Assessment of microplastics in environmental samples by infrared microscopic system

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Introduction

Plastic pollution is one of the major environmental issues faced at global scale. Interest in this topics has exponentially increased in the past years. Microplastics are minute pieces of not easily-degradable plastics with size ranging from few microns to several millimeters (Figure 1). They are persistent in the environment and can act as sinks for other contaminants. Hence, they can cause adverse effects to aquatic ecosystems.

Figure 1. Dissection of a dead seabird (left). Some microplastics were found in the stomach (right)

Therefore, the hazardous impact of increasing amount of microplastics in aquatic environments calls for more scientific research to understand their occurrence, effects and mitigation strategies. The FTIR (Fourier-Transform Infrared) and FTIR microscopy techniques have shown that they are very powerful techniques to detect and characterize a variety of microplastics.

In this work, we describe the analysis of primary and secondary microplastics. Primary microplastics are used as raw materials for industrial polishing and scrubbing agents, and are already 5.0 mm in size or less before entering the environment. On the other hand, secondary microplastics are created from the degradation of larger plastic products once they enter the environment through external processes such as ultraviolet rays and crush.

Instruments and Measurement Parameters

Microplastic detection, characterization and mapping were carried out using Shimadzu IRTracer-100 FTIR spectrophotometer with AIM-9000 FTIR automated microscope system and ATR (Attenuated Total Reflectance) accessory (Figure 2). Method conditions are listed in Table 1.

Figure 2. Shimadzu IRTracer-100 FTIR spectrophotometer (left) attached to AIM-9000 Infrared Microscope (right)

Instrument	Shimadzu IRTracer-100 and AIM-9000 FTIR microscope
Measurement mode	Transmission
Resolution	4.0 cm^{-1}
Number of scan	50 times
Aperture size	100 x 100 µm Or 50 x 50 µm

Table 1. Measurement Parameters

Analysis of Primary Microplastics

Sample :
Primary microplastics in facial cleanser (Figure 3).

Figure 3. Primary microplastic sample

Pretreatment :
Microplastics dispersed in water was suction filtered using cellulose filter paper (Figure 4).

Measurement :
The sample collected on the filter paper was moved to diamond cell to measure transmission. Area without plastics was set as background.

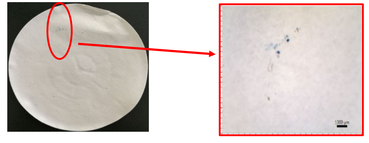

Figure 4. Microplastics on cellulose filter paper

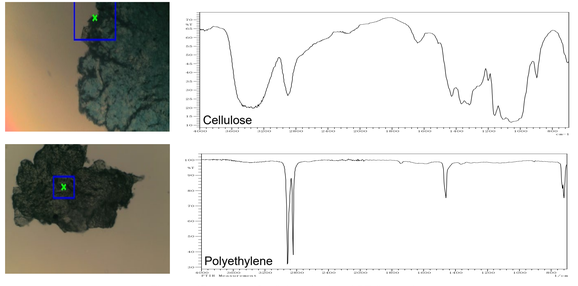

Figure 5. IR spectra of cellulose (top) and PE (bottom).

Observation:
From transmission spectra of primary microplastics, we were able to determine that the sample was a mixture of polyethylene (PE) and cellulose. The presence of cellulose in the sample was confirmed carrying out appropriate background spectral subtractions to eliminate spectra from the filter (also cellulose). Spectra are shown in Figure 5.

Analysis of Secondary Microplastics and Mapping

Sample :
Secondary microplastics in ocean water.

Pretreatment :
Microplastics dispersed in water was suction filtered using PTFE filter paper (infrared absorption in the vicinity of 1,200 cm^{-1}).

Measurement :
The sample collected on the PTFE filter paper was moved to diamond cell to measure transmission. PTFE is a convenient filter for direct measurement although noisy spectra around 1,200 cm^{-1} is observed.

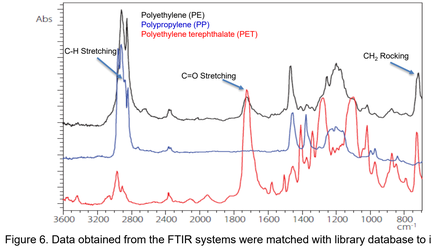

Figure 6. Data obtained from the FTIR systems were matched with library database to identify and quantify microplastics

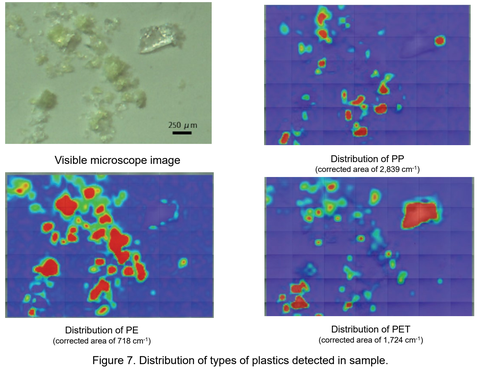

Figure 7. Distribution of types of plastics detected in sample.

Observation:
Library matching of spectra (Figure 6) and mapping results (Figure 7) allowed us to determine the composition of microplastics in the ocean water sample.

Conclusion

FTIR and FTIR Microscopy are suitable techniques to detect and characterize microplastic samples. The ease of use and mapping features provided by these instruments keep the sample preparation minimum while helping properly identify the different types of microplastics in real-world samples.