INVESTIGATION ON THE USE OF LASER-INDUCED FLUORESCENCE FOR THE RECYCLING OF BLACK PLASTICS

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INTRODUCTION

Improving the quality of the recovery and recycling of post-consumer plastic packaging is one of the aims of the circular economy. The research of innovative techniques apply to the recycling sector play a key role in the enhancement and optimization of the polymer waste recovery process.

AIM OF STUDY

The proposed study was carried out to develop an efficient sorting strategy for black plastics in recycling plants, based on a non-invasive and non-destructive technique, i.e., laser-induced fluorescence (LIF) technique, in order to improve the recovery and recycling of plastic materials.

MATERIALS

Twelve black plastic packaging samples were selected among the most commonly found in household waste.

Expanded Polystyrene (EPS)

EPS 1

EPS 2

EPS 3

Polystyrene (PS)

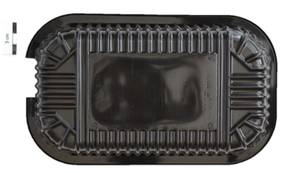
PS 1

PS 2

PS 3

Polypropylene (PP)

PP 1



PP 2

PP 3

Polyethylene (PE)

PE 1

PE 2

PE 3

METHODS

Fourier Transform infrared spectroscopy

Fourier transform infrared spectroscopy (FT-IR) with attenuated total reflectance (ATR) working in the range of 3800-550 cm-1, was employed to confirm the resin identification codes found on samples and to validate the polymer identification results, using a Shimadzu spectrophotometer (IRAffinity-1S).

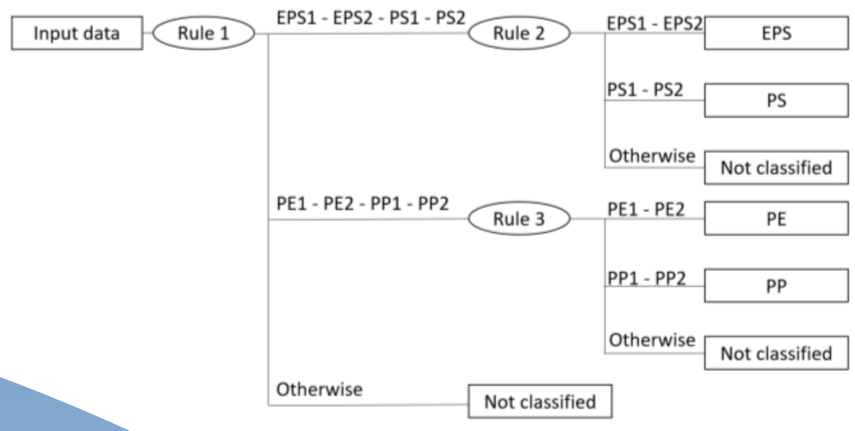
Laser-induced fluorescence

LIF measurements were carried out by a punctual scanning system, called Lifart developed at the Diagnostics and Metrology Laboratory of ENEA. The used instrument works remotely up to 10 m distance from the target and is equipped with a diode pumped solid state laser emitting in the UV at 266 nm. The fluorescence spectra cover the spectral range 270-750 nm, however, since no signal was found after 550 nm, to reduce the number of wavelengths to be processed the selected range for this case study was 270-550 nm.

Data processing

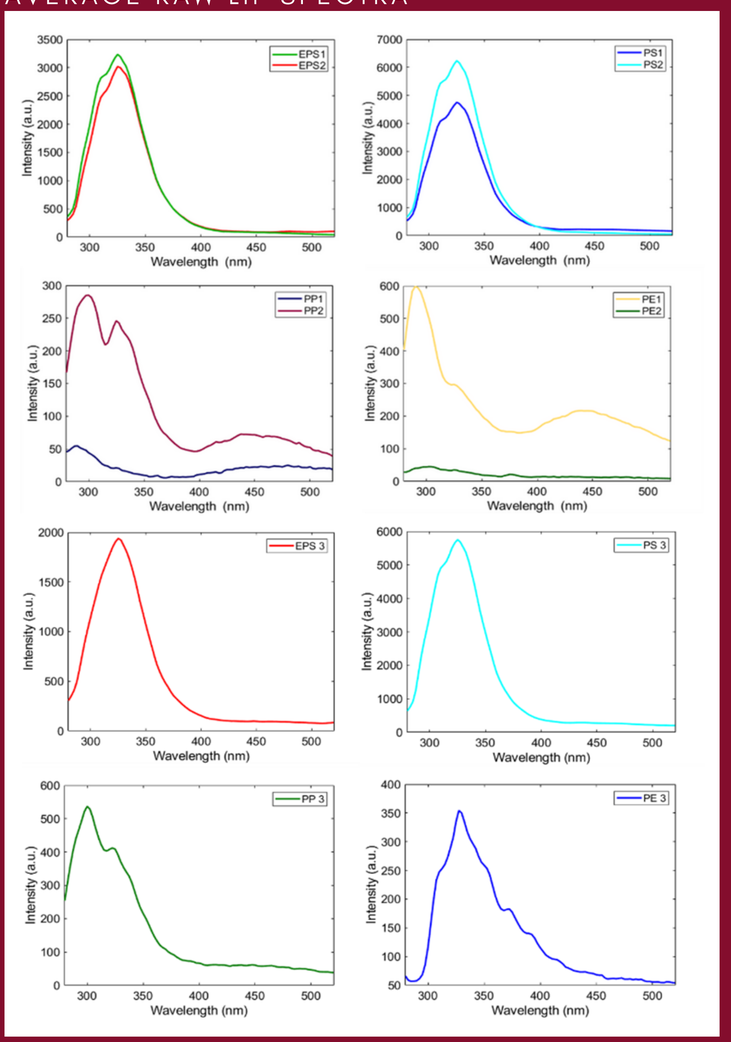
- Different preprocessing algorithms were applied, i.e., normalization, first derivative, centering.
- Principal component analysis (PCA) was chosen to perform exploratory analysis about the spectral variability of data.
- Three different partial least squares-discriminant analysis (PLS-DA), i.e., Rule 1, 2 and 3, were assembled in a hierarchical structure, constituting a single classification model.

HIERARCHICAL PLS-DA STRUCTURE

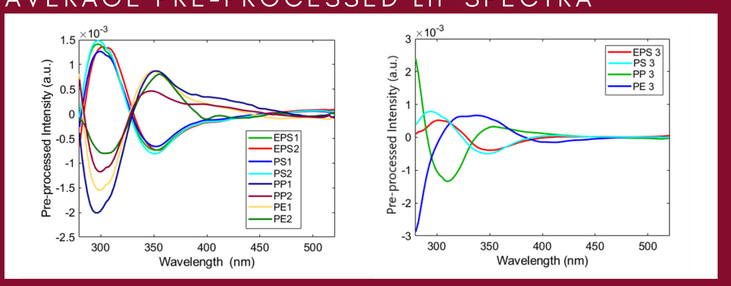


RESULTS & DISCUSSION

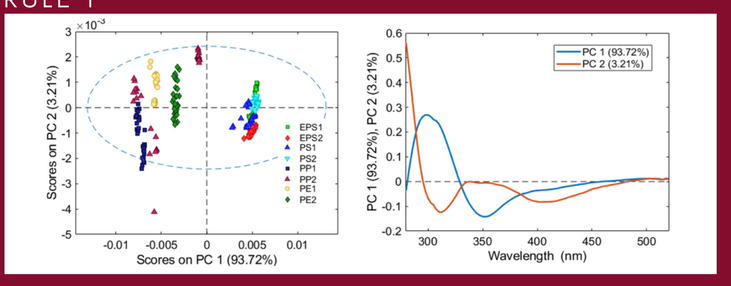
AVERAGE RAW LIF SPECTRA



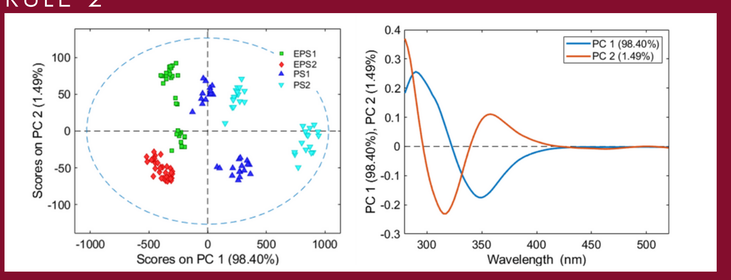
AVERAGE PRE-PROCESSED LIF SPECTRA



RULE 1



RULE 2



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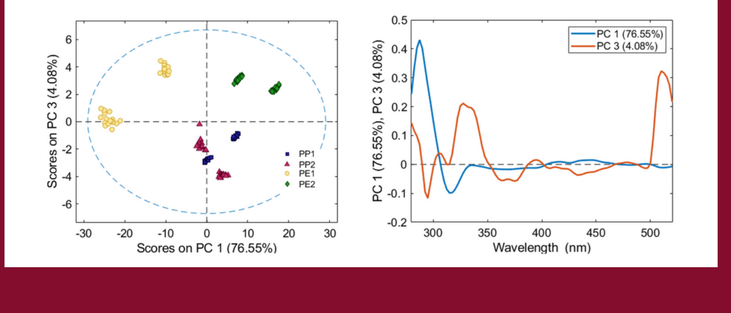

HIERARCHICAL PLS-DA PERFORMANCE RESULTS

Rule	Classification output	Sensitivity (Cal)	Specificity (Cal)	Sensitivity (CV)	Specificity (CV)	Sensitivity (Pred)	Specificity (Pred)
1	a) PP/PE	1.000	1.000	1.000	1.000	1.000	1.000
	b) EPS/PS	1.000	1.000	1.000	1.000	1.000	1.000
2	c) EPS	1.000	1.000	0.984	1.000	1.000	1.000
	d) PS	1.000	1.000	1.000	0.984	1.000	1.000
3	e) PP	1.000	1.000	1.000	1.000	1.000	1.000
	f) PE	1.000	1.000	1.000	1.000	1.000	1.000

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