

# **Differentiation of Commercially Available Plastics via NIR Handheld Spectrometer**

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## **Abstract**

A summary of a project intended to separate and discriminate between common commercial plastic types is presented. Different plastic substances, such as HDPE (High-Density Polyethylene), LDPE (Low-Density Polyethylene) and Styrofoam all contain different polymers, different consistencies, and even different fundamental substances. These differences lead to challenges in the recycling process, as these materials all require drastically different treatments in order for recycling to be effective. In many recycling plants, plastic sorting is done by hand, but the small markers and inconsistent labeling between companies can lead to the task being slow and arduous. A NIR (Near-Infrared) Spectrometer measures the interference experienced by electromagnetic waves between 700 nanometers and 1500 nanometers in diameter. The interference felt by these waves differentiates substances and can measure the density, composition, and even surface-level contamination of the substance. Because of the handheld nature of this tool, it is very simple to implement in day-to-day life, with no installation needed and very little software, just an easily-accessible phone app to access the spectrometer and generate the data. Because of this, the goal of this project was to use the data generated by the spectrometer to differentiate between different common commercially available plastics and create an app that would quickly alert the user of the plastic type being sorted. Unfortunately, due to time constraints and data inconsistencies, the project's results are inconclusive.

## **Methodology**

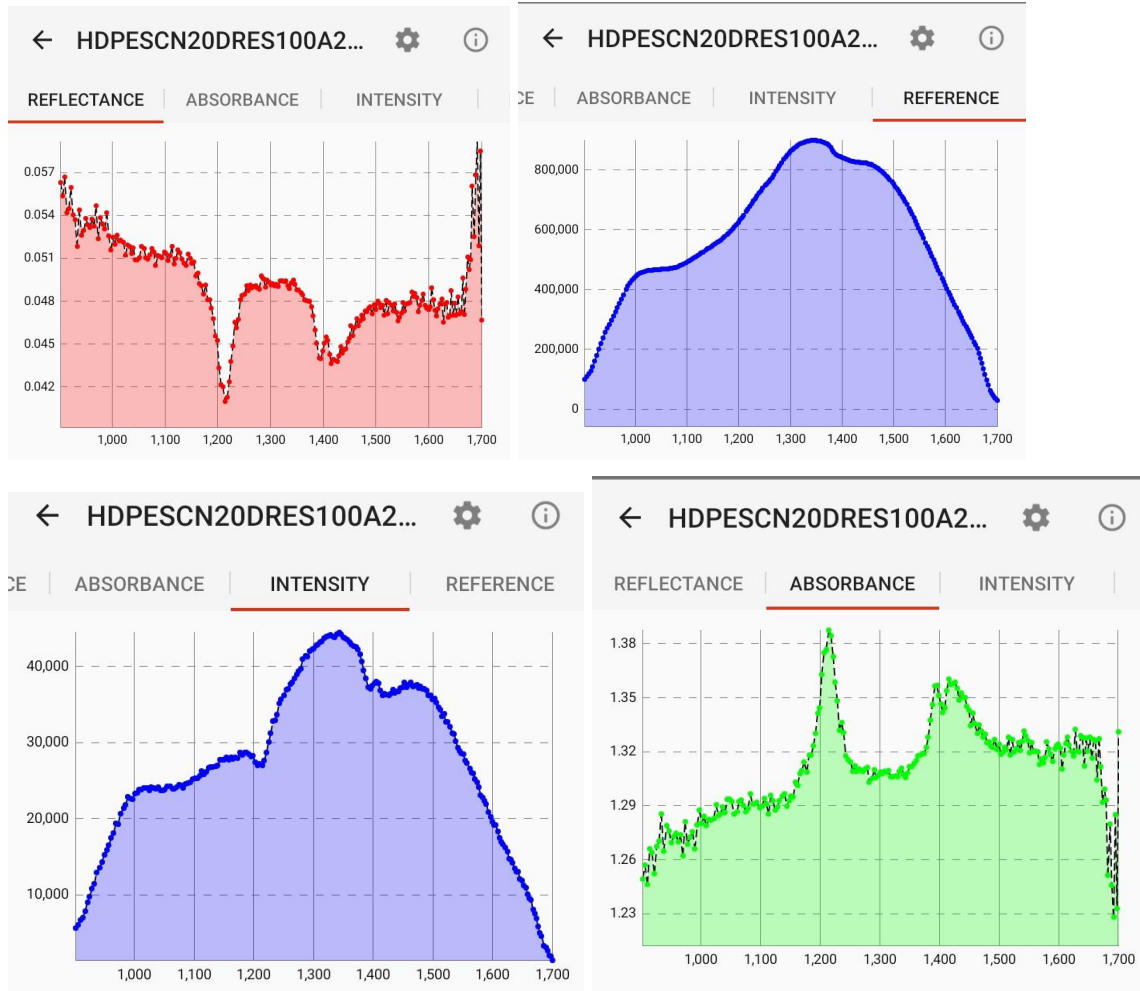
The project began with the purchase of a handheld NIR S-G1 spectrometer. The device was controlled with a phone app made by InnoSpectra called ISC Nirvascan. The app displayed graphs of the data, created parameters that could be changed when

concerning the data collection, and stored the data that was collected in spreadsheets.

Lamp-Stable Time(ms)	625	Exposure Time (ms)	0.635
Scan Method	Column	Continuous Scan Mode	OFF
Spectral Start (nm)	900	Scan Interval Time (sec)	0
Spectral End (nm)	1700	Continuous Scan Repeats	6
Scan Width (nm)	2.34	Stop Continuous Scan	STOP
D-Res. (pts, max:448)	15	Set all config	SET
NORMAL QUICK SET MANUAL MAINTAIN	NORMAL QUICK SET MANUAL MAINTAIN		
SCAN	SCAN		

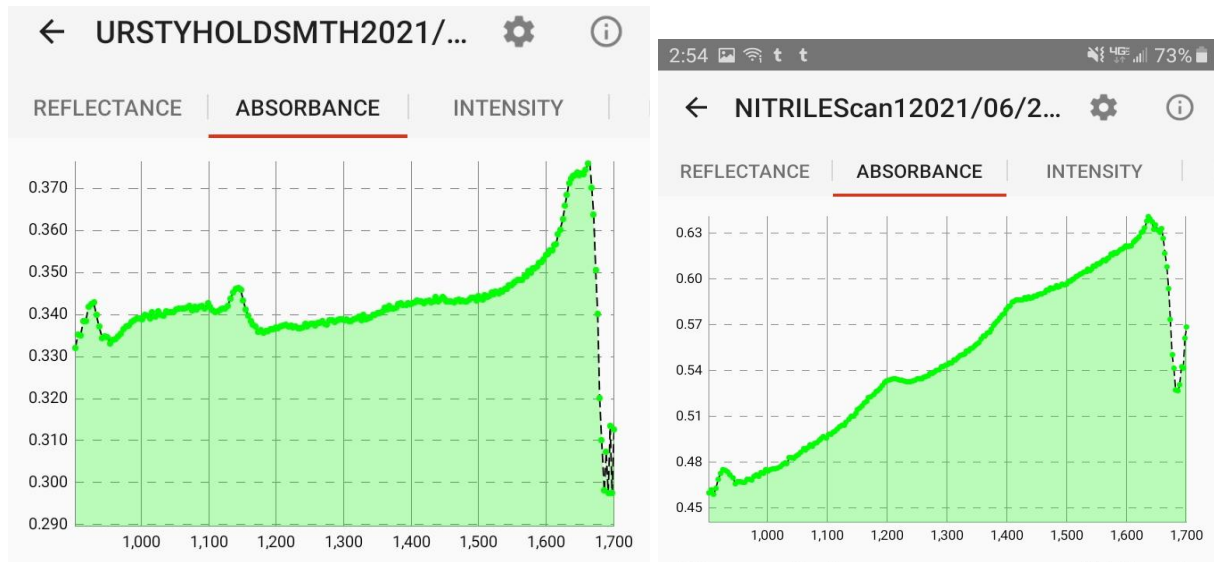
(Two examples of the phone app's settings. A setting for the scanner light's timer, the method for displaying the scan method, the size of the spectrum of light, the width of the scan, the number of data points (or D-res) and the exposure time are all shown)

The screen would show 4 possible graphs when data collection was achieved: Absorption, Reflection, Intensity and Reference. Absorption indicated where the greatest number of wavelengths had been absorbed, or not come back to the sensor. Reflection indicated where the greatest number of waves had been reflected, or had been sensed after bouncing back by the sensor. Intensity was an indicator of which wavelengths were being interacted with either through reflection or absorption most strongly, and Reference was an indicator of how the wavelength distribution would behave without an object.



(4 images of the graphs generated by the ISC app, one displaying the singular hump pattern of thin HDPE, one displaying the reference wavelengths, one displaying the intensity distribution and one displaying the absorbance pattern)

An important but minor point is that the absorption and reflectance graphs are always reflections of each other, as they are in summation all of the possible effects on the waves. The units for all of these graphs are wavelengths on the x-axis and the extent of the measured effect on the y-axis (reflection, absorbance, etc). In order to streamline results, absorbance was the primary method of measuring results, with intensity, reflection and reference all being ignored for the most part. Several substances had clear differentiation between their absorbance graphs (thin HDPE had a distinct downcurve, styrofoam had a consistent small hump at 1150 nanometers, a long and slight dip over the interval between 1200 and 1300 nanometers when nitrile was scanned, etc)



(Two images of the absorbance scans of styrofoam and nitrile gloves, with distinctive peaks and valleys at different locations.)

However, there were significant difficulties isolating these patterns, and there is a high likelihood that they were due more to sample contamination than to the content of the samples themselves. Purer samples of HDPE and nitrile, for example, ended up without these patterns being visible, and the replicability of many of these patterns was low. When a PCA model was applied to the data using the Heroku analysis cloud application, the rating was consistently around 500, when data should ideally be under 300. (Currently the cloud is being repaired and no screenshots were taken as evidence, unfortunately.) Couple this with the fact that the spreadsheets consistently indicated less deliberate peaks and valleys (compare the spreadsheet-generated absorbancy graph to the app-generated one featured above), and the end result was a lack of replicable data with no real way of modeling the data into a comprehensive phone app.

Further experimentation would have to include utilizing many more samples and involving more testing of sample contamination, as well as possibly attempting to use algorithms and machine learning in order to more exactly differentiate between samples.