SPECTRAL ENGINES
MEMBER OF THE NYNOMIC GROUP

APPLICATION NOTE

INDUSTRY

SPECTRAL SENSING IN CIRCULAR ECONOMY: SMART SORTING OF WASTE TEXTILES

Background

After the industrial revolution around 200 years ago, our world economy shifted towards a linear economy from the circular economy it had been broadly operating before that time. In the linear economy, raw natural resources are taken, transformed into products, and get disposed of. The circular economy is based on minimizing waste; this is achieved by designing products to last by using good quality materials that are easily recyclable for reuse. One of the main objectives is to have a positive effect on the planet's ecosystem by fighting the excessive exploitation of natural resources. In fact, the pathway to low-carbon future to comply with the agreements to limit global warming can only be achieved via the circular economy.

The textile industry is the world's second-largest industrial polluter after the oil and petrochemical industry. Textiles account for 10% of global carbon emissions, use vast amounts of water and energy, and get produced with highly toxic chemicals. Petrochemical textile materials such as acrylic, modacrylic, polyester, nylon, and spandex are immensely toxic and pollutive to the environment, as their production requires significant amounts of energy, water, and chemicals, not to mention being a massive source of microplastics. This combined with rapid fashion culture and the short lifetime of clothing, on the average of about three years, causes an immense waste problem: 85% of clothes end up in a landfill. Once in landfills, natural fibers can take hundreds of years and synthetic fibers thousands of years to decompose. They also release methane and CO_2 gas into the atmosphere. Additionally, synthetic textiles are designed not to decompose at all. In a landfill, they release toxic substances into groundwater and surrounding soil.

There is an obvious need to recycle our textiles better. Accurate sorting is crucial for producing high-quality recycled material. NIR spectroscopy is a great option for automated sorting as it offers specificity without any surface pre-treatment. During the identification, light from an incandescent bulb is reflected in the material. A certain type of material can be identified by the diffuse reflectance of the light back to a receiver, which is sensitive to the near-infrared part of the spectrum. Different types of materials are then distinguished by their unique reflectance curve "fingerprint", by using state-of-the-art machine learning algorithms. This makes the technique ideal for sorting unknown recycled textiles with high accuracy, regardless of their color.

Spectral Engines® solution

Spectral Engines product offering is based on mass-producible NIRONE® spectral sensors. Even though the size of NIRONE Sensor is small, the performance is very well comparable with the performance of laboratory instruments. Spectral Engines utilizes the so-called true NIR region from 1350 nm to 2450 nm in its measurement specifications. This range offers very good selectivity and sensitivity in material identification applications compared to broadly used shorter wavelength technologies e.g. silicon sensor technologies. For example, our NIRONE sensors can be applied to industrial sorting machines, where the sensors identify and materials in various steps of the material flow and sort them by type, or incorporated into smart collection bins to identify the recyclable materials and help sort them more accurately.

Spectral Engines has developed NIRONE Scanner, a solution for creating hand-held material sensing products, which combines powerful NIR spectroscopy, Cloud data management, and advanced machine learning algorithms. Hand-held scanners are a useful tool for speeding up and improving the quality of manual sorting where needed. Perhaps in the future, a handheld material scanner could help sort the materials at home before they get thrown in the recycling bins. NIRONE Scanner is the world's smartest, fastest, and easiest way to create your unique material sensing solution.

The benefits of Spectral Engines' solutions are:

- Fast and accurate measurements in the field
- Real-time measurement data realized with compact spectral sensors
- No sample preparation
- Affordability, portability and connectivity enables online analytics
- Easy-to-use mobile app

USE CASE

Sorting waste textiles

In processing plants, waste textile fabrics are often manually sorted by workers with a visual inspection of the fabric and its label. However, labels may be inaccurate or missing altogether. Textile fabrics and clothing commonly consist of natural fibers, such as cotton, and synthetic fibers such as polyester. The composition influences the method of recycling, and misidentified samples may lead to time-consuming and expensive cutting and shredding equipment breakdowns.

Spectral Engines NIR technology can be used to identify recycled textile fabrics. We have found that NIRONE 2.0 (1550 nm – 1950 nm) and 2.2 (1750 nm – 2150 nm) perform very well in identifying pure textiles and the major component of mixed textiles. Figure 1 shows NIR spectral data of various cotton, wool, polyester, and polyamide fabrics measured with NIRONE Device 2.0. Figure 2 shows the fingerprints obtained through preprocessing and principal component analysis of the spectral data. The results show that it is possible to identify these samples with 100% accuracy.

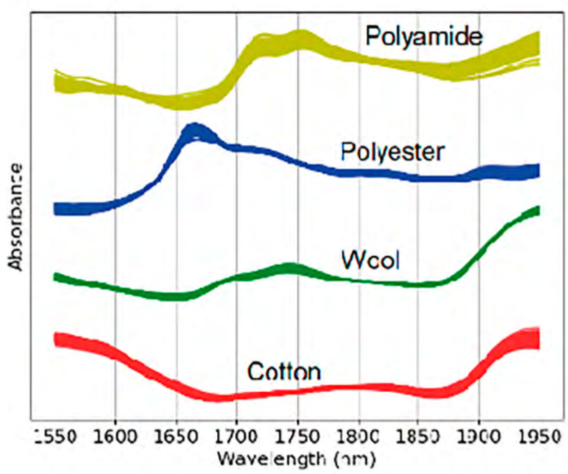

Figure 1: NIR absorbance spectra of various cotton, wool, polyester, and polyamide fabrics.

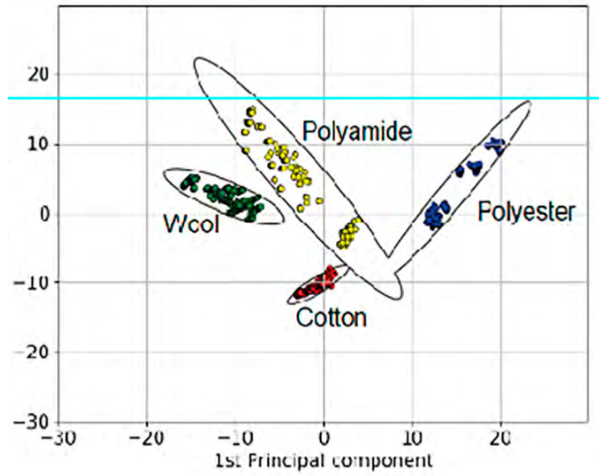

Figure 2: First two components of PCA on preprocessed textiles NIR spectra.

Conclusion

Spectral Engines' solutions provide small, robust, and fast measurement technology for the process- and field identification waste textiles. These applications work best with NIRONE 2.0 and 2.2 family of products, which offer excellent sensitivity and specificity. Cost-effective sensors can be combined with advanced machine learning algorithms to increase the performance of NIR spectroscopy in demanding identification or classification use cases.

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