Identification of Microplastics in Food and Food Packaging using FTIR Spectroscopy

Uwe Oppermann[1], Johannes Hesper[1], and Marion Egelkraut-Holtus[1] [1]Shimadzu Europa GmbH, 47269 Duisburg, Germany

Figure 1: Microplastics/ Plastic soups in the oceans

1. Overview

Microplastics (MPs) are small pieces and particles of plastic that pollute the environment such as rivers, lakes and the oceans. Microplastics are classified in two segments, the primary and secondary types. Primary microplastics include fragmented fibers and particles generated in the washing drainage of the synthetic fiber from the clothing, and waste of the particle materials like plastic beads included directly in industrial abrasives, like face wash, cosmetics or grinding materials. Secondary microplastic is formed in the process of being gradually broken down into small fragments by the force of waves wind and ultraviolet rays from the sun over a longer period of time. As for the size, the definition is being discussed in the International Organization for Standardization (ISO), and studies are underway at approximately 5 mm or less in diameter and 0.1 mm or more regardless of the particle shape.

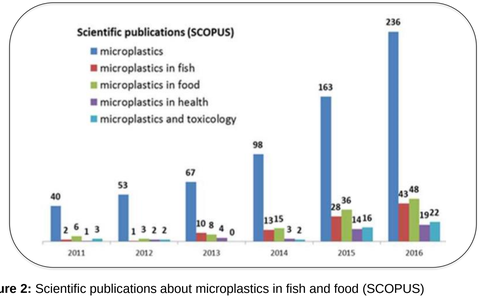

Figure 2: Scientific publications about microplastics in fish and food (SCOPUS)

The presence of microplastics in our ecosystem is not only discussed in scientific literature frequently but it also dominates the public press over the past years, which all in all indicates the high relevance of this environmental topic [1]. Several studies are existing about sampling, sample preparation, and measurement techniques for the determination of microplastics in environmental samples, fish, food and more as indicated in Figure 2.

2. Analysis using FTIR

Analysis of microplastics is mainly performed using Fourier transformation infrared spectroscopy/microscopy (FTIR/ µFTIR). Figure 3 shows a typical “beached” sample, a fishing net and fishing lines collected at Mallorca Island in Spain and Texel Island in the Netherlands. The results of measurement using FTIR showed the typical infrared spectrum and polyethylene was identified as one of the main components in this example and polypropylene can be identified as another additional component. Usually the analysis of marine waste such as microplastics requires a large number of samples, and simple and quick measurements. The compact Fourier transform infrared spectrophotometer IRSpirit is able to identify organic materials as well as some inorganic materials, so it can quickly determine the main components and identify the measured contaminants using a spectral library.

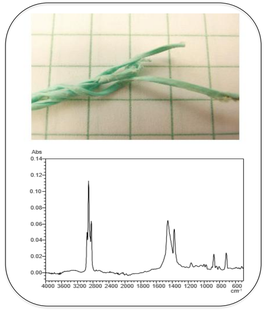

Figure 3: FTIR spectrum of fishing nets identified as Polyethylene/ Polypropylene

3. Identification by Spectral Libraries

Shimadzu “LabSolutions” software for FTIR include approximately 12,000 spectra in a proprietary spectral library. Furthermore, a "Thermally degraded plastic library" is available as an optional software package, which contains a total of 111 spectra of unheated and heat-degraded at 200 ° C to 400 ° C for 13 types of plastics. Chemical degradation of plastics is almost always considered as oxidative degradation. In the infrared spectrum, broad spectral peaks derived from the chemical structure of the C = O group around 1700 cm^{-1} and the OH group around 3300 cm^{-1} are observed respectively and these peaks are gradually growing according to the degree of resin deterioration (Figure 4). It is found out that this is also effective for the characteristics of UV-degraded microplastic.

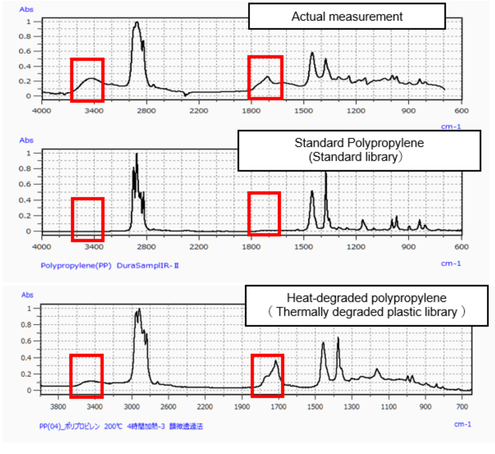

Figure 4: Infrared spectrum and library search result of MPs

A significant difference was observed in the area of the OH group and the C=O group, which is considered to be the effect of oxidative degradation.

4. Analysis using Infrared Microscope

In addition to the FTIR measurements with IRSpirit, analyses of secondary microplastic particles have been done utilizing an IRTracer-100 in combination with infrared microscope AIM-9000. Secondary microplastics such as that found in oceans and rivers were prepared as a sample and measured. Microplastics dispersed in water were filtered and collected using a polytetrafluoroethylene (PTFE) filter. In order to identify the microplastic particles collected on the filter, mapping analysis was performed using infrared transmission micro-spectroscopy. Figure 5 shows an optical microscopic image of the microplastics on the filter. Figure 6 shows typical infrared spectra from the areas in Figs. 5-(a) to (c). The measurements revealed that the microplastics in the sample were polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET).

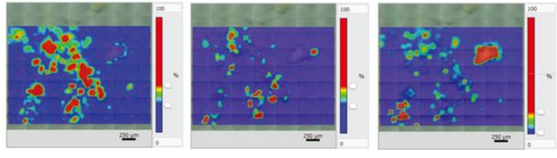

Figure 5: (a): PE distribution (b) PP distribution (c) PET distribution

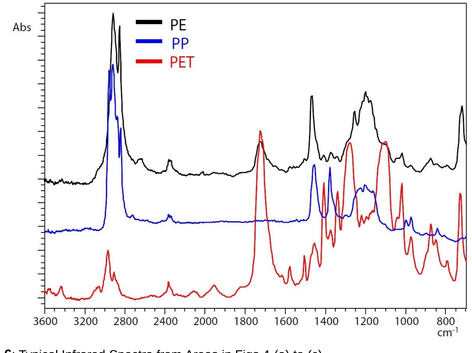

Figure 6: Typical Infrared Spectra from Areas in Figs.4-(a) to (c)

5. Summary

FTIR/ µFTIR in combination with sophisticated libraries are perfect tools for the identification of microplastics. Additives or organic contaminants in MPs can be toxic, can develop endocrine effects, can give an unpleasant taste to the food or even enhance degradation needs analysis by GC/LC-MS techniques. Heavy metals like cadmium, arsenic, hexavalent chromium, and lead are well known for their high level of toxicity and need analysis using atomic spectroscopy/ x-ray fluorescence.or LC-ICPMS. Shimadzu can offer the full solution out of the analytical toolbox.

6. References

[1] European Union, 2018, JRC 110629
[2] Sources of microplastics relevant to marine protection in Germany, BfR, 2015/64