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How to accurately identify submicron microplastics with O-PTIR

by Photothermal Spectroscopy Corp. | February 25, 2025
| Technical article (https://www.photothermal.com/technical-article/)

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As microplastics emerge as a significant environmental concern, their detection and accurate identification have become critical to assessing their impact on ecosystems and human health. Microplastics as small as a few microns can enter cellular boundaries, transport toxins, and pose unknown risks. However, traditional tools for microplastic analysis, such as direct IR (FTIR/QCL), struggle with particles smaller than 20 microns due to spatial resolution limitations and particle size-dependent artifacts.

Raman spectroscopy does have spatial resolution on the order of up to one micron but can often suffer from significant fluorescence interferences and poor spectral sensitivity. Optical photothermal infrared (O-PTIR) spectroscopy enhances microplastic analysis by delivering submicron spatial resolution, with spectral quality that is independent of particle shape/size and without any fluorescence interferences. Thus, O-PTIR delivers unparalleled accuracy and confidence in microplastic identification. When coupled with simultaneous IR (O-PTIR) and Raman data collection modes, samples are fully characterized, ensuring all sample types, whether they have strong IR and/or Raman signals, are fully covered.

The Challenge of Microplastics Detection

The complexity of microplastics stems from their diverse shapes, sizes, and chemical compositions. There is a growing consensus that the smaller—sub-20 micron, even submicron—fractions that likely pose the greatest biological risks, due to increased chance of entering the bloodstream or even entering cells. Current detection tools face the following key limitations:

- Direct IR (FTIR/QCL): Though chemically specific, traditional direct IR tools lack sufficient spatial resolution, often limited to 20 microns or larger. Moreover, it is prone to scattering artifacts from irregular particle shapes and sizes, degrading spectral accuracy.
- Raman Spectroscopy: While offering high spatial resolution, Raman suffers from fluorescence interference on many microplastic types and requires long acquisition times due to low sensitivity.
- Optical Microscopy: Studies have shown that fluorescence-based Nile Red staining can detect polymeric particles, but the technique lacks chemical specificity, making it unsuitable for robust analysis.

These challenges underscore the need for a technique that overcomes both spatial resolution and spectral reliability issues—a gap that O-PTIR fills.

How O-PTIR Revolutionizes Microplastics Identification

O-PTIR's innovative approach enables multimodal, correlative spectroscopy and microscopy into a single platform, addressing the limitations of traditional techniques:

- Submicron Spatial Resolution: By using a visible green laser to detect photothermal effects, O-PTIR achieves spatial resolutions below one micron, surpassing traditional IR diffraction limits.
- Artifact-Free Spectra: O-PTIR provides FTIR transmission/ATR mode quality spectra that are unaffected by particle shape and size, ensuring robust and repeatable chemical identification, even using existing commercial or customer FTIR databases.
- Non-Contact, Non-Destructive Analysis: O-PTIR's reflection-mode measurement preserves the integrity of microplastic samples while delivering accurate results.
- Simultaneous IR and Raman Spectroscopy: This capability allows researchers to collect complementary chemical data from the exact same particle, enhancing confidence in identification.

- Co-located fluorescence microscopy and O-PTIR can provide a unique methodology for quickly identifying specific MP types and subsequent O-PTIR spectroscopy.

Key Applications of O-PTIR in Microplastics Research

1. Identifying Microplastics in Environmental Samples: Microplastics from aquatic and soil environments often consist of weathered particles. O-PTIR can measure these particles directly on specific filters, without additional preparation steps. The resulting FTIR-like spectra enable precise identification of polymers like polyethene and polypropylene.
2. Analyzing Submicron Particles: Unlike traditional techniques, O-PTIR can identify sub-micron particles. A recent analysis demonstrated the identification of single 500-nanometer polystyrene beads, with spectra comparable to bulk FTIR results, achieved in seconds.
3. Combining Fluorescence and O-PTIR Imaging: Nile Red staining highlights polymeric particles within complex samples. O-PTIR combines fluorescence imaging with infrared spectroscopy to confirm the chemical composition of the highlighted particles, reducing false positives and ensuring efficient analysis by directing the O-PTIR measurements to only the polymeric particles, which often are a minority amongst all common particles, thus enabling increased sample throughput.
4. Distinguishing Between Polymers: O-PTIR excels at differentiating chemically similar polymers by leveraging its extended spectral range, including the CH stretch region, a region inaccessible to other QCL-based IR systems. This enables researchers to analyze particles that would otherwise produce overlapping or ambiguous signals with traditional FTIR.

Case Study: Accurate Microplastics Analysis with O-PTIR

During a recent webinar demonstration (https://www.photothermal.com/webinars/accurate-microplastics-identification-from/), microplastics collected on a gold-coated polycarbonate filter were analyzed to showcase O-PTIR's capabilities. The particles ranged from 500 nanometers to 50 microns in size and included both fibers and irregular shapes. O-PTIR measured the particles in reflection mode, producing FTIR-quality spectra free from scattering artefacts. Even for submicron particles, the spectra were reproducible and searchable against existing FTIR libraries, confirming the polymers' identities with high confidence. The integration of Raman data provided additional validation, demonstrating the technique's robustness.

Why O-PTIR Is Decisive for Microplastics Research

O-PTIR addresses long-standing challenges in microplastics analysis by delivering:

- High Spatial Resolution: Measure large (mm's) down to submicron, even sub-500nm sized particles.
- Reliable Spectra: Artifact-free, high-quality spectra independent of particle morphology.
- Speed and Efficiency: Submicron measurements in seconds, reducing analysis time significantly.
- Comprehensive Chemical Data: Simultaneous IR and Raman data collection provides confirmatory results.
- Flexibility: Compatibility with various sample substrates and minimal sample preparation requirements.

Looking to Identify Submicron Microplastics?

As microplastic contamination raises global concerns, accurate identification methods are essential for research and mitigation efforts. O-PTIR offers a transformative approach, combining submicron spatial resolution, artefact-free spectra, and simultaneous IR and

Raman capabilities. By addressing the limitations of traditional techniques, O-PTIR empowers researchers (https://www.photothermal.com/) to advance the understanding of microplastics' impact on the environment and human health.

Ready to elevate your microplastics research? Contact Photothermal today to learn how O-PTIR can revolutionize your analysis.

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