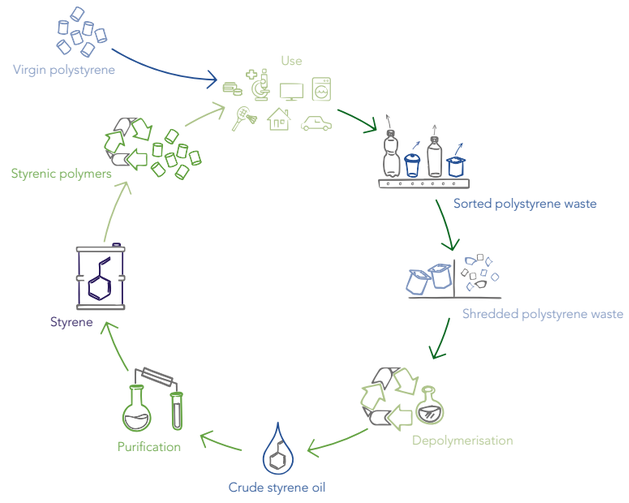
Research on a recycling method for the circular economy of polystyrene

In the project "ResolVe: Recycling of polystyrene by raw material recovery", the factors influencing the thermal depolymerization of polystyrene were systematically investigated on a laboratory scale - especially with regard to process control in a twin-screw extruder. Furthermore, purification by distillation, utilization of by-products in a cracking process and re-polymerization were analyzed. Based on these results, the process was evaluated in a life cycle analysis. The project results demonstrate the possibility of transition from a linear economy to a circular economy for polystyrene.

Purification of the condensate by distillation on the laboratory scale.

Life cycle assessment demonstrates ecological and economic advantages

The life cycle assessment shows that the depolymerization process saves 37% CO_2 emissions compared to the standard petroleum-based styrene production process (based on the 2018 electricity mix in Germany). There is also an advantage from an economic point of view due to lower energy costs.



Circular economy: Schematic representation of the production of food-grade polystyrene by depolymerization of polystyrene waste.

IMPRINT

Authors
Schäfer, Philipp; Kolb, Tristan; Nosić, Franziska; Nießner, Norbert

Institution
Institute for Plastics Processing at RWTH Aachen University, Neue Materialien Bayreuth GmbH, INEOS Styrolution Group GmbH

Contact
Franziska.Nosic@ineos.com

Design
Lena Aebli, Ecologic Institute

Status
January 2022

www.bmbf-plastik.de/en @plastik_umwelt

This fact sheet was prepared as part of the research focus "Plastics in the Environment" (duration 2017-2022), funded by the German Federal Ministry of Education and Research (BMBF). The authors are solely responsible for the contents of the fact sheet. They do not reflect the official opinion of the BMBF.

Schäfer, Philipp; Kolb, Tristan; Nosić, Franziska; Nießner, Norbert (2021): Thermal depolymerization using twin screw extruders: A technology to support the transition to a circular economy. Fact sheet 21 of the BMBF research focus Plastics in the Environment.

All fact sheets in this series can be found at:
https://bmbf-plastik.de/en/results/factsheets