GL Sciences

Application Note 140

Pyrolysis–GC–MS for Microplastic Analysis Using the OPTIC-5 Pyrolyzer; Polystyrene (PS)

OPTIC-5

Pyrolyzer

Keywords
Pyrolysis, OPTIC-5, LINEX, Py–GC–MS

1. Introduction
Microplastics, particularly polystyrene (PS), are persistent environmental pollutants of growing concern due to their potential health impacts and widespread occurrence. Analytical techniques capable of identifying and quantifying microplastics at trace levels are essential for environmental monitoring. This application note describes a method for the analysis of polystyrene microplastics using Pyrolysis–Gas Chromatography–Mass Spectrometry (Py–GC–MS) equipped with an OPTIC-5 programmable pyrolyzer inlet and the LINEX automated liner exchange system.

Pyrolysis–GC–MS is a powerful analytical technique that allows for the detailed analysis of polymer degradation products. The OPTIC-5 Pyrolyzer provides precise control over the pyrolysis process, and when coupled with the LINEX Liner Exchanger, it facilitates automated and reproducible sample introduction. This automation is especially valuable for the analysis of microplastics, where consistent sample handling and high throughput are essential.

The OPTIC-5 Pyrolyzer, paired with the LINEX automatic liner exchanger, facilitates precise and reproducible pyrolysis, while the ChromIdent software ensures reliable pyrogram identification and analysis.

This application note demonstrates the analysis of PS microplastics using Pyrolysis–GC–MS with the OPTIC-5 and LINEX Liner Exchanger, offering a rapid and reliable method for characterizing the thermal degradation products of PS microplastics.

2. Instrumentation
OPTIC-5 Pyrolizer – : A high-precision pyrolysis unit capable of rapid and efficient heating, offering a range of temperature control settings for different materials. The OPTIC-5 Pyrolyzer ensures that polypropylene is broken down into its constituent monomers and other pyrolysis products at controlled temperatures up to 1000°C.

LINEX Automatic Liner Exchanger – The LINEX system automates the exchange of pyrolysis liners, ensuring a contamination- and oxygen-free sample introduction and maintaining reproducibility between sample runs. It is particularly useful when analyzing multiple samples of microplastics in a high-throughput setting.

GC–MS System – The GC is equipped with a non-polar column for optimal separation of pyrolysis products. The Mass Spectrometer operates in electron impact (EI) ionization mode for the identification of the pyrolyzed products.

ChromIdent Software – ChromIdent software is specifically designed for pyrogram analysis. It helps identify the chemical structures of pyrolysis products based on their mass spectra

and chromatographic retention times. ChromIdent also supports data interpretation and compares results with libraries of known pyrolysis products.

3. Experimental

A small amount of microplastic sample is weighed into a µ-vial . Following the µ-vial is put in a quartz liner, getting placed in a sample rack of the PAL3 xyz-autosampler. Once the GC–MS system is ready for analysis, the LINEX head for automatic tube exchanges opens and gives access to the OPTIC-5 Pyrolyzer. The PAL3, equipped with a LINEX Tool places the tube into the OPTIC-5 Pyrolyzer, after which the LINEX head closes. After closing the LINEX head, the tube is purged with carrier gas during 30 seconds at 50 ml/min. Once purging is finished, the tube is rapidly heated with 60°C/sec to 700°C, where it is held during 10 seconds. The pyrolysis products are transferred to the capillary column with a split flow of 100 ml/min. For GC separation of the pyrolysis products, the GC oven starts at 40°C where it is held during 2.0 minutes. Then, the GC oven is ramped with 10°C/min to 350°C where it is held during 3.0 minutes. The capillary column is a 30 m × 0.25 mm × 0.25µm InertCap 5HT from GL Sciences with 5 m ProGuard capillary, The ProGuard prevents for bleeding products from the head of the capillary being connected to the OPTIC-5 Pyrolyzer. The helium column flow is constant at 1.5 ml/min. The mass spectrometer is running in scan mode in the mass range 29 – 800 amu, after a delay of 1.5 minutes. Figure 1 gives a schematic overview of the LINEX on top of the OPTIC-5 Pyrolyzer with the connected capillary column. All analytical conditions are summarised in Table 1. Figure 2 gives an impression of the workflow.

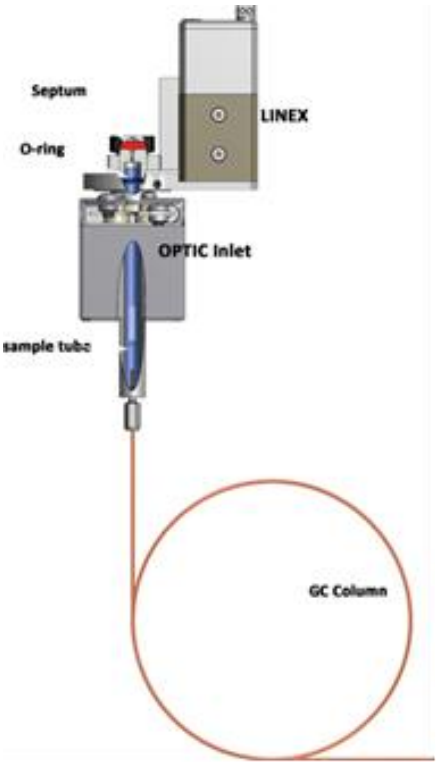

Figure 1: Hardware setup. The LINEX opens/closes the head of the OPTIC automatically to enable the placement/removal of the sample tube, containing a µ-vial with the microplastic sample.

Table 1: Analytical conditions.

Parameter	Setting
OPTIC-5 Pyrolyzer	
Sample	1 mg Polystyrene (PS)
Tube	Quartz DMI Liner [2414-1018] containing a µ-vial [2406-1020]
Purge flow	50 ml/min
Temperature	40°C(10 sec) – 60°C/sec – 700°C(10 sec)
Column flow	1.5 ml/min
Gas Chromatograph	
Temperature	40°C(2.0 min) – 10°C/min – 350°C(3 min)
Capillary column	InertCap 5HT ProGuard 5m, 30+5m × 0.25 mm × 0.25µm [1010-90926]
Mass Spectrometer	
Delay	1.5 minutes
Mass Range	29 – 800 amu

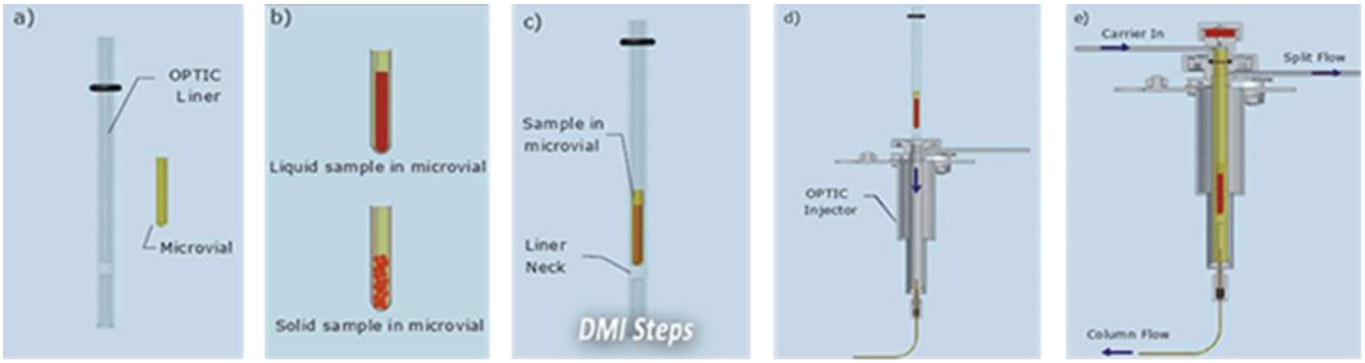

Figure 2: Impression of the workflow.

4. Results

Upon pyrolysis, polystyrene decomposes into characteristic pyrolyzates, notably styrene monomer, dimers, and trimers, which serve as key markers for identification. The main peaks observed in the chromatogram included:

- Styrene (m/z 104)
- 1,3-Diphenylpropane
- Styrene dimer and trimer species

Using extracted ion chromatograms (EIC) for m/z 104, selective detection of polystyrene fragments was achieved, even in complex environmental matrices.

The reproducibility of the pyrolysis profiles between liners confirmed consistent thermal decomposition, enabling confident qualitative and quantitative assessments.

The pyrolysis products were successfully separated using the InertCap 5HT ProGuard column, which provided high resolution separation for the volatile degradation products. A characteristic series of peaks was observed, corresponding to styrene monomers, di- and trimers compounds. The mass spectra of these compounds were consistent with the degradation products reported for PS, with well-defined peaks matching known fragmentation patterns.

The use of the LINEX Liner Exchanger for automated sample introduction enhanced the throughput and reproducibility of the analysis. Automated liner exchange reduced the potential for contamination between samples and ensured that each sample was introduced in a consistent manner. This automation is particularly beneficial for high-throughput analyses, such as those required for environmental monitoring or large-scale studies of microplastics.

The total analysis time per sample was approximately 30 minutes, including pyrolysis, chromatographic separation, and mass spectrometric detection. This rapid analysis time makes the system ideal for analyzing large numbers of PS microplastic samples in a relatively short period. The LINEX Liner Exchanger further optimized sample handling, allowing for automated sample introduction and reducing manual intervention.

Besides the typical pyrolysis products of PS, this polymer produces a very distinctive Pyrogram. Figure 3 presents the Pyrogram of PS using the OPTIC-5 Pyrolyzer. The compounds mentioned above are identified by their mass spectrum.
An additional way for microplastic identification is the summed Total-ion-current (TIC) mass spectrum, over the whole pyrogram. Figure 4 presents the summed TIC mass spectrum of the pyrogram in Figure 3.

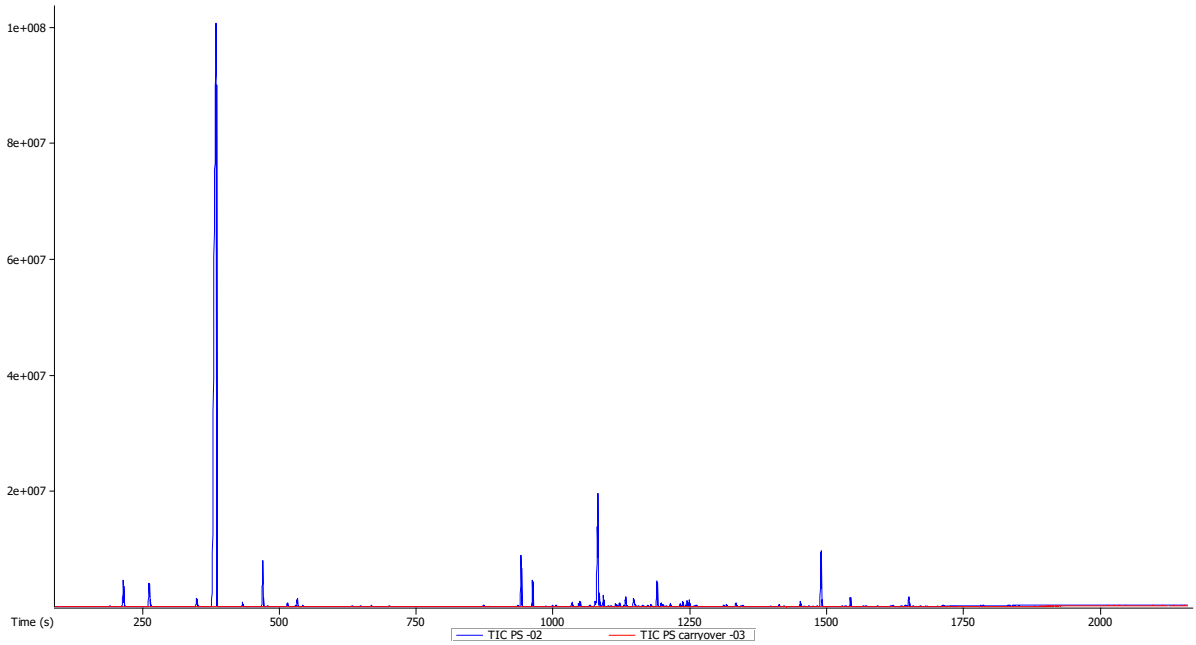

Figure 3: Pyrogram of PS. Blue, Pyrogram; Red, blank run after pyrolysis-run.

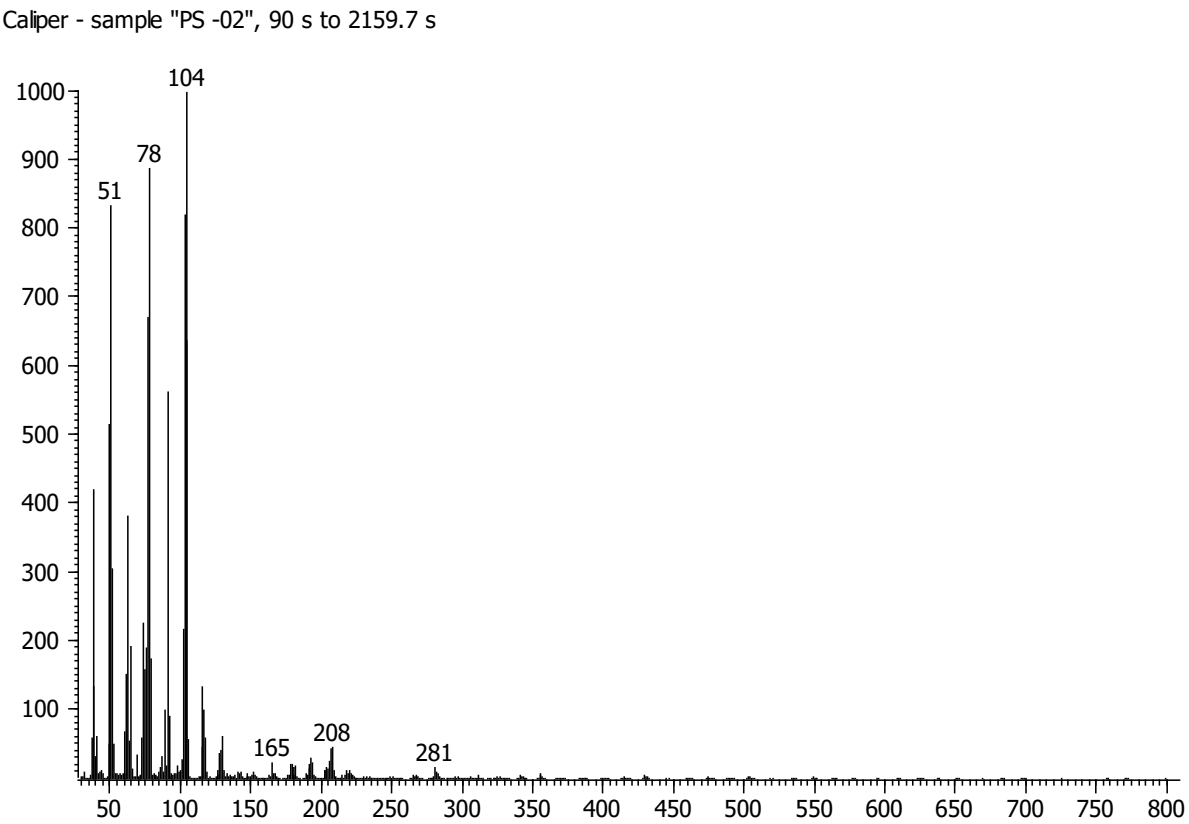

Figure 4: Summed TIC mass spectrum of PS.

By utilizing ChromIdent software, the pyrolysis products are easily identified based on their mass spectra, and their chemical structures are confirmed through the comparison with known reference libraries. The software compares the retention times and mass spectra of the identified peaks against an internal library of known pyrolysis products. This improves the accuracy of polymer and micro-plastic identification, especially for complex mixtures, and reduces the need for manual interpretation of the pyrogram.

The amount of PS in an environmental sample can be quantified by integrating the area under the peaks corresponding to the characteristic pyrolysis products. Calibration curves can be prepared using known concentrations of pure PS to convert peak areas into microplastic concentrations.

5. Conclusions

This method demonstrates that Py–GC–MS using the OPTIC-5 Pyrolyzer and the LINEX liner exchange system is highly effective for the qualitative and quantitative analysis of polystyrene microplastics. The system enables reproducible and efficient analysis with minimal manual handling, making it suitable for routine environmental testing and microplastic research.

- **Precision and Control** – The OPTIC-5 Pyrolyzer offers precise control over pyrolysis conditions, ensuring reproducibility and accuracy in the analysis of microplastics.
- **Minimal Sample Preparation** – This technique requires minimal sample preparation, allowing for the direct analysis of microplastics in environmental samples with high sensitivity.
- **Small Sample Size** – The OPTIC-5 can analyze small sample amounts (as low as a few milligrams), which is advantageous when working with limited microplastic samples.
- **No Carryover** – There is no need to run a blank between samples, since the OPTIC-4 Pyrolyzer is free of carryover, even after high sample load.
- **No thermal oxidation** – Since the sample is purged with carrier gas, all oxygen is vented prior to pyrolysis. This absolutely prevents for thermal oxidation of the sample.
- **Comprehensive Polymer Characterization** – Pyrolysis-GC-MS provides detailed molecular information, allowing for the identification of polyethylene even in complex environmental matrices.

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