Mid infrared acousto-optical tunable filter-spectrometer for rapid identification of black plastics from automobile construction

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Black plastics are common compounds of many technical devices and consumer goods. A well known example is the usage in automobile construction. Plastic recycling is gaining more and more importance, with fast plastic type identification being an essential question. This article presents a cost-effective and rugged alternative to FT-IR techniques, based on an acousto-optical tunable filter spectrometer, which is able to master the special difficulties in the recognition of black plastics.

Keywords: Black plastics, identification, remote, AOTF, infrared, spectroscopy.

The recycling of plastics is gaining more and more importance. The separation of different polymer types is crucial for the production of high quality recycling resins. This is the reason why great efforts are undertaken to develop economical separation or identification methods. It has been shown that polymers used in electronic devices can be identified by near infrared (NIR) spectroscopy. With black plastics the problem exists that NIR light (0.7–2.5 μm) is strongly absorbed by electronic resonances of the colorant (carbon black). The application of mid infrared spectroscopy (MIR) in the spectral fingerprint region (2.5–20 μm) suffers from noise generated by the thermal background. However, it can be demonstrated that the restriction to the wavelength region between 2.5 and 4 μm, where the fundamentals of the CH– and NH–stretching vibrations are observed, is sufficient for a reliable distinction of the major types of (blackened) technical plastics. To provide a rugged and cost-effective alternative to the FT-technique often applied to this task, an MIR spectrometer with an Acousto-Optical Tunable Filter (AOTF) as a wavelength selecting device and a new type of peltier cooled Mercurium Cadmium Telluride (MCT) detector has been devel-

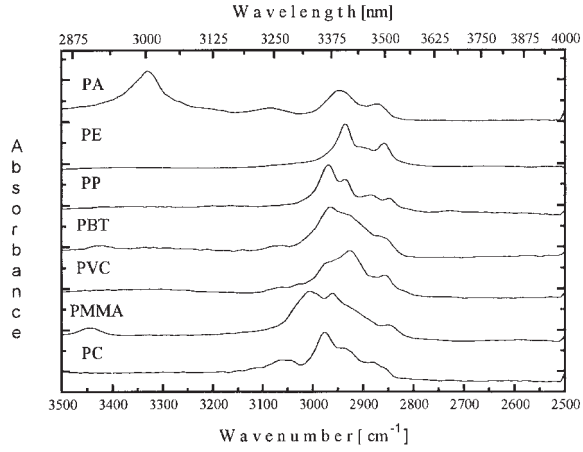

Figure 1. Spectra of some polymers used in automobile construction.

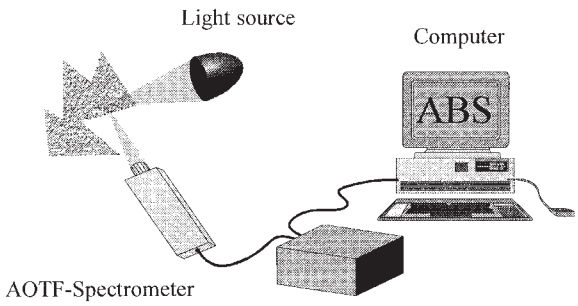

Figure 2. Basic system setup.

oped. In Figure 1 spectra of (blackened) plastics used in automobile construction are shown, which were obtained with the new spectrometer.

Of course, the spectrometer is not restricted to black plastics only; it is also applicable for the identification of different types of polymers used for electronic devices. Since spectra can be taken within less than one second, the system can manage high throughputs of, for example, electronic waste. The basic set-up of the system is shown in Figure 2.

Results and discussion

Plastics often applied in automobile construction are Acrylonitrilebutadiene (ABS), Polyamide (PA), Polybutyleneterephtalate (PBT), Polyethylene (PE) and Polypropylene (PP). Figure 4 shows spectra of these polymers. Differences between the polymer spectra become visible after derivating the spectra as shown in Figure 4.

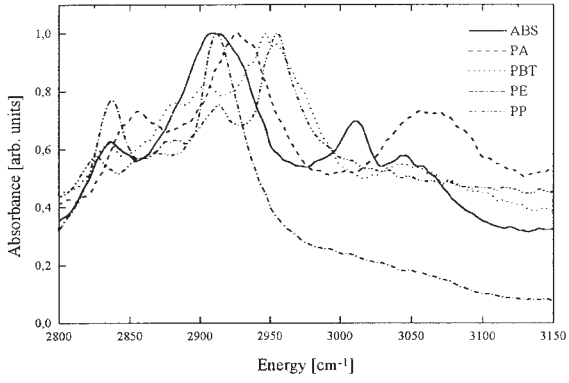

Figure 3. Spectra of polymeres ABS, PA, PBT, PE and PP.

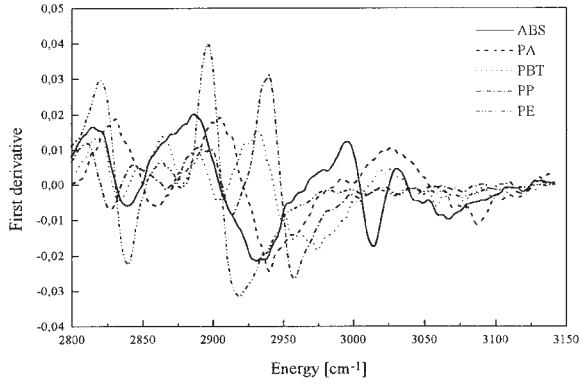

Figure 4. First derivative spectra of the polymers shown in Figure 3.

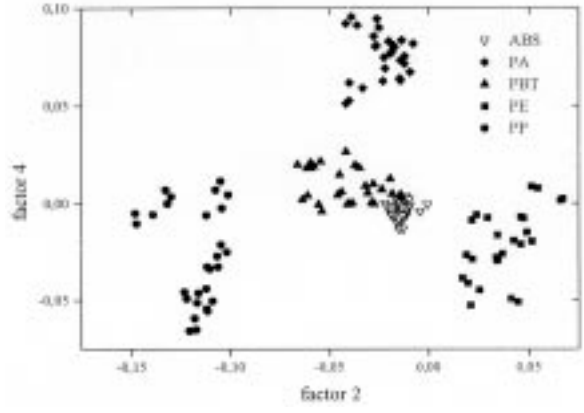

Figure 5. Clusterplot of preprocessed spectra of 147 samples.

Figure 5 shows the result of a Principal Component Analysis (PCA) of spectra of different polymer types after pre-processing (ddifferentiating, scaling, smoothing). A good distinction between the clusters is already observed in only two dimensions. The automated separation of these clusters is possible by applying neural networks as identification algorithm (we use a FuzzyARTMAP classificator).

Conclusion

The MIR-AOTF-spectrometer provides a fast identification of different types of blackened plastics and also polymers used in electronic devices. The system can be applied to contact-free on-line measurement or used as a handheld device. There is no restriction to the polymers described here; since we use neural networks other polymers can easily be trained and then recognised. Another positive aspect for industrial use is the absence of moving parts, so the spectrometer is mechanically very robust.