POLYMER CHARACTERIZATION & SUSTAINABILITY

From raw material suppliers to brand owners and end market users, there is a concerted shift towards tackling plastics waste and making plastics more sustainable. Whether you are incorporating recycled resins in existing processes or designing new polymers with end-of-life recycling in mind, answer key questions and unlock insights into your material properties with a comprehensive suite of analysis tools.

The Polymer Value Chain and Our Instruments

Raw Materials Suppliers

Monomer(s), Catalysts

HPLC:
(Im)purity

LCMS:
(Im)purity, elucidation/ confirmation, lower levels (ppm)

High-Pressure Thermogravimetric Analyzers:
Catalyst activation/ deactivation

TGA-EGA:
Catalyst yield and kinetics

Polymer Manufacturers

Resin Production

SEC (APC):
MW Distribution

Differential Scanning Calorimeters:
Phase Transitions, Heat Capacity

Thermogravimetric Analyzers:
Thermal stability, degradation

Rheology:
Processability

Dynamic Mechanical Analysis:
Mechanical Properties

Load Frames:
Material strength, Final Assembly Strength

Compounder/ Masterbatchers

Additive Research & Formulation

LC(MS):
Additives characterization

Differential Scanning Calorimeters:
Phase Transitions, Thermal Stability

Thermogravimetric Analyzers:
Thermal Stability, Composition determination

Rheology:
Processability

Dynamic Mechanical Analysis:
Mechanical Properties

Converters

Injection/ Blow Molding, Extrusion

Dynamic Mechanical Analysis:
Mechanical Properties at temperature/humidity, Blend Compatibility

Differential Scanning Calorimeters:
Thermal Stability, Crystallinity

Thermogravimetric Analyzers:
Thermal Stability, Composition determination

Rheology:
Processability, Melt strength

End Market

Components, Final Product

Load Frames:
Material strength, Final Assembly Strength

Dynamic Mechanical Analysis:
Mechanical Properties at temperature, humidity

Differential Scanning Calorimeters:
Thermal Stability, Crystallinity

Thermogravimetric Analyzers:
Thermal Stability

High Resolution Mass Spectrometry:
Non Intentionally added substances, Migrants: Extractables & Leachables

End-of-Life Recycling

Mechanical, Chemical/ Advanced

Differential Scanning Calorimeters:
Polymer Identification through phase transitions

TGA/EGA:
Decomposition Analysis, Catalyst yield and kinetics (Pyrolysis)

High-Pressure TGA:
Pyrolysis - Catalyst activation/deactivation

Rheology:
Processability of Post Consumer Recycled (PCR) resin

Dynamic Mechanical Analysis:
Mechanical Properties of products with PCR

Load Frames:
Material strength and Final Assembly Strength with PCR

High Resolution Mass Spectrometry:
Non Intentionally added substances, Migrants: Extractables & Leachables

Polymer Processing

Answer Key Questions With Analytical Testing

Heat to Melt (Soften the Resin)

Common thermoplastic processing techniques, like extrusion, injection molding, and blow molding, require the resin to be heated above the melting point for easy processing. For thermoforming and blow molding, the resin is heated above its glass transition temperature to soften it, without completely melting it. During this stage, it is important to carefully control the processing temperatures to avoid resin degradation that can occur at elevated temperatures.

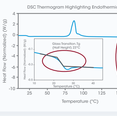
What is the processing temperature for this resin?

Feedstock evaluation
Is this a neat polymer, or is it a blend? Can vendor A's resin be replaced with lower-cost resin from vendor B?

After Processing
Is there a thermal history after processing vs. as-received? (1st vs. 2nd heat)

Processing
How much thermal energy is needed to completely melt the resin pellets?

End-of-life
Does this batch of PCR (post-consumer resin) have significant contamination from other polymers?



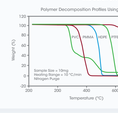
How does this resin decompose?

Feedstock evaluation
At what temperature does this resin decompose? What is the decomposition profile?

Failure Analysis
Is there a difference in the filler content or the decomposition profiles of the good vs. bad parts?

Processing
Are there volatile materials in this batch of resin? Will there be off-gassing after processing?

End-of-life
During pyrolysis, at what temperature does the maximum weight loss occur? What contaminants are presents in this batch of recycled resin?



Deform Into the Final Shape

In the next stage of thermoplastics processing, the melted polymer is deformed into the desired shape for the final product. Here, viscosity quantifies the material's internal resistance to flow. During injection molding, resins with higher viscosity flow slower and take more time to fill the mold, increasing the cycle time and introducing the possibility of defects like short shots. For blow molding, extensional viscosity measurements are correlated with melt strength and bubble stability.

Is the resin's viscosity suitable for processing?

Feedstock evaluation
How is the viscoelastic profile affected by batch-to-batch changes in the resin's Molecular Weight/ Molecular Weight Distribution?

Processability
Does the resin have the right viscosity at all shear rates relevant to the manufacturing process?

End-of-life
How do contamination and MW variation in the recycled resin impact processing?

Is this resin suitable for blow molding?

Processability
What is the melt strength of this resin? How much stretching can the bubble withstand before it breaks?

End-of-life
Do the processing parameters need to change for this batch with recycled resins?

What additives are needed to process this batch of recycled resins into a film? (e.g., chain extenders)

Cool the Molded Product and Release

After the part has been molded or blown into the desired shape, it is cooled to freeze the shape. At this stage, semi-crystalline polymers can form locally ordered, crystalline regions depending on the process conditions. Crystallinity confers desirable end-use properties such as increased strength, wear performance, and chemical resistance. However, it is important to carefully control the process and measure crystallinity since high levels can increase brittleness, reduced optical clarity, or introduce shrinkage defects.

How do process conditions affect the product's crystallinity?

Processing
What cooling rates are needed to achieve the required crystallinity?

Are nucleating agents needed?

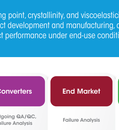
End-of-life
How can the crystallinity of products made with PCR be matched with those from virgin materials?

How does the product perform?

Processing
Was this batch of resins blended uniformly to achieve miscibility?

Product Performance
Does this product have the right mechanical strength/ stiffness for the intended end-use environmental conditions (temperature, relative humidity)?

End-of-life
Do products produced with recycle resin match the mechanical properties of those made with virgin resins?



Polymer Characterization From R&D to QA/QC

Measure process-relevant fundamental polymer properties such as melting point, crystallinity, and viscoelasticity with thermal analysis, rheology and mechanical testing. At every stage of product development and manufacturing, accurate measurements enable you to optimize processing and improve product performance under end-use conditions.

Technique	Polymer Manufacturers R&D, Outgoing QA/QC, Failure Analysis	Compounders/ Masterbatchers Incoming QA/QC, R&D, Outgoing QA/QC	Converters Outgoing QA/QC, Failure Analysis	End Market Failure Analysis	End-of-Life Recycling Outgoing & Incoming QA/QC of PCR
Differential Scanning Calorimetry (DSC)	●●●	●●●	●●○	●●○	●●●
Thermogravimetric Analysis (TGA)	●●●	●●●	●●○	●●○	●●●
Thermogravimetric Analysis EGA (TGA-EGA)	●●○	●○○	●●●	●●○	●●●
Rheology	●●●	●●●	●●○	●○○	●●●
Dynamic Mechanical Analysis (DMA)	●●●	●●●	●●○	●●●	●●○
Mechanical Testing	●●●	●○○	●●●	●●●	●●●
Thermomechanical Analysis (TMA)	●●○	●○○	●●●	●●●	●●○

Most Relevant ●●● ●●○ ●○○ Least Relevant

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