SPECIM
SPECTRAL IMAGING

PLASTICS SORTING
WITH SPECIM FX CAMERAS

Plastics are all around us, but what really happens to them after we throw them in recycling bins? Large quantities end their life in a landfill or incinerators, never being recycled at all.

Only a small portion of plastics have value to the recycling industry, but it is costly and time-consuming to separate these high-value materials.

Labeling plastics resins for macro identification (see Fig.1 below), but this is not useful when breaking the materials into parts or when the labeling is inaccurate. In these cases, sorting is incorrect or impossible by hand, color visualization, or advanced AI and machine learning techniques.

Our environment would benefit significantly from a process that could safely, quickly, and cleanly separate materials to increase the recycled volume. In addition to preserving the resources required to generate new plastics, better sorting processes can also reduce visual and hazardous chemical pollution in the atmosphere.

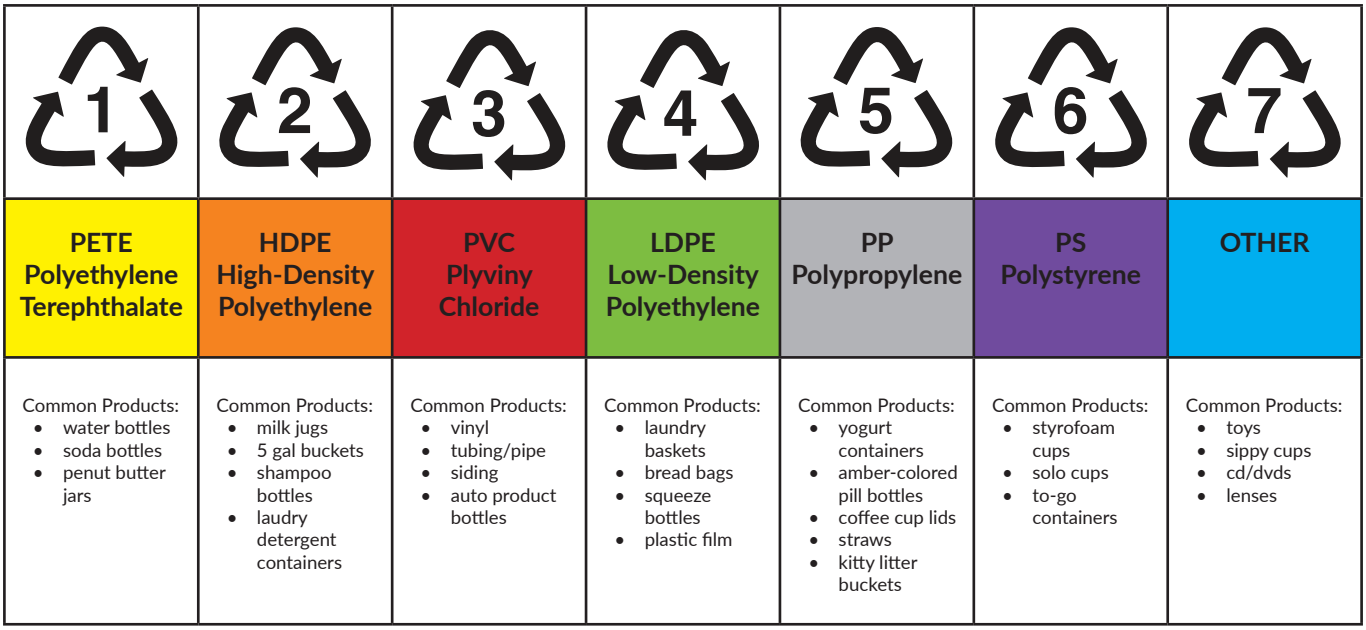

Figure 1: plastics labelling and code number.

Hyperspectral imaging relies on plastic resins' chemical composition and has been more widely used by the recycling industry in recent years. The capability of hyperspectral cameras to sort plastics is not new. However, some limitations prevented this technology from being implemented by the plastic recycling industry worldwide:

- HSI cameras were slow, which means the return of investment was long.
- Black plastics could not be sorted with spectroscopic methods.
- Cameras were prohibitively expensive.

With the Specim FX series hyperspectral cameras, we've broken these hurdles, and new applications have risen. The FX cameras are fast, affordable, and cover an extensive spectral range. Specim is the only hyperspectral camera manufacturer dedicated to covering the full spectral range of 400 – 5200 nm for the industry. Specim FX10 covers the spectral range of 400 – 1000 nm, Specim FX17 covers 900 – 1700 nm, the SWIR camera covers 1000 – 2500 nm, and the Specim FX50 2700 – 5200 nm.

Specim is the global leader in hyperspectral imaging, especially for the recycling industry, with many FX series cameras used in recycling plants for sorting different types of plastics.

We have done extensive studies for many plastic sample types across the complete spectral range offered. We can confidently recommend the best camera solution based on the plastic-type or application of the end-user.

Our studies included measurement, analysis, and classification of samples of PE, ABS, PVC, PS, PA, PP, PC, and PET. Those are the most commonly recycled plastics (and labeled as in Fig.1). Samples were mostly white or transparent and measured in the Specim laboratory.

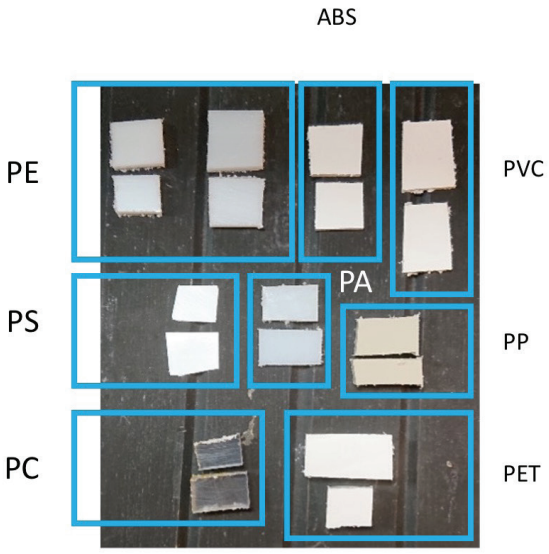

Figure 2: Samples to be measured.

We processed the data with our SpecimINSIGHT software, part of the SpecimONE Platform*, and built PLS-DA models for each data cube. We limited the spectral range to 700 – 1000 nm of the FX10 to remove any bias in the sample's color.

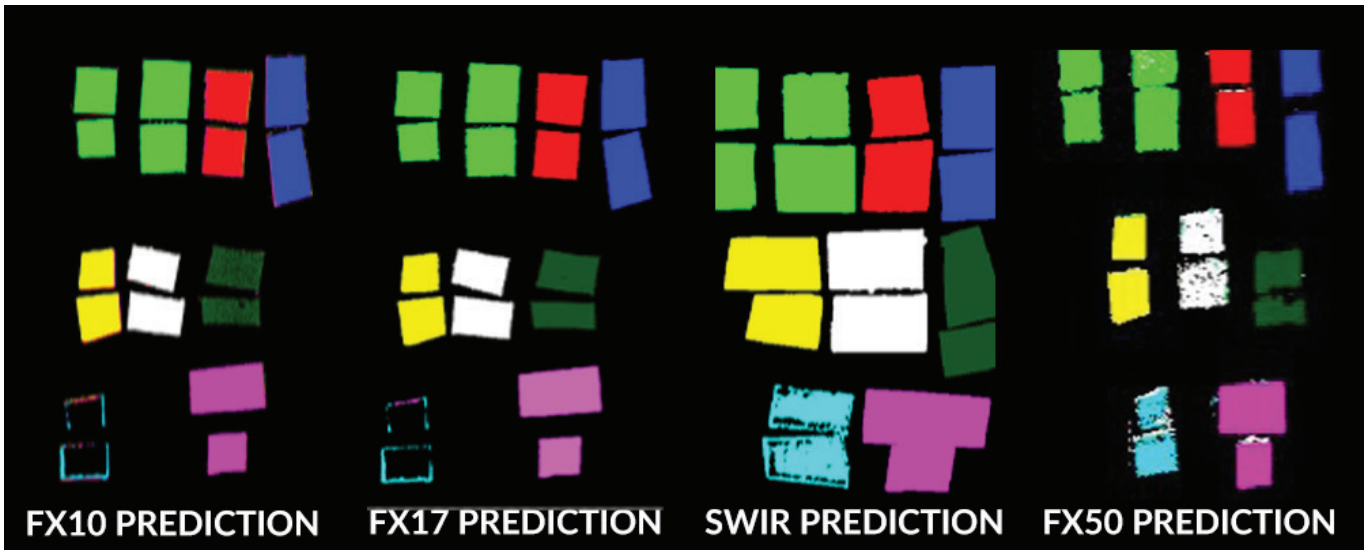

Figure 3: Sorting results for each camera; Green: PE; Red: ABS; Blue PVC; Yellow: PS; White: PA; Sea green: PP; Cyan: PC and Purple; PET.

As can be seen in Fig.3, in general, sorting was relatively efficient.

- For FX10, we can sort most of the samples.

Notice that PC is usually transparent, so only the edge can be sorted with the center misclassified as background.

- For FX17, we produced an accurate and robust model.

Same remark as for FX10 regarding the samples made of PC

- For the SWIR camera, we produced the most accurate model. All samples were well sorted, even the one made of PC.
- The model based on the FX50 data was not as robust and accurate as the ones built with the SWIR and FX17 cameras but is still very relevant. We also could sort transparent PC.

The spectral signature of all these samples can be found in Fig.4 below.

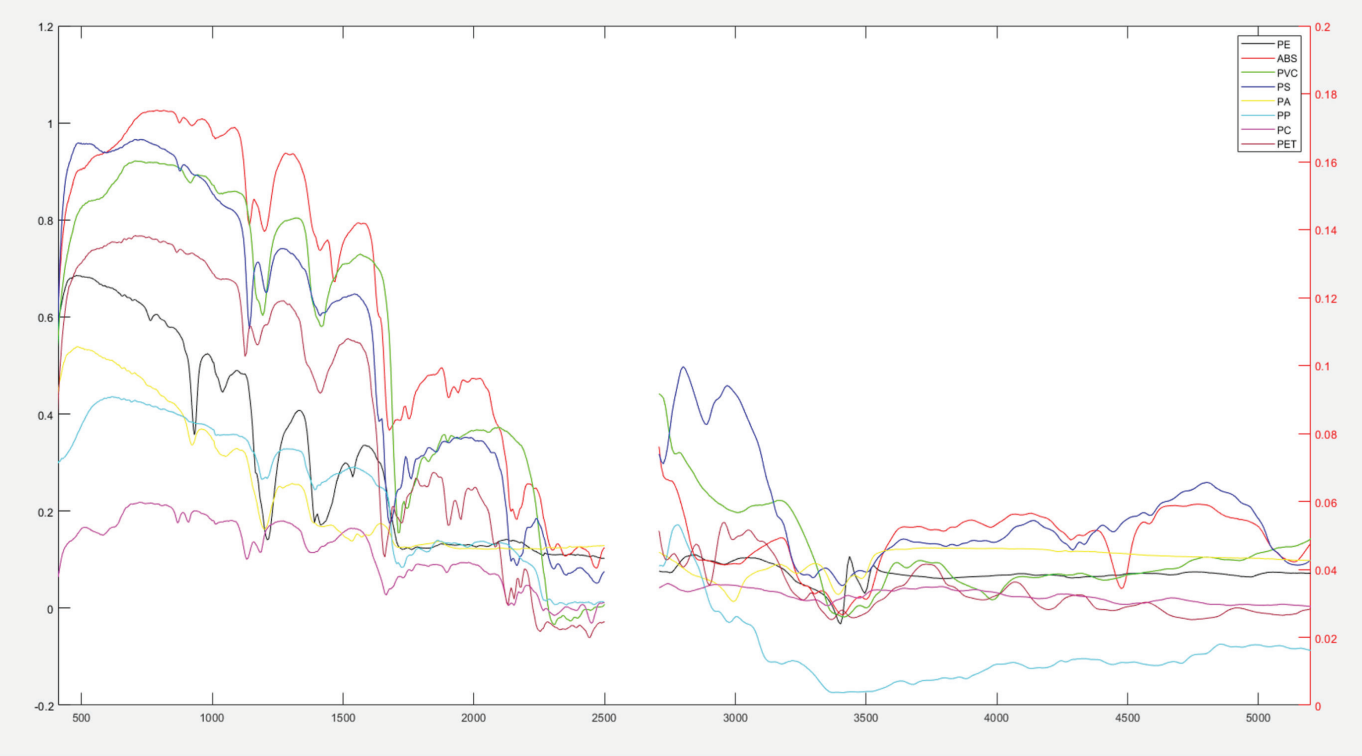

Figure 4: full spectra (400 – 5300 nm) measured by SPECIM cameras of the most common plastics, i.e. PE, ABS, PVC, PS, PA, PP, PC and PET.

It is well known that black plastics are problematic and cannot be sorted with traditional NIR cameras. However, black plastics are used extensively in the automotive and electronics industries, so sorting and recycling are vital. In 2019, we developed the Specim FX50 as the only available hyperspectral solution for sorting black plastics. To demonstrate the power of FX50, we measured similar samples as those presented previously, but with carbon contained within the polymers to make them black. Again, we used our SpecimINSIGHT software to build PLS-DA models for data classification. Results are shown in Fig.5 a with samples made of PS, ABS, PE, PA, and PC: We sorted all plastic types.

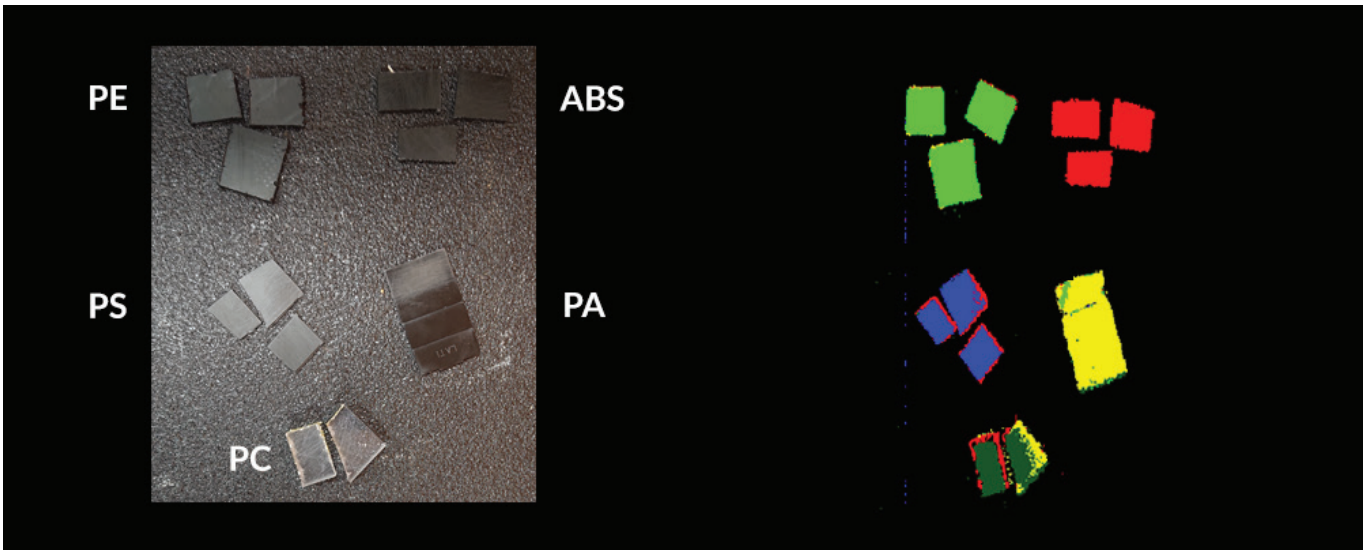

Figure 5

In summary, we can say that Specim FX cameras are suitable to sort plastics, regardless of their coloration. Depending on the application requirements, different cameras can be used. Table 1 below summarizes the results.

PLASTICS	FX10	FX17	SWIR	FX50**
PE	YES*	YES*	YES*	YES*
ABS	MODERATE	YES	YES	YES
PVC	MODERATE	YES	YES	YES
PS	MODERATE	YES	YES	YES
PA	MODERATE	YES	YES	YES
PP	NO	YES	YES	YES
PC	NO	NO	YES	MODERATE
PET	MODERATE	YES	YES	YES

Table 1: plastics and the sorting ability of each camera.
* PE, LDPE and HDPE can not be separated.
** Black plastics can also be sorted

*SpecimONE is a new spectral imaging platform dedicated to industrial sorting, with real-time data processing, to make hyperspectral imaging easy.