SPECTRAL ENGINES
MEMBER OF THE NYNOMIC GROUP

APPLICATION NOTE

SMART INDUSTRY

Spectral Sensing in Circular Economy: Smart Sorting of Waste Plastics

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.

Plastic pollution in one form or another can be found virtually everywhere on our planet. From cigarette butts, plastic bags, and water bottles to microplastics, plastic is polluting our habitats, rivers, forests, beaches, and oceans. Our tremendous attraction to plastic, coupled with its properties such as durability and resistance to corrosion and our single-use throw-away culture, has caused plastics to become ubiquitous. All of this creates a severe challenge for nature, society, and the global economy.

Plastics were introduced to the world in the late 1940's and early 50's. Plastics became popular fast. They are versatile, lightweight, flexible, moisture resistant and strong. Unfortunately, they are also a menace to the environment, as these kinds of synthetic or semi-synthetic materials are made first and foremost from fossil fuels: crude oil, gas and coal. Its many variations such as ABS, Polycarbonate, Polyethylene, PET, PVC, Polypropylene and Polystyrene, are used in a huge and growing range of applications.

There is an obvious need to recycle our plastics 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 and plastics 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 1150 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 plastics

The world needs more solutions for dealing with what happens with plastics after it is thrown away. A critical factor in this is the proper analysis of waste plastics as early as possible because separation costs increase the further the logistics chain the plastic waste goes through unsorted. With the help of sorting methods based on NIR spectroscopy, efficient plastic recycling is doable at home, collection points, and sorting facilities.

Spectral Engines NIR technology can be used to identify recycled plastics. We have found that NIRONE 2.0 (1550 nm – 1950 nm) and 2.2 (1750 nm – 2150 nm) perform very well in identifying the most common plastics. Figure 1 shows NIR spectral data of various silicone, polystyrene, PVC, HDPE, and PET plastics 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.

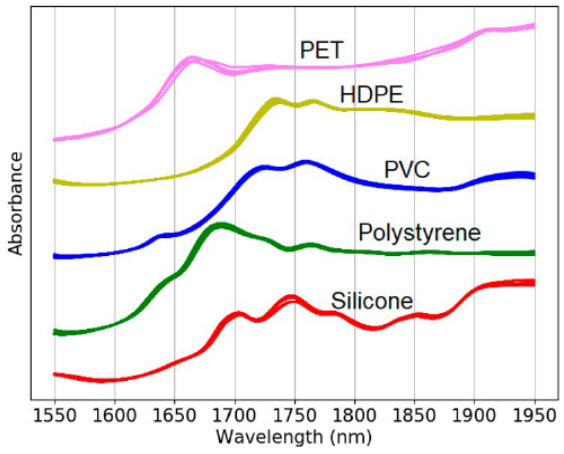


Figure 1: NIR absorbance spectra of PET, HDPE, PVC, Polystyrene and Silicone.

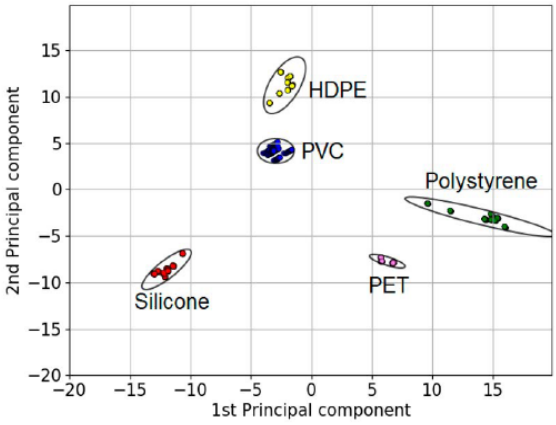
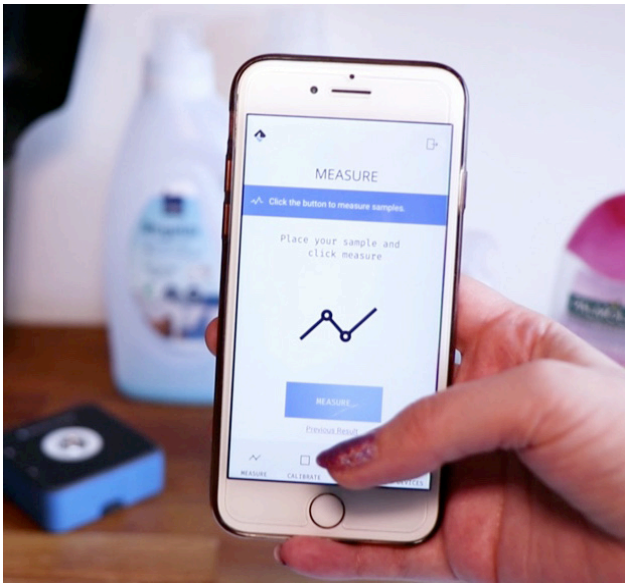


Figure 2: Fingerprints obtained through preprocessing and principal component analysis of the spectral data.



Conclusion

Spectral Engines' solutions provide small, robust, and fast measurement technology for the process- and field identification waste textiles and plastics. 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.

Finnish company Head Recycle Systems is solving the plastic crisis one food wrapper at a time with the help of NIR spectroscopy. The company has developed a solution that can be mounted into sorting bins at regular apartment buildings. Head Recycle Systems' collaboration with Spectral Engines started from a mutual interest towards circular economy and a shared understanding about using NIR technology for expanded business opportunities. NIR technology is an efficient tool for solving many global problems and this is one of the reasons why NIRONE Sensors have now been integrated into HRS's solution.

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