

Identifying Plastics for Recycling with a Hand-Held Instrument

APPLICATION NOTE



Introduction

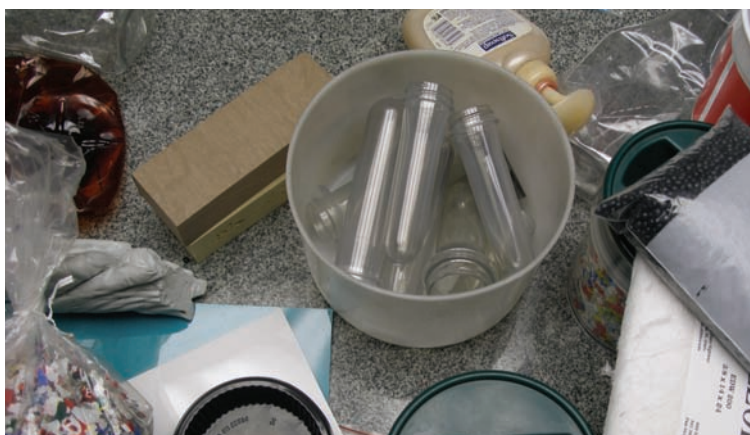
Cost-effective recycling – getting the most money for scrap – requires that materials be rapidly and positively identified so that they can be processed appropriately. The Anavo™ Analyzer material identification system was developed for the rapid identification of materials in industrial environments. For routine use the operator simply places the analyzer against the material to be identified, presses the trigger and the identity of the material is displayed on the on-board display in less than one second. The system comes with an on-board model for identification of 15 common plastic materials and additional materials can be added to the library.

Carpets and Plastics

The Anavo™ was developed in partnership with leaders in the carpet recycling industry to meet their need for rapid identification of post consumer and post industrial carpet. The system as used for this application is effectively a polymer identification analyzer. It is estimated that around 2.5 million tons of waste carpet is sent to landfills in the United States each year, while less than 5% is recycled.¹ Carpet waste includes polymers such as PET (polyethylene terephthalate), PP (polypropylene), Nylon 6, Nylon 6,6 and also wool; these can be recycled profitably if the facility is able to quickly and cost-effectively identify and separate carpet fibers containing the different face fiber polymers. In recent years, many outlets have been developed for recycled carpet fibers; for instance, polypropylene is used in leachfield drainage chambers² as well as ‘plastic lumber’ products like fence posts, decking and railroad ties³, while Nylon 6 may be depolymerized back to caprolactam.¹ Carpet recycling, therefore, has multiple benefits: less material in landfills, lower consumption of petroleum feedstocks, and lower cost resins needed for economically-viable production of industrial and consumer products.⁴

Post-industrial plastic scrap can include runners and sprues from injection molding, trim, product overruns, and quality rejects. Extrusion processes generate scrap in the form of fiber, sheet, film and process scrap: blocks of extrudate at the beginning and end of a run. Post-industrial scrap might be homogeneous and relatively clean, but not clearly identified by polymer type.

Post-consumer plastic scrap includes end-of-life electronics (personal computers, copiers, ink and toner cartridges, phones, etc.), automotive parts, as well as materials gathered through corporate recycling contracts. These span a wider range of materials, and can include high-value engineering thermoplastics like



PC (polycarbonate), ABS (acrylonitrile-butadiene-styrene), polystyrene, acetal and nylons. These finished goods are not likely to be labeled for polymer type, and might comprise unique blends and fillers.

Near-Infrared Spectroscopy

All organic materials absorb and reflect light in the near-infrared (NIR) region of the spectrum, and the particular pattern of reflectance, how much at each wavelength, is that material's spectrum. The NIR spectrum gives us a chemical ‘fingerprint’ of that material, and this fingerprint can be used to positively identify it. Near-infrared light is harmless – it's all around us – and therefore completely safe and non-destructive. Some examples of these ‘fingerprints’ for carpet fibers are shown in Figure 1

While NIR spectroscopy is an ideal identification technique, traditional NIR spectrometers are quite large and delicate, typically 2-foot square beige boxes, run from a PC, and are designed to be used in vibration-free and environmentally controlled situations, such as a laboratory. As a laboratory instrument, their cost is also typically beyond what a recycling operation would be able to afford. However, new technology, adapted from instruments developed for telecommunications, has simultaneously reduced the size of these instruments, and made them both portable and rugged

Carpet Recycling

The Anavo Carpet Analyzer is specifically designed for fiber recycling, and is targeted at PP, PET, Nylon 6, Nylon 6,6 and wool. The on-board database includes the spectra of the fibers that are commonly used in carpeting, in a wide variety of physical forms and colors, and the operator can add spectra of other materials if desired. This flexibility ensures that the system will continue to meet the requirements of the facility as new materials are encountered. Blends are reported as 'unknown', because these materials will contaminate a pure recycling stream. The color of the carpet does not affect the measurement, and wet, oily and dirty carpets have all been identified successfully.

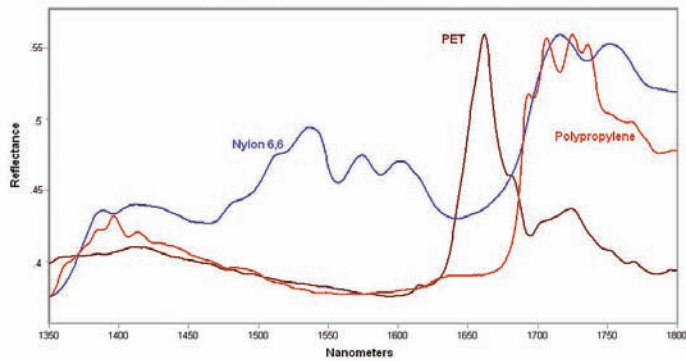


Figure 1. The near-infrared spectra of polypropylene (PP), polyethylene terephthalate (PET) and Nylon 66 (N66) carpet fibers demonstrate clear spectroscopic differences between these materials, and thus the ability to identify them using a hand-held spectrometer.

A Hand-Held Identifier

The new Axsun Anavo™ Analyzer (Axsun Technologies, Billerica, MA), which is shown in Figure 2, is a self-contained, hand-held NIR spectrometer. It collects the spectrum of a sample in a single second, and compares it with an on-board database to provide a positive identification. The spectrometer is sealed into a rugged enclosure, and is specifically designed for use in the physically challenging environment of a recycling facility, which can be hot, humid and dusty. The Anavo Analyzer is battery-powered, dustproof, and designed to withstand a 3-foot drop onto a concrete floor; one of these instruments has already survived a trip through a carpet baling machine. Ease of use is accomplished by automatic calibration and standardization, performed when the Anavo Analyzer is turned on. Unlike many other instruments, the Anavo Analyzer does not require routine maintenance or periodic replacement of a light source.



Figure 2. Axsun Anavo™ NIR Analyzer

The Anavo is powered by a commercially-available rechargeable battery which can provide service for greater than four hours. If desired, it can also be operated using line power; this configuration makes this analyzer extremely useful as part of an on-line testing system. When it is used for portable or on-line measurements, data can be sent to an external logger or spreadsheet application, via a wired or wireless connection.



Figure 3. To identify materials, the Anavo is pressed up against the sample, and an answer is given in less than one second.

The operation of the Anavo is straightforward, as shown in Figure 3; the operator simply holds the sample in front of its sampling window and presses a trigger to initiate the measurement; the data collection process and analysis is automatic. If a match is made, the corresponding light on the analyzer will be lit within one second, and the name of the material is announced in the local language through an on-board speaker, or to an ear-piece.

Plastics Recycling

In plastics recycling, a much wider variety of materials are encountered. Axsun's general purpose Material Analyzer operates in exactly the same way, but can identify hundreds of materials, showing the results on its built-in display. The physical form of the plastic does not matter; the Anavo can obtain its spectral fingerprints from rigid materials, sheets, film, flake and pellets, for example. A filler like talc also has a 'fingerprint', and Figure 4 shows the spectra of two grades of polypropylene, one of which has 30% talc content. The talc shows up as a sharp feature around 1390nm, enabling these two grades to be clearly separated.

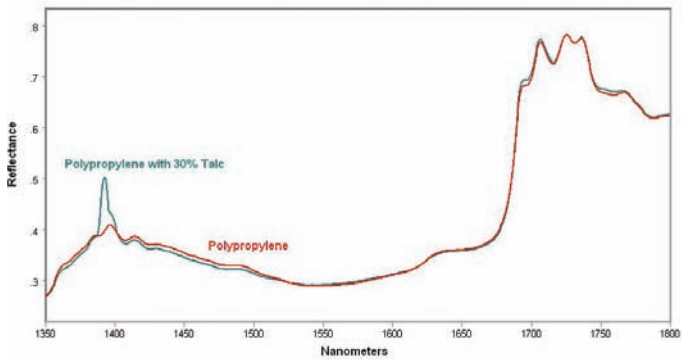


Figure 4. Near-infrared spectroscopy clearly detects fillers like talc

Biodegradable materials like PLA (polylactic acid) and PHA/PHB (polyhydroxyalkanoate) are also identified. Today, these both fall under Resin Code 7 ("other"), but ironically PLA is a particular problem in recycling if it not sorted properly. PLA is used in some brands of disposable tableware (e.g., transparent drinking cups), and is visually indistinguishable from PET, but easily identified by the Anavo™ (Figure 5). However, it will cause significant problems if it is mixed in with a PET stream to be recycled, because PLA has a significantly lower melting point.

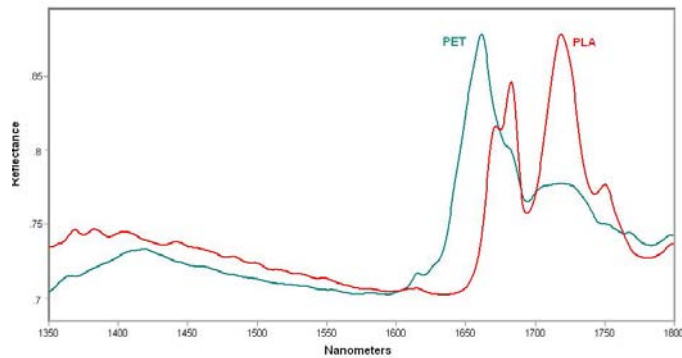


Figure 5. PET and PLA drinking cups are physically very similar, but they are readily distinguished by near-infrared spectroscopy.

Engineering resins used in electronic equipment (personal computers, monitors, copiers, etc.) may contain flame retardant additives, and these can pose a problem in recycling, depending on the particular additives used. Additives can include organophosphates, hydrated minerals (such as magnesium and aluminum

Common materials identified by the Anavo™

Polypropylene

PET

Polyethylene

Nylon

Polycarbonate

ABS

PC-ABS

Polystyrene

PVC

Polyurethane

Polysulfone

Others

(continued)

hydroxides), and halogenated organics (such as PBDPEs, polybrominated diphenyl ethers). Figure 6 shows that there are significant spectroscopic differences between ABS (acrylonitrile-butadiene-styrene) resins with and without flame retardant additives.

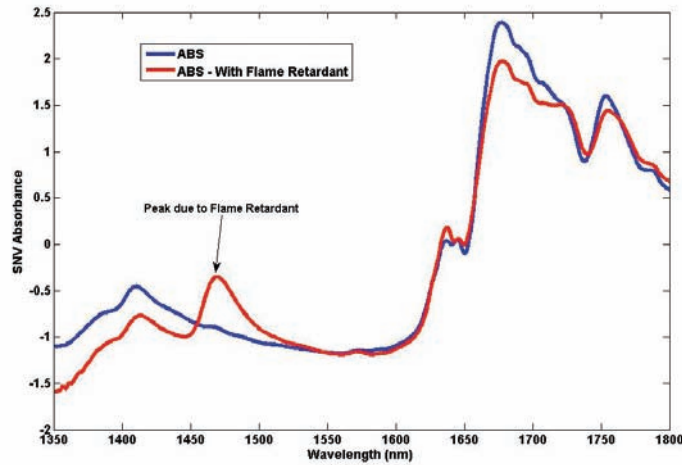


Figure 6. Axsun Anavo™ NIR Analyzer

Conclusions

In conclusion, Axsun's Anavo is a rugged, portable analyzer that can quickly and accurately identify different fibers and plastics, enabling high-value materials to be separated and recycled efficiently. Typical figures are that clean, well-characterized, recycled material can command up to 75% of the price of virgin resin, whereas ground mixed flake may sell for less than 10% of that. Those higher prices can be attained for recycled carpet fibers and post-industrial plastics, and some customers have reported payback on the system cost in as little as 2-3 months.

1. Michael McCoy, "Finding New Life For Old Carpets", *Chemical & Engineering News*, 84 (43) 33-38 (2006).
2. For more information on these products, see the Infiltrator Systems web site, www.infiltratorsystems.com/
3. Prabhat Krishnaswamy and Richard Lampo, "Recycled-Plastic Lumber Standards: From Waste Plastics to Markets for Plastic Lumber Bridges", *ASTM Standardization News*, December 2001.
4. For more information on carpet recycling, see the Carpet America Recovery Effort web site, www.carpetrecovery.org

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