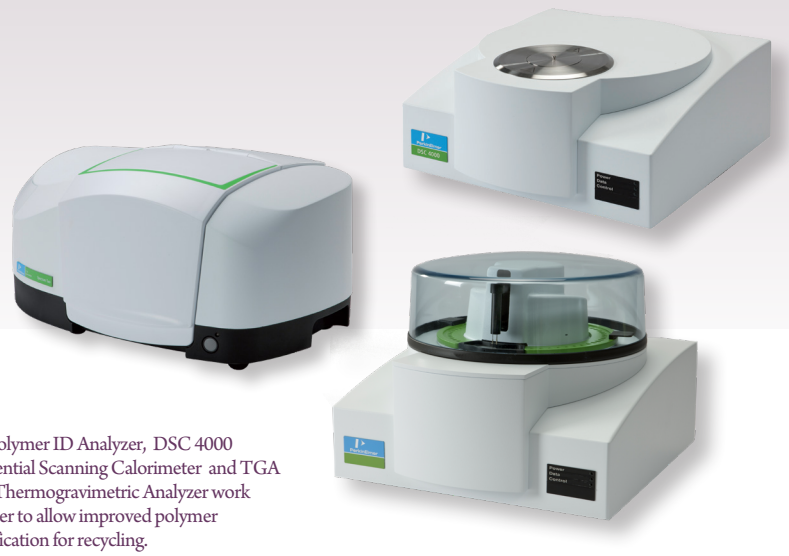
PRODUCT NOTE

Thermal Analysis
FT-IR Spectrometry



The Polymer ID Analyzer, DSC 4000 Differential Scanning Calorimeter and TGA 4000 Thermogravimetric Analyzer work together to allow improved polymer identification for recycling.

Polymer Recycling Package

Introduction

Plastics are inexpensive, easy to mold, and lightweight. These and various other attributes make plastics a popular choice for a multitude of commercial applications.

Plastic recycling reduces environmental problems caused by polymeric waste accumulation generated from daily usage of polymer materials in packaging and construction. Increased recycling will lead to a decrease in oil consumption and green-house gas emissions, as well as a reduction in the use of other valuable natural resources.

Polymer and plastics recycling is a rapidly growing industry, fueled by the increasing consumption of goods and the associated increase in landfill waste. The increasing quantities of material are creating challenges for this industry, since it is crucial to get materials with similar properties then feedstock out of the recycling process. Also contaminations causing issues for the next processing steps. Regulatory pressure regarding recycled material has brought to light the challenges associated with the sorting and recycling processes of these materials. Global (or multinational) companies struggle to realize recycling commitments as they are faced with the dilemma of sorting materials and meeting quality control requirements.

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In general, there are two major approaches of plastic recycling processes:

- Mechanical recycling which refers to operations that aim to recover plastics waste via mechanical processes (i.e. grinding, washing, separating, drying, re-granulating and compounding). In mechanical recycling, polymers stay intact, permitting multiple re-uses of materials in the same or similar product — effectively creating a closed loop.
- Chemical recycling a term generally used to describe innovative technologies where post-consumer plastic waste is converted into valuable chemicals, to be used as feedstock by the chemical industry. These technologies include pyrolysis, gasification, chemical depolymerization, catalytic cracking and reforming, and hydrogenation. With chemical recycling, plastic waste is converted into feedstock, i.e. monomers, oligomers and higher hydrocarbons that can be used to produce virgin-like polymers to create new plastic materials.

Plastic recyclers need to segregate plastics waste and produce a polymer granulate to be used by plastic processors (converters and compounders). In the past recycled polymers have been added to lower value products, obviating quality concerns. The demand to incorporate recycled material into new products has changed this, and requirements for quality controls are rapidly growing. For example, cosmetic and food companies committed to 100% recycled packaging requiring uniform high-quality polymers for their PP/PE bottles; product quality is of the utmost importance.

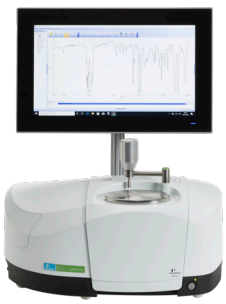
The PerkinElmer Recycling Packages make use of the most commonly used techniques for material characterization. Material identification and characterization can be performed throughout the entire recycling process allowing for an in-depth understanding of the materials from start to finish. These include techniques for:

- Raw Materials Identification
- Polymer/Material Characterisation
- Mechanical and Thermal Characterisation

Additionally, the Recycling packages support the Plastic Identification Codes (PIC), used worldwide for packaging applications. The PIC was introduced by the Society of the Plastics Industry, Inc., to provide a uniform system for the identification of various polymer types and to help recycling companies separate various plastics for reprocessing.

The chemical identification of the polymer can be easily performed using the PerkinElmer Polymer ID Analyzer see Figure 1.

Spectroscopic chemical identification alone is not always sufficient for polymer classification. For example, Codes 2 and 4 are chemically the same polymer, high density and low density polyethylene, respectively, and therefore have identical infrared spectra as shown in Figure 2. To differentiate between these two identical polymers, thermal analysis is a complementary technique which helps to get a better understanding of the material properties.



PerkinElmer Polymer ID Analyzer

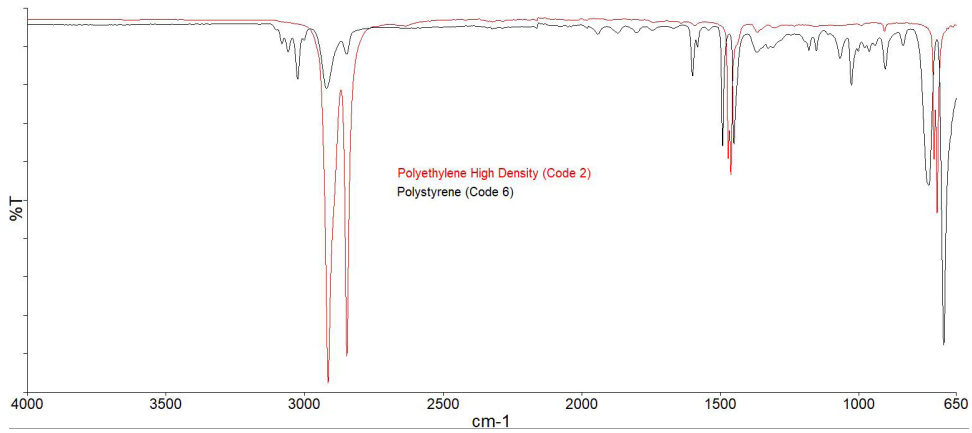


Figure 1. Overlay of polyethylene (PE) and polystyrene (PS) spectra in the FT-IR . FT-IR is a fast and accurate way to detect chemical differences in polymers.

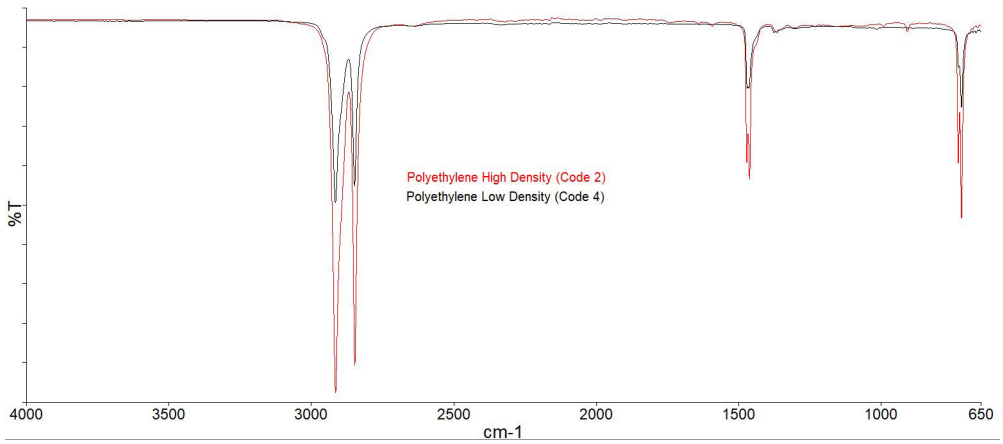


Figure 2. Overlaying Code 2 and 4, both polyethylenes, show very similar FT-IR spectra. Other methods are needed to see the differences.

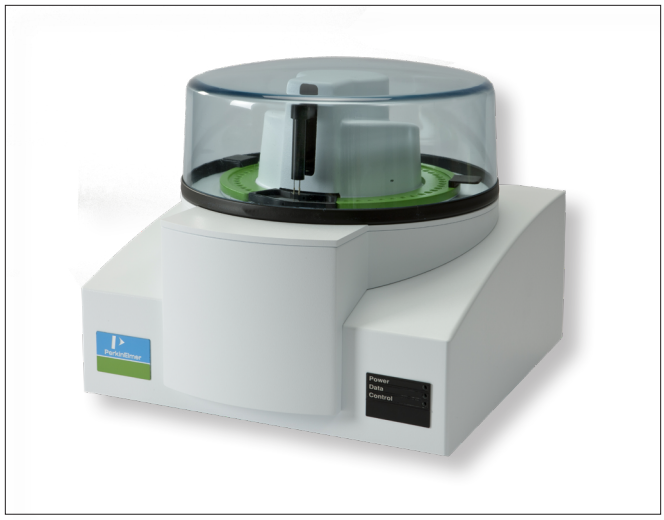


Figure 3. TGA4000 Thermogravimetric Analyzer.

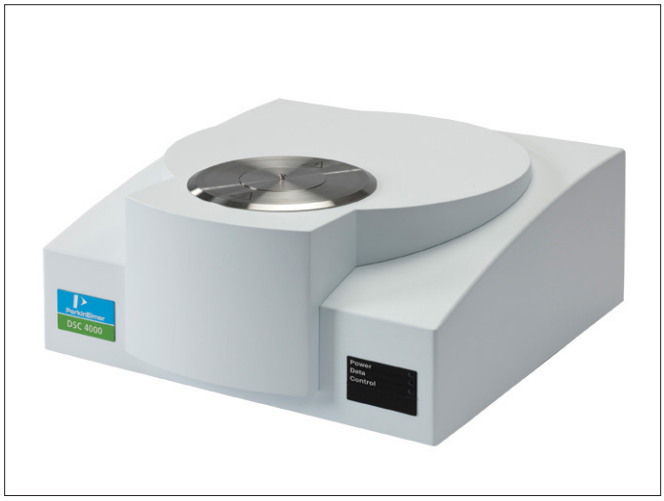


Figure 4. DSC4000 Differential Scanning Calorimeter.

Differential Scanning Calorimetry (DSC) Figure 4 can be used to identify the difference between LDPE and HDPE by analyzing the temperature of the materials phase transition (Figure 5). The temperature at which LDPE melts is about 15 degrees lower than that of HDPE even though these two materials are spectroscopically the same. Not only can DSC be used to identify the correct form of a polymer, it can also determine if a finished product contains a physical mixture of polymers and in some case, the amount of each component. For example, Figure 6 shows the DSC curve for a thin multilayer film where the weight percent of HDPE is estimated to be between 12-14%.

Additionally, the amount of fillers used in materials, such as glass fibers, calcium carbonate, talc, etc., can be detected using Thermogravimetric Analysis (TGA) Figure 3. Within the compendium library, files are provided to demonstrate how one can use TGA to determine the amount of filler in a polymer (Figure 7).

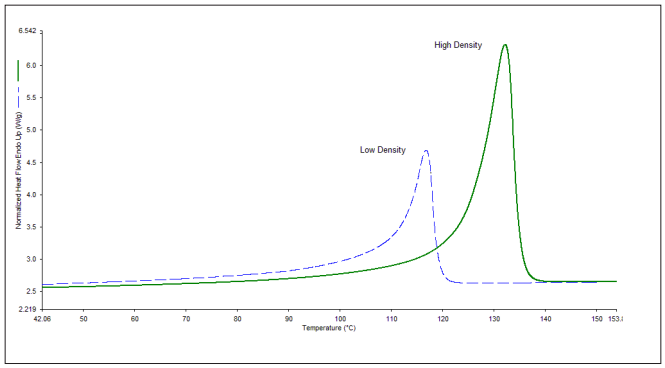


Figure 5. DSC curve of plastics Code 2 and 4 showing significant temperature difference in heat flow between the two grades (codes).

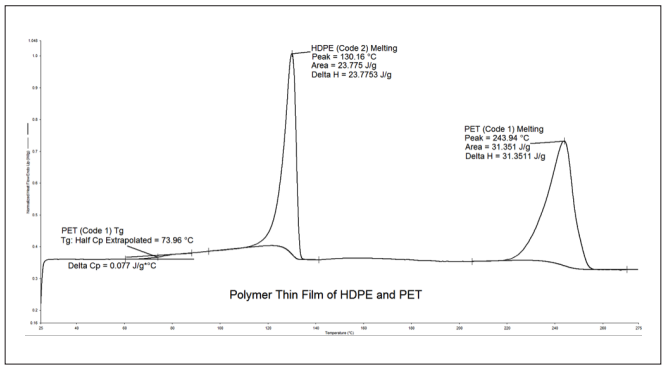


Figure 6. Thin film analysis by DSC, detecting the presence of two polymers within the sample.

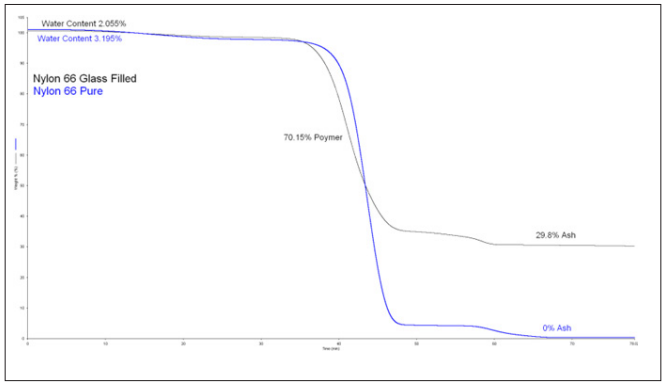


Figure 7. TGA weight loss curve for the detection of filler in Nylon 66.

The Polymer Recycling Package is available in three different configurations:

IR Recycling Package

- Polymer ID Analyzer, a comprehensive Fourier Transform Infrared (FT-IR) polymer analysis system that helps you quickly and accurately identify unknown polymer samples, determine the composition of polymer blends, and verify quality of raw materials
- Polymer Recycling Resource Pack

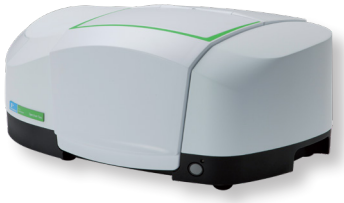
DSC Recycling Package

- DSC4000 Autosampler System, a compact workhorse that performs like a champion. It's the single-furnace solution you can depend on for a wide range of routine and traditional materials characterization research applications. DSC application include the determination of melting point, glass transition, and crystallization. It's also used to differentiate the type of polymer or analyze mixtures. Not only is the DSC 4000 consistent, reliable and easy-to-use, it's also upgradeable to meet your laboratory's future needs
- Polymer Recycling Resource Pack
- Chiller
- Crimper Press
- Set of Aluminum Sample Pans

TGA Recycling Package

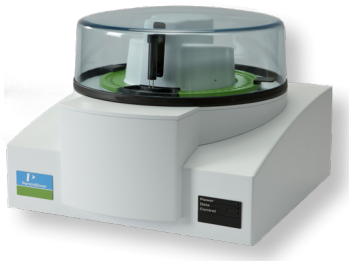
- TGA 4000 Autosampler System provides valuable information that can be used to select materials for certain end-use applications, predict product performance, and improve product quality. The technology quantifies the weight change of a sample in dependence of temperature, atmosphere, and time. It's used in laboratories to perform thermal stability testing; to understand the impact of flame retardants, filler, or volatile content; and for product-failure and oxidative-stability analysis.
- Polymer Recycling Resource Pack
- Chiller
- Set of Ceramic Sample Pans

The Polymer Recycling Resource Pack includes a polymer compendium which provides methods to identify the various grades or codes used in recycling, common problems encountered with data interpretation, and three libraries; one each for FT-IR, DSC, and TGA. The compendium is helpful to chemically identify the material and get more precise information on the quality or state of the material.



Polymer ID Analyzer

DSC 4000 Differential Scanning Calorimeter



TGA4000 Thermogravimetric Analyzer

The Polymer Compendium

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