
Miriam Unger¹

Mustafa Kansiz², Carolin Borbeck¹, Eoghan Dillon²

1. Photothermal Spectroscopy Corp. GmbH, Landgrafenstr.12, 45476 Muelheim an der Ruhr, Germany

2. Photothermal Spectroscopy Corp., 325 Chapala Street, Santa Barbara, CA 93101, USA

miriam@photothermal.com

Smaller Plastics, Bigger Risks: Revealing Micro- and Nanoplastics with Submicron IR (O-PTIR) Microspectroscopy

Microplastic (MP) contamination has become a global environmental and health concern, with particles now detected in water, air, soil, and biological systems. These particles can enter the human body through ingestion or inhalation, where submicron microplastics and nanoplastics ($<1\ \mu\text{m}$) are of particular concern due to their ability to cross biological barriers and accumulate in tissues.

Infrared (FTIR/QCL) and Raman spectroscopy are the most widely used tools for MP analysis, yet both face major challenges at small particle sizes. Conventional FTIR microscopy is generally limited to particles $>20\ \mu\text{m}$ due to diffraction and suffers from scattering artefacts that compromise spectral reproducibility. Raman spectroscopy offers higher spatial resolution ($<10\ \mu\text{m}$) but is often limited by fluorescence interference, reduced sensitivity, and frequent false-positive assignments, including the misidentification of long-chain molecules such as stearates as polymers like polyethylene. These limitations leave a critical analytical gap in characterizing submicron plastics, the size range most relevant to biological uptake and toxicity.

Optical Photothermal Infrared (O-PTIR) spectroscopy overcomes these constraints by delivering true submicron infrared spatial resolution ($<500\ \text{nm}$) in an optical microscope format. Operating in reflection mode, O-PTIR provides FTIR transmission- or ATR-like spectral quality without contact or scattering artefacts and is unaffected by fluorescence or dark or highly absorbing samples. In addition, its multimodal capability enables simultaneous, same-spot, same-time, same-resolution Raman measurements for complementary chemical information.

We have developed automated workflows for the detection and chemical characterization of micron and submicron MP particles using combined O-PTIR and Raman spectroscopy. Following optical or fluorescence-based screening, particles of interest are automatically measured to acquire both IR and Raman spectra. Real-world case studies demonstrate how this approach enables high-confidence detection, identification, and spatial mapping of micro- and nanoplastics in environmental and biological samples, revealing what has long remained inaccessible to conventional vibrational spectroscopy.