

Advanced polymer characterization and processing

Multimodal characterization and processing
technologies for advanced polymer development

Introduction

Polymers continue to drive innovation across industries where performance, efficiency, and sustainability are critical. This compendium highlights advanced analytical and processing techniques—including rheology, Raman spectroscopy, FTIR spectroscopy, dynamic mechanical thermal analysis (DMTA), time-temperature superposition (TTS), capillary rheometry, and twin-screw extrusion—to provide deeper insight into process behavior and relationships between material structures and properties. By connecting molecular-level characterization with compounding, curing, recycling, and scale-up strategies, these application notes support scientists and engineers in optimizing polymer materials from laboratory development to industrial production.



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Producing master curves for polymeric materials

What if you could see how your polymer behaves across the full range of real processing conditions?

Discover how time–temperature superposition (TTS) is used to generate master curves that extend rheological data far beyond a single frequency sweep. By building a comprehensive viscoelastic profile, you gain access to key material parameters such as zero-shear viscosity, relaxation behavior, and shear-thinning characteristics. The result: more reliable predictions of extrusion and injection molding performance, improved material comparisons, and better-informed processing decisions.



[View application note](#)

Identical MFR. Different processing results. Why?

How capillary and rotational rheology reveal processing-critical differences invisible to melt flow rate testing

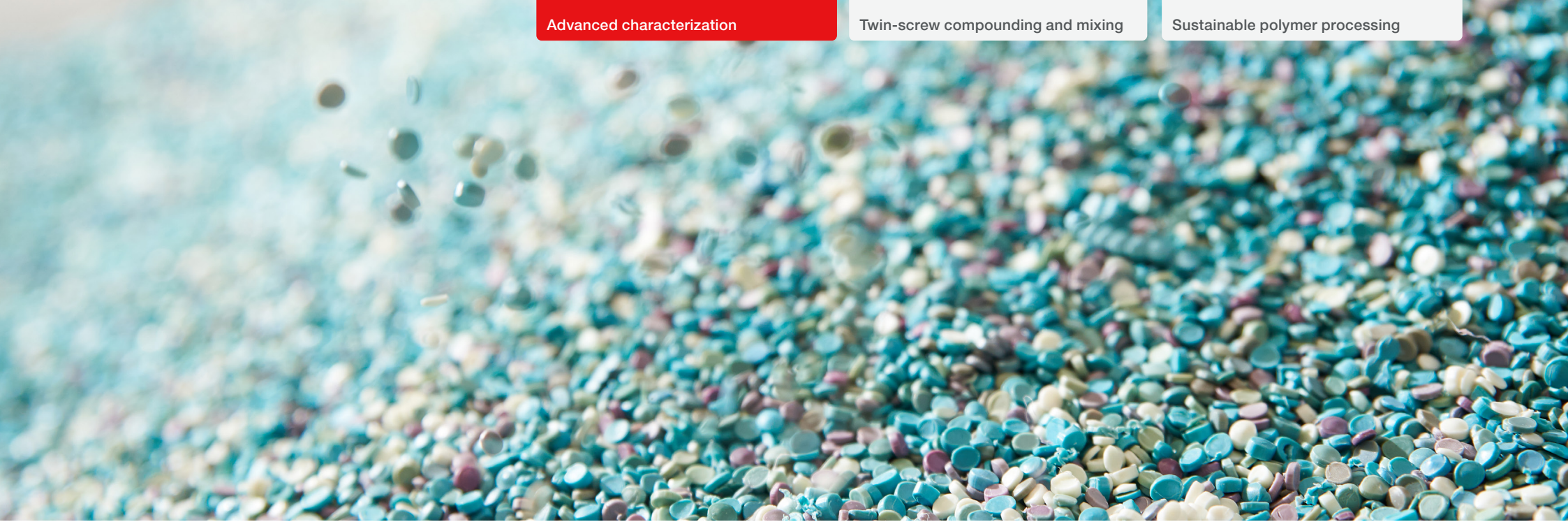
When materials perform unexpectedly on the production line, MFR often isn't enough to explain why. This paired set of application notes shows how extrusion capillary rheometry detects high-shear differences during processing, while rotational rheology reveals underlying viscoelastic properties, molecular weight distribution, and long-chain branching—giving you the tools to select materials with confidence.



[Read: Why materials with the same MFR can behave differently](#)



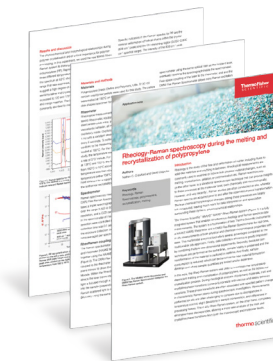
[Examining the rheological behavior of nearly identical LLDPE samples](#)



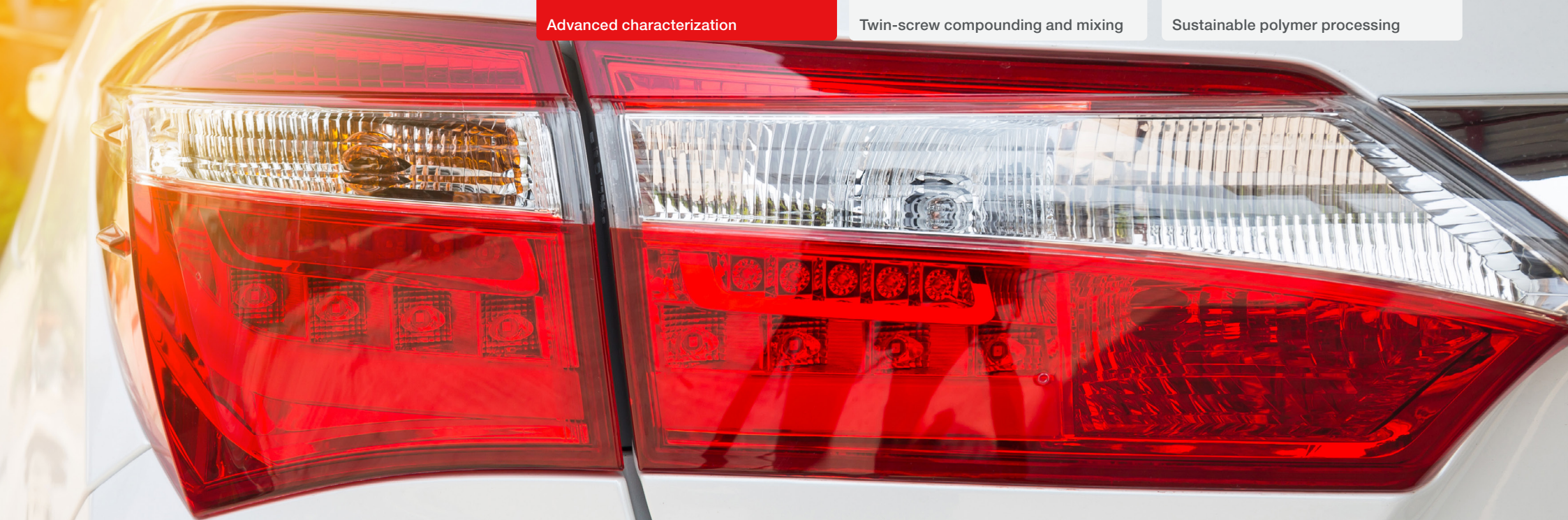
Revealing melting and recrystallization in polypropylene with rheology and Raman spectroscopy

Linking molecular structure to thermal and flow behavior in real time

See how simultaneous rheology and Raman spectroscopy provide direct insight into polypropylene's melting and recrystallization processes. This combined approach connects molecular-level changes with macroscopic material behavior—supporting better process understanding and optimization.



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Understanding polymer blend miscibility with DMTA

How dynamic mechanical thermal analysis reveals phase structure and glass transition behavior in PC/PMMA systems

Polymer blending enables tailored material performance—but phase structure determines success. This application note demonstrates how Dynamic Mechanical Thermal Analysis (DMTA) sensitively detects glass transition shifts, partial miscibility, and phase interactions in PC/PMMA systems.



[View application note](#)



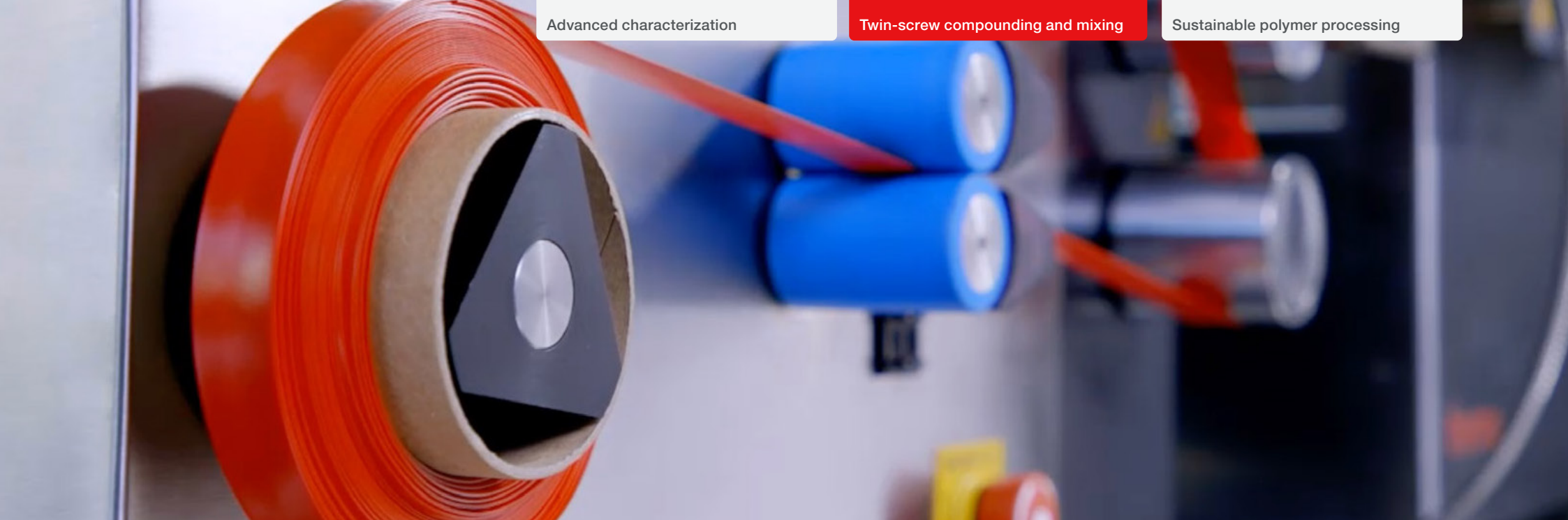
Key process parameters for twin-screw compounding

Optimizing screw configuration, throughput, and thermal management for consistent, high-quality compounding

Discover how critical variables—such as screw design, residence time, and temperature profile—influence mixing efficiency, dispersion, and product performance in twin-screw compounding. This application note provides practical guidance to help you understand, control, and optimize compounding conditions for a wide range of polymer formulations.



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Real-time monitoring of polymer extrusion using a process Raman analyzer integrated with a twin-screw extruder

What if you could observe what's happening inside your extruder as the material is processed?

This whitepaper shows how integrating a process Raman analyzer directly with a twin-screw extruder enables real-time, in-line monitoring of polymer composition, structural transitions, and material changeovers during extrusion.



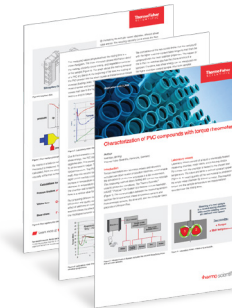
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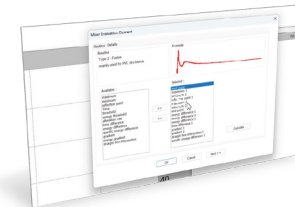
Characterizing PVC compounds using torque rheometry

How mixer and extruder rheology reveal processing behavior, viscosity, stability, and formulation effects in PVC dry blends

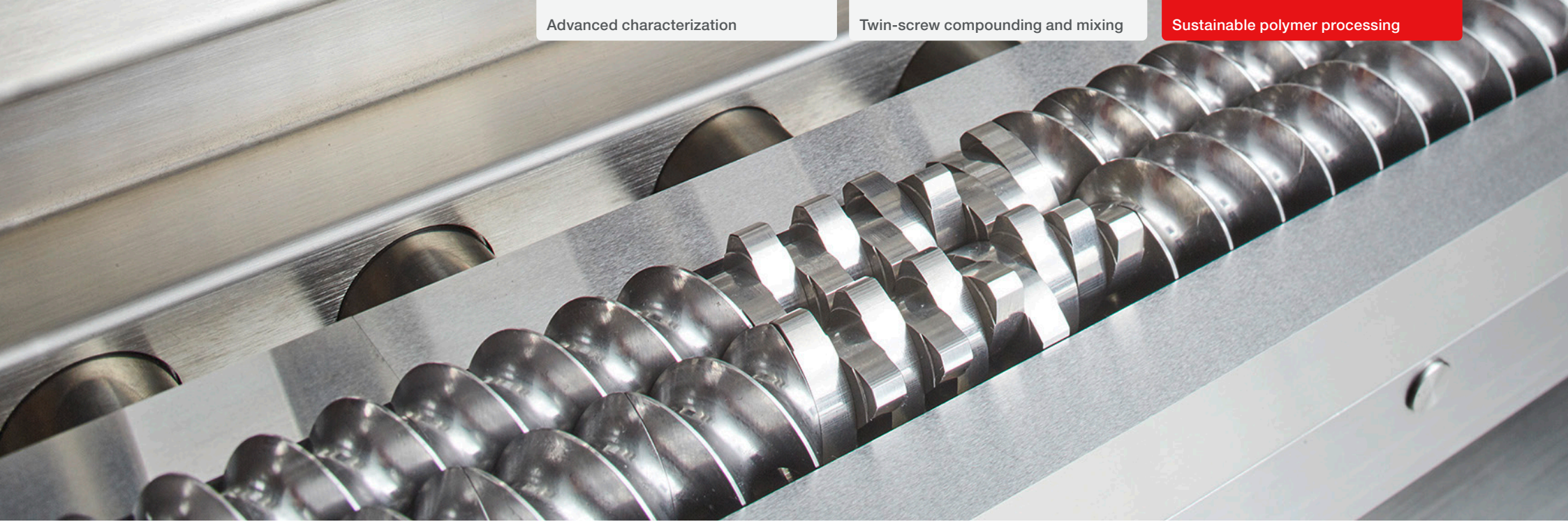
Discover theory and practical hands-on session how modern torque rheometers and laboratory extruders simulate real production conditions to test and compare PVC compounds. Discover how mixer rheograms and extruder pressure/viscosity measurements provide insight into melting, flow, cross-linking, and stability—allowing you to evaluate recipe variations, stabilizer effects, and rheological behavior to improve processing and product performance.



[View application note](#)



[View hands-on session: Mixer test with PVC dry blends](#)



Enabling sustainable polymer upcycling through reactive extrusion

How process innovation and molecular-level analysis are advancing circular plastics manufacturing

In this expert discussion, Lucivan Barros, PhD, and Ron Rubinovitz, PhD, both Senior Applications Scientists at Thermo Fisher Scientific, explore how reactive extrusion and advanced FTIR microscopy are enabling the upcycling of plastic waste into high-performance materials. Learn how combining innovative processing with molecular-level analysis supports a more circular and sustainable plastics economy.

Watch the discussion to see how process and analytical science are driving sustainable polymer innovation.



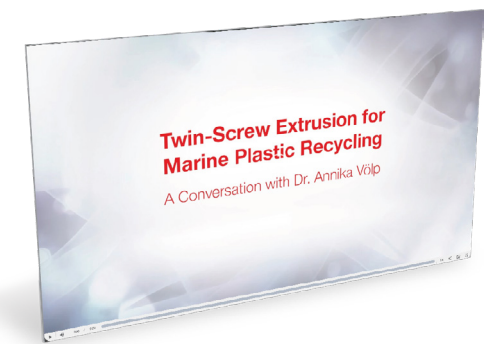
[Watch video](#)



Mechanical recycling of plastic waste

Can marine plastic waste be transformed into high-quality materials again?

Explore how advanced mechanical recycling and twin-screw compounding technologies enable the recovery and reprocessing of marine debris and degraded plastics. Comprehensive multi-analytical characterization evaluates the physical and thermal performance of recycled blends, benchmarking them against market-grade virgin materials. The results highlight the potential to reclaim and repurpose marine plastic waste—supporting more sustainable material solutions and expanding opportunities for environmental and industrial applications.



[Watch video](#)

Discuss your analytical and processing challenges with our specialists

Our fully equipped application laboratories support customers worldwide in testing samples and optimizing advanced polymer applications. Our team of application scientists and interdisciplinary specialists is ready to help you solve your analytical and processing challenges.

Contact us to arrange a consultation or application-focused demonstration at thermofisher.com/contact-mc

Polymer resources

Thermo Fisher Scientific delivers integrated analytical and processing solutions across the polymer value chain—from raw material development to recycling and scale-up. Our portfolio combines rheology, spectroscopy, X-ray diffraction, twin-screw extrusion, and web gauging technologies to optimize formulations, improve efficiency, and support data-driven decisions in R&D, QC, and manufacturing.

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