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Microplastics spectroradiometric characterization to remote sensing detection

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ABSTRACT

The amount of plastics produced and dispersed in the environment, especially during the last decades is alarming. Recently, field surveys allowed detecting high microplastics' concentrations in the Mediterranean Sea; the most common polymers are: ethylene vinyl acetate (EVA), polyethylene terephthalate (PET), high density polyethylene (HDPE), polypropylene (PP) and polystyrene (PS). Due to the difficulties of carrying out *in situ* campaigns an indoor laboratory experiment was conducted to spectrally characterizing the aforementioned virgin polymers both in dry condition and on water surface.

A spectral separability analysis was conducted to determine optimal band combinations with the aim of addressing the detection of these polymers using imaging techniques (e.g. satellite or other platforms). The results showed that the WorldView-3 sensor appears the most suitable for the detection also considering its higher spatial resolution compared to other sensors. This study is a first step for an operational marine plastics detection exploiting a bottom-up approach.

MATERIALS AND METHODS

Virgin polymers

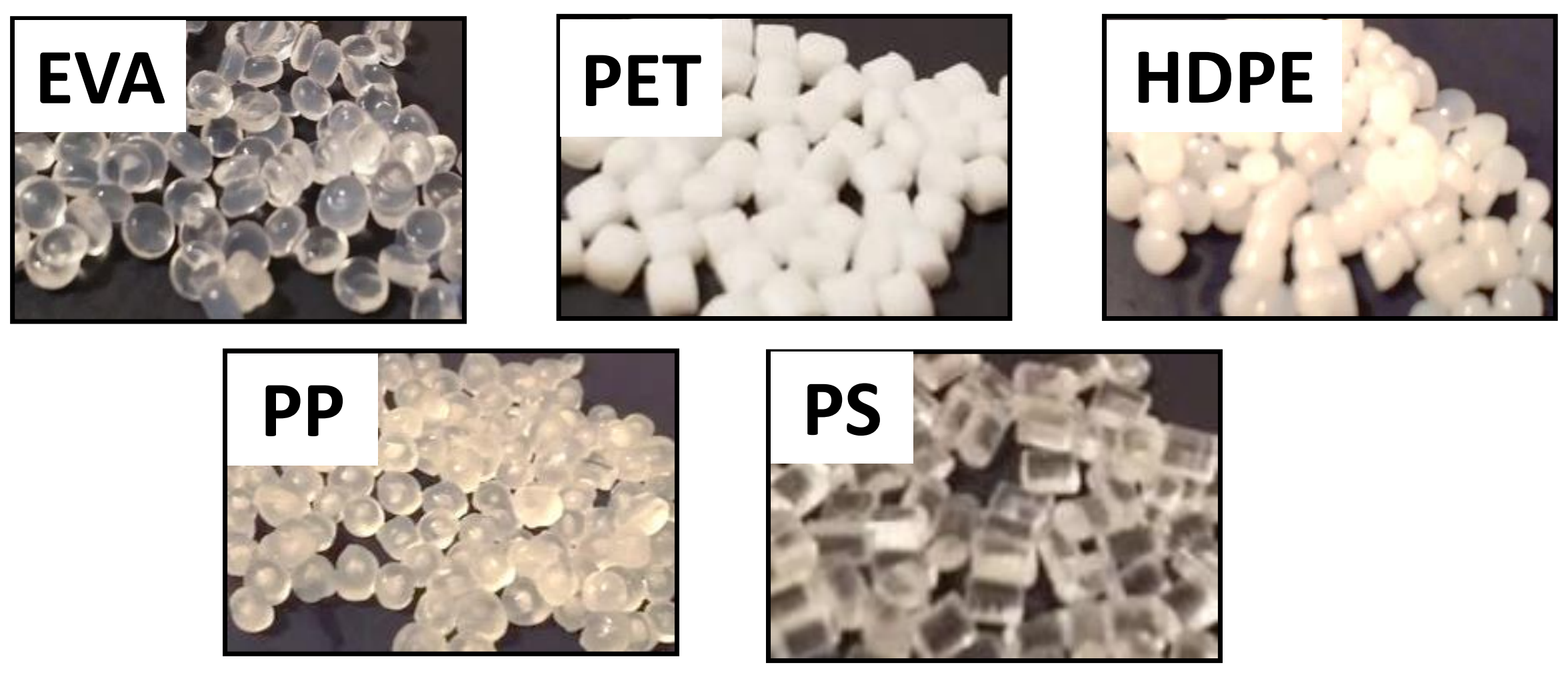
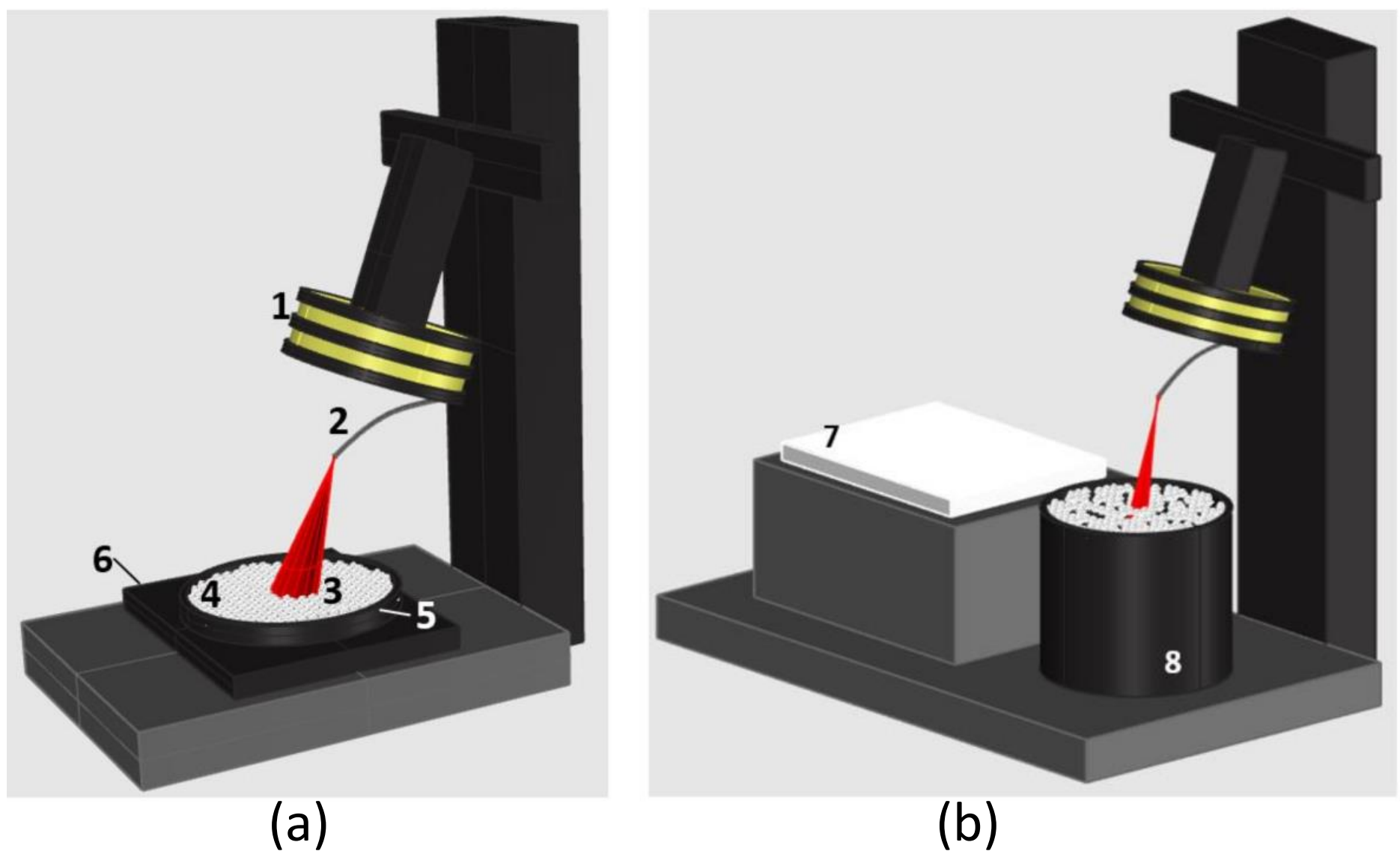


Figure 1. Spectrally characterized polymers.

Experimental setup

The experiment was carried out using a FieldSpec 4 Hi-Res (ASD, Analytical Spectral Devices) spectroradiometer. Two different setups were considered for the dry and on water experiments (Figure 2).



(a) (b)

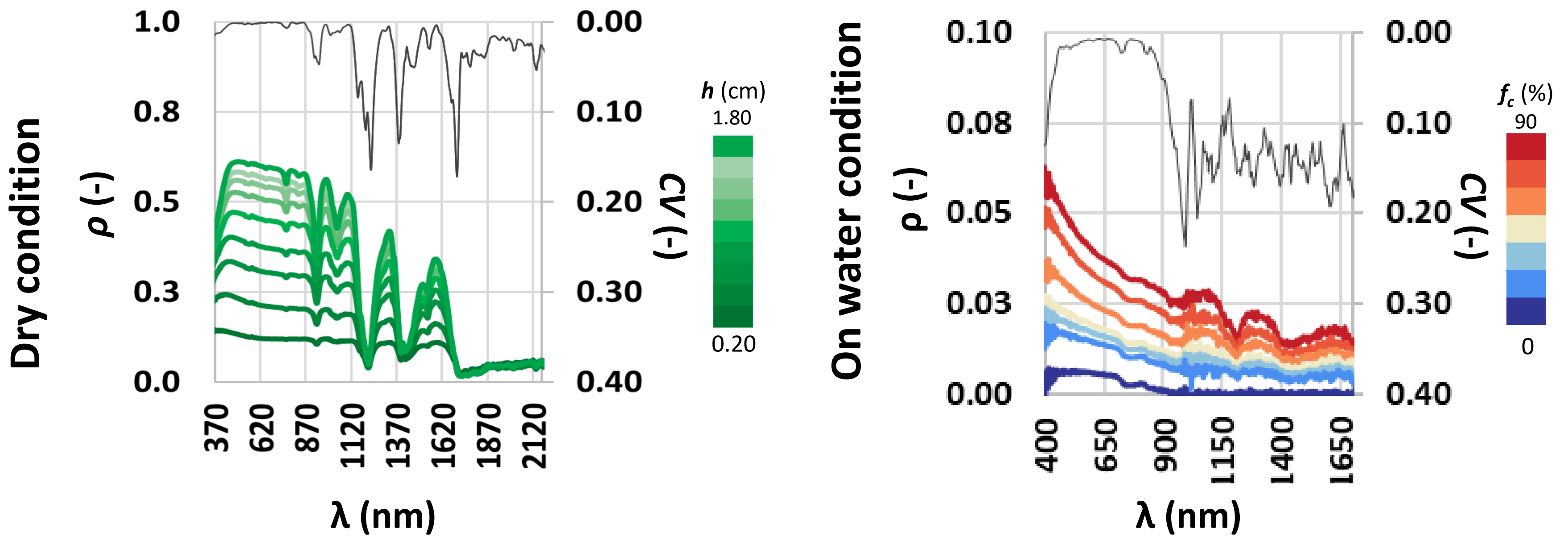
Figure 2. Spectroradiometric apparatus of (a) the dry microplastic and (b) the microplastics floating on water experiments. Indicated with numbers: (1) lamp, (2) optical fiber, (3) field of view, (4) microplastics, (5) ring, (6) black panel, (7) white reference panel, (8) tank.

Spectroradiometric characterization

Dry experiment. The reflectance on dry samples was measured by bounding polymers with a black ring placed on a black opaque fabric. The measures were carried out increasing the number of polymer layers, *h*, each one 0.18–0.20 cm in thickness, until the influence of the underneath black panel was considered negligible by comparing two consecutive spectral radiance measures.

On water condition. The microplastic samples were floating inside an opaque black tank full of water. Spectral measures were carried out with different quantity of polymers (fraction of polymers f_C).

Spectral signatures example: EVA's case study



(a) (b)

Figure 3. Spectral signatures of EVA in (a) dry condition and (b) on water respectably for increasing layers depth *h* and fractional cover f_c . Light grey lines represent the CV averaged at 20 nm, while the CV values in selected spectral windows are represented in dark grey.

Band combination

$$C\,(n,k) = \frac{n!}{(k!\cdot(n-k)!)}$$

$n\ (-)$: number of bands
$k\ (-)$: clustering of bands

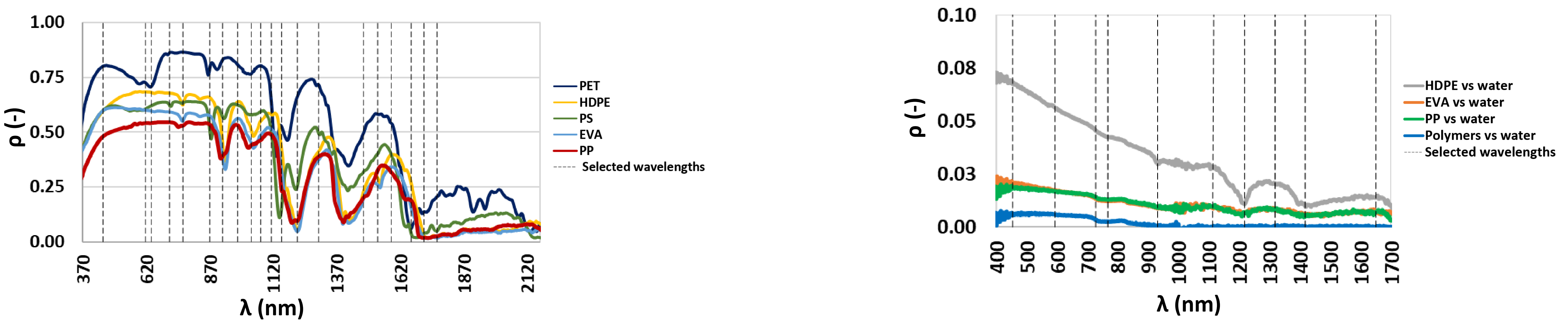
Spectral separability, *d*

$$d(x,y) = \sqrt{\sum_{i=1}^{n}\left(\rho_{i_j} - \rho_{i_t}\right)^2}$$

$\rho_{i_j}\ (-)$ and $\rho_{i_t}(-)$: reflectances of the $\mathrm{j_{th}}$ and $\mathrm{t_{th}}$ spectral signatures, respectively

RESULTS

The wavelengths in which there are "singularities", in terms of different behaviour between the polymers' signatures, were selected (Figure 4). For the on water experiment, the wavelengths were selected considering the spectral signature corresponding to 25% of EVA, HDPE and PP and the spectral signature of water.



(a) (b)

Figure 4. (a) Spectral reflectance of dry microplastic at plateau. (b)Spectral signatures of 25% for each microplastics on water and the spectral signature of water.

Sets of band combination, *C*, were determined using the previously selected bands. The first derivative of the spectral separability, *d' (–)* allowed determining the best bands combinations (Table 1). Based on this result, a selection of the sensor that could investigate the presence of microplastics on sea water were identified (Table 2).

Table 1. Separability of dry versus floating on water microplastics.

	Dry microplastics	**Microplastics on water**
C (n,k) (nm)	920 – 1152 – 1215 – 1298	454 – 593 – 727 – 767 – 931
d (-)	0.46	0.052

Table 2. Separability using the bands available on the current sensors.

	OLCI	**WorldView – 3**
Bands (nm)	767 – 931	454 – 593 – 727 – 931
d (-)	0.025	0.048

CONCLUSIONS

The experiment was conducted on dry and water-floating microplastics. The possible use of the current operational sensors was investigated: the WorldView-3 has some bands which are characterized by the best average spectral separability (if compared to those achievable with other operating sensors). The future development of this work may include the acquisition of spectral signatures outdoor and the increase of the collection set of microplastics spectral signatures. Further, it will be necessary to consider other effects exerted on the sea surface by the atmosphere, the sunlight, the waves and the wind.

Reference: Corbari L., Maltese A., Capodici F., Mangano M. C., Sarà G. & Ciraolo. G., 2020. 'Indoor Spectroradiometric Characterization of Plastic Litters Commonly Polluting the Mediterranean Sea: Toward the Application of Multispectral Imagery'. Nature scientific reports. DOI:10.1038/s41598-020-74543-6.