Polymer sustainability applications compendium

Accelerate innovative design & plastic recycling

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As a leading manufacturer of small-scale extruders, torque rheometers and rotational rheometers, Thermo Fisher Scientific supports the polymer industry in designing modern, recyclable products and developing high-value recyclate that meets new government regulations and standards, such as the EU packaging and packaging waste directive.

Small-scale laboratory extruders and laboratory batch mixers provide numerous advantages to research and development in plastics recycling. These devices enable compounding or mixing as well as detailed testing with minimal material usage, which in turn speeds up the experimental process and saves lab space while requiring less manpower to operate. The versatility of our lab-scale instruments and a broad range of associated accessories allows for the acceleration of application testing, process optimization, and material advancement for a wide range of polymeric materials.

Rheometers, used in product development and extrusion process optimization, provide essential insights into the viscoelastic properties of polymeric materials. By performing rheological tests, users can understand the flow and deformation behavior of their polymers at different temperatures. These tests help detect anomalies, allowing manufacturers to optimize process conditions, adapt processes to specific material properties and ensure end-product quality.

With our global demonstration labs and multidisciplinary team of scientists, we have decades of application expertise to help you achieve your specific sustainable application goals. Talk to our experts today to learn more about how we can help you move forward in this innovative field (**contact us**).

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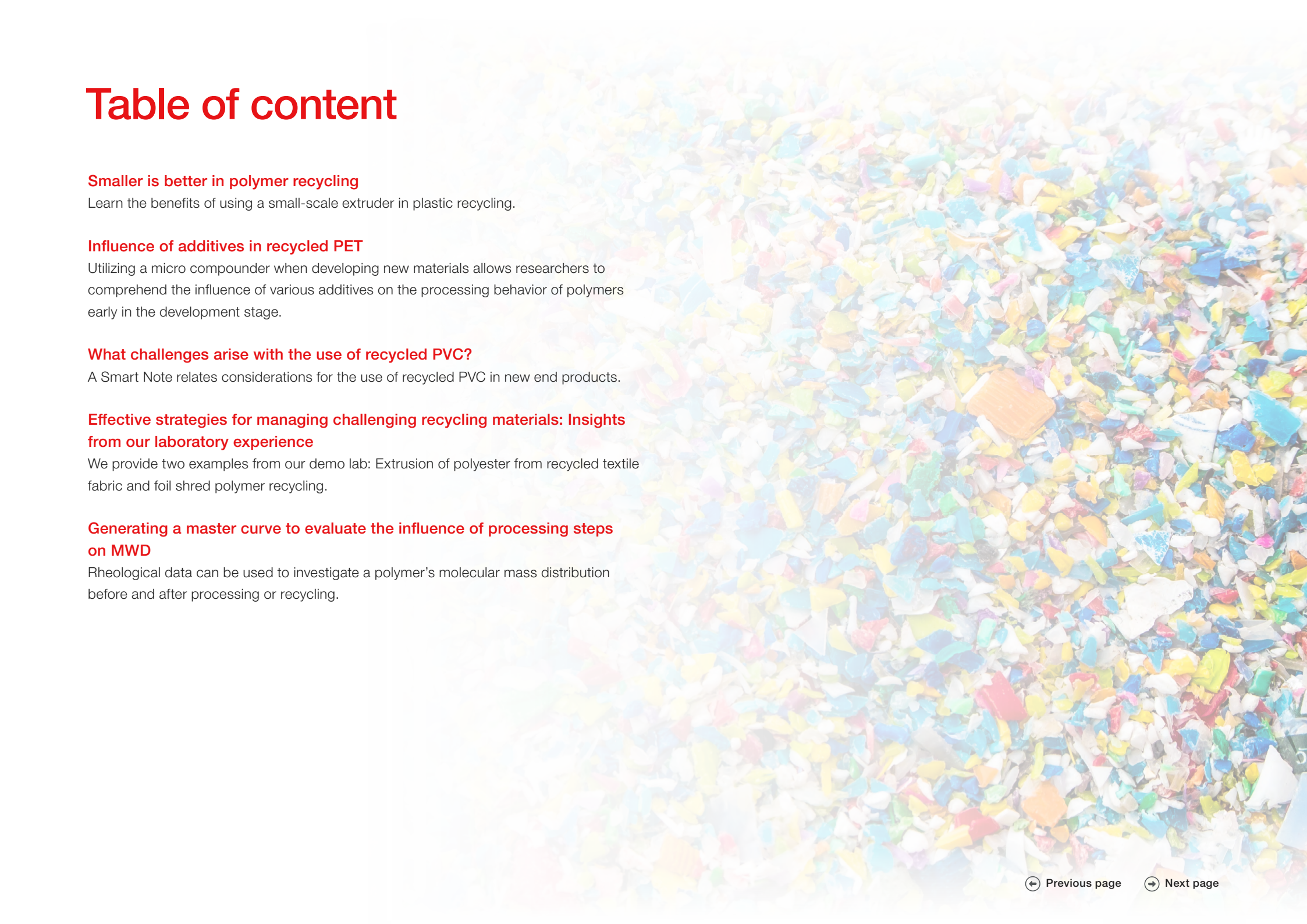


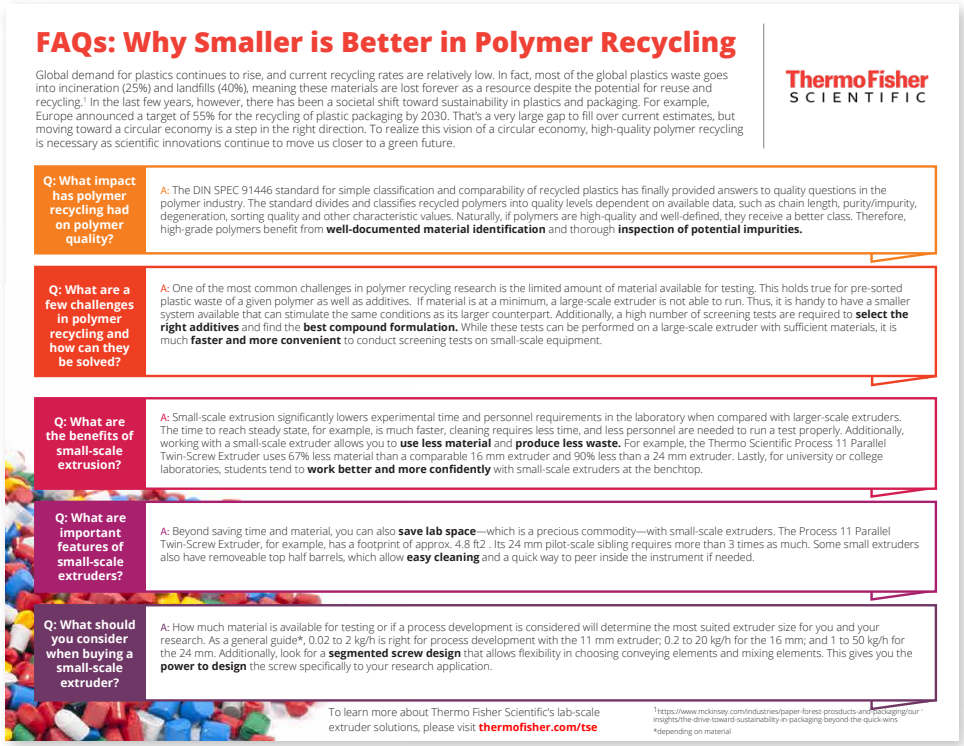
Smaller is better in polymer recycling

Answers to your FAQs

Although recycling companies are not necessarily limited by the amount of material available for testing, working with small quantities for numerous studies and trials offers several advantages. Small-scale twin-screw extrusion requires less material, significantly reducing testing time and labor requirements in the lab compared to larger extruders. Read the answers to some frequently asked questions to learn how you can reduce material consumption and waste in your recycling research.

View the FAQs

View the video: Discover the small-scale twin-screw extruder capabilities.



FAQs: Why Smaller is Better in Polymer Recycling

Global demand for plastics continues to rise, and current recycling rates are relatively low. In fact, most of the global plastics waste goes into incineration (25%) and landfills (40%), meaning these materials are lost forever as a resource despite the potential for reuse and recycling.[1] In the last few years, however, there has been a societal shift toward sustainability in plastics and packaging. For example, Europe announced a target of 55% for the recycling of plastic packaging by 2030. That's a very large gap to fill over current estimates, but moving toward a circular economy is a step in the right direction. To realize this vision of a circular economy, high-quality polymer recycling is necessary as scientific innovations continue to move us closer to a green future.

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Q: What impact has polymer recycling had on polymer quality?

A: The DIN SPEC 91446 standard for simple classification and comparability of recycled plastics has finally provided answers to quality questions in the polymer industry. The standard divides and classifies recycled polymers into quality levels dependent on available data, such as chain length, purity/impurity, degeneration, sorting quality and other characteristic values. Naturally, if polymers are high-quality and well-defined, they receive a better class. Therefore, high-grade polymers benefit from **well-documented material identification** and thorough **inspection of potential impurities.**

Q: What are a few challenges in polymer recycling and how can they be solved?

A: One of the most common challenges in polymer recycling research is the limited amount of material available for testing. This holds true for pre-sorted plastic waste of a given polymer as well as additives. If material is at a minimum, a large-scale extruder is not able to run. Thus, it is handy to have a smaller system available that can stimulate the same conditions as its larger counterpart. Additionally, a high number of screening tests are required to **select the right additives** and find the **best compound formulation.** While these tests can be performed on a large-scale extruder with sufficient materials, it is much **faster and more convenient** to conduct screening tests on small-scale equipment.

Q: What are the benefits of small-scale extrusion?

A: Small-scale extrusion significantly lowers experimental time and personnel requirements in the laboratory when compared with larger-scale extruders. The time to reach steady state, for example, is much faster, cleaning requires less time, and less personnel are needed to run a test properly. Additionally, working with a small-scale extruder allows you to **use less material** and **produce less waste.** For example, the Thermo Scientific Process 11 Parallel Twin-Screw Extruder uses 67% less material than a comparable 16 mm extruder and 90% less than a 24 mm extruder. Lastly, for university or college laboratories, students tend to **work better and more confidently** with small-scale extruders at the benchtop.

Q: What are important features of small-scale extruders?

A: Beyond saving time and material, you can also **save lab space**—which is a precious commodity—with small-scale extruders. The Process 11 Parallel Twin-Screw Extruder, for example, has a footprint of approx. 4.8 ft2 . Its 24 mm pilot-scale sibling requires more than 3 times as much. Some small extruders also have removeable top half barrels, which allow **easy cleaning** and a quick way to peer inside the instrument if needed.

Q: What should you consider when buying a small-scale extruder?

A: How much material is available for testing or if a process development is considered will determine the most suited extruder size for you and your research. As a general guide*, 0.02 to 2 kg/h is right for process development with the 11 mm extruder; 0.2 to 20 kg/h for the 16 mm; and 1 to 50 kg/h for the 24 mm. Additionally, look for a **segmented screw design** that allows flexibility in choosing conveying elements and mixing elements. This gives you the **power to design** the screw specifically to your research application.

To learn more about Thermo Fisher Scientific's lab-scale extruder solutions, please visit **thermofisher.com/tse**

[1] https://www.mckinsey.com/industries/paper-forest-prosducts-and-packaging/our-insights/the-drive-toward-sustainability-in-packaging-beyond-the-quick-wins

*depending on material

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Influence of additives in recycled PET

Analyzing the influence of additives on polymers using a micro compounder

Polyethylene terephthalate (PET) is a versatile plastic that is frequently mixed with additives to enhance its strength and rigidity. However, these additives can affect the recycling process of PET, resulting in specific processing requirements. The Thermo Scientific™ HAAKE™ MiniLab™ Micro Compounder is a valuable tool for evaluating the impact of different additives. It only requires a small sample size of 7 grams and provides quick insights into the functionality of the additives through examination of pressure dependence data.

View the application note

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What challenges arise with the use of recycled PVC?

Considerations for the use of recycled PVC in new end products

PVC is widely used in various products with many applications for construction and housing. With the onset of more environmental concerns and regulations, PVC producers and users are facing greater pressure to recycle their polymer waste so it can be made into useful products. This smart note presents considerations for the use of recycled PVC in new end products.

View the smart note

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Smart Notes

Q A

What challenges arise with the use of recycled PVC?

PVC (polyvinyl chloride) is a widely used plastic material in the manufacturing of various products such as window profiles, pipes, and other extruded products. PVC compounders and companies engaged in PVC profile extrusion are facing increasing pressure to recycle their polymer waste due to environmental concerns and regulations.

To accommodate these demands, PVC compounders find they must increase the use of stabilizers in their formulations to allow for additional extrusion steps. The increased use of stabilizers can change the processing behavior of the overall compounds, making it more challenging for manufacturers to maintain consistent product quality. Additionally, the use of recycled PVC (re-ground material) can also change the processing behavior and properties of the final product.

WATCH VIDEO

See how the HAAKE PolyLab OS Torque Rheometer System supports the development of next generation materials.

To ensure consistent product quality while incorporating formula changes, comprehensive testing of many different formulations is necessary. Processing behavior must be characterized and process parameters such as fusion behavior, compound stability and melt viscosity must be determined. Specimens must also be tested for mechanical properties such as tensile strength and elongation.

In summary, PVC compounders and companies engaged in PVC profile extrusion are facing increased pressure to recycle their polymer waste, which requires them to increase the stabilization of their formulations and to use more recycled PVC. These changes can affect the processing behavior and properties of the final product, making it more challenging to maintain consistent product quality.

HAAKE PolyLab OS Torque Rheometer with counter-rotating Twin-Screw Extruder

The Thermo Scientific™ HAAKE™ PolyLab™ OS Torque Rheometer System is the ideal tool to address these challenges. This flexible torque rheometer system can be equipped with laboratory mixers and single- or twin-screw extruders.

With the laboratory mixer, a user can determine the fusion and degradation behavior of PVC dry blends and pellets. With an extruder attachment it is possible to simulate the production process and create product samples that can be used for mechanical testing. In combination with rheological dies, PolyLab extruders can be used to perform viscosity measurements on PVC melts.

For the extrusion of rigid PVC compounds, counter-rotating twin-screw extruders are used because they can provide the shear and pressure necessary to form a homogenous melt. Additionally, the extruders ensure a short and defined residence time, which is needed to avoid material degradation. All these attributes of the PolyLab system help address challenges that may arise when manufacturers use recycled PVC.

Learn more about Thermo Scientific Torque Rheometer Systems at **thermofisher.com/torquerheometer**

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Effective strategies for managing challenging recycling materials

Fluffy foil shred and fibers with low bulk density can be efficiently fed

Insights from our laboratory experience

The method of recycling plastic through melting and re-extrusion is an established approach, but it usually happens on a large industrial scale. Did you know scaled-down extruders can be used for polymer recycling research on a laboratory or pilot system scale, using readily available but hard-to-handle materials like shredded plastic foils and low-density plastic fibers or textile fabrics?

View laboratory demonstration: Foiled shred polymer recycling

View laboratory demonstration: Polyester from recycled textile fabric

Read the application note

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Generating a master curve to evaluate the influence of processing steps on MWD

Introduction to master curve creation and rheological curve fitting models to evaluate effects on MWD

The application note describes the benefits of generating a master curve from frequency sweep data acquired at different temperatures by utilizing the TTS principle. Additionally, the Carreau-Yasuda curve fitting model is discussed as a method to obtain polymer-specific parameters from master curves. These parameters can be used to characterize the impact of various processing techniques or recycling steps on the average molecular mass or molecular weight distribution (MWD) of a polymer material.

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Polymer sustainability resources

Application laboratories

Our fully equipped application laboratories are in constant demand for testing customer samples and developing and optimizing pioneering applications. We provide a broad range of product and application solutions, and our team of application scientist and interdisciplinary technique specialists is on hand to answer your questions (**contact us**).

Register for application and product information at **thermofisher.com/specoptin** to gain access to the latest resources to accelerate your research and improve laboratory productivity.

Seminars and trainings

Comprehensive training programs, in-house seminars, and practical rheology and extrusion courses in various locations around the world. We support our customers with comprehensive on-demand training (webinars, videos, and application notes) from our experts, and benefit from our interdisciplinary knowledge in polymer science and technologies.

Polymer extrusion: **thermofisher.com/extruders**
Polymer rheology: **thermofisher.com/rheometers**

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